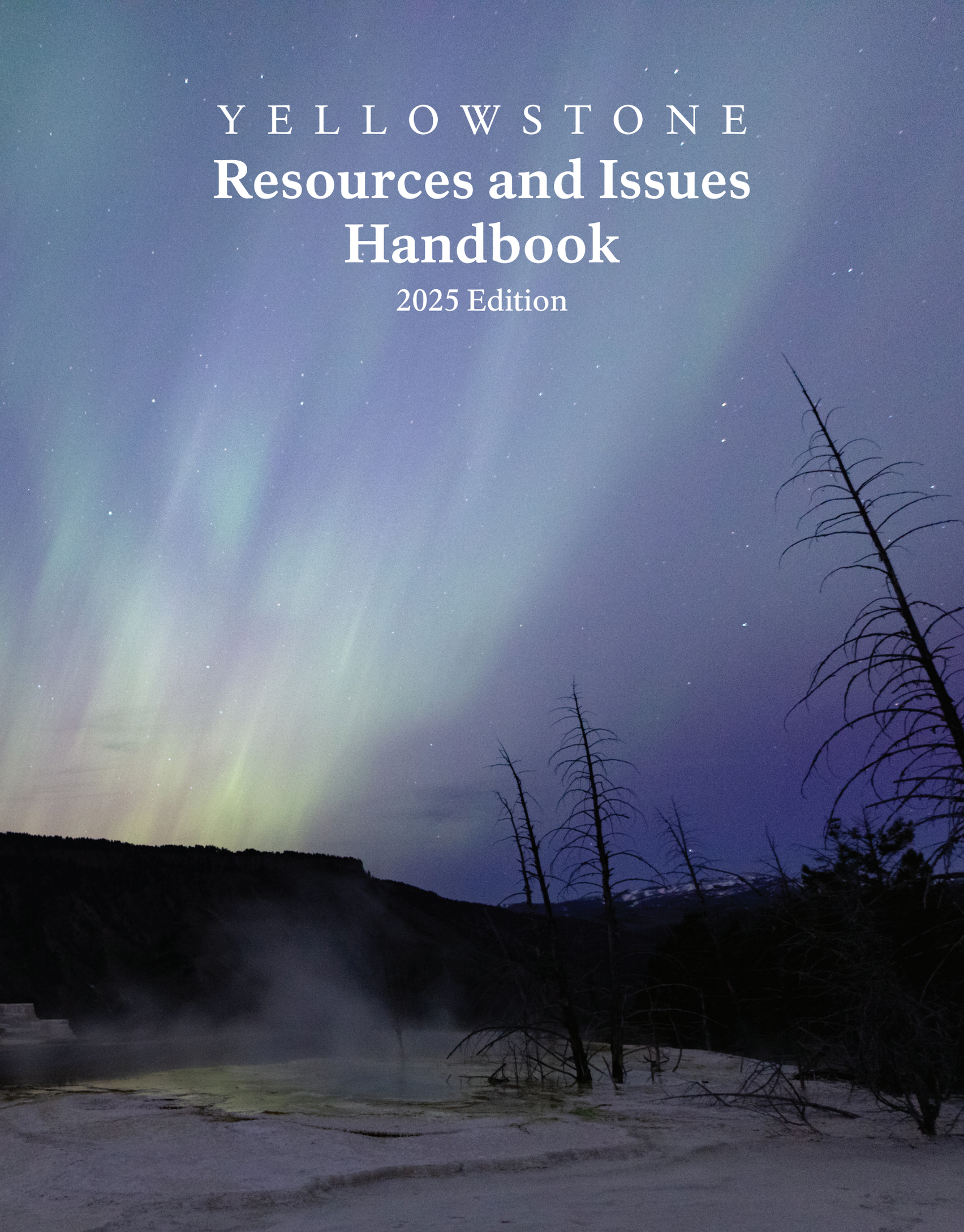

YELLOWSTONE

Resources and Issues Handbook

2025 Edition

Yellowstone Park and Protection Act

In 1872, the US Congress established Yellowstone National Park. The Yellowstone National Park Protection Act states, "the headwaters of the Yellowstone River … is hereby reserved and withdrawn from settlement, occupancy, or sale … and dedicated and set apart as a public park or pleasuring-ground for the benefit and enjoyment of the people."

The Organic Act of the National Park Service

On August 25, 1916, President Woodrow Wilson signed the act creating the National Park Service, a federal bureau in the Department of the Interior. The Organic Act of the National Park Service states "the Service thus established shall promote and regulate the use of Federal areas known as national parks, monuments and reservations … by such means and measures as conform to the fundamental purpose of the said parks, monuments and reservations, which purpose is 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."

ON THE COVER

Aurora Borealis over Canary Spring, Upper Terraces of Mammoth Hot Springs, May 10, 2024. NPS / Jacob W. Frank

YELLOWSTONE

Resources and Issues Handbook

2025

An annual compendium of information about
Yellowstone National Park

U.S. Department of the Interior • National Park Service • Yellowstone National Park
Yellowstone National Park, Wyoming 82190

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Yellowstone National Park, the world's first national park, is named after the Yellowstone River.

Welcome

Yellowstone National Park is as wondrous as it is complex. The park has rich human and ecological stories that continue to unfold. When Yellowstone was established as the world's first national park in 1872, it sparked an idea that influenced the creation of the National Park Service and the more than 400 sites it protects today across the United States. Yellowstone National Park also forms the core of the Greater Yellowstone Ecosystem. At 34,375 square miles, it is one of the largest, nearly intact temperate-zone ecosystems on Earth. The park continues to influence preservation and science, and we are pleased to share its stories with you.

Many people have dedicated their lives and careers to studying Yellowstone, and the park has a long history of research and public interest. In a given year, the park hosts between 115 and 150 researchers from various agencies, universities, and organizations. These researchers produce hundreds of papers, manuscripts, books, and book chapters on their work annually—a volume of information that is difficult to absorb. This compendium is intended to help you understand the important concepts about Yellowstone's many resources and contains information about the park's history, natural and cultural resources, and issues.

In addition to the references listed for each topic covered in this handbook, here are some interdisciplinary sources:

- www.nps.gov/yell
- *Yellowstone Science,* free from the Yellowstone Center for Resources, in the Yellowstone Research Library, or online at www.nps.gov/yellowstonescience.
- The park visitor guide, distributed at entrance gates and visitor centers.
- Site bulletins, free upon request at visitor centers. Published as needed, these provide more detailed information on park topics.
- Trail guides, available at all visitor centers. A $1 donation is requested.

Park Facts

Yellowstone National Park was established on March 1, 1872.

Yellowstone is the world's first national park.

GEOGRAPHY

3,472 square miles (8,991 km^2)
2,221,766 acres or 899,116 hectares. *Note: No area figures have been scientifically verified. Efforts to confirm the park's total area continue.*
63 air miles north to south (102 km)
54 air miles east to west (87 km)
96% in Wyoming, 3% in Montana, 1% in Idaho
Highest Point: 11,358 feet (3,462 m; Eagle Peak)
Lowest Point: 5,282 feet (1,610 m; Reese Creek)
Larger than Rhode Island and Delaware combined
About 5% covered by water; 15% by grassland; and 80% by forests

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

Temperature
Average daily, at Mammoth:
January: 9ºF (–13ºC)
July: 80ºF (27ºC)
Records:
High: 99ºF (37ºC), 2002 (Mammoth)
Low: –66ºF (–54ºC), 1933 (West Entrance, Riverside Station)

Yellowstone Lake
131.7 square miles of surface area (341.1 km^2)
141 miles of shoreline (227 km)
20 miles north to south (32 km)
14 miles east to west (22 km)
Average depth: 138 feet (42 m)
Maximum depth: 430 feet (131 m)

GEOLOGY

An active volcano
One of the world's largest calderas at 45 x 30 miles (72 x 48 km)
1,000–3,000 earthquakes annually
More than 10,000 hydrothermal features
About 500 active geysers (more than half the world's active geysers)
About 290 waterfalls
Tallest waterfall near a road: Lower Falls of the Yellowstone River at 308 feet (94 m)

WILDLIFE

67 species of mammals, including
7 species of native ungulates
2 species of bears
~330 species of birds (150 nesting)
16 species of fish (5 nonnative)
More than 7 aquatic nuisance species (3 having significant detrimental effect)
5 species of amphibians
6 species of reptiles
2 threatened species: Canada lynx, grizzly bears

VEGETATION

9 species of conifers (more than 80% of forest is lodgepole pine)
1,000+ native plant taxa (3 endemic)
238 nonnative plant taxa
186 species of lichens

CULTURAL RESOURCES

27 associated Native American tribes
More than 1,800 known archeological sites
More than 300 ethnographic resources (animals, plants, sites)
25 sites, landmarks, and districts on the National Register of Historic Places; many more eligible for listing
1 National Historic Trail
More than 840 historic buildings
More than 720,000 museum items, including 30 historic vehicles
Millions of archived documents
More than 20,000 books (many rare), manuscripts, periodicals

EMPLOYEES

National Park Service
Total during summer: 748
Permanent: 392
Term (variable duration): 4
Seasonal: 356

Concessioners
About 3,200 people work for concessioners at summer peak.

FACILITIES

11 visitor centers, museums, and contact stations
9 hotels/lodges (2,000+ hotel rooms/cabins)
6 NPS-operated campgrounds (300+ sites)
5 concession-operated campgrounds (1,700+ sites)
More than 1,450 buildings
52 picnic areas, 1 marina

ROADS AND TRAILS

5 park entrances
457 miles (735 km) of roads (392 miles [630 km] paved)
More than 15 miles (24 km) of boardwalk, including 13 self-guiding trails
Approximately 1,100 miles (1,770 km) of backcountry trails
92 trailheads
299 backcountry campsites

BUDGET

Fiscal Year 2024 (in millions)
Total: $128.1
Federal Funding: $94.7
Operations and staff (base): $39.8
Facility Construction, Rehab, & Cyclic Maintenance: $50.3
Wildland Fire: $1.4
Other Appropriations: $3.2
Other Funding: $33.4
Donations and Grants: $2.1
Fees: $24.8
Utilities & Agreements (Reimbursable): $6.5

Distribution of Budget
Park Support: 11%
Includes human resources, contracting, budget and finance, partnerships, telecommunications, and information technology.
Facility Operations and Maintenance: 58%
Includes utilities, roads, trails, structures, historic preservation coordination, construction management.
Park Protection: 14%
Includes law enforcement, emergency medical services, search and rescue, entrance station operations, structural fire activities.
Resource Stewardship: 11%
Includes management operations and monitoring of natural and cultural resources, invasive species management, research coordination.
Visitor Services: 6%
Includes interpretation and education, and park concessions management.

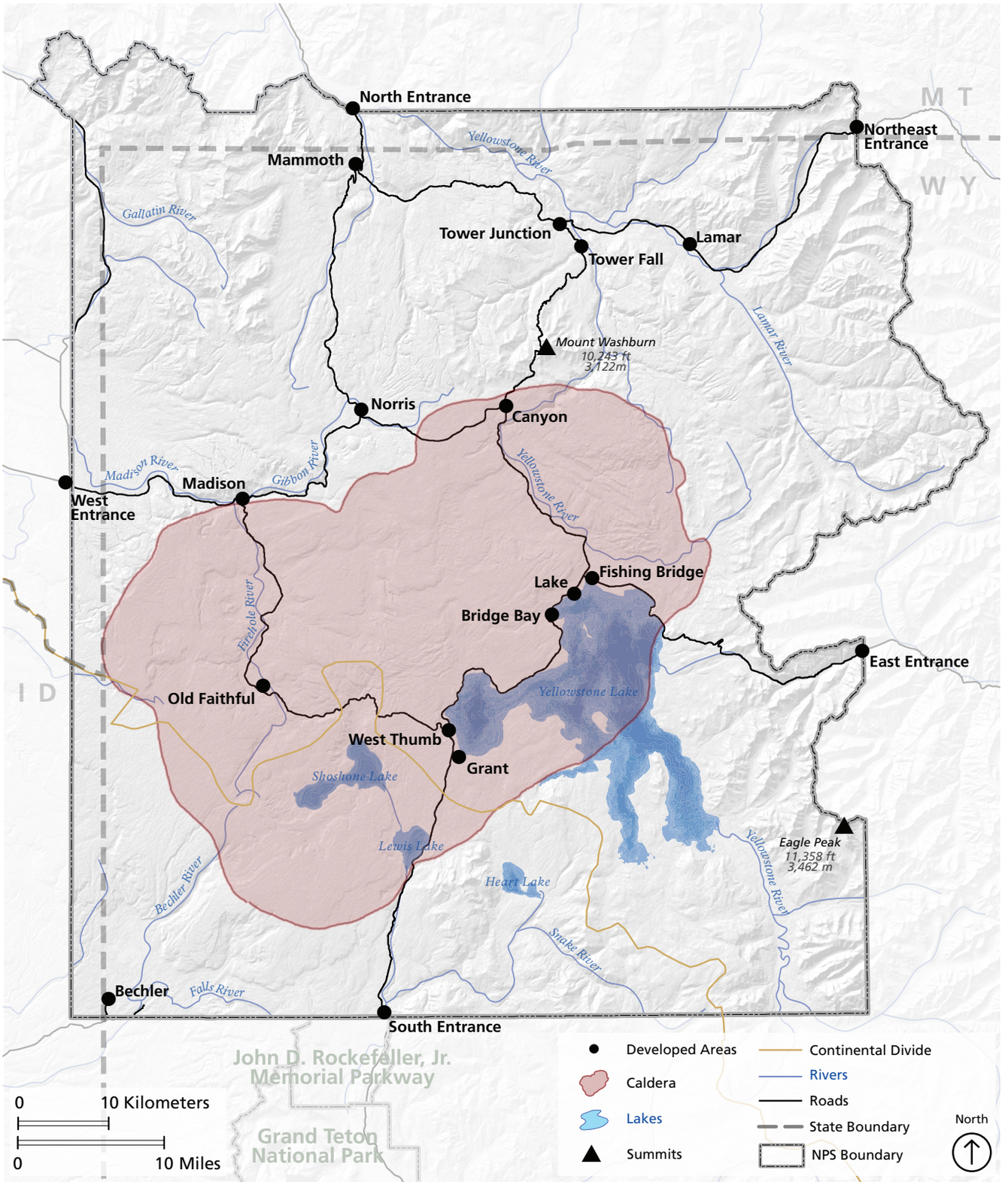
VISITATION

The park recorded 4.74 million visits in 2024, up 44% from 2022, during which historic floods disrupted public access to sections of the park.
Detailed park visitation information is available at https://irma.nps.gov/Stats/

Top 10 Visitation Years

1.	2021	4,860,242
2.	2024	4,744,353
3.	2023	4,501,382
4.	2016	4,257,177
5.	2017	4,116,524
6.	2018	4,115,000
7.	2015	4,097,710
8.	2019	4,020,287
9.	2020	3,806,306
10.	2010	3,640,185

Yellowstone National Park



Frequently Asked Questions

How did Yellowstone get its name?

Yellowstone National Park is named after the Yellowstone River, the major river running through the park. According to French-Canadian trappers in the 1800s, they asked the name of the river from the Minnetaree tribe, who live in what is now eastern Montana. They responded "Mi tse a-da-zi," which translates as "Yellow Stone River." The trappers translated this into French, and, in 1797, explorer-geographer David Thompson first used the English translation. Lewis and Clark called the Yellowstone River by the French and English forms. Subsequent use formalized the name "Yellowstone."

Is Yellowstone the largest national park?

No. More than half of Alaska's national park units are larger, including Wrangell–St. Elias National Park and Preserve, which is the largest unit (13 million acres) in the National Park System. Until 1994, Yellowstone (at 2.2 million acres) was the largest national park in the contiguous United States. That year Death Valley National Monument was expanded and became a national park—it has more than 3 million acres.

Is Yellowstone the most visited national park?

No. Yellowstone is in the top five national parks for number of recreational visits. In 2024, Great Smoky Mountains National Park had the most—just under 12.2 million. Zion came in second at 4.95 million visits, followed by Grand Canyon (4.91 million), Yellowstone (4.74 million), and Rocky Mountain (4.15 million). Visit the website https://nps.gov/aboutus/visitation-numbers.htm to find out more details about how many visitors come to our national parks.

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

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 Forest Service is mandated to wisely manage resources for many sustainable uses. Six national forests surround Yellowstone National Park.

How many rangers work in Yellowstone?

Approximately 750 people work for the National Park Service during the peak summer season. In 2024, approximately 392 were permanent employees. Park rangers work in education, resource management, law enforcement, emergency medical services, and backcountry operations. Other employees specialize in research, maintenance, management, administration, trail maintenance, fire management, and fee collection.

How do you become a park ranger?

Park rangers have a variety of different duties. Most have a bachelor's degree in a related field, and some may have advanced degrees or additional special training in law enforcement, education, or wildlife management. Park rangers are federal employees hired by individual parks. Many National Park Service employees begin their careers as volunteers or as seasonal employees. Hiring is very competitive and is conducted through the Office of Personnel Management website: usajobs.gov.

Approximately 750 people work for the National Park Service in Yellowstone National Park during the peak summer season.

Can we swim in rivers and lakes?

Swimming is not recommended, and is occasionally prohibited, because most lakes and streams are dangerously cold. Firehole Canyon, near Madison Junction, has a swimming area popular in summer.

Soaking in thermal features is illegal.

What is the highest peak in the park?

Eagle Peak in the southeastern part of Yellowstone is the highest at 11,358 feet (3,462 m).

Why is Yellowstone called a biosphere reserve and a world heritage site?

The United Nations designated Yellowstone National Park as a biosphere reserve and a world heritage site in recognition of the worldwide significance of its natural and cultural resources. These designations have nothing to do with how Yellowstone is managed—the United Nations has no authority to dictate federal land management decisions in the United States—nor do they change the fact that Yellowstone is under the legal authority of the United States of America.

The October 26, 1976, United Nations designation of Yellowstone as a biosphere reserve stated:

> *Yellowstone National Park is recognized as part of the international network of biosphere reserves. This network of protected samples of the world's major ecosystem types is devoted to conservation of nature and scientific research in the service of man. It provides a standard against which the effect of man's impact on the environment can be measured.*

The September 8, 1978, United Nations designation of

Yellowstone as a world heritage site, requested by US President Richard Nixon and Congress, stated:

> *Through the collective recognition of the community of nations … Yellowstone National Park has been designated as a World Heritage Site and joins a select list of protected areas around the world whose outstanding natural and cultural resources form the common inheritance of all mankind.*

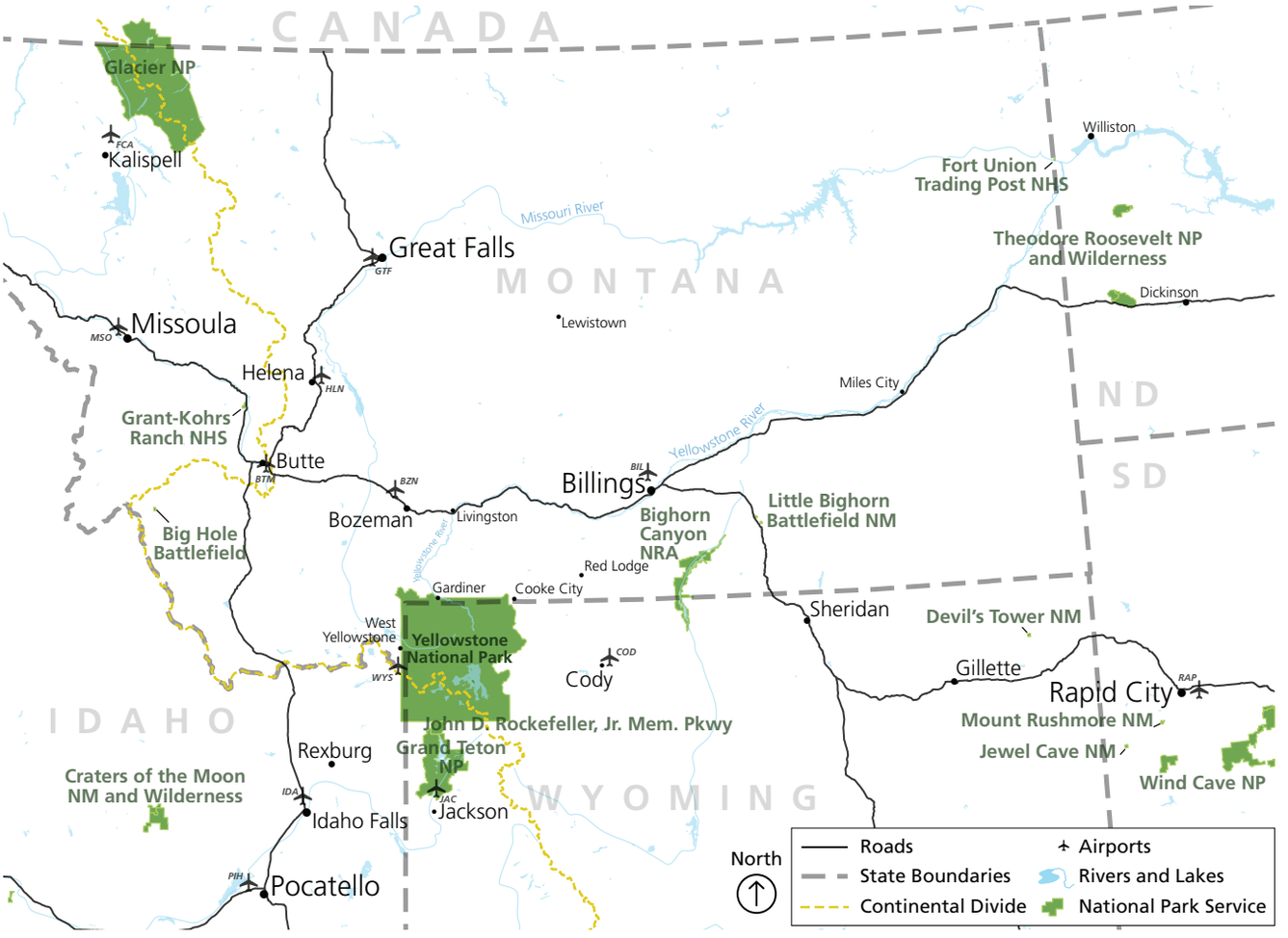
To find out more, visit www.unesco.org/mab.

What is the Continental Divide?

Think of the Continental Divide as the crest of the continent. Theoretically, when precipitation falls on the west side of the Divide, it eventually reaches the Pacific Ocean. When it falls on the east side of the Divide, it eventually reaches the Atlantic Ocean. In Yellowstone (as elsewhere), this ridgeline is not straight. You cross the Continental Divide three times between the South Entrance and the Old Faithful area. Craig Pass is the highest crossing, at 8,262 feet (2,518 m).

How did Mt. Washburn form?

At 10,219 feet (3,115 m), this peak can be seen from many locations in the park. It is a remnant of an extinct volcano from the Absaroka Volcanics of about 50 million years ago. The volcano was literally split in two by a volcanic eruption 631,000 years ago. Only the northern part of the original volcano is still visible.



The National Park Service manages approximately 83 million acres in 50 states, the Virgin Islands, Puerto Rico, Guam, and American Samoa. Here are the sites near Yellowstone.

The Lower Falls shown here, are 308 feet (94 m) tall.

Canyon Village Area

Notable Areas and Structures

- Artist Point
- Grand Canyon of the Yellowstone River
- Mount Washburn
- Hayden Valley

How tall are the falls?

Upper Falls: 109 feet (33 m).; Lower Falls: 308 feet (94 m).

How big is the Grand Canyon of the Yellowstone?

This huge canyon is roughly 20 miles (32 km) long, more than 1,000 feet (305 m) deep, and 1,500–4,000 feet (457–1,219 m) wide at various points.

How did the canyon form?

Scientists continue to develop theories about its formation. After the Yellowstone Caldera eruption 631,000 years ago, lava flows and volcanic tuffs buried the canyon area, but hydrothermal gases and hot water weakened the rock. The river eroded this rock, carving a canyon in the Yellowstone River beginning at Tower Fall and heading upstream to Lower Falls.

Where can I see the canyon and falls?

North Rim Drive: Walkways at Lookout Point and Brink of the Lower Falls lead to views of the waterfalls (just not both waterfalls from the same location). The longest stretch of accessible trail can be accessed from parking lots at Lookout or Grand View. You can also see the Lower Falls from Red Rock and Inspiration points.

South Rim Drive: See the Lower Falls at Artist Point, and from a few places along the South Rim Trail; see the Upper Falls from two viewpoints at Upper Falls Viewpoints. Due to improvement projects, please consult the park newspaper for the latest information concerning access.

Visit ***Brink of Upper Falls*** from a viewing area just off the Grand Loop Road south of Canyon Junction, between the entrances to North and South Rim drives.

Where can I see both falls at once?

The canyon bends between the Upper and Lower falls, so there is no location where they can be seen at the same time.

What causes the different colors in the canyon?

You could say the canyon is "rusting." The colors are caused by oxidation of iron compounds in the rhyolite rock, which has been hydrothermally altered ("cooked"). The colors indicate the presence or absence of water in the individual iron compounds and hydration of minerals in the rock. Most of the yellows in the canyon result from iron and sulfur in the rock.

How much water goes over the falls?

The volume varies from 63,500 gallons (240,000 l) per second at peak runoff to 5,000 gallons (18,900 l) per second in the late fall.

What causes the Lower Falls' green stripe?

The natural color of the water. A notch in the lip of the brink makes the water deeper and keeps it from mixing with air and becoming frothy, so the color is visible as it goes over the edge.

Can I get to the bottom of the canyon?

Only one trail in this area leads to the bottom of the canyon—Seven Mile Hole Trail, a strenuous, steep round trip of 10.2 miles.

Is Artist Point the location where Thomas Moran painted his Grand Canyon of the Yellowstone?

No. It is thought that some sketches were made from Moran Point and that multiple canyon views were incorporated into the final painting.

What animals can I see in this area?

Inside the canyon, look for osprey soaring over the river or perched on their five-foot (1.5 m)-diameter nests. They nest here from late April until early September. Also look for ravens and swallows. During July, a variety of butterflies feasts on the abundant flowers in the meadows.

Hayden Valley, approximately five miles (8 km) south of Canyon Junction, is one of the best places in the park to view a wide variety of large mammals. Grizzly bears and black bears are often seen in the spring and early summer. Large herds of bison may be seen in the spring, early summer, and during the rut in August. Coyotes can almost always be seen in the valley; wolves are often seen as well.

Mount Washburn is an excellent place for viewing wildlife. Bighorn sheep and marmots can be seen on its slopes in the summer. Elk and bison frequent the valley north of the mountain.

Fishing Bridge, located on the Yellowstone River at Yellowstone Lake, is a good place to watch trout, though fishing is now prohibited from the bridge.

Fishing Bridge, Lake, and Bridge Bay

Historic Areas and Structures

- Fishing Bridge
- Fishing Bridge Visitor Center
- Lake Historic District
- Lake Fish Hatchery Historic District
- Lake Hotel
- Bridge Bay Marina Historic District
- East Entrance Historic Road

Where does the Yellowstone River begin? Where does it end?

It begins on the slopes of Younts Peak in the Absaroka Mountains southeast of the park. From here it flows 671 miles (1080 km) to the Missouri River near the Montana–North Dakota border. Its waters then travel to the Mississippi River and into the Atlantic Ocean at the Gulf of America. It is the longest undammed river in the contiguous United States.

How big is Yellowstone Lake? How deep? Is it natural?

The lake is natural and has 131.7 square miles (341.1 km^2) of surface area and 141 miles (227 km) of shoreline; it is 20 miles (32 km) long by 14 miles (22 km) wide. Its deepest spot is about 430 feet (131 m); its average depth is 138 feet (42 m). The lake's basin has an estimated capacity of 12,095,264 acre-feet ($1.5x10^{13}$ l) of water. Because its annual outflow is about 1,100,000 acre-feet ($1.3x10^{12}$ l), 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 (2 m). It is the largest lake at high elevation (above 7,000 ft/2134 m) in North America.

How did Yellowstone Lake form?

The lake's main basin is part of the Yellowstone Caldera, which was formed 631,000 years ago. West Thumb was formed by a later, smaller eruption. The arms of the lake were formed by uplift along fault lines and sculpting by glaciers. The lake drains north at Fishing Bridge. Some scientists consider LeHardys Rapids to be the geologic northern boundary of the lake because the periodic rise and fall of that site appears to control lake outflow.

Why can't we fish from Fishing Bridge?

Overfishing for cutthroat trout here contributed to their decline in the lake. The trout also spawn here. For these reasons, fishing is prohibited from the bridge. It's still a good place to watch trout.

How cold is Yellowstone Lake?

During late summer, Yellowstone Lake becomes thermally stratified, with several water layers having different temperatures. The topmost layer rarely exceeds 66°F (18.8°C), and the lower layers are much colder. Because of the extremely cold water, survival time for anyone in the lake is estimated to be only 20 to 30 minutes. In winter, ice thickness on Yellowstone Lake varies from a few inches to more than two feet with many feet of snow on top of the ice.

What happened to the old campground at Fishing Bridge?

The National Park Service campground was located where bears came to fish, and many conflicts between humans and bears occurred. It was closed in 1989. A recreational-vehicle park, operated by a concessioner, still exists in the area. Only hard-sided camping units or RVs are allowed at this campground.

What animals can I see in this area?

The lake is home to the largest population of Yellowstone cutthroat trout in North America. From Fishing Bridge, you can see these trout and longnose suckers. In spring, you might be able to see trout leaping upstream at LeHardys Rapids, three miles north of Fishing Bridge. Also look for white pelicans, bald eagles, osprey, and a variety of ducks and other water birds.

The Fishing Bridge area, including Pelican Valley to the north and east, is especially significant to bears and other wildlife because lake, river, and terrestrial ecosystems merge here to create a diverse natural complex. Bears visit numerous streams in the spring and early summer to eat spawning trout. A bison herd winters in Pelican Valley, and individuals can be seen throughout the area. Moose used to be seen in the Yellowstone Lake area much more than they are today; look along water edges and in marshes. At Bridge Bay Marina, look for river otters.

What's that smell at Mud Volcano?

That "rotten egg" smell comes from hydrogen sulfide gas. Sulfur, in the form of iron sulfide, gives the features their many shades of gray.

The Madison River is a good place to watch wildlife. Bison use the meadows adjacent to the Madison and Gibbon rivers and in the summer, move to Hayden Valley, their traditional summer habitat and breeding area.

Madison and West Yellowstone Area

Historic Areas and Structures

- Madison Information Station

How did Madison Junction get its name?

Here, the Gibbon River joins the Firehole River to form the Madison River. (The Gibbon River flows from Grebe Lake through the Norris area to Madison Junction. The Firehole River starts south of Old Faithful and flows through the park's major hydrothermal basins north to Madison Junction.) The Madison joins the Jefferson and the Gallatin rivers at Three Forks, Montana, to form the Missouri River.

What forms the cliffs around Madison Junction?

Part of what you see is the rim of the Yellowstone Caldera, and adjacent lava flows. National Park Mountain is actually part of the lava flows. Some of these lava flows come down to the road through Firehole Canyon, approximately one mile (1.6 km) south of Madison Junction. Gibbon Falls, four miles (6.4 km) north of the junction, drops 84 feet (26 m) over a remnant of the caldera rim.

Why is the bridge between Madison and the West Entrance called "Seven Mile Bridge"?

Seven Mile Bridge is located midway between (and seven miles from both) the West Entrance and Madison Junction. This landmark serves as a convenient reference point and separates the rugged lava-lined Madison Canyon east of the bridge from the gentle hills to the west.

Where is the swimming area?

South of Madison Junction is the entrance to the Firehole Canyon Drive, a one-way route that follows the Firehole River. Along this route are views of the Firehole Falls and a swimming area where the water is influenced by thermal activity from upstream. Swimming is undertaken at your own risk. Please note that climbing the cliffs around the swimming area erodes the thin topsoil and damages area habitat. Jumping from the cliffs is very dangerous and is forbidden.

What animals can I see in this area?

During the fall rut, elk frequent the meadows from Seven Mile Bridge to Madison Junction.

During spring, fall, and winter, herds of bison favor the meadows adjacent to the Madison and Gibbon rivers. Bison often use the entrance road to travel from one foraging area to another. In summer, they move to Hayden Valley, their traditional summer habitat and breeding area.

Bald eagles have nested west of Seven Mile Bridge in recent years. Several pairs of ospreys also nest along the Madison. You might also see trumpeter swans, Canada geese, mallards, Barrow's goldeneyes, and other water birds.

What is the National Park Mountain story?

The legend, which you can read about at the Madison Information Station, tells of explorers camping here in 1870 and deciding Yellowstone should be set aside as a national park. It is a wonderful story, but it isn't true. Explorers did camp at the junction in 1870, but they apparently did not discuss the national park idea.

They camped in a location where people have camped for millennia. Archeologists have found campfire remnants, obsidian flakes, and bone fragments dating back at least 10,000 years.

Mammoth Hot Springs is noted for its hot springs and history. Visitors can tour the Mammoth Terraces on foot and by car and take a self-guided or guided tour of historic Fort Yellowstone.

Mammoth Hot Springs Area

Historic Areas and Structures

- Mammoth Hot Springs Historic District
- Fort Yellowstone Historic Landmark District
- Obsidian Cliff National Historic Landmark
- US Post Office
- Administrative Headquarters
- Roosevelt Arch

Are the springs drying up?

No, the overall activity and volume of water remains relatively constant. Sometimes the water is concentrated in a few springs; at other times, it may spread across many outlets. In every case, water follows the path of least resistance, which could be above ground or underground. Scientists estimate that, at any given time, about 10% of the water in the Mammoth Hot Springs system is on the surface; the other 90% is underground.

Why are the dry springs so white?

Limestone, a naturally white rock, underlies this area. Hot water dissolves the compound calcium carbonate from the limestone, which is deposited at the surface to form travertine. Colors in the hot springs come from thermophilic organisms (thermophiles).

Where does the water come from?

In the surrounding mountains, rain and snow soak through the ground. The water is heated below the surface. As it rises, it dissolves the limestone rock that lies beneath the Mammoth area.

The terraces are like living sculptures, shaped by the volume of water, the slope of the ground, and objects in the water's path. Travertine builds up rapidly and causes features to change quickly and constantly.

Does the heat for the hot springs come from the Yellowstone Caldera?

Mammoth Hot Springs lies to the north of the caldera. Scientists continue to study where the heat for the hot springs comes from. One possibility is the volcano's magma chamber, similar to the heat source for other thermal areas closer to the 631,000-year-old caldera. There may also be basaltic magma bodies, related to the Yellowstone Volcano, deep underground between Norris and Mammoth, which could be a contributing heat source.

Can we soak in the hot springs?

No. The travertine features are very fragile.

How was Bunsen Peak formed?

At 8,564 feet (2610 m), Bunsen Peak (south of Mammoth) is an intrusion of igneous material (magma) formed approximately 50 million years ago. Bunsen Peak and the "Bunsen burner" were named for physicist Robert Wilhelm Bunsen. He was involved in pioneering geyser research in Iceland. His theory on geyser activity, published in the 1800s, is still considered accurate.

What were these old buildings?

Many of the older buildings grouped together in Mammoth belong to Fort Yellowstone, built by the US Army from 1891 to 1913, when it managed the park. A self-guided trail goes through this National Historic Landmark District.

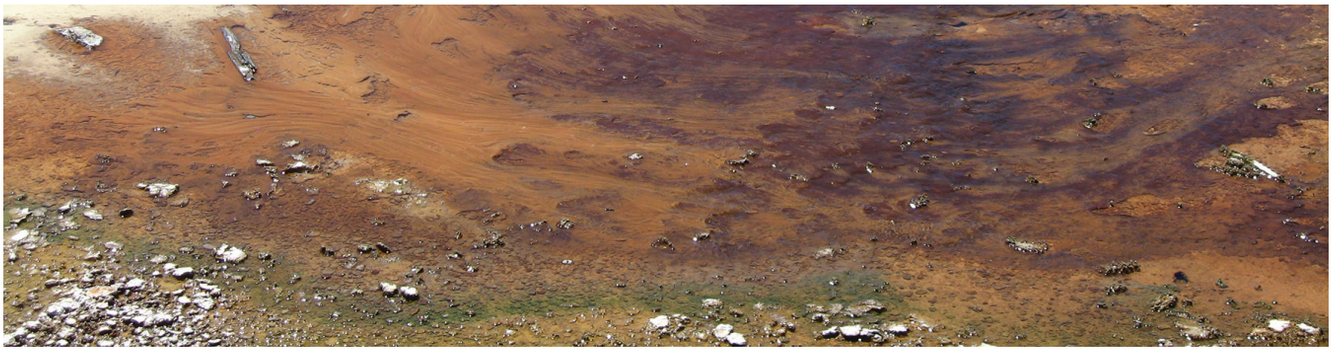
Most of the buildings constructed during the Army era are still standing and used by the National Park Service as park headquarters. At present, many of these buildings are used for park administration. Others are employee residences.

What forms the big, long mountain north of Mammoth?

The mountain is called Mount Everts, 7,841 feet (2390 m) high. It consists of layered sandstones and shales—sedimentary deposits from a shallow inland sea 70–140 million years ago. Its steep cliffs—eroded by glaciers, floods, and landslides—provide habitat for bighorn sheep. It was named for explorer Truman Everts, a member of the 1870 Washburn Expedition who became lost. He was found east of the mountain, near Blacktail Plateau.

What animals can I see in this area?

Elk live here all year, and they are wild and unpredictable. Every year visitors are chased, trapped, and sometimes injured by elk. Look for Uinta ground squirrels in front of the visitor center and among the hotel cabins during summer. South of Bunsen Peak is Swan Lake Flat, where visitors often see elk, bison, and sometimes grizzlies and wolves. It is also an excellent place for watching cranes, ducks, and other birds.



The Norris Geyser Basin periodically experiences widespread change lasting from a few days to a few weeks, often referred to as "thermal disturbance."

Norris Area

Historic Areas and Structures

- Norris Soldier Station (now the Museum of the National Park Ranger)
- Norris Geyser Basin Museum

When will Steamboat Geyser erupt?

Steamboat's major eruptions (more than 300 feet high) are unpredictable and often many years apart. Steamboat Geyser began an eruptive period on March 15, 2018, after a more than 3.5-year dormancy. The geyser has been erupting somewhat regularly (but not predictably) since that date up to publication of this handbook. Its frequent "minor phase" eruptions eject water 10 to 40 feet high.

When does Echinus Geyser erupt?

Once very predictable, Echinus's eruptions are now months to years apart but could become frequent again.

Why is Norris so colorful?

The colors here, as in other hydrothermal areas, are due to combinations of minerals and life forms that thrive in extreme conditions. At Norris, silica or clay minerals saturate some acidic waters, making them appear milky. Iron oxides, arsenic, and cyanobacteria create the red-orange colors. *Cyanidium* glows bright green. Mats of *Zygogonium* are dark purple to black on the surface where they are exposed to the sun, bright green beneath. Sulfur creates a pale yellow hue.

Is Norris Geyser Basin within the Yellowstone Caldera?

Norris is not in the Yellowstone Caldera, but it is close to the caldera rim, with its associated ring fractures and faults. The northern edge of the first caldera lies near the southern base of Mount Holmes, which is north of Norris. The Yellowstone Caldera's rim is south and east of Norris.

What is the "thermal disturbance" at Norris that people talk about?

Periodically, Norris Geyser Basin undergoes a large-scale basin-wide thermal disturbance lasting from a few days to a few weeks. Water levels fluctuate, temperatures and pH change, color changes, and eruptive patterns change throughout the basin. No one is sure what causes a thermal disturbance. It might be caused by a massive fluctuation in the underground reservoirs providing water to the basin's features. In the fall, this may happen when surface-water levels decrease, causing a decrease in pressure in deeper, underground thermal water. This may allow the deeper thermal waters to mix and flow to the ground surface.

How did Norris get its name?

The area is named for Philetus W. Norris, the second superintendent of Yellowstone, who provided early detailed information about the hydrothermal features. Two historic buildings remain in this area: The Norris Geyser Basin Museum and the Museum of the National Park Ranger, which is located in the Norris Soldier Station, one of the only remaining soldier stations in the park.

What causes the roar of Roaring Mountain?

Early visitors would recount "roars" from Roaring Mountain, a large, acidic hydrothermal area (solfatara) with many fumaroles. The number, size, and power of the fumaroles have ebbed and flowed over time. Today the fumaroles are most easily seen in the cooler, low-light conditions of morning and evening.

What will I see on Virginia Cascade Drive?

This one-way drive east of Norris follows the Gibbon River upstream, alongside outcrops of volcanic rock (Lava Creek Tuff). Here, you are close to the Yellowstone Caldera's rim. Virginia Cascade is formed by the Gibbon River as it crosses the tuff.

Are mudpots in this area?

Yes, at Artists' Paintpots, which is located 3.8 miles south of Norris Junction. The steep trail to the mudpots is one-mile (1.6 km) round-trip.

What animals can I see in this area?

Black and grizzly bears are sometimes seen. Grizzlies feed on carcasses of elk and bison that died in the hydrothermal areas during the winter.

Norris is one of the few areas in the park where sagebrush lizards live. They can survive here due to the warmth of hydrothermal activity. Listen for chorus frogs in spring.

Killdeer are found in the basin year-round, taking advantage of the brine flies and other insects that live in the warm waters.

Visitors have long gathered near the Old Faithful Inn to watch Old Faithful Geyser erupt. Visitors can view other geysers and thermal features on boardwalks that wind through the basins.

Old Faithful Area

Notable Places

- Upper, Midway, and Lower geyser basins

Historic Areas and Structures

- Nez Perce National Historic Trail
- Old Faithful Inn
- Old Faithful Lodge
- Old Faithful Historic District
- Both general stores
- Queen's Laundry, begun in 1881 but never finished, in Sentinel Meadows

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

The median interval between eruptions of Old Faithful Geyser changes; as of January 2025, it is 102 minutes ± 10 minutes, with intervals ranging from 54 to 118 minutes. Old Faithful can vary in height from 106 to more than 180 feet (32.3–54.8 m), averaging 130 feet (40 m). Eruptions normally last between 1½ to 5 minutes and expel from 3,700 to 8,400 gallons (14,000–31,800 l) of water. At the vent, water is 203°F (95.6°C).

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

Since its formal discovery in 1870, Old Faithful has been one of the more predictable geysers. Over time, the average interval between eruptions has increased, in part due to ongoing processes within its plumbing. Changes also result from earthquakes. Prior to the Hebgen Lake Earthquake (1959), the interval between Old Faithful's eruptions averaged more than one hour. After the earthquake, it started erupting with two distinct intervals—a short and a long one. Its average interval increased. After the 1983 Borah Peak Earthquake, centered in Idaho, it increased again. In 1998, an earthquake near Old Faithful lengthened the interval again; subsequent earthquake swarms further increased intervals. Sometimes the average interval decreases.

How can you predict it, if it changes so much?

Old Faithful Geyser has been analyzed for years by mathematicians, statisticians, and dedicated observers. They have shown that a relationship exists between the duration of Old Faithful's eruption and the length of the following interval. During a short eruption, less water and heat are discharged; thus, they recharge in a short time. Longer eruptions mean more water and heat are discharged and they require more time to recharge. In the early morning, staff use information posted online by geyser enthusiasts who are in the basin or watching Old Faithful on the webcam outside of the regular operating hours of the visitor education center.

What else can I see at this geyser basin?

The Upper Geyser Basin has 150 geysers in one square mile, plus hundreds of hot springs. Five large geysers are predicted regularly by the education ranger staff. You can reach these and other features on boardwalks that loop through this basin. Walk or drive to nearby Black Sand Basin and Biscuit Basin to view their features.

What will I see at Midway Geyser Basin?

This geyser basin, six miles (9.6 km) north of the Old Faithful area, is small but spectacular. Excelsior Geyser is a 200 x 300-foot (61 x 91.4 m) crater that constantly discharges more than 4,000 gallons (15,142 l) of water per minute into the Firehole River. Grand Prismatic Spring, Yellowstone's largest hot spring, is 200–330 feet (61–100 m) in diameter and more than 121 feet (36.8 m) deep.

Can I see mudpots in this area?

You'll see all four types of thermal features (geysers, hot springs, fumaroles, and mudpots) at Fountain Paint Pot, eight miles north of Old Faithful and two miles north of Midway Geyser Basin. Be sure to drive the Firehole Lake Drive, where you can walk past hot cascades, see hot springs large and small, and view geysers such as White Dome and Great Fountain.

What animals can I see in this area?

Hydrothermal basins provide important habitat for wildlife in the Old Faithful area. Bison, coyotes, and ravens live here year-round. In the winter, bison take advantage of the warm ground and thin snow cover. Both black and grizzly bears are seen, especially during the spring when winter-killed animals are available. In summer, yellow-bellied marmots are frequently seen in the rocks behind Grand Geyser and near Riverside Geyser. Thermophiles live in the runoff channels of hot springs and geysers, providing food for tiny black ephydrid flies. The flies, in turn, lay their eggs in salmon-colored clumps just above the water surface where they are then preyed upon by spiders. Killdeer also feast on the adult flies.

The rock columns in the canyon north of Tower Fall were formed by a lava flow that cracked into hexagonal columns as it slowly cooled.

Tower–Roosevelt Area

Notable Places

- Lamar Valley
- Northeast Entrance Road

Historic Areas and Structures

- Lamar Buffalo Ranch
- Northeast Entrance Station
- Tower Ranger Station Historic District
- Roosevelt Lodge Historic District
- Roosevelt Lodge

Why is this area called "Tower"?

The area is named for its major waterfall, Tower Fall, which is named for the tower-like rock formations at its brink.

How tall is Tower Fall?

132 feet (40 m).

Old pictures show a big boulder at the brink of Tower Fall. When did it fall?

W.H. Jackson's photograph in 1871 clearly shows the boulder. For more than a century, visitors wondered when it would fall. It finally did in June 1986.

Can I hike to the bottom of Tower Fall?

No. The lower part of the trail is closed because of severe erosion. You can walk past the Tower Fall Overlook for 0.75-mile (1.2 km), ending with a view of Tower Creek flowing into the Yellowstone River. If you have heart, lung, or knee problems, you may want to enjoy the view from the overlook.

What formed the rock columns in the canyon north of Tower Fall?

The rock columns were formed by a basaltic lava flow that cracked into hexagonal columns as it slowly cooled. You can see other basalt columns at Sheepeater Cliff along the Gardner River between Mammoth and Norris.

How did Petrified Tree become petrified?

Petrified Tree, west of Tower Junction, is an excellent example of an ancient redwood. Petrification of this and other trees occurred for two main reasons. They were buried rapidly by volcanic deposits and mudflows 45–50 million years ago, which minimized decay. The volcanic deposits also contributed high amounts of silica to the groundwater. Over time, the silica precipitated from ground water, filled the spaces within the trees' cells, and petrified the trees.

In Yellowstone, glacial ice, running water, and wind have uncovered vast areas of petrified trees. With proper optical aids, you can see some of these areas from the road that follows the base of Specimen Ridge, east of Tower Junction.

Did Teddy Roosevelt really stay at Roosevelt Lodge?

No, but President Theodore Roosevelt camped nearby during his visit to Yellowstone in 1903. The lodge opened in 1920. The area is registered as the Roosevelt Lodge Historic District. Contrary to popular belief, it was not President Roosevelt but President Ulysses S. Grant who signed the order that created Yellowstone National Park.

What animals can I see in this area?

Elk, bison, deer, and pronghorn thrive in the grasslands of this area known as the northern range. Some of the largest wild herds of bison and elk in North America are found here. The northern range is critical winter habitat for these large animals, which in turn provide food for several packs of wolves. Coyotes are also common, and occasional bobcat, cougar, or red fox are reported.

The gorge and cliffs between the junction and Tower Fall provide habitat for bighorn sheep, osprey, peregrine falcons, and red-tailed hawks. Both grizzly and black bears are sighted throughout the area, particularly in the spring. Black bears are more commonly seen around Tower Fall and Tower Junction. Grizzlies are sometimes seen in the Lamar Valley and on the north slopes of Mount Washburn, particularly in the spring when elk are calving. Moose are most often observed between Pebble Creek and the Northeast Entrance. Road pullouts provide excellent places from which to watch wildlife.

What is the purpose of the fenced areas north of the Blacktail Ponds?

Many park researchers have used the fenced areas on the northern range to study the long-term effects of grazing by fencing out large herbivores. Researchers can use existing data from the permanent plots or collect new data.

West Thumb is the largest geyser basin on the shore of Yellowstone Lake. Hydrothermal features also lie under the lake, melting ice on the lake's surface during winter.

West Thumb and Grant Village Area

Why is this area called West Thumb?

Yellowstone Lake resembles the shape of a human hand; West Thumb is the large western bay that would be the thumb. The bay is a caldera within a caldera. It was formed by a volcanic eruption approximately 174,000 years ago. The resulting caldera later filled with water, forming an extension of Yellowstone Lake.

West Thumb is also the largest geyser basin on the shore of Yellowstone Lake—and its hydrothermal features lie under the lake too. The heat from these features can melt ice on the lake's surface.

How did Fishing Cone get its name?

People learned they could stand on this shoreside geyser, catch a fish in the cold lake, and cook it in the hot spring. Fortunately for anglers, this geyser has only two years of known eruptions: In 1919, it erupted frequently to 40 feet and, in 1939, to lesser heights. Fishing here is now prohibited.

How hot are the springs at West Thumb?

Temperatures vary from less than 100°F (38°C) to just over 200°F (93°C).

How deep are Abyss and Black pools?

Abyss is about 53 feet deep; nearby Black Pool is 35–40 feet deep.

The mudpots here aren't like they used to be. What happened?

Like all hydrothermal features, the West Thumb Paint Pots change over time. During the 1970s and 1980s, they were less active; they became more active in the 1990s.

What happened to the development at West Thumb?

Early visitors would arrive at West Thumb via stagecoach from the Old Faithful area. They could continue on the stagecoach or board the steamship "Zillah" to reach the Lake Hotel.

Later, a gas station, marina, photo shop, store, cafeteria, and cabins were built here. They were removed in the 1980s to protect the hydrothermal features and improve visitor experience. Grant Village now provides most of these facilities. West Thumb still has restrooms, picnic tables, and a bookstore and information desk in the historic ranger station.

What can I do in the Grant Village and West Thumb area?

This area provides numerous opportunities for adventure. Take in the spectacular views of West Thumb and the Absaroka Mountains from the shores of Yellowstone Lake. Explore the hot springs, mud pots, and geysers of the West Thumb Geyser Basin. Hike one of the local trails, such as the Scenic Lake Overlook, or begin an overnight backpacking excursion at one of the many wilderness trailheads. Also, private and commercial paddling excursions launch from the Grant Village Marina.

Why does Grant Campground open so late in the year?

Grizzly and black bears frequent this area in spring when cutthroat trout spawn in five nearby streams. To protect bears and people, the campground opens after most of the spawn is over.

Isn't there a unique lake nearby?

That's Isa Lake, at Craig Pass. At one time, it was probably the only lake on Earth that drained naturally backwards to two oceans, the east side draining to the Pacific and the west side to the Atlantic. If this phenomenon still occurs, it is only at the peak of snow melt after winters with deep snowfall.

What's that big lake you see south of Craig Pass?

Shoshone Lake is the park's second-largest lake and is thought to be the largest lake in the lower 48 states that cannot be reached by road. Its maximum depth is 205 feet (62.4 m), and it has an area of 8,050 acres (32.6 km^2). The Shoshone Geyser Basin contains one of the highest concentrations of geysers in the world—more than 80 in an area 1,600 x 800 feet (488 x 244 m).

What animals can I see in the West Thumb area?

In addition to the bears that frequent this area in spring, elk cows and their new calves are often seen here in May and June. Bald eagles and osprey dive into the bay to catch cutthroat trout. Other birds include ravens, common loons, and bufflehead and goldeneye ducks.

In winter, pine marten are sometimes seen. River otters pop in and out of holes in the ice. Coyotes and bald eagles eat their fish scraps.

People have spent time in the Yellowstone region for more than 11,000 years. Rock structures like this are evidence of the early presence of people in the area.

History of the Park

The human history of the Yellowstone region extends back more than 11,000 years. The stories of people in Yellowstone are preserved in archeological sites and objects that convey information about past human activities in the region and in people's connections to the land that provide a sense of place or identity.

Today, park managers use archeological and historical studies to help understand how people lived here in the past. Ethnography helps us learn how groups of people identify themselves and their connections to the park. Research is also conducted to learn how people continue to affect and be affected by these places, many of which have been relatively protected from human impacts. Some alterations to the landscape, such as the construction of roads and other facilities, are generally accepted as necessary to accommodate the needs of visitors today. Information on the possible consequences of modern human activities, both inside and outside the parks, is used to determine how best to preserve Yellowstone's natural and cultural resources and the quality of the visitor experience.

History of Yellowstone National Park

Precontact

- People have been in Yellowstone more than 11,000 years, as shown by archeological sites, trails, and oral histories.
- Although the Tukudika (a.k.a. Sheep Eaters) are the most well-known group of Native Americans to use the park, many other tribes and bands lived in and traveled through what is now Yellowstone National Park prior to and after European American arrival.

European Americans Arrive

- European Americans began exploring in the early 1800s.
- Osborne Russell recorded visits in the 1830s.
- First organized expedition explored Yellowstone in 1870.

Protection of the Park Begins

- Yellowstone National Park established in 1872.
- Railroad arrived in 1883, allowing easier visitor access.
- The US Army managed the park from 1886 through 1918.
- Automobiles allowed into the park in 1915, making visits easier and more economical.
- National Park Service created in 1916.
- First boundary adjustment of the park made in 1929.

Park Management Evolves

- 1963: "Leopold Report" released, recommending changes to how wildlife is managed in the park.
- 1970: New bear management plan eliminated open-pit garbage dumps in park.
- 1988: "Summer of Fire."
- 1995: Wolves restored to the park.
- 1996: Federal buyout of gold mine northeast of Yellowstone protected the park.

Paleoindian Period

~11,000 years ago

A Paleoindian point from this period was made from obsidian quarried from Obsidian Cliff.

10,000 years ago

Sites all over the park yield paleoindian artifacts, particularly concentrated around Yellowstone Lake. Clovis peoples hunted large game and gathered resources across North America.

Hell Gap point, made 9,600 to 10,000 years ago

The Earliest Humans in Yellowstone

Human occupation of the greater Yellowstone area seems to follow environmental changes of the last 15,000 years. How far back is still to be determined—there are no known sites in the park that date to this time—but humans probably were not using this landscape when glaciers and a continental ice sheet covered most of what is now Yellowstone National Park. The glaciers carved out valleys with rivers that people could follow in pursuit of Ice Age mammals such as the mammoth and the giant bison. The last period of ice coverage ended 13,000 to 14,000 years ago. Sometime after that, but before 11,000 years ago, humans were here on this landscape.

Archeologists have found physical evidence of human presence in the form of distinctive stone tools and projectile points. From these artifacts, scientists surmise that they hunted mammals and gathered berries, seeds, and plants.

As the climate in the Yellowstone region warmed and dried, the animals, vegetation, and human lifestyles also changed. Large Ice Age animals that were adapted to cold and wet conditions became extinct. The glaciers left behind layers of sediment in valleys in which grasses and sagebrush thrived, and pockets of exposed rocks that provided protected areas for aspens and fir to grow. The uncovered volcanic plateau sprouted lodgepole forests. People adapted to these changing conditions. As early as 9,500 years ago, they were eating a diverse diet including medium and small animals such as deer and bighorn sheep.

Cody knife (c. 9,350 years ago) from the Yellowstone National Park museum collection

This favorable climate would continue more than 9,000 years. Evidence of these people in Yellowstone remained uninvestigated long after archeologists began excavating sites elsewhere in North America. Archeologists used to think high-elevation regions such as Yellowstone were inhospitable to humans and, thus, did little exploratory work in these areas. However, recent research in the park has located archaeological sites at high elevations, with several sites over 11,000 feet above mean sea level (AMSL). Today, archeologists study environmental change to better understand human uses of areas such as Yellowstone through time.

More than 2,000 archeological sites have been documented in Yellowstone National Park, with the majority dating to the Archaic period, spanning from about 8,000 to 1,500 years ago. Obsidian from several sources in the park was used as toolstone. Sites contain evidence of an increase in hunting a wide variety of game, including bison, bear, deer, sheep and goats, felines, rabbits, birds, and other small game. Campsites and trails in Yellowstone also provide evidence of early use. Some of the trails used in the park today have likely been used by people since the Paleoindian period.

Increased Use

People seem to have increased their use of the Yellowstone area beginning about 3,000 years ago. During this time, people deepened their reliance on bison hunting. Technological innovations during this period in the Greater Yellowstone Ecosystem include use of tipis as the main form of shelter, bison jumps and corrals, sheep traps, and evidence of widespread trade across North America. Bow and arrow technology, adopted after 1,500 before present (BP), replaced the atlatl, or spear-thrower, that had been used for thousands of years. The number

Paleoindian Period

9,350 years ago

A site on the shore of the Yellowstone Lake has been radiocarbon dated to 9,350 years ago. People likely occupied this site for short seasonal periods.

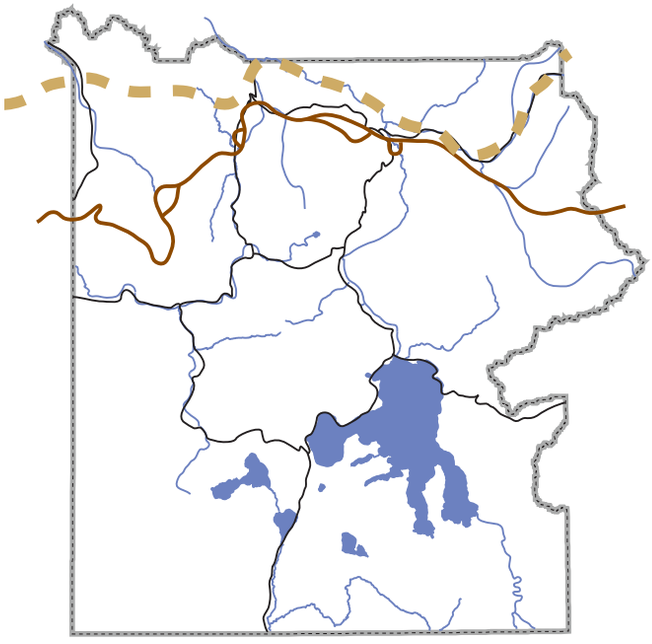
9,000 years ago

9,000 years ago until 1,000 common era (CE), people leave traces of camps on the shores of Yellowstone Lake.

CE = Common Era (replaces AD)

of radiocarbon dates in the park rapidly increases in the park after 1,500 BP, with a peak between 1,200 and 1,000 BP. This increased use of Yellowstone likely occurred when the environment was warmer, favoring extended seasonal use on and around the Yellowstone Plateau. Archeologists and other scientists are working together to study evidence such as plant pollen, landforms, and tree rings to better understand how the area's environment changed over time.

Some of the historic peoples from this area, such



An ancient trail, now called the Bannock Trail, is shown in two possible locations. Physical evidence of the trail is extremely difficult to find. Historic maps and journals do not match modern maps, and oral histories of tribes do not always correlate with what little evidence exists of the trail. The solid line shows the trail's location as interpreted from 1878 to about 1960. Some scholars today think the dashed line shows the main Bannock Trail more accurately, but it is still subject to discussion because of the many known 'spokes' of the trail and some errors on the 1869 map.

Obsidian Cliff National Historic Landmark

Location
Grand Loop Road between Mammoth and Norris.

Significance

- Obsidian is found in volcanic areas where the magma is rich in silica and the lava flow has cooled without forming crystals, creating a black glass that can be honed to an exceptionally thin edge.
- Unlike most obsidian, which occurs as small rocks strewn amid other formations, Obsidian Cliff has an exposed vertical thickness of about 98 feet (30 m).
- Obsidian was first quarried from this cliff for tool-making more than 11,000 years ago.
- It is the United States' most widely dispersed source of obsidian by hunter-gatherers. It is found along trade routes from western Canada to the Great Lakes and Ohio.
- Obsidian Cliff is the primary source of obsidian in a large concentration of Midwestern sites, including about 90% of obsidian found in Hopewell mortuary sites in the Ohio River Valley (about 1,850–1,750 years ago).

Recent History
About 90% of the forest on Obsidian Cliff plateau burned in 1988. The fire did not damage the cliff face, but it cleared the surface, creating optimal conditions for archeological surveys. Those surveys added substantially to knowledge about how obsidian was mined from the bedrock and collected as cobbles from the overlying glacial till. Staff are now researching the intensity of use of this obsidian, both within the park and across North America.

The kiosk at Obsidian Cliff, constructed in 1931, was the first wayside exhibit in a US national park. It was listed on the National Register in 1982. The site was designated a National Historic Landmark in 1996.

Archaic Period (8,000–1,500 years ago)

8,000 years ago

Vegetation similar to what we find today begins to appear. This period is characterized by use of large side-notched projectile points and atlatl technology.

3,000 years ago

Bison jumps and corrals begin to be used in the Rocky Mountain region. Oral histories of the Salish place their ancestors in the Yellowstone area.

1,500 years ago

Bow and arrow begins to replace atlatl (throwing spear). Sheep traps begin to be used in the mountains.

as the Crow and Sioux, arrived sometime during the 1500s and around 1700 CE, respectively. Prehistoric vessels known as "Intermountain Ware" have been found in the park and surrounding area, linking the Shoshone to the area as early as approximately 700 years ago.

The Little Ice Age

Climatic evidence confirms the Yellowstone area experienced colder temperatures during what is known as the Little Ice Age—mid-1400s to mid-1800s. Fewer archeological sites date to this time, suggesting a decreased human presence. Campsites appear to have been used by smaller groups of people, mostly in the summer. Such a pattern of use would make sense in a cold region where hunting and gathering were practical for only a few months each year.

Historic Tribes

Greater Yellowstone's location at the convergence of the Great Plains, Great Basin, and Columbia Plateau American Indian cultures means that many tribes have traditional connections to the land and its resources. For thousands of years before Yellowstone became a national park, it was a place where people hunted, fished, gathered plants, quarried obsidian, and used the thermal waters for religious and medicinal purposes.

Tribes used hydrothermal sites ceremonially and medicinally. The Mud Volcano area is especially significant for the Kiowa. Their tradition says that a hot spring called Dragon's Mouth (above) is where their creator gave them the Yellowstone area for their home. The Crow also have stories about this feature.

Wickiups provided temporary shelter for some Native Americans while they were in Yellowstone. No archeological, standing wickiups are known to remain in the park.

American Indian tribes' oral histories indicate more extensive use of the area during the Little Ice Age. Kiowa stories place their ancestors here from around 1400 to 1700 CE. Ancestors to contemporary Blackfeet, Cayuse, Coeur d'Alene, Bannock, Nez Perce, Shoshone, Crow, Sioux, Lakota, and Umatilla, among others, continued to travel the park on the already established trails. They visited geysers, conducted ceremonies, hunted, gathered plants and minerals, and engaged in trade. The park's associated

500-1700 CE

1400

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

1450

Little Ice Age begins

A Note About Terms

Native American is typically used in political and academic matters. When Native Americans refer to themselves and to personal matters, they might use *Indian, American Indian, First American, First Peoples,* or *Indigenous Peoples* instead of *Native American*.

Ethnocentrism—a tendency to see other cultures through the lens of one's own culture; relatedly, the belief that one's cultural practices and beliefs are superior to those of other groups

tribes report family groups came to lands now part of Yellowstone to gather obsidian, which they used to field-dress bison. Some associated tribes used the Fishing Bridge area as a rendezvous site.

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

In the early 1700s CE, some American Indian tribes in this region acquired the horse. Some historians believe the horse fundamentally changed their lifestyles because tribal members could now travel faster and farther to hunt bison and other animals of the plains.

Tukudika, or Sheep Eaters

The Tukudika, or Sheep Eaters, are a band of Mountain Shoshone that lived for thousands of years in the area that would become Yellowstone National Park. Throughout the park, archeological sites reflect use of resources within this landscape by the Tukudika and other American Indian tribes.

The Name *Tukudika*

Traditionally, Shoshone names were derived from places the bands traveled to or from foods they hunted or gathered. Tukudika (also Tukudyka'a, Tukadika) means "eaters of the mountain sheep." The Tukudika lived in northwestern Wyoming, southwestern Montana, and eastern Idaho. Other Shoshone bands bore the names "salmon eaters," "elk eaters," and "bison eaters."

Because the name *Sheep Eater* can appear to equate this American Indian tribe with the bighorn sheep itself, the term was once considered derogatory. The name *Sheep Eater* suggests a Shoshone

Quick Facts

- The Tukudika were skilled hunters and artisans known for their horn bows, obsidian arrows and tools, stone-and-timber game and fish traps, sheepskin clothing, and steatite bowls.
- At least 50% of the Tukudika's diet consisted of plants, roots, nuts, and berries; the bighorn sheep was the primary source of meat.
- The Tukudika remained in the park until the late nineteenth century when they were forcibly removed to reservations. They were incorporated into the Wind River Shoshone and Fort Hall Shoshone-Bannock tribes. Some descendants prefer the name *Mountain People.*
- Chief Togwotee was the Tukudika guide for President Chester A. Arthur's 1883 trip through Yellowstone.

500–1700s CE

1600s

North American tribes in the southwest begin acquiring horses in the mid- to late 1600s. Ancestors of the Crow may have come into the Yellowstone ecosystem during this time.

1700s

Lakota Sioux begin exploring the Yellowstone area.

A family group photo, possibly taken by W.H. Jackson. Bannock elders reported this may be a photograph of Chief Tendoy, Chief of the Lemhi Shoshones. Tendoy Falls on Ferris Fork in the southwestern part of the park is named after him.

social hierarchy on which the Tukudika occupied one of the lowest rungs: whereas other Shoshone bands were hunting and consuming the "grander" bison and elk, the Tukudika were hunting the "inferior," elusive, mountain-dwelling bighorn sheep. Contemporary understanding of this name is more nuanced. The name does not signify that Tukudika ate only bighorn sheep; it means, simply, that the bighorn sheep was this group's primary source of meat. Indeed, the Tukudika's diet consisted of at least 50% plants, roots, nuts, and berries.

Tukudika Culture

Traveling in extended-family groups, the Tukudika followed the park's rivers and streams to hunt game, harvest plants, and find suitable campsites. They traveled to higher elevations in the warmer months and stayed at lower elevations during the colder months. According to the Shoshone-Bannock tribes of southeastern Idaho, some Tukudika stayed in the park year-round.

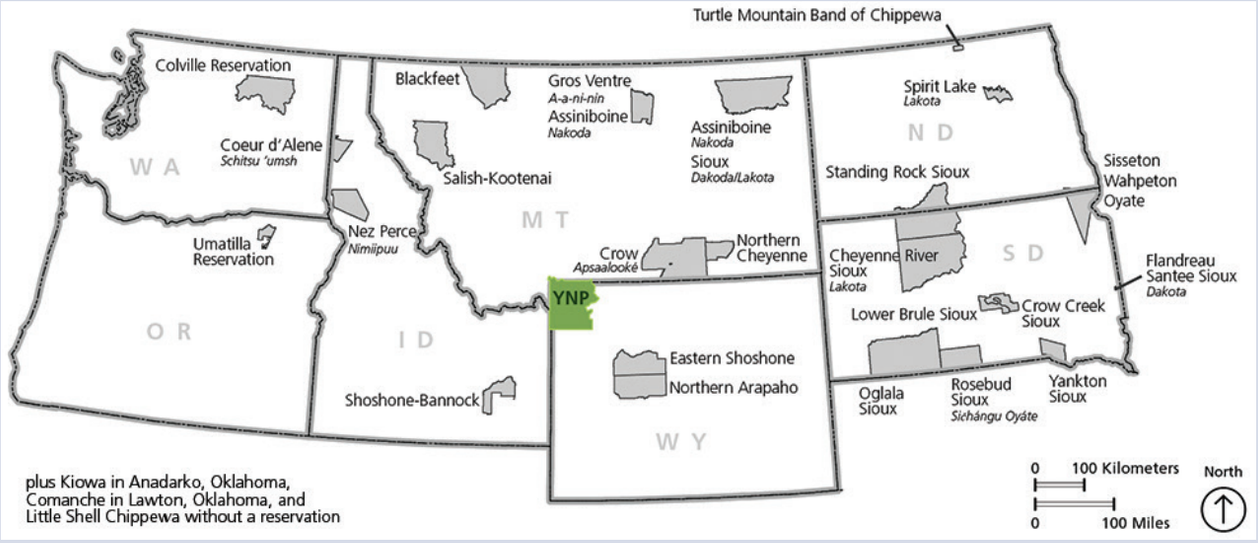
The Tukudika built simple yet versatile shelters composed of curved lodgepole and grass thatching. When situated against a rock face, these *newe-gahni* (Shoshone houses, houses built to suit a specific purpose) proved sturdy and resistant to the elements. These structures are similar to, but probably distinct from, the wickiup, or conical timber lodge, a structure found throughout the park and associated with several tribes.

When they lived in the park, the Tukudika quarried obsidian (*dupi* or *tuupi*) at Obsidian Cliff. Working in family groups, tribal members quarried obsidian with shovels made from bison or elk bone. After quarrying the obsidian, the Tukudika worked the material with elk antlers. A cantaloupe-sized rock yielded two to three arrowheads. It is reported that because of its sharpness, obsidian was the primary material for arrowheads and tools.

The Tukudika paired arrowheads manufactured from obsidian and other stone materials with well-designed, extremely durable hunting bows made from the horns and sinews of bighorn sheep. The Indians soaked the horns in geothermal waters to soften them, then shaped the pliable horns into bows. These highly effective bows were sought-after objects which the Tukudika traded with other tribes throughout the Rocky Mountains and the Northern Plains. Sheepskin was used to make distinctive, high-quality clothing, another desirable trade good from this Native American group.

The Tukudika were skilled hunters. They designed drive lines and corrals to aid in the hunting of bighorn sheep, and they built fish traps of stone and timber. Unlike most other American Indian tribes of the western United States, including other bands of Shoshone, the Tukudika did not adopt the horse. Instead, they continued to hunt on foot, accompanied by dogs (*satii, sadee*). These medium to large dogs resembled both wolves and huskies, and served as both work dogs and companions. Some scholars have speculated that hunting on horseback would have hindered the group's techniques for alpine

Associated Tribes of Yellowstone National Park



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

Note: Map shows modern tribal reservations; it does not show historic territory.

hunting. Dogs were used to pull travois (two-pole sleds) laden with game or belongings. Evidence that Native Americans, possibly Tukudika, were buried with their dogs has been found throughout the Greater Yellowstone Ecosystem.

For cooking and storage, the Tukudika crafted bowls and other containers out of steatite, or soapstone, a metamorphic rock soft enough to scratch with a fingernail. Although steatite is a soft stone, it is surprisingly durable. Steatite deposits are plentiful throughout the Greater Yellowstone Ecosystem, but archeologists have not yet determined whether this material was quarried in the park. Steatite vessels may have been cached and returned to, season after season. The containers may also have been heirlooms or ceremonial vessels transported from site to site. These stone bowls are distinct from Intermountain Ware, a type of pottery made from different clays and tempers and associated with Shoshone groups.

Encounter

The stories that a culture creates and transmits are rooted in that culture's traditions, customs, social mores, and belief system. When two cultures encounter one another, misunderstandings and conflicts can arise. In the Rocky Mountain West, some of the first recorded stories of encounter between European-Americans and American Indians came from Lewis and Clark's Corps of Discovery expedition of 1804–6. Thirty years later, Osborne Russell, then a young fur-trapper, wrote some of the first descriptions of European-American–Tukudika encounters in the park. In 1835, he met a small group of Tukudika in the Lamar Valley, and he portrayed them favorably, if somewhat romantically. Other explorers and trappers were not so open-minded. Many accounts were one-sided, prejudiced, fearful, or even hostile. These stories and reports failed to consider the American Indian tribes' agency, self-sufficiency, and vast knowledge of Yellowstone's landscape and resources.

Prior to the establishment of Yellowstone National Park, the military was in the last stages of moving American Indian tribes onto reservations throughout the west. Early park superintendents actively discouraged tribes from visiting the newly established park to hunt or collect resources.

Change

The Tukudika continued to inhabit the Greater Yellowstone area for several years after Yellowstone National Park was established in 1872. By 1900, the Tukudika were incorporated into the Eastern Shoshone tribe of the Wind River Reservation in central-western Wyoming, and into the Mountain and Lemhi Shoshone and Bannock tribes of the Fort Hall Reservation in southeastern Idaho. Once confined to reservations, the Tukudika suffered the partial collapse of their traditional lifeways. Although the Tukudika continued to live traditionally for a generation or two after their removal to reservations, they eventually adapted to the ways of these other tribes, whose own cultural practices had already been altered by their earlier removal to reservations. Today, some Tukudika descendants live on both of the aforementioned reservations. Some of these descendants prefer the name *Mountain People* to *Tukudika* or *Sheep Eater* for its emphasis upon place rather than food source.

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late 1700s-1806 CE

late 1700s

Fur traders travel the rivers into the Yellowstone region. Tribes in the Yellowstone area begin using horses.

1804–1806

The Lewis and Clark Expedition passes within 50 miles of Yellowstone.

European Americans Arrive

In the late 1700s, fur traders traveled the great tributary of the Missouri River, the Yellowstone, in search of Native Americans with whom to trade. They called the river by its French name, "Roche Jaune." As far as historians know, pre-1800 European Americans did not observe the hydrothermal activity in this area, but they probably heard about these features from Native American acquaintances.

The Lewis and Clark Expedition (1804–1806), sent by President Thomas Jefferson to explore the newly acquired lands of the Louisiana Purchase, bypassed Yellowstone. They had heard descriptions of the region but did not explore the Yellowstone River beyond what is now Livingston, Montana.

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

Not long after Colter's explorations, the United States became embroiled in the War of 1812, which drew men and money away from exploration of the Yellowstone region. The demand for furs resumed after the war and trappers returned to the Rocky Mountains in the 1820s. Among them was Daniel Potts, who published the first account of Yellowstone's wonders as a letter in a Philadelphia newspaper. Osborne Russell also published an account of his fur trapping in and around Yellowstone during the 1830s and early 1840s

Mountain man Jim Bridger also explored Yellowstone during this time. Like many trappers, Bridger spun tall tales as a form of entertainment around the evening fire. His stories inspired future explorers to travel to see the real thing.

As quickly as it started, the trapper era ended. By the mid-1840s, the market for beaver dropped, and trappers moved on to guiding or other occupations.

Looking for Gold

Between 1863 and 1871, prospectors crisscrossed the Yellowstone Plateau every year, searching for gold and other precious minerals. Although gold was found nearby, no big strikes were made inside what is now Yellowstone National Park.

Expeditions Explore Yellowstone

Although Yellowstone had been thoroughly tracked by tribes and trappers, in the view of the nation it was really "discovered" by a series of formal expeditions. The first organized attempt came in 1860 when Captain William F. Raynolds led a military expedition, but this group was unable to explore the Yellowstone Plateau due to late spring snow. The Civil War preoccupied the government during the next few years. Immediately after the war, several explorations were planned, but none got underway.

The 1869 Folsom-Cook-Peterson Expedition

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

1807–1835 CE

1807–1808

John Colter first known European-American to visit present-day Yellowstone.

1834–1835

Trapper Osborne Russell encounters Tukudika ("Sheep Eaters") in Lamar Valley.

The 1870 Washburn-Langford-Doane Expedition

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

The 1871 Hayden Expedition

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

The history of science in Yellowstone formally began with Hayden's expeditions. Hayden's 1871 survey team included two botanists, a meteorologist, a zoologist, an ornithologist, a mineralogist, a topographer, and an agricultural statistician/entomologist, in addition to an artist, a photographer, and support staff. The survey brought back scientific corroboration of the earlier tales of thermal activity. The expedition gave the world an improved map of Yellowstone and visual proof of the area's unique curiosities through the photographs of William Henry Jackson and the art of Henry W. Elliot and Thomas Moran. The expedition's reports excited the scientific community and aroused national interest.

Hayden noted that in terms of scientific value, "The geysers of Iceland. . .sink into insignificance in comparison with the hot springs of the Yellowstone and Fire-Hole Basins."

The continued reports by mountain men about the wonders of the Yellowstone area, artist renderings of the area, and reports by explorers contributed to the establishment of Yellowstone National Park in 1872.

Birth of a National Park

In the United States, 1872 was a year of possibilities. Falling at the tail end of the Reconstruction Era and the beginning of the Gilded Age, this time marked a tumultuous shift in the direction of the country. Just two years prior, the final confederate states were readmitted to the Union and the 15th Amendment was ratified, granting freed black men the right to vote. At the same time, the Gilded Age was a dynamic time of expansion and industrialization. The Homestead Act had been in effect for a decade, and many families moved west with hope for a better life. Railroads would soon follow. As the country went through this transitional period, former Union General Ulysses S. Grant was serving as President. He presided over the Plains Indian Wars in the West, which were slowly waning with the Battle of Little Bighorn and the Flight of the Nez Perce still a few years away.

In this age of consumption, expansion, and national identity formation, a small group of citizens, businessmen, state officials, and members of exploratory parties lobbied the United States Congress to reserve around two million acres in Montana, Idaho, and Wyoming territories as a "public pleasuring ground," setting the area aside from settlement or exploitation. After little debate, President Grant signed the Yellowstone National Park Act on March 1, 1872. On the face of it, the Act was to protect the natural wonders that had caught the imagination of

1850s–1871 CE

1850s	1860	1862	1869	1870	1871
Little Ice Age ends, climate begins to warm.	First organized expedition attempts, but fails, to explore the Yellowstone Plateau.	Gold strikes northwest of Yellowstone.	Folsom–Cook–Peterson Expedition.	Washburn–Langford–Doane Expedition; Old Faithful Geyser named.	First Hayden Expedition.

Several early trappers and expeditions passed by Tower Fall, depicted here by painter Thomas Moran, who accompanied the Hayden Expedition. One of the first trappers may have been John Colter, who left the Lewis and Clark Expedition as they returned east to join fur trappers in the Yellowstone area. He probably crossed the Yellowstone River near Tower Fall.

the nation—the thousands of geysers and hot pools, the colorful Grand Canyon of the Yellowstone, and the "glass mountain" of Obsidian Cliff. But with that Act, Congress created a new cultural norm as well: that the American federal government would reserve land by creating imaginary boundaries, even crossing state or territory lines, for the public wellbeing. Thus marked an important step in public land conservation and was one of the early markers in the emerging field of environmentalism.

The world's first national park quickly became a point of national pride, putting America on even footing with Europe. According to the late historian Richard A. Bartlett, "Europe had her Greek and Roman ruins, her gloomy castles and gothic cathedrals, but Americans could boast of natural scenery that Europe could not duplicate [...] a variegated canyon painted by nature [...] and a high-altitude lake to match the beauties of Switzerland's Lake Constance. Here, in a region sixty-two by fifty-two miles, was picturesque America, mountainous, unusual, and beautiful, concentrated and on display for all the world to see." And see it they did. Visitors from around the world began making the arduous trek to this remote outpost and eventually, the national park idea spread to nations across the planet.

Formative Years

The park's promoters envisioned Yellowstone National Park would exist at no expense to the government. Nathaniel P. Langford, member of the Washburn Expedition and advocate of the Yellowstone National Park Act, was appointed to the unpaid post of superintendent. (He earned his living elsewhere.) He entered the park at least twice during five years in office—as part of the 1872 Hayden Expedition and to evict a squatter in 1874. Langford did what he could without laws protecting wildlife and other natural features, and without money to build basic structures and hire law enforcement rangers.

Political pressure forced Langford's removal in 1877. Philetus W. Norris was appointed the second superintendent, and the next year, Congress authorized appropriations "to protect, preserve, and improve the Park."

Norris constructed roads, built a park headquarters at Mammoth Hot Springs, hired the first "gamekeeper," and campaigned against hunters and vandals. Much of the primitive road system he laid out remains as the Grand Loop Road. Through constant exploration, Norris also added immensely to geographical knowledge of the park.

1872–1891 CE

1872

March 1, Yellowstone National Park Established; first "hotel" in park opens at Mammoth.

1877

1st budget for park; Nez Perce (Nee-me-poo) flee US Army through Yellowstone.

1883

Northern Pacific Railroad arrives near Gardiner, MT.

1885

First hotel at Old Faithful opens, known as the Shack Hotel.

1886

Army arrives to manage Yellowstone, creating the temporary Camp Sheridan at Mammoth.

1891

First Lake Hotel built.

Flight of the Nez Perce

Summer 1877 brought tragedy to the Nez Perce (or, in their language, Nimi'ipu or Nee-Me-Poo). A band of 800 men, women, and children—plus almost 2,000 horses—left their homeland in what is now Oregon and Idaho pursued by the US Army. Settlers were moving into their homeland and the US Government was trying to force them onto a reservation. At Big Hole, Montana, many of their group, including women and children, were killed in a battle with the Army. The remainder of the group continued fleeing, and entered Yellowstone National Park on August 23.

In Yellowstone

Only a small part of the route taken by the Nez Perce who fled from the US Army in 1877 went through Yellowstone, and the Native Americans largely eluded their pursuers while in the park. However, the 13 days that the Nez Perce spent in Yellowstone became part of the tragic story they continue to pass down to their children.

During the time they crossed the park, the Nez Perce encountered about 25 visitors in the park, some more than once. Warriors took hostage or attacked several of these tourists, killing two. The group continued traveling through the park and over the Absaroka Mountains into Montana. The Army stopped them near the Bear's Paw Mountains, less than 40 miles (64 km) from the Canadian border. This is where it is believed the flight ended and Chief Joseph said, "From where the sun now stands, I will fight no more forever." Some Nez Perce escaped to Canada, but after fierce fighting and a siege, the rest of the band surrendered on October 5, and most of the survivors were sent to the Indian Territory in Oklahoma.

Nez Perce Commemorative Sites

The Nez Perce National Historical Park, established by Congress in 1965 and managed by the National Park Service, includes 38 sites in Idaho, Montana, Oregon, and Washington that have been important in the history and culture of the Nez Perce.

Many of these sites are also on the 1,170-mile (1,882-km) Nez Perce National Historic Trail, established in 1986 and managed by the US Forest Service. The route extends from Wallowa Lake, Oregon, to the Bear's Paw Mountains in Montana. The historic trail goes through the park, and it is considered a sacred place by many Nez Perce who continue to honor their ancestors and carry on their memories through ceremonies conducted in the park. Beginning in 2006, the National Park Service undertook a multiyear archeological inventory project along the Nez Perce trail through the park. These efforts not only identified locations of several Nez Perce, US Army, and tourist encampments, but also clarified the general route the Nez Perce followed through the Absaroka Mountains.

- Nez Perce National Historic Trail: http://www.fs.usda.gov/npnht/
- Nez Perce National Historical Park: http://www.nps.gov/nepe/

As Yellowstone's second superintendent, Philetus Norris set the future course of national parks on many fronts: protection, addressing visitors' needs and interests, and science-based management. Despite a lack of support from the Department of the Interior or Congress, he pleaded for legislation that would adequately protect the park, and he had grand aspirations for Yellowstone.

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

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

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

FREQUENTLY ASKED QUESTION:

Did other national parks exist before Yellowstone?

Some sources list Hot Springs in Arkansas as the first national park. Set aside in 1832, forty years before Yellowstone was established in 1872, it was actually the nation's oldest national reservation, set aside to preserve and distribute a utilitarian resource (hot water), much like our present national forests. In 1921, an act of Congress established Hot Springs as a national park.

Yosemite became a park before Yellowstone, but as a state park. Disappointed with the results of state management, 26 years later in 1890, Congress made Yosemite one of three additional national parks, along with Sequoia and General Grant, now part of Kings Canyon. Mount Rainier followed in 1899.

As an older state park, Yosemite did have a strong influence on the founding of Yellowstone in 1872 because Congress actually used language in the state park act as a model. It's entirely possible that Congress may have preferred to make Yellowstone a state park in the same fashion as Yosemite, had it not been for an accident of geography that put it within three territorial boundaries. Arguments between Wyoming and Montana territories that year resulted in a decision to federalize Yellowstone.

The Army Arrives

In 1886 Congress refused to appropriate money for ineffective administration. The Secretary of the Interior, under authority given by the Congress, called on the Secretary of War for assistance. On August 20, 1886, the US Army took charge of Yellowstone. The Army strengthened, posted, and enforced regulations in the park. Troops guarded the major attractions and evicted troublemakers, and cavalry patrolled the vast interior.

The most persistent menace came from poachers, whose activities threatened to exterminate animals such as the bison. In 1894, soldiers arrested a man named Ed Howell for slaughtering bison in Pelican Valley. The maximum sentence possible was banishment from the park. Emerson Hough, a well-known

1894–1917 CE

1894	1904	1908	1915	1916	1917
1st Lacey Act makes it illegal to kill wildlife in the park.	Old Faithful Inn opens.	Union Pacific train service begins at West Yellowstone.	Automobiles allowed on park roads.	The National Park Service Organic Act establishes the National Park Service.	Private and commercial horse-drawn conveyances banned on Park Roads.

journalist, was present at the arrest and wired his report to *Forest & Stream*, a popular magazine of the time. Its editor, renowned naturalist George Bird Grinnell, helped create a national outcry. Within two months Congress passed the National Park Protection Act, which increased the Army's authority for protecting park treasures. (This law is known as the Lacey Act, and is the first of two laws with this name.)

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 in the late 1800s and early 1900s was separately administered, resulting in uneven management, inefficiency, and a lack of direction.

The National Park Service Begins

National parks clearly needed coordinated administration by professionals attuned to the special requirements of these preserves. The management of Yellowstone from 1872 through the early 1900s helped set the stage for the creation of an agency whose sole purpose was to manage the national parks. Promoters of this idea gathered support from influential journalists, railroads likely to profit from increased park tourism, and members of Congress. The National Park Service Organic Act was passed by Congress and approved by President Woodrow Wilson on August 25, 1916.

Yellowstone's first rangers, which included veterans of Army service in the park, became responsible

Guidance for Protecting Yellowstone National Park

Yellowstone Purpose Statement
Yellowstone National Park, the world's first national park, was set aside as a public pleasuring ground to share the wonders and preserve and protect the scenery, cultural heritage, wildlife, and geologic and ecological systems and processes in their natural condition for the benefit and enjoyment of present and future generations.

Significance of Yellowstone

- Yellowstone National Park is the world's first national park, an idea that spread throughout the world.
- Yellowstone was set aside because of its geothermal wonders—the planet's most active, diverse, and intact collections of combined geothermal, geologic, and hydrologic features and systems—and the underlying volcanic activity that sustains them.
- The park is the core of the Greater Yellowstone Ecosystem, one of the last, largest, nearly intact natural ecosystems in the temperate zone of Earth. It preserves an exceptional concentration and diversity of terrestrial, aquatic, and microbial life. Here, natural processes operate in an ecological context that has been less subject to human alteration than most others throughout the nation—and indeed throughout the world. This makes the park not only an invaluable natural reserve, but a reservoir of information valuable to humanity.
- Yellowstone contains a unique and relatively pristine tapestry of prehistoric and historic cultural resources that span more than 11,000 years. The archeological, architectural, historical, and material collections constitute one of the largest and most complete continua of human occupation in the western US, and collectively represent the material remains of the birth of the National Park and conservation movement.
- Yellowstone was the first area set aside as a national public park and pleasuring ground for the benefit, enjoyment, education, and inspiration of this and future generations. Visitors have a range of opportunities to experience its unique geothermal wonders, free-roaming wildlife, inspiring views, cultural heritage, and spectacular wilderness character.

Yellowstone Mission Statement
Preserved within Yellowstone National Park are Old Faithful and the majority of the world's geysers and hot springs. An outstanding mountain wildland with clean water and air, Yellowstone is home to the grizzly bear and wolf and free-ranging herds of bison and elk. Centuries-old sites and historic buildings that reflect the unique heritage of America's first national park are also protected. Yellowstone National Park serves as a model and inspiration for national parks throughout the world. The National Park Service preserves, unimpaired, these and other natural and cultural resources and values for the enjoyment, education, and inspiration of this and future generations.

1918–1948 CE

1918
NPS takes over management of Yellowstone and the Army leaves.

1919
Horace Albright becomes first NPS superintendent.

1930s
CCC and other government-funded work crews complete work in Yellowstone.

1934
NPS Director's Order prohibits killing predators.

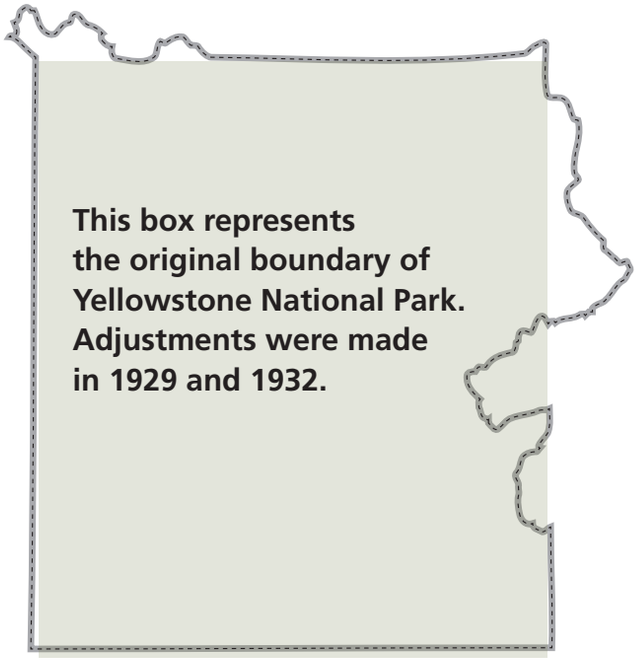
1943–1944
Much of the park closes for WWII.

1948
Yellowstone receives one million visitors.

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

Boundary Adjustments

Almost as soon as the park was established, people began suggesting that the boundaries be revised to conform more closely to natural topographic features, such as the ridgeline of the Absaroka Range along the east boundary. Although these people had



the ear of influential politicians, so did their opponents—which at one time included the United States Forest Service. Eventually a compromise was reached, and, in 1929, President Hoover signed the first bill changing the park's boundaries: The northwest corner now included a significant area of petrified trees; the northeast corner was defined by the watershed of Pebble Creek; the eastern boundary included the headwaters of the Lamar River and part of the watershed of the Yellowstone River. (The Yellowstone's headwaters remain outside the park in Bridger-Teton National Forest.)

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

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

Two "Organic Acts"

The laws creating Yellowstone National Park and the National Park Service (also called "enabling legislation") are both referred to as "The Organic Act" because each created an entity. However, the name most often refers to the law that created the National Park Service. To avoid confusion, we refer to the laws by their names as listed in the US Code Table of Popular Names: The Yellowstone National Park Protection Act and The National Park Service Organic Act.

National Park Service Organic Act
Passed in 1916, this law created the National Park Service and established its mission:

> *"to conserve the scenery and the natural and historic objects and the 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."*

National Park Service Mission
The National Park Service preserves unimpaired the natural and cultural resources and values of the National Park System for the enjoyment, education, and inspiration of this and future generations. The National Park Service cooperates with partners to extend the benefits of natural and cultural resource conservation and outdoor recreation throughout the United States and the world.

1949–1963 CE

1949
First motorized oversnow vehicles allowed in park.

1955
Mission 66 begins in Yellowstone to revitalize lodging, dining, education, and infrastructure.

1959
West of Yellowstone, a 7.5 *M* earthquake strikes, killing campers in the Custer-Gallatin NF and affecting thermal features and infrastructure in the park.

1963
Leopold Report leads to the last of the bear-feeding dumps closing over the following several years.

1963
Robert Reamer-designed Canyon Hotel burns to the ground.

Yellowstone Superintendent Horace Albright, shown here with future president Herbert Hoover in 1928, was involved in the creation of the National Park Service. Later, as agency's director, he greatly increased the number of parks east of the Mississippi and expanded the agency's mandate to include preservation of historic sites, creating a more truly "national" park system.

World War II

World War II drew away employees, visitors, and money from all national parks, including Yellowstone. The money needed to maintain the park's facilities, much less construct new ones, was directed to the war effort. Among other projects, the road from Old Faithful to Craig Pass was unfinished. Proposals again surfaced to use the park's natural resources—this time in the war effort. As before, the park's wonders were preserved.

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

Mission 66

Neglected during World War II, the infrastructure in national parks continued to deteriorate as visitation soared afterward, leading to widespread complaints. In 1955, National Park Service Director Conrad Wirth persuaded Congress to fund an improvement program for completion by the National Park Service's 50th anniversary in 1966. Although also designed to increase education programs and employee

Park Superintendents

Formative Years
Nathanial P. Langford,1872–1877
Philetus W. Norris, 1877–1882
Patrick H. Conger, 1882–1884
Robert E. Carpenter, 1884–1885
David W. Wear, 1885–1886

Under the US Army
Captain Moses Harris, 1886–1889
Captain Frazier A. Boutelle, 1889–1891
Captain George S. Anderson, 1891–1897
Captain Samuel B.M. Young, 1897
Captain James B. Erwin, 1897–1899
Captain Wilbur E. Wilder, 1899
Captain Oscar J. Brown, 1899–1900
Captain George W. Goode, 1900–1901
Captain John Pitcher, 1901–1907
General Samuel B.M. Young, 1907–1908
Major Harry C. Benson, 1908–1910
Colonel Lloyd M. Brett, 1910–1916
Chester A. Lindsley, 1916–1919

National Park Service
Horace M. Albright, 1919–1929
Roger W. Toll, 1929–1936
John W. Emmett, 1936
Edmund B. Rogers, 1936–1956
Lemuel A. Garrison, 1956–1964
John S. McLaughlin, 1964–1967
Jack K. Anderson, 1967–1976
John A. Townsley, 1976–1982
Robert Barbee, 1983–1994
Michael Finley, 1994–2001
Suzanne Lewis, 2002–2010
Dan Wenk, 2011–2018
Cameron Sholly, 2018–Present

1965–1975 CE

1965

Park sees 2,000,000 visitors for first time.

1966

The thermophile *Thermus aquaticus* is discovered in a Yellowstone hot spring.

1970

New bear management plan begins, which includes closing open-pit dumps in park.

1971

Overnight winter lodging opens in park and continues yearly.

1975

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

Today's National Park Service

Implementing the National Park Service Mission
The National Park Service mission includes the responsibility to preserve the natural and cultural resources and values of the National Park System. Consistent with this high standard of care, the National Park Service makes these areas accessible for public use and enjoyment.

- **Natural resources** (biological and physical, natural sounds, night skies, scenic vistas, and other aesthetic values) are managed to maintain, rehabilitate, and perpetuate their inherent integrity. Native species that have been exterminated are reintroduced and nonnative species eliminated, if possible. Livestock grazing, hunting, and resource extraction are prohibited in National Park System areas, with a few exceptions.
- **Cultural resources** (prehistoric and historic structures, landscapes, archeological and ethnographic resources, and museum collections) are preserved.

International Leadership
The National Park Service example has inspired countries around the world to establish more than 100 national parks—modeled in whole or part on Yellowstone National Park and the National Park Service idea. Additionally, the National Park Service lends its experienced staff to other countries to evaluate park proposals, management plans, and resource issues. As the first national park, Yellowstone also continues to be a leader in developing and implementing policies in the National Park Service.

The National Park Service manages approximately 83 million acres in all 50 states, the Virgin Islands, Puerto Rico, Guam, and American Samoa.

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

Total National Park Service sites = 433

When Frances Pound applied for a position in 1926, Yellowstone Superintendent Albright suggested she use her nickname, Jim. She was one of the first women hired to do law enforcement in Yellowstone. Today's National Park Service workforce aims to reflect our nation's diversity.

National Battlefields	11
National Battlefield Parks	4
National Battlefield Site	1
National Military Parks	9
National Historical Parks	63
National Historic Sites	76
International Historic Sites	1
National Lakeshores	3
National Memorials	31
National Monuments	87
National Parks	63
National Parkways	4
National Preserves	19
National Reserves	2
National Recreation Areas	18
National Rivers	4
National Wild and Scenic Rivers and Riverways	10
National Scenic Trails	6
National Seashores	10
Other Designations	11
Total Units	433

As of February 5, 2025.

For a complete list see www.nps.gov/faqs.htm

1988–2000 CE

1988
Wildfire burns approximately 36% of the park.

1991
Clean Air Act Amendments require air-quality monitoring at sites including Yellowstone, a Class I airshed.

1992
Park sees 3,000,000 visitors for the first time.

1994
Congress enacts a law allowing a percentage of park entrance fees to be kept in the parks.

1995
Wolves reintroduced.

1996
New World Mine, near park's northern boundary, halted.

2000
1st Interagency Bison Management Plan.

Yellowstone Park Concession Employee Slang, c. 1920s

Concession employees in the 1920s were often college students looking for adventure on their summer breaks. Many of them came back to Yellowstone multiple times, met their spouses here, and made life-long friends. As a sign of their youthful enthusiasm, they soon developed a unique lingo to use among themselves.

- Concession Employees: Savages
- Visitors on full-package tours: Dudes
- Campers: Sagebrushers
- Dishwashers: Pearl Divers
- Maids: Pillow Punchers
- Laundry Workers: Bubble Queens and Kings
- Laundry Carts: Mollies
- Waitresses: Heavers
- Porters: Pack Rats
- Bus Drivers: Gearjammers
- Courting in the evenings: Rotten Logging

housing, Mission 66 focused mainly on visitor facilities and roads. Trained as an architect, Wirth encouraged the use of modern materials and prefabricated components to quickly and inexpensively construct low-maintenance buildings. This architectural style, which became known as Park Service Modern, was a deliberate departure from the picturesque, rustic buildings associated with national parks; their "fantasy land" quality was considered outmoded and too labor-intensive for the needed scale of construction.

Mission 66 revitalized many national parks; in Yellowstone, intended to be the program's showpiece, its legacy is still visible. It was a momentous chapter in the park's history, and as the park continues to reflect changing ideas about how to enhance the visitor experience while protecting the natural and cultural resources, the question of how to preserve the story of Mission 66 is being addressed.

The elk and bison populations were actively managed until the mid-1960s, when park managers allowed "natural regulation."

Work in Yellowstone included the development of Canyon Village. Aging visitor use facilities were replaced with modernistic visitor use facilities designed to reflect American attitudes of the 1950s. Visitor services were arranged around a large parking plaza with small cabins a short distance away. The first Mission 66 project initiated by the National Park Service, Canyon Village opened in July 1957.

Modern Management

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

In 1963, a national park advisory group, composed of prominent scientists, released a report recommending parks "maintain biotic associations" within the context of their ecosystem and based on scientific research.

Involving Native Americans

Yellowstone National Park has 27 associated tribes. Some have evidence of their ancestral presence in Yellowstone National Park through ethnohistoric documentation, interviews with tribal elders, or

2002 CE–present

2002
National Academy of Sciences confirms effectiveness of Ecological Process Management (aka natural regulation).

2007
Yellowstone's grizzly bears removed from federal threatened species list.

2008
Scientific review panel recommends an increase in lake trout removal operations on Yellowstone Lake.

2009
Grizzly bears returned to threatened species list. Bioprospecting final EIS completed; science agenda established for Greater Yellowstone Ecosystem.

2011
Grey wolves removed from the endangered species list in MT, ID, OR, and WA. Remain listed in WY until 2017.

2015
Park sees 4,000,000 visitors for the first time.

A Decade of Environmental Laws

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

The Wilderness Act of 1964 particularly influences the management of national parks.

The National Environmental Policy Act (NEPA), passed in 1970, establishes a national policy "to promote efforts which will prevent or eliminate damage to the environment … stimulate the health and welfare of man … and enrich the understanding of ecological systems …" It requires detailed analysis of environmental impacts of any major federal action that significantly affects the quality of the environment. Environmental assessments (EAs) and environmental impact statements (EISs) are written to detail these analyses and to provide forums for public involvement in management decisions.

The Clean Air Act (1970) mandates protection of air quality in all units of the National Park System; Yellowstone is classified as Class 1, the highest level of clean air protection.

The Clean Water Act (1972) is enacted to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" by prohibiting the discharge of pollutants.

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

ongoing consultations. Others are affiliated because of documented spiritual or cultural connection to places or resources. Many park resources remain important to these tribes' sense of themselves and in maintaining their traditional practices.

In addition, tribes are sovereign nations whose leaders have a legal relationship with the federal government that is not shared by the general public. Consequently, representatives of Yellowstone's associated tribes participate in consultation meetings with park managers. They bring tribal perspectives to current issues such as bison management. Tribes also comment on park projects that could affect their ethnographic resources.

Complex Issues

Change and controversy have occurred in Yellowstone since its inception. In the last three decades, many issues have arisen involving natural resources.

One issue was the threat of water pollution from a gold mine outside the northeast corner of the park. Among other concerns, the New World Mine would have put waste storage along the headwaters of Soda Butte Creek, which flows into the Lamar River and then the Yellowstone River. After years of public debate, a federal buyout of the mining company was authorized in 1996.

In an effort to resolve other park management issues, Congress passed the National Parks Omnibus Management Act in 1998. This law requires using high-quality science from inventory, monitoring, and research to understand and manage park resources.

Park facilities are seeing some improvements due to a change in funding. In 1996, as part of a pilot program, Yellowstone National Park was authorized to increase its entrance fee and retain 80% of the fee for park projects. (Previously, park entrance fees did not specifically fund park projects.) In 2004, the US Congress extended this program until 2015 under the Federal Lands Recreation Enhancement Act. Projects funded in part by this program include a major renovation of Canyon Visitor Education Center, campground and amphitheater upgrades, preservation of rare documents, and studies on bison.

A Living Legacy

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 of wilderness as the inheritance of all people, who gain more from an experience in nature than from private exploitation of the land.

The national park idea was part of a new view of the nation's responsibility for the public domain. By the end of the 1800s, many thoughtful people no longer believed that wilderness should be fair game for the first person who could claim and plunder it. They believed its fruits were the rightful possession of all the people, including those yet unborn. Besides the areas set aside as national parks, still greater expanses of land were placed into national forests and other reserves so that the United States' natural wealth—in the form of lumber, grazing, minerals, and recreation lands—would not be consumed at once by the greed of a few, but would perpetually benefit all.

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

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Staff Reviewers

Tobin Roop, Chief, Branch of Cultural Resources
Beth Horton, Park Archeologist
Alicia Murphy, Park Historian

Yellowstone's cultural resources tell the stories of people. Fort Yellowstone was constructed when the US Army administered the park. The protection of resources affects how the park is managed today.

Preserving Cultural Resources

Yellowstone National Park's mission includes preserving and interpreting evidence of past human activity through archeology and historic preservation; features that are integral to how a group of people identifies itself (ethnographic resources); and places associated with a significant event, activity, person or group of people that provide a sense of place and identity (historic buildings, roads, and cultural landscapes). All of these materials and places tell the story of people in Yellowstone. Collectively, they are referred to as cultural resources.

Archeology

Archeological resources are the primary—and often the only—source of information about humans in Yellowstone for nearly the entire time that people have been in the area. Archeological evidence indicates that people began traveling through and using the area that was to become Yellowstone National Park more than 11,000 years ago. Because the intensity of use varies through time as environmental conditions shift, archeological resources also provide a means for interdisciplinary investigations of past climate and biotic change.

Many thermal areas contain evidence that early people camped close to these resources. At Obsidian Cliff, a National Historic Landmark, volcanic glass was quarried for the manufacture of tools and ceremonial artifacts that entered a trading network extending from western Canada to the Midwest. (Obsidian from different lava flows can be distinguished from one another other using X-ray fluorescence

Quick Facts

Archeological
- More than 2,000 known prehistoric and historic Native American archeological sites and historic European American archeological sites.

Ethnographic
- More than 300 ethnographic resources (animals, plants, sites, etc.).

Historic
- 25 sites, landmarks, and districts listed on the National Register of Historic Places, many more eligible for listing.
- More than 840 historic structures.
- 1 National Historic Trail.

Collections
Housed in the Yellowstone Heritage and Research Center.
- Museum collection of more than 1 million museum items, including 30 historic vehicles.
- Archives containing millions of historic documents.
- Research library holds more than 20,000 books and periodicals available to the public; plus manuscripts and rare books available to historians and other researchers.

analysis [XRF].) These remnants of past cultures must be preserved, as they are invaluable in our understanding of early people in this region. Historical archeological sites in Yellowstone reflect Native American activities, early tourist camps and hotels, and events of the 1877 Flight of the Nez Perce, as well as US Army activities.

Findings in Yellowstone

Although more than 2,000 archeological sites have been documented since the park's archeology program began in 1995, less than 3% of the park has been inventoried. Most known sites are located in developed areas because archeological resources have been identified as part of National Historic Preservation Act compliance research related to construction, hazard fuel reduction, or other projects. Multiple prehistoric sites throughout the park are eligible for listing on the National Register of Historic Places.

Condition assessments performed on most of the documented sites found 1,109 are in good condition, 467 are fair, 209 are in poor condition, and 250 lack condition data. Twenty-four of the sites no longer exist because of two sites being combined into one, natural erosion, damage from the historic 2022 flood, or disturbance as a result of construction or other authorized activity. Excavations have been conducted at some sites where archeological remains are especially vulnerable to disturbance or loss through erosion or illegal collecting.

Prehistoric sites contain projectile points, knives, scrapers, abraders, and other tools, and concentrations of burned and butchered animal bone. Radiocarbon dating is used to establish the age of organic artifacts such as charcoal or bone. Organic materials (wood, bone, basketry, textiles) rarely persist in the Yellowstone environment because of the acidic, thermally influenced soils within the caldera. However, ice patches in some areas of the park can and do preserve fragile organic artifacts. These perishable artifacts complement the oral histories of indigenous peoples as well as an archaeological record of abundant stone tools and manufacturing debris.

Stone artifacts provide most of the chronological information on Yellowstone's prehistory. Most of the stone tools are associated with a particular time period based on distinctive stylistic characteristics, which define a point type. These include some knives, such as Cody knives, or projectile points, such as spear and dart points, as well as arrowheads. At several locations in the park, campsites from distinct periods of indigenous use spanning more than 9,600 years are layered upon each other starting at five feet below the surface. These occupations reveal how tool manufacture and lifeways changed in this region through time.

The earliest evidence of humans in Yellowstone are two 11,500 to 10,900-year-old Clovis-type spear points found near Yellowstone Lake and north near

Cultural Resource Laws

The Antiquities Act (1906)
Provides for the protection of historic, prehistoric, and scientific features and artifacts from federal lands.

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

The National Historic Preservation Act (1966)
Requires that federal agencies take into account effects of their undertakings on historic properties. Authorizes the creation of the National Register of Historic Places and gives extra protection to National Historic Landmarks and properties listed on the National Register. National parks established for their historic value are automatically registered; others, such as Yellowstone, must nominate landmarks and properties to the register.

The Archeological and Historic Preservation Act (1974)
Provides for the preservation of significant scientific, historic, and archeological material and data that might be lost or destroyed by federally sponsored projects. For example, federal highway projects in Yellowstone include archeological surveys.

American Indian Religious Freedom Act (1978)
Protects and preserves American Indian access to sites, use and possession of sacred objects, and the freedom to worship through ceremonial and traditional rites.

The Archaeological Resources Protection Act (1979)
Provides for the preservation, protection, and custody of archaeological sites, excavated materials, records, and data.

The Native American Graves Protection and Repatriation Act (1990)
Assigns ownership or control of Native American human remains, funerary objects, and sacred objects of cultural patrimony to culturally affiliated Native American groups.

Executive Order 13007
Guarantees access to and ceremonial use of Indian sacred sites by Indian religious practitioners to ensure that these sites are not adversely affected.

the Yellowstone River. Later, projectile point types increase, both in number and the variety of types (style), which may indicate an increase in the number and diversity of peoples using the area. Most documented sites in the park date to the Archaic period (8,000–1,500 years ago), suggesting that may have been the most intense period of use by pre-park peoples. Recent archeological surveys have identified a large number of sites dating to later periods in prehistory (approximately 1400–1800 CE). Distinguishing use of these sites by different ethnic groups or specific tribes, however, has not yet been possible.

Selection of meal-related artifacts manufactured from 1883 to 1923 recovered from a refuse dump near Lake Lodge. These items were commonly used by concessioners to serve visitors throughout the park.

Yellowstone Lake

Some of the earliest intact archeological deposits in the park have been found at a site on the shore of Yellowstone Lake. The site was excavated because it was at high risk of erosion, and that work revealed evidence of a 9,350-year-old camp likely occupied by several families. People used this area while hunting a wide variety of game, including bison, sheep, bear, elk, deer, felines, rabbits, birds, and other small game, gathering plants for food and medicine, and making tools and clothes. Artifacts dating to 3,000 years ago have also been discovered on islands in the lake, leading some archeologists to speculate that indigenous peoples used watercraft to travel on the lake, or crossed over on the frozen lake.

Tourism in Yellowstone

The majority of historical archeological sites in the park are associated with tourism in some manner. Examining these types of sites help us trace the park's history. Tourism is directly connected to larger social and economic changes occurring across America, including widespread settlement of the American West, and the increasing shift towards a globally integrated economy.

Refuse dumps, also known as trash middens, are important sources of information, as they contain a variety of artifacts which provide insight into people living and working in the park. In 2019, archeological fieldwork near Lake Lodge revealed over 450 artifacts dating to the late nineteenth/early twentieth century associated with meals, such as ceramic tableware, utensils, drinking glasses beverage bottles, and butchered animal bone. The various types and qualities of goods, reflected through artifact collections, grant us a unique view of leisure and tourism development in Yellowstone over the past 140 years, a viewpoint that is unavailable in most other places in North America.

Assessing Wildland Fire Impacts

Archeological resources can inform us about paleoclimate, paleoenvironment, and the human response to climate change over the past 11,500 years. Long-term climate data suggest current temperature rise and precipitation contribute to longer annual droughts and shorter wet seasons. Given changing environmental conditions, in 2016 the park embarked on a ten-year project to assess wildfire impacts on archeological resources, including those impacted by the historic 2016 Maple Fire and Tatanka Fire Complex. Data indicate sites subjected to intense heat and loss of vegetation are more susceptible to post-fire erosion, flooding, and other landscape processes which expose or threaten archeological resources.

Obsidian Sourcing Studies

Archeologists have completed intensive inventories across several river valleys that served as transportation corridors for many pre-park peoples. Newly identified sites include prehistoric quarries, campsites, and lithic scatters dating to between 11,500 and 300 years ago, as well as historical period quarries, campsites, and refuse dumps. These prehistoric sites are increasing our understanding of how early humans procured and used obsidian across the park. Most sites in the northern portion of the park show a heavy reliance on Obsidian Cliff materials and chert, a cryptocrystalline sedimentary rock. Materials from smaller obsidian sources in the park were locally used, supplementing the Obsidian Cliff toolstone.

However, along the Lewis and Snake rivers a more diverse range of materials was used. Obsidian was primarily locally sourced from nearby Warm Spring, Teton Pass, and Park Point quarries, while ortho-quartzite, a classic sedimentary rock, was the most common material used for manufacturing tools.

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Staff Reviewers

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Tribal Affairs & Parnerships

Yellowstone National Park is the traditional shared homelands of many Tribal Nations whose cultures and traditions have shaped the landscape throughout generations. The National Park Service honors with gratitude these Indigenous peoples and values their continuous connections to their homelands. We are committed to working together to protect the land and resources now known as Yellowstone National Park.

Our Goals

- **We respect and strengthen Indigenous connections to Yellowstone and their role in park stewardship.** Indigenous stories, traditions, and ethnographic resources are an important part of the history and current stewardship of Yellowstone. Creating space for Indigenous people to share their own connections to the land and including these perspectives is a critical part of stewarding Yellowstone.
- **We enhance Nation-to-Nation relationships.** To honor the federal Indian trust responsibility, the National Park Service consults with Yellowstone's Associated Tribes, who are sovereign nations, on a government-to-government basis when making decisions that affect culturally significant resources.
- **We incorporate Indigenous perspectives and voices into interpretation and education programming.** Yellowstone offers opportunities for visitors to hear directly from Tribal members at the Yellowstone Tribal Heritage Center and special Indigenous cultural events and to learn about Tribes through publications, exhibits, and educational programs.

Tribal Affairs

Park managers with the National Park Service meet periodically with Tribal representatives for government-to-government consultations to formally exchange information about park projects and ethnographic resources. Tribes provide input into resource management and decision-making, conduct ceremonies and other events in the park, and identify plants and minerals for traditional uses.

Bison Management

Many Tribes have a physical and spiritual connection

In 2022, members of the Nez Perce Appaloosa Horse Club rode in traditional regalia and presented about the history and culture of the NiMiiPuu (Nez Perce).

The Yellowstone Youth Conservation Corps provides an opportunity for young people aged 14–17 to come work, live, and learn in Yellowstone National Park.

to bison in Yellowstone. Starting in 2007, some Associated Tribes have exercised their treaty rights and conducted bison hunts outside the park.

Starting in 2009, the Confederated Salish and Kootenai Tribes of the Flathead Reservation, the InterTribal Buffalo Council, and the Nez Perce Tribe have joined the Interagency Bison Management Plan and participate in the development of adaptive management strategies for bison and brucellosis in the areas immediately outside Yellowstone.

Tribal Representation

In 2018, the park consulted with Associated Tribes on increasing opportunities for non-consumptive ceremonial use of the park. Consultants also reviewed park educational media and programming for representation of native peoples and perspectives.

Previous education consultation focused on the Yellowstone segment of the Nez Perce National Historic Trail and the associated sites and events of the 1877 Flight of the Nez Perce and the park has worked with many other Tribes on vetting educational content. In partnership with Yellowstone Forever, the park continually works with a collaborative group of Indigenous educators to review and incorporate Indigenous perspectives into the park's educational content.

Place Names

In 2016, the Executive Committee of the Blackfoot Nation contacted Yellowstone National Park to request name changes of two locations inside the park. National place names are managed by the United States Geologic Survey (USGS), and the representatives were referred to the USGS Board of Geographic Names at that time. The committee requested the park change Mount Doane to "First Peoples Mountain" and change Hayden Valley to "Buffalo People's Valley."

In 2022, the USGS, based on a recommendation by the NPS, changed the name of Mount Doane to First People's Mountain.

Native Student Opportunities

Currently, Yellowstone hosts an internship program which places Native American students into resource management and resource education internships with the National Park Service. In addition, Yellowstone also hosts Native American youth conservation volunteers through the Montana Conservation Corps.

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Historic Structures, Districts, and Cultural Landscapes

Historic districts, historic structures, and cultural landscapes built between 50 and 150 years ago are cultural resources that tell the story of how people managed, enjoyed, and traveled through the world's first national park.

The park's front country consists of developments that were historically constructed around Yellowstone's natural features. A figure-eight system of roads provided access to these developed areas and features. Much of the front country contains buildings (e.g., lodges, cabins, employee quarters, ranger stations), roads and bridges, trails, and cultural landscape features and patterns (e.g., overlook structures, vegetation patterns, viewsheds) that are considered historic properties or contribute to the character of a historic district. Historic districts can be comprised of a variety of buildings, sites, structures, and/or objects listed on or eligible for listing on the National Register of Historic Places.

Yellowstone's backcountry cabins are part of a large network of patrol or snowshoe cabins, based on a geographically strategic patrol operation established during the military administration of the park (1886–1918), and expanded through the National Park Service's leadership (1918–present). They continue to be used today.

The legal requirement to protect and understand the importance of these resources affects how the park is managed today. So far, 843 structures including roads, bridges, utility structures, and grave markers are listed on or eligible for listing on the National Register of Historic Places. Over 600 of these structures are buildings. The park is in the process of evaluating properties for National Register of Historic Places eligibility, including 173 structures on the List of Classified Structures, approximately 127 buildings constructed during the NPS Mission 66 period (1945–1972), and 124 trails. To date, seven (25%) of the park's cultural landscapes have been inventoried and evaluated for their historical significance.

The Old Faithful Upper Service Station, built in 1929, is an example of rustic architecture, intended to enhance rather than detract from the setting of the Old Faithful Geyser.

Unlike other park resources, historic structures and cultural landscapes require cyclic maintenance such as in-kind replacement of roofs and pavement. Alterations are often required to bring historic structures up to safety codes such as strengthening a building so it withstands seismic events. Preserving a historic structure or cultural landscape requires

Historic Designations

The **National Register of Historic Places** is the nation's official list of historic places worthy of preservation. Authorized by the National Historic Preservation Act of 1966, the National Register coordinates and supports efforts to identify, evaluate, and protect historic and archeological resources that are significant in American history, architecture, archeology, engineering, and culture. Properties from Yellowstone include

- Grand Loop Road Historic District
- Fishing Bridge Historic District
- Lake Fish Hatchery Historic District
- Lamar Buffalo Ranch Historic District
- Mammoth Hot Springs Historic District
- North Entrance Road Historic District
- Old Faithful Area Historic District
- Roosevelt Lodge Historic District
- Obsidian Cliff Kiosk
- Queen's Laundry Bathhouse
- Mammoth Post Office

National Historic Landmarks are nationally significant historic places designated by the Secretary of the Interior because they possess exceptional value or quality in illustrating or interpreting the heritage of the United States. Today, fewer than 2,500 historic places bear this national designation. In Yellowstone, they include

- Fishing Bridge, Madison, and Norris Trailside museums
- Fort Yellowstone; includes Norris and Bechler River soldier stations, and Roosevelt Arch.
- Northeast Entrance Station
- Obsidian Cliff Archeological Site
- Old Faithful Inn
- Lake Hotel

minimizing the rate at which historic fabric is lost and ensuring additions and alterations are compatible with historic character.

National Historic Landmarks (NHLs) possess exceptional value as commemorating or illustrating the history of the United States. The National Park Service is required to exercise a higher standard of care when considering undertakings that may directly or adversely affect NHLs. Fort Yellowstone National Historic Landmark District is located within Mammoth Hot Springs Historic District and continues to be the headquarters for Yellowstone National Park. Historic buildings, structures (Roosevelt Arch, Powerhouse), and sites (parade grounds, cemetery) contribute to the significance of this district.

Yellowstone is also home to five NHLs that are nationally influential examples of park "rustic" architecture—the Old Faithful Inn, the Northeast Entrance Station, and the Norris, Madison, and Fishing Bridge museums.

Lake Hotel, 1891

The Lake Hotel is the oldest operating hotel in the park. It was designated a National Historic Landmark in 2015. When it opened in 1891, the building resembled other hotels financed by the Northern Pacific Railroad. In 1903, the architect of the Old Faithful Inn, Robert Reamer, designed the Ionic columns, extended the roof in three places, and added the 15 false balconies, which caused it to be known for years as the "Lake Colonial Hotel." By 1929, additional changes—dining room, porte-cochere (portico), sunroom, plus interior refurbishing—put the finishing touches on the "grande damme" we see today.

Yellowstone Lake Fish Hatchery, 1930

People began stocking western high-elevation lakes with fish in the 1800s. Hatchery operations at Yellowstone Lake became part of this undertaking when fish hatched from Yellowstone's trout were used to stock waters in the park and elsewhere; sportfishing was promoted to encourage park visitation, and satisfying a recreational interest took precedence over protection of the park's natural ecology. Built in 1930 by the National Park Service, the hatchery's log frame is also an example of the period of rustic architectural design in national parks.

The hatchery was thought to be among the most modern in the West. The main room was outfitted with tanks and raceways for eggs, fingerlings, and

Lake Hotel resembled other hotels financed by the Northern Pacific Railroad when it opened in 1891.

brood fish taken from 11 streams that flowed into the lake. Small fry were fed in three rectangular rearing ponds in a nearby creek until they were ready for planting. Superintendent Horace Albright explained that the hatchery had also been designed with visitor education in mind, by making it possible "to take large crowds through the building under the guidance of a ranger naturalist without in any way impairing the operations of the Bureau of Fisheries."

Yellowstone was the largest supplier of wild cutthroat trout eggs in the United States, and park waters received native and nonnative fish. A rift developed, however, between the federal fish agencies and the National Park Service, which began moving away from policies that allowed manipulation of Yellowstone's natural conditions. In 1936, Yellowstone managers prohibited the distribution of nonnative fish in waters that did not yet have them and opposed further hatchery constructions in the park's lakes and streams. After research showed that it impaired fish reproduction, egg collection was curtailed in 1953. Four years later, the fish hatchery ceased operations, and the US Fish and Wildlife Service transferred ownership of the building to the National Park Service. Official stocking of park waters ended by 1959.

Current Status

Vegetation and stream flow have largely reclaimed the rearing ponds on Hatchery Creek, but their outlines can still be detected. Today, the hatchery building has changed relatively little. Nearly all of the exterior and interior materials are original to the building or have been repaired in kind. Now used as a storage facility, it is the primary structure of the nine buildings in the Lake Fish Hatchery Historic District, which was listed on the National Register in 1985.

Mammoth Hot Springs Historic District and Fort Yellowstone Historic Landmark District

The Mammoth Hot Springs Historic District has statewide significance as the administrative and concession headquarters of the largest national park in Wyoming. Park managers here developed significant conservation policies that greatly influenced the nascent National Park Service. It is also significant for its architecture, which includes Colonial Revival, Rustic, Prairie, Art Moderne, French Renaissance, and English Tudor styles. The district contains 189 buildings, 2 sites (Mammoth Hot Springs Campground and Fort Yellowstone Parade Ground), and 1 object (flagpole). Of these, 35 buildings also contribute to the significance of the overlapping Fort Yellowstone National Landmark, as does one structure (Fort Yellowstone Powerhouse) and one site (Fort Yellowstone Parade Ground). These remain from the 1890s and early 1900s when the US Army administered the park. They reflect the layout and architecture of a typical western army fort of the nineteenth century.

Albright Visitor Center, part of the Mammoth Hot Springs Historic District and Fort Yellowstone Historic Landmark District, housed the first "information office" (visitor center).

Mail Carrier's Cabin, 1800s

The origins of the building at the edge of Fort Yellowstone that became known as the mail carrier's house are unclear, but it is significant as the only 1800s log structure still standing in Mammoth Hot Springs. Its style is more typical of construction of the area and time than the buildings put up by the US Army for Fort Yellowstone. It was probably built in the mid-1890s, and over the years it has provided quarters for mail carriers as well as employees of concessions and the National Park Service.

History

When mail delivery was not yet provided in rural areas, mail carriers delivered the mail from railroad distribution points to post offices, where people traveled, often from many miles away, to pick up their mail, their only link to the rest of the world. In the 1800s, a mail carrier was contracted to transport mail from the railroad station in Livingston, Montana, to Mammoth Hot Springs and then to Cooke City, Montana, before returning to Livingston, a trip of several days' duration.

The cabin was either built by or later sold to an early park concession, the Yellowstone Park Association. A lean-to with a shed roof was built onto the back of the two-room structure in about 1903 to serve as a kitchen and dining area. In the 1930s, a mudroom and bathroom were added to the north side of the building, bringing the total square footage to 512. In the early 2000s, removal of the insulation added to the walls and ceilings in the 1930s exposed

The mail carrier's house, built around 1895, photographed at an unknown date (left) and in 2009 (right).

a layer of newspapers beneath, announcing the 1903 flight of the Wright Brothers at Kitty Hawk.

In 1972, the building, then owned by a park concessioner, was "in a state of general deterioration." Historic structure experts recommended that the vacant house be demolished because they doubted that it "could serve any useful function" that would justify the "great cost" of restoration. However, the house was listed on the National Register in 1982. Despite the building's poor condition, it continued to house park staff for another two decades. It was structurally stabilized in 2009.

Mammoth Post Office, 1938

Yellowstone's main post office was one of 1,007 post offices constructed from 1935 to 1938 during the Great Depression "with a view to relieving countrywide unemployment." Using standardized plans developed from guidelines provided by the Treasury Department, these post offices were built in sizes and styles that reflect transitions in architectural design and the context of the communities in which the offices were located. The Yellowstone Post Office is a concrete building with a hipped roof in the French Renaissance Moderne style, compatible with the Art Moderne style ornament on the nearby Mammoth Hot Springs Hotel, which was partially rebuilt in 1936. The post office lobby has walls of travertine from a quarry outside the park's north entrance. It is still a working post office today, serving park residents and visitors.

Current Status

The Yellowstone post office was listed on the National Register of Historic Places in 1987 with 11 other Wyoming post offices built from 1908 to 1939. The buildings were said to "record the evolution of both the political/economic philosophies and the design philosophies of the federal government" during a period when building design was used "to provide a symbol of the monumental presence of the federal government in its post offices."

Roosevelt Arch, 1903

The five-mile road from the park's boundary at Gardiner, Montana, to its headquarters at Mammoth Hot Springs, Wyoming, was built in 1884. The arch constructed over the road became known as Roosevelt Arch because President Theodore Roosevelt, who happened to be vacationing in the park, spoke at the ceremony to lay the cornerstone in 1903. The plaque on the arch is inscribed with a phrase from the legislation that established Yellowstone National Park: "For the benefit and enjoyment of the people." Roosevelt Arch continues to serve as a historical marker for a time when cultural values called for a monumental entrance to Yellowstone.

The two bears at the post office entrance were added in 1941 and commissioned by the Federal Works Agency to enhance federal buildings with artwork. Gladys Caldwell Fisher sculpted the cubs from Indiana limestone based on her observations of grizzly bears at one of the feeding grounds then permitted in the park. The three-ton bears were shipped by rail from Denver to Gardiner, Montana.

The Roosevelt Arch is in the North Entrance Road Historic District and is part of the Fort Yellowstone Historic Landmark District. The structure was conceived by US Engineer Hiram Chittenden; architect N.J. Ness contributed to the design, and Robert Reamer may have also worked on it.

The Roosevelt Arch, pictured here on a Haynes postcard.

The Old Faithful Historic District, which includes the inn and many of the surrounding buildings, was listed on the National Register of Historic Places in 1982.

Old Faithful Historic District

The Old Faithful Historic District, which includes the inn and many of the surrounding buildings, was listed on the National Register of Historic Places in 1982. Like the Old Faithful Inn, the district is historically significant because of its rustic architecture and its role in the development of concessions to accommodate growing tourism in the early 1900s. The Old Faithful Lodge, located near the Inn, reached its present configuration in 1928 after numerous changes. The consolidation into one complex was designed by NPS Landscape architect Daniel Hull in collaboration with Gilbert Stanley Underwood, a famous architect of the time.

Old Faithful Inn, 1904

Named for the nearby geyser, the Old Faithful Inn exemplifies the use of rustic architecture at a large scale to complement a natural landscape. The rhyolite that formed Yellowstone's caldera during volcanic upheavals provided the stone for the building's foundation, and local lodgepole pine the logs for its walls. Skilled craftsmen embellished the windows and stairways with gnarled wood selected for its inherent beauty. As designed by architect Robert Reamer, the inn combines rugged materials and organic motifs in a way that expresses both frontier sensibilities and elegance.

The roof shingles of the Old Faithful Inn, shown here in 1912, were originally coated with a red mineral paint believed to hinder flammability.

History

After the only hotel in the Upper Geyser Basin burned down in 1894, park officials pressured the Yellowstone Park Association, which held the lease on the property, to replace it with something more substantial. In 1902, the president of the concession, Harry Child, obtained financing from the Northern Pacific Railroad for a new structure, the first parts of which would become known as the Inn's Old House. The lobby, rising six stories beneath a steeply sloped roof, was flanked by a dining room and two three-story wings containing guest rooms.

The Old Faithful Inn was built over the winter of 1903–1904, and was equipped with electric lighting, but Reamer designed the light fixtures to look like candlesticks. Both the electricity and the radiators were fueled by a steam generator. Evening meals were accompanied by a string quartet, and dancing was customary six nights a week. Under Robert Reamer's supervision the east wing was added in 1913 and the west wing in 1927, bringing the inn's total number of guest rooms to about 340.

The August 1959 Hebgen Lake earthquake shook the Old House from its foundation and damaged the roof and chimneys, but no guests were seriously injured. After closing early for the winter, the inn re-opened the following summer. Another evacuation took place in September 1988 when the North Fork Fire destroyed some small buildings nearby, but the Old Faithful Inn was preserved with the help of firefighters and roof sprinklers installed the previous year.

Historic preservation has maintained the appearance and condition of the famous Old Faithful Inn lobby, shown here in the first half of the 1900s (top) and in 2003 (bottom).

Current Status

The Old Faithful Inn was designated a National Historic Landmark in 1987. A major renovation program of the Old House was launched in 2004 to meet current building codes and restore the lobby so that it more closely replicates Reamer's original design. The walls and roof were reinforced with steel to make the structure more seismically stable, and electrical, plumbing, and heating systems were replaced and made less conspicuous. With the completion of this program, the Old Faithful Inn is considered to be in good condition.

The Lamar Buffalo Ranch, in operation from 1906 until the 1950s, was the center of efforts to increase the herd size of bison in Yellowstone.

Lamar Buffalo Ranch Historic District, 1906

The extermination of bison herds throughout the West in the 1800s nearly eliminated them from Yellowstone; even after the park was established in 1872 poachers faced few deterrents. With only 25 bison, counted in the park in 1901, Congress appropriated $15,000 to augment the herd by purchasing 21 bison from private owners. As part of the first effort to preserve a wild species through intensive management, these bison were fed and bred in Lamar Valley at what became known as the Buffalo Ranch.

As the herd grew in size, the animals were released to breed with the park's free-roaming population and used to start and supplement herds on other public and tribal land. Today the Yellowstone bison population of approximately 5,900 is one of the largest in North America and among the few that is genetically pure because it has not been interbred with cattle. The buffalo ranch is therefore significant for its role in the history of wildlife management and the preservation of the American bison.

Current Status

A program to raise bison like domestic cattle in Yellowstone may seem incongruous in retrospect, but the buffalo ranch stands as a reminder that today's well-intended wildlife management policies may have unintended consequences and be overturned by changing values and advances in ecological knowledge.

The Lamar Buffalo Ranch Historic District includes five buildings: a ranger station, constructed in 1915 as the buffalo keeper's residence; a pole-fenced corral built and rebuilt from 1915 to the 1930s; a log barn for hay and horses (1927); a bunkhouse (1929); and a residence used for the assistant buffalo keeper.

The vegetation around the ranch is mostly sagebrush and nonnative grasses that were planted during the period of hay cultivation or that migrated into the area. Remnants of irrigation ditches, fencing, and water troughs can still be found.

The bunkhouse is used by the Yellowstone Forever Institute, which conducts classes and seminars during the summer, and by Expedition Yellowstone, the park's overnight program for school groups. In 1993, Yellowstone Forever (then the Yellowstone Association) replaced the old tourist cabins with insulated and heated cabins. Except for the phone line, the cabins and other buffalo ranch facilities are off grid. The main source of power is a 7-kilowatt photovoltaic array installed in 2000 with industrial battery storage and two alternating 12-kilowatt engine generators.

Funding from the park's non-profit partner, Yellowstone Forever, is enabling the National Park Service to use the buffalo ranch as a model for off-grid environmental stewardship by adding more solar panels, low-flow water fixtures, micro-hydropower, on-demand hot water, zero-waste and recycling programs, and more energy-efficient windows, while preserving the historic integrity of the original structures.

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Bison calf butting park ranger at the buffalo ranch, 1930s.

Roosevelt Lodge Historic District

The Roosevelt Lodge Historic District, which includes 130 buildings, was listed on the National Register of Historic Places in 1983, with a period of significance from 1906 to 1948. The accommodations are still rustic, with unpaved roads into and around the lodge and cabins.

The area has undergone intermittent expansion and changes as visitor use has changed and facilities have aged over the years. The architectural appearance of the original lodge is retained only in the lounge and dining room. The other sections of the building have been modified. The interior has become congested with multiple activities, some of which were not part of the original building—a bar, merchandise cases, and offices.

In 2009, the National Park Service completed an environmental assessment for the Tower–Roosevelt area in order to protect the area's natural resources and preserve its historical character, including the rustic architecture of Roosevelt Lodge and the view from the lodge porch across the meadow to the distant mountains. The plan also called for pulling the parking lot away to improve views and reduce congestion near the lodge, which was accomplished in 2021.

Roosevelt Lodge, 1920

Indians, fur trappers, and explorers on the Bannock Trail camped in this area where a sagebrush meadow was encircled by Douglas fir, quaking aspen, and a mountain stream that tumbled toward the Yellowstone River. As part of his journey through the park, President Chester Arthur camped in this

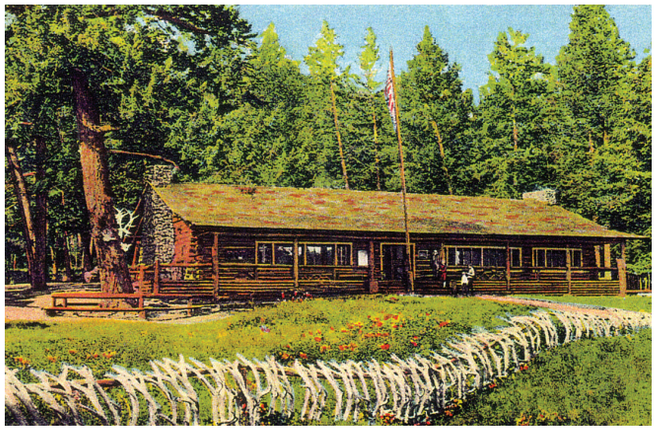
area in 1883. In 1906, the Wylie Permanent Camping Company built a tent camp that became known as "Camp Roosevelt," though Theodore Roosevelt never camped there. The tents were replaced by a lodge and cabins in the 1920s, and Lost Creek has shifted course, but people still enjoy staying at this scenic spot on the park's northern range.

For Dudes and Scientists

Camp Roosevelt's location provided an overnight stop for visitors traveling between Mammoth Hot Springs and Canyon. As at other Wylie camps, guests slept in striped tents with wood floors, gathered at a larger tent for communal meals and sing-alongs, and were transported around the park in the Wylie Company's vehicles. The successor to the Wylie Company, the Yellowstone Park Camping Company, built the park's first and smallest lodge at Camp Roosevelt in 1919. The lodges were built to accommodate the increasing number of visitors arriving in their own automobiles who wanted something more than a tent but less expensive and formal than the park's hotels.

At Camp Roosevelt, the concessioners wanted to create the atmosphere of a dude ranch, and Superintendent Horace Albright described it as "a place visitors would like to stay indefinitely." It did provide a base for fishing parties and saddle-horse trips, but it also served as a field laboratory where teachers and their students could conduct research at minimum expense, a purpose that the first director of the National Park Service, Stephen Mather, promoted for the parks. In what was a forerunner to the

Roosevelt Lodge interior with photograph of Theodore Roosevelt, 1920s.



The Roosevelt Lodge before it faced a parking lot (Haynes postcard, 1927).

educational programs found in the parks today, the National Park Service hired H.S. Conard, a naturalist at Grinnell College, to present lectures and to conduct daily field trips for Camp Roosevelt visitors and collect botanical specimens for the park museum. Scientists based at the lodge conducted studies on the park's wildlife. From 1921 to 1923, the lodge was the headquarters for a boy's summer camp run by Alvin Whitney of the New York State School of Forestry at Syracuse University.

The Buildings

The lodge, constructed of unpeeled logs and completed in 1920, was originally surrounded by 43 small log cabins, the first of which were completed in 1922. Over the years, the Roosevelt Lodge area became a repository for guest cabins brought from areas in the park where they were no longer wanted. By 1982, the corral had been moved farther from the cabins, of which there were now 110 of four main types.

Northeast Entrance, 1935

The entrance station and ranger residence at Yellowstone's Northeast Entrance were constructed in 1935 in a rustic style that was becoming emblematic of national park architecture. According to its listing as a National Historic Landmark in 1987, the entrance station "subconsciously reinforced the visitor's sense of the western frontier and the wilderness he was about to enter. The building was not only the physical boundary, but the psychological boundary between the rest of the world and what was set aside as a permanently wild place." The station is considered "the best of its type remaining in the National Park System."

Northeast Entrance station is considered "the best of its type remaining in the National Park Service."

Pelican Springs backcountry cabin is an example of early rustic style of national park architecture.

The entrance station was constructed with two traffic lanes passing through it. When it became necessary to accommodate the increasing number of recreation vehicles too tall to fit in the passage, a lane was added to each side of the building rather than alter it.

The station is currently considered to be in good condition. Extensive rehabilitation of the entrance station in 1984 repaired log ends and replaced log rafters and the roof. The oakum rope chinking remains. Two street lights and a flagpole were added, and concrete bollards were placed on the east and west sides to prevent vehicles from driving into the building. The interior of the checking station has undergone little change over the years. Although the original plans called for earthen floors, the rooms have concrete floors that were probably poured sometime after construction. The original wood stove that heated the central portion of the station was replaced with an oil stove in the same location.

Backcountry Cabins

Backcountry cabins are part of a large network of patrol or snowshoe cabins, based on a geographically strategic patrol operation established during the military administration of the park (1886–1918), and expanded by the National Park Service (1918–present). The original purpose of these cabins was to prevent poaching and vandalism.

The spacing between each cabin is roughly a day's walk or ski, and allows for full coverage of monitoring the park, even during the winter months and in the most remote areas. They are stocked with survival rations, firewood, cleaning supplies, and basic furnishings. Strict rules, handed down from the Army, dictate how the cabins are kept clean and tidy, and ready for the next occupant. For example, firewood must be brought in and kindling laid for the next fire in the wood stoves, in case someone reaches the cabin in danger of frostbite or hypothermia and needs to light a fire quickly.

Architectural styles include primitive log structures (soldier stations or snowshoe cabins, which were constructed by the US Army), and Early NPS Rustic style, many of which were constructed by the CCC during the 1930s. The cabins are often accompanied by a barn, corral, and/or privy. These cabins are still used today for research, resource management, search and rescue operations, and backcountry patrol against poachers; they are significant in Yellowstone's history for the role they played in the preservation, maintenance, and resource management throughout the park and the role the US Army played in the park's early management.

Historic Roads, 1905

The road construction that began in Yellowstone in the 1870s became the United States' first large-scale road plan and served as a model for other parks, especially in its use of local materials. Even after Yellowstone could be reached by train in 1883, the difficulty of transport and road construction in a geologically and climatically challenging terrain required enormous labor and innovative engineering. The development of a road system was essential in making Yellowstone more accessible to the public. Over the years, advances in road standards and construction technology have led to changes in the roads' appearance, but the overall design has remained largely intact, along with many historical features such as bridges, culverts, and guardrails.

Touring the Park

At first, travel to and within the park was difficult. Visitors had to transport themselves or hire an expensive guide. In the park, they found only a few places for food and lodging. Access improved in 1883 when the Northern Pacific Railroad reached Cinnabar, Montana, a town near the north entrance.

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

These visitors carried home unforgettable memories of experiences and sights, and they wrote hundreds of accounts of their trips. They recommended the tour to their friends, and each year more came to Yellowstone to see its wonders. When the first automobile entered in 1915, Yellowstone became accessible to anyone in the nation who could afford a car.

Hiram Chittenden

The 310-mile (500 km), figure-eight road system that connects Yellowstone's five entrances, developed areas, and major attractions remains largely the same as when United States Army Corp of Engineers engineer Major Hiram Chittenden finished his work on it in 1905. Through his role in designing Yellowstone's roads, bridges, and other structures, Chittenden had a lasting effect on the appearance of our national parks. While stating that they should be maintained "as nearly as possible in their natural condition, unchanged by the hand of man," he would use masonry and add or remove trees and other landscaping so that "the roads will themselves be made one of the interesting features of this interesting region."

Throughout the park, he replaced many wooden bridges with steel or concrete. His most difficult project was the replacement of the rickety trestle at Golden Gate with a 200-foot (61-meter) viaduct, a series of 11 concrete arches built into the cliff wall over a canyon. In 1902, he persuaded Congress to make the appropriation needed to complete the park's road system. This included some of Chittenden's signature achievements: the road over Sylvan Pass, the road to Mount Washburn (now called Chittenden Road), and the first bridge over the Yellowstone River above the Upper Falls, which at last provided a direct means of getting to the east bank of the river. Over the years, the Golden Gate viaduct had to be reconstructed, and the bridge over the Yellowstone River was condemned in 1959 and replaced by a modern bridge.

Before leaving Yellowstone in 1906, Chittenden was also responsible for overseeing the redesign of the park's north entrance, including construction of the arch and, through irrigation, fertilization, and the planting of alfalfa, transforming 50 acres adjacent to Gardiner into a green field that would provide winter forage for pronghorn and other game animals. Today, park staff and partners are working to restore the field to its natural condition, but the Roosevelt Arch endures.

Trailside Museums (1929–1932)

The museums at Fishing Bridge, Madison Junction, and Norris Geyser Basin were designated National Historic Landmarks in 1982 because their exaggerated features and organic forms exemplify rustic design in the national parks and served as models for hundreds of park buildings constructed during work relief programs of the 1930s. As envisioned by the chairman of the American Association of Museums, Hermon Bumpus, they also established the idea of "trailside museums" where visitors could learn about an area within a park. Bumpus regarded national parks as "roofless museums of nature" with unlabeled exhibits and the trailside museum as the place to provide the labels.

Designed by architect Herbert Maier in a style that became known as "Parkitecture," the museums have the battered rubble masonry and clipped gables of a traditional bungalow style, but use locally available materials left in their natural condition to reflect the scale and roughness of the landscape. The asymmetrical boulders and gnarled logs display the irregularities of nature. Maier, who also designed museums for Grand Canyon and Yosemite, regarded buildings in national parks as "necessary evils" because even the best was "somewhat of an intruder." Maier's designs laid these buildings lightly on the landscape, using retaining and foundation walls made of large boulders that allowed the retention of adjacent trees and blurred the line between where the building ended and the natural landscape began. The buildings' National Register nomination described the trailside museums as "a perfect solution for an architecture appropriate to the outdoors: informal through the use of natural materials and horizontal lines," but with "a strength of design and heavy-handed expressions" that "suggested the smallness of man in relation to nature."

History

In 1928, Yellowstone Superintendent Horace Albright proposed the construction of "small local museums" to provide visitors with information that would "make their sojourn educationally as well as recreationally profitable." With a grant from a foundation set up by John D. Rockefeller and the guidance of Dr. Bumpus, the American Association of Museums built four such museums in Yellowstone.

The Museum of Thermal Activity, constructed at Old Faithful, opened to acclaim for its quality materials and construction, and for the way it blended into its surroundings. However, it was razed and replaced by a more modern visitor center in 1971. The exteriors of the other museums have changed little since their completion by 1932, but the interiors have undergone some alterations in design and use. Only the Norris Geyser Basin Museum still has its original name.

In a 1942 report, park naturalist Bert Long pointed out that "due to lack of funds," there were "many obvious gaps and inadequately told phases" of the Yellowstone story as told in its museums, and that many of the exhibits contained obsolete scientific theories. "Every attempt should be made to include in each museum information pointing out what there is to do of a recreational nature in its surroundings," Long urged. "Get the people out of their cars, on the trails to the features and half the battle is more than won." The difficulty of funding and keeping exhibits up to date has not lessened over the years, nor has the goal of getting people out of their cars.

Fishing Bridge Museum, 1931

Now called the Fishing Bridge Visitor Center, the building was designed so that visitors approaching from the parking lot could see through it to Yellowstone Lake, where stone steps lead down to the shore.

Antlers, rams' horns, and bighorn sheep skulls still decorate the two wrought-iron chandeliers, but they were removed from the log frame around the screen in the adjacent amphitheater, where the original log seats have been replaced with thick plank seats. No longer used, the fireplace beneath the large stone chimney inside the museum is concealed from public view in a small area used for offices. In 2021-2022, linoleum tiles were removed to reveal the original

The Fishing Bridge Museum, 1931.

The Norris Geyser Basin Museum, c. 1930.

The Madison Information Station, c. 1930s.

scored concrete floor, and plywood covers were removed to reveal original windows that had been covered to accommodate shelving in the book sales area. The museum display cases (many designed and built by Dr. Carl Russell) were also rebuilt to accommodate shatter proof glass and reinstalled.

Norris Geyser Basin Museum, 1929

The open foyer through the middle of the Norris Museum still functions as the visitor's gateway to the Norris Geyser Basin; in particular, it frames the view to the north of the Porcelain Basin. One of the two rooms on either side of the foyer originally contained bird specimens, but both now have exhibits explaining hydrothermal activity and life in thermal areas. In 2020, the exhibits were updated, windows uncovered, and a removeable ramp was installed. Also designed by Maier with rustic architectural features, the nearby comfort station was converted to a Yellowstone Forever bookstore after a larger restroom of more contemporary style was built closer to the parking area.

Madison Museum, 1929

Overlooking a meadow beyond which the Gibbon and Firehole rivers join to form the Madison River, the Madison Museum was intended to focus on park history, especially the nearby site where the 1870 Washburn Expedition was thought to have originated the idea of a national park as a way to protect the thermal areas from commercial development. In accordance with Bumpus's vision of the museum's "function as a national monument," a large glass transparency created from a 1930 photograph was placed prominently in a window where the light shone through a re-enactment of the Washburn party gathered around a campfire.

In 1940, a park naturalist suggested that the main room's floor, made of large, uneven pieces of rhyolite, should be covered with oak or pine to "avoid possible hazards to visitors from stumbling falls" and make it easier to clean. That did not happen, but when the building was transformed into the "Explorers' Museum" as part of Yellowstone's 1972 centennial celebration, carpeting and track lighting were installed, the wood stove that used to heat the building was removed, and the exhibits were redesigned.

In acknowledgement of evidence long put forth by historian Aubrey Haines that refuted the "campfire story," the re-enactment image and references to the Washburn party's role in establishing the first national park were removed from the museum. However, in deference to Albright, still influential in retirement, and National Park Service officials who would not abandon the story, the purported campfire discussion was commemorated in a sign placed outside the museum: "…there emerged an idea… that there should be no private ownership of these wonders but that the area should be preserved for public enjoyment."

Haynes Photo Shops

As leaders in concessions development in Yellowstone from 1884 to 1962, Frank Jay Haynes and his son, Jack Ellis Haynes, constructed many buildings for their enterprises. Among the few that remain, the Haynes stores at Old Faithful (1897 and 1927) and in Mammoth Hot Springs (1929) were most important to the primary business of taking, developing, and selling photographs. By helping Yellowstone gain international recognition for its natural wonders, the Haynes' photography promoted both tourism in the West and the idea of a national park.

The Old Faithful building is an example of the rustic style that was becoming popular in western parks, while the Mammoth building displays a transitional architectural style influenced by the Crafts movement, a departure from more traditional revival styles prevalent in Mammoth and unrelated to the rustic architecture common elsewhere in the park.

History

F. Jay Haynes first photographed Yellowstone National Park in 1881 to publicize the Northern Pacific Railroad. Encouraged by Superintendent Philetus Norris, who wanted to promote park visitation, Haynes built stores on land leased in Mammoth Hot Springs in 1884 and at Old Faithful in 1897. After he retired, his son Jack took over the business, and in 1927 built stores, called photo or picture shops, in the Mammoth and Fishing Bridge campgrounds, and a larger facility near what was then the Old Faithful Auto Camp. Eventually, 13 Haynes stores were opened in hotels or their own buildings.

The 1927 Old Faithful store, designed and constructed in two months by contractor George Larkin, had living quarters on the second floor over a photo-finishing operation as well as a retail shop. A two-story dormitory for Haynes employees was added in 1951, and an addition to the rear of the building several years later.

The Mammoth Hot Springs facility, designed by Bozeman, Montana, architect Fred Willson and completed in 1929, served as the headquarters for the Haynes photographic business in the park. It included an overnight photo-finishing service, and retail space that carried an assortment of photographs, books, camera film, and other supplies. The drive-through canopy acknowledged the growing influence of the automobile on architectural design.

From a Haynes postcard of the Haynes Picture Shops Headquarters at Mammoth Hot Springs, 1934.

Current Status

Jack Haynes operated the family business until his death in 1962. After running the company for another five years, his wife Isabel sold it to Hamilton Stores, owned by the Povah family. After most of the Old Faithful building was moved in three pieces and reconfigured near the newly constructed Snow Lodge in 1971, Hamilton Stores renovated the dormitory and added a front porch. Nearly all of the exterior materials on the original store are still present or have been replaced by the same materials. By 1998, the original Snow Lodge had been razed and a new Snow Lodge opened immediately adjacent to the Hamilton Store.

When the Hamilton Stores contract expired in 1999, the National Park Service purchased the buildings at Old Faithful and Mammoth. The Old Faithful store detracted from the appearance of the new Snow Lodge, and after considering several alternatives, in 2009 the National Park Service dismantled the dormitory and moved the original portion of the building to a site near its original location. Yellowstone Forever now occupies the old photo shop. Its former site has been landscaped as public open space.

The Mammoth Hot Springs photo shop has been used for multiple purposes since it was sold, including retail and storage. Over the years, its condition deteriorated significantly. After a considerable rehabilitation and restoration project, the park concessioner, Xanterra Travel Collective, has relocated their headquarters to the building.

The Fountain Hotel (left) and Grand Canyon Hotel (right), shown here from Haynes postcards, are two of several hotels that are no longer standing in Yellowstone.

Lodging No Longer Standing

Marshall's Hotel, which stood near the present-day intersection of Fountain Flats Drive and Grand Loop Road, was built in 1880 and was the second hotel in the park. Later renamed the Firehole Hotel, it was mostly razed in 1895, with other buildings removed later.

Fountain Hotel opened in 1891 north of Fountain Paint Pot. This was one of the first Yellowstone hotels where bears were fed for the entertainment of guests. The hotel closed after 1916 and was torn down in 1927.

Four lodging facilities were built at Norris. Three were built between 1886 and 1892; the first two burned. The last hotel at Norris, which overlooked Porcelain Basin, served the public from 1901 to 1917.

Three hotels were built in succession at Canyon, the last being the largest structure in the park. Sited where the horse stables are now, the Canyon Hotel was closed in 1958 due to financial and maintenance problems and burned in 1960.

These and other sites of former park facilities are historic archeological sites. They are studied and documented for what they reveal about past visitor use in the park.

Construction of Other Park Buildings

Lake General Store, 1920

Lake Ranger Station, 1922–23

Mammoth Chapel, 1912–13

Mammoth Gas Station, 1920

Old Faithful Gas Station (Lower), 1920, 1925

Old Faithful Lower General Store, 1897, 1921 addition

Old Faithful Upper General Store, 1929–30

South Entrance Ranger Station Duplex, 1928

Tower General Store, 1932

West Thumb Ranger Station 1925; now an information station

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Staff Reviewers

Zehra Osman, Landscape Architect

Alicia Murphy, Park Historian

Jacey Anderson, Research Assistant

Cultural Landscapes

Cultural landscapes are settings that human beings have created in the natural world. They are geographic areas that have been shaped by human manipulation of natural and cultural resources and are associated with historic events, people, or activities in the park. They reflect significance of the historic setting and recognize the influence of human beliefs and actions over time on the natural landscape. A cultural landscape is an indicator of cultural patterns, values, and heritage through the way the land is organized and divided, patterns of settlement, land use, circulation, and the types of structures that are built and their placement in the landscape.

Yellowstone National Park contains an array of landscapes that reflect the park's history, development patterns, and a changing relationship between people and the unique Yellowstone environment. In Yellowstone, these landscapes are often a physical record of the early and ongoing efforts to balance resource preservation and facility development for public enjoyment. They include sites such as Artist Point and Apollinaris Spring and the landscape features and patterns that contribute to the character of the Roosevelt Lodge Historic District. They also include areas significant to Native American cultures, such as Obsidian Cliff and sacred sites. Yellowstone's cultural landscapes are being inventoried to identify landscapes eligible for the National Register and to ensure new undertakings are compatible with them.

This iconic view of the Lower Falls of the Yellowstone River was photographed from Artist's Point. Artist's Point was named to recognize the crucial role of the work of artists in the creation of Yellowstone National Park. The work of photographers and painters like Thomas Moran, persuaded distant legislators of Yellowstone's awesome beauty and natural and cultural significance.

T. MORAN/DEPARTMENT OF THE INTERIOR MUSEUM

Grand Canyon of the Yellowstone River. Oil on Canvas 1872 by Thomas Moran.

Staff Reviewer
Zehra Osman, Landscape Architect

More Information

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Collections

Yellowstone's collections document the cultural and natural history of the world's first national park and the conditions of its resources. The historic collections document the park from pre-history through the present. The collections include objects and written records that document the history and science of the park, changes in perception and meaning over time, and the interaction between people and nature. Specimens range from geologic and natural history to Native American and European American cultural materials.

It is National Park Service policy to collect, protect, preserve, provide access to, and use objects, specimens, and archival and manuscript collections to aid understanding and advance knowledge. Collections play important roles in resource management, research, and education programs, and function as baseline databases for park natural and cultural resources.

With over 6.7 million items, Yellowstone has one of the largest collections in the National Park Service. The collections grow continuously with the addition of archival records, archeological artifacts, and scientific specimens.

The Heritage and Research Center houses Yellowstone's museum collection, archives, and research library.

Heritage and Research Center

Before 2005, Yellowstone's collections were stored in various locations both inside and outside the park, where they were subject to deterioration, damage, and theft. With the opening of the Heritage and Research Center, these collections, apart from historic vehicles, were relocated and stored in a single location. This state-of-the-art storage facility meets standards set by the National Park Service, the American Alliance of Museums, and the National Archives and Records Administration. Both the Heritage and Research Center and its staff enable the continued preservation of Yellowstone's collections.

Most of these items are kept in the Heritage and Research Center, which is located in Gardiner, Montana. The Heritage and Research Center is a collections storage facility that also houses the park's herbarium and archeology lab, and features small rotating exhibits in the lobby.

Quick Facts

Numbers in Yellowstone

- More than one million museum items, including 30 historic vehicles
- The archives housing more than 5.6 million collections, including manuscripts, photos, maps, films, oral histories, administrative records, and scientific data that documents the natural and cultural resources of the park as well as its development and management
- A research library containing more than 20,000 books, periodicals, theses and dissertations, unpublished manuscripts, microfilm and other micrographic formats of historical newspapers and scrapbooks, brochures, technical reports, and audio visual material

Together, more than four million items, one of the largest in the National Park System.

Where to See

Gardiner, Montana

- The Heritage and Research Center is open Monday–Friday, 9 am–4:00 pm (except federal holidays); the public is welcome to tour the temporary exhibits located in the lobby.
- The library is open to the public Monday–Friday.
- The archives, herbarium, and museum collections may be accessed for research purposes by appointment.
- Public tours may be available from June to September. Call (307) 344-2264 to reserve a space.

Conducting Collections Research

Anyone can conduct research in the collections. Archives finding aids and the library's catalog are available online. Additionally, a growing amount of material has been digitized and made available online. Visit the collection webpage for links to these materials.

For onsite research, please email us at yell_heritage_center@nps.gov to schedule an appointment or to consult with the archivists, librarians, and curators.

For more information, visit www.nps.gov/yell/learn/historyculture/collections.htm

Museum Collection

Yellowstone's museum collection contains more than one million items that, along with the archives and library collection, document the cultural and natural history of the park. The museum collection consists of natural history, archeological, and cultural objects, including obsidian points, skulls from the first wolves reintroduced in the park, Thomas Moran's original watercolor field sketches, William Henry Jackson's photographs, furniture from the historic hotels and other historic structures, and an extensive historic vehicle collection ranging from stagecoaches and wagons, through early buses and automobiles, to fire trucks and a snowmobile.

The collection is used each year by park staff and other researchers looking for background information on Yellowstone history, specific reference material, and illustrations for commercial products, school programs, special events, and adult education. The televised series, "The National Parks: America's Best Idea," by Ken Burns contained hundreds of images from Yellowstone's collections.

While the Heritage and Research Center does have some rotating exhibits in the lobby area, the facility was not designed to be a museum, but rather a research center and a state-of-the-art storage facility. With the exception of some restricted collections, such as Thomas Moran's original watercolor field sketches, William Henry Jackson's photographs, and other rare or fragile items, the museum collections are accessible to researchers by appointment only and require at least 24-hours advanced notice.

One of more than 150 skulls and skeletal materials in the museum collection from the park's Wolf Project, wolf 007F was released in Yellowstone in 1995 as a Rose Creek pup. She joined 002M from the Crystal Creek pack in 1996 to form the Leopold Pack, the first naturally formed pack of the new era. She was killed by wolves of the Geode Creek pack in 2002.

Historic Vehicle Collection

Yellowstone National Park's historic vehicle collection currently includes thirty horse-drawn and motorized vehicles. They range from stagecoaches operated by the Yellowstone Park Transportation Company (later the Yellowstone Park Company) and Monida and Yellowstone Stage Company (later the Yellowstone-Western Stage Company), to early Yellowstone Park Transportation Company touring cars, buses, and service trucks, to National Park Service scooters and a fire engine. Also represented in the collection are numerous human-powered vehicles, including fire hose carts and handcarts, or "Mollys" used by hotel maids and bellmen.

The vehicle collection is one of the largest in the National Park System. Currently housed in an historic structure (a former Yellowstone Park Transportation Company structure built in 1925 to replace the original transportation facilities destroyed by fire), it is hoped that a more suitable storage/exhibit facility will eventually be constructed, possibly as a wing of the Yellowstone Heritage and Research Center. The vehicle collection is currently not open to the public.

The majority of the vehicles were received from TW Recreational Services, Inc. (successor to the Yellowstone Park Company) in 1991. Others have been added to the collection (such as the Willys fire truck) when they became obsolete or surplus to National Park Service needs. In 2016, a 1965 Bombardier Model R-12 snowcoach (#706) became the most recent addition to the historic vehicle collection when the park phased out the use of these coaches.

Volunteers performed initial cleaning of the

Yellowstone's historic vehicle collection, one of the largest in the National Park System, includes this 1917 touring car.

vehicles, and the Yellowstone Association and Yellowstone Park Foundation (which merged in 2016 to become Yellowstone Forever) have also provided funding for preservation and conservation efforts.

More recently, some federal funding was provided for extensive preventative conservation treatment (cleaning and stabilizing some of the vehicles) by National Park Service staff. Some of the vehicles have been loaned to other museums and institutions for special exhibits, and the entire collection was the focus of a segment in "Hidden Yellowstone," a film aired by the Discovery Channel.

Archives

The Yellowstone Archives contains records documenting the natural and cultural resources of Yellowstone. They also detail the military administration of the park (1886–1918), the evolution of the national park concept following Yellowstone's establishment, the formulation of management policies, records of park concessioners, and ongoing developments in park management today. The collection includes historic maps, photographs, films, oral histories, administrative records, and scientific data.

The Yellowstone Archives is an affiliate of the US National Archives and Records Administration (NARA), which allows the park to permanently hold federal records instead of transferring them to the National Archives. While legal custody of these records belongs to NARA, physical custody is kept by Yellowstone National Park to allow researchers to have the best access to both current and historical resources in one location.

Research Library

The research library collects published and unpublished materials related to the greater Yellowstone area to make them available to park staff, researchers, and the public. The library collection consists of more than 20,000 books, periodicals, theses and dissertations, maps, unpublished manuscripts, microforms of historic newspapers and scrapbooks, brochures, technical reports, and audio-visual material. Support from Yellowstone Forever, private donors, and federal funding have allowed our staff to curate an impressive, possibly unsurpassed, library of Yellowstone's resources. The library collection is owned by the National Park Service and is managed through a cooperative agreement process with the Great Basin Institute.

The Map Room collection includes a large number of published maps from 1865 to the present. In the Rare Book Room are first editions of classic volumes pertaining to the park such as Hiram Chittenden's Roads in Yellowstone National Park reports and John Steinbeck's *Travels with Charley*; one-of-a-kind annotated volumes, including Superintendent Nathanial Langford's edition of the Vigilantes of Montana; and unique ephemeral publications like tourist guidebooks, concessioner brochures, and railroad timetables. Donations from Yellowstone Forever (formerly the Yellowstone Association and Yellowstone Park Foundation), and private donors, as well as funding provided by the National Park Service, have made possible an impressive, possibly unsurpassed, example of Yellowstone National Park resources.

The archives are an affiliate of the National Archives and include records from the US Army's administration of the park.

The Yellowstone Research Library is in the midst of a digitization project that will make library records accessible online.

Library cards are available to all park staff and volunteers, cooperator and concessions employees, and local residents. Many books and media resources are available for check-out. The library also participates in worldwide interlibrary loan (ILL) services; contact your local library for more information.

Since 2006, the library has operated a monthly bookmobile service that travels around the park interior during the summer season. A wide range of resources, from scientific and historical non-fiction to guidebooks and fun fiction are available to NPS, cooperator, and concession employees.

Staff Reviewer
Anne Foster, Park Archivist
Miriam Watson, Museum Curator

FREQUENTLY ASKED QUESTION:

Can I access the collections online?

The Yellowstone Research Library's catalog is available through the Wyoming Library Databases consortium (**https://wyld.ent.sirsi.net/client/en_US/yrl**) and the National Park Service's libraries (**www.library.nps.gov**). Records that are available online are linked through the library catalog. Finding aids for processed archives collections may be accessed at **www.nps.gov/yell/historyculture/archives.htm**.

A growing amount of the collections have been digitized and made available online: Superintendent's reports, oral histories, photographs, documents, maps, and architectural drawings can be found on the Montana Memory Project (**https://mtmemory.recollectcms.com**). Additional photographs can be found on the Open Parks Network, **https://openparksnetwork.org/explore/collections/yellowstone-photo-albums/**. Electronic files of published scientific articles are available in the Data Store on the Integrated Resources Management Applications (IRMA) website, **irma.nps.gov/Portal**.

Some of the museum collections may be viewed on the NPS Web Catalog: **https://museum.nps.gov/**

The Greater Yellowstone Ecosystem, with Yellowstone at its core, is one of the largest nearly intact temperate-zone ecosystems on Earth.

Greater Yellowstone Ecosystem

At 3,472 square miles (8,991 km^2), Yellowstone National Park forms the core of the Greater Yellowstone Ecosystem—one of the largest nearly intact temperate-zone ecosystems on Earth. Greater Yellowstone's diversity of natural wealth includes hydrothermal features, wildlife, vegetation, lakes, and geologic wonders like the Grand Canyon of the Yellowstone River.

Heart of an Ecosystem

Yellowstone National Park was established in 1872 primarily to protect geothermal areas that contain about half the world's active geysers. At that time, the natural state of the park was largely taken for granted. As development throughout the West increased, the 2.2 million acres (8,903 km^2) of habitat that now compose Yellowstone National Park became an important sanctuary for the largest concentration of wildlife in the lower 48 states.

The abundance and distribution of these animal species depend on their interactions with each other and on the quality of their habitats, which in turn is the result of thousands of years of volcanic activity, forest fires, changes in climate, and more recent natural and human influences. Most of the park is above 7,500 feet (2,286 m) in elevation and underlain by volcanic bedrock. The terrain is covered with snow for much of the year and supports forests

Quick Facts

Space and Ownership

- 12–22 million acres; 18,750–34,375 square miles (sizes, boundaries, and descriptions of any ecosystem can vary.)
- States: Wyoming, Montana, Idaho
- Encompasses state lands, two national parks, portions of five national forests, three national wildlife refuges, Bureau of Land Management holdings, private and tribal lands.
- Managed by state, federal, and tribal governments, and private individuals

Wildlife

- One of the largest elk herds in North America
- Largest free-roaming, wild herd of bison in United States
- One of few grizzly populations in contiguous United States
- Rare wolverine and lynx sightings

Management Challenges

- Climate change
- Invasive species
- Managing an ecosystem across political boundaries
- Land use change
- Conservation of migration corridors
- Increasing visitation
- Wildlife diseases
- In Yellowstone:
  - Bison management
  - Grizzly bear management
  - Native fish conservation
  - High visitation

dominated by lodgepole pine and interspersed with alpine meadows. Sagebrush steppe and grasslands on the park's lower-elevation ranges provide essential winter forage for elk, bison, and bighorn sheep.

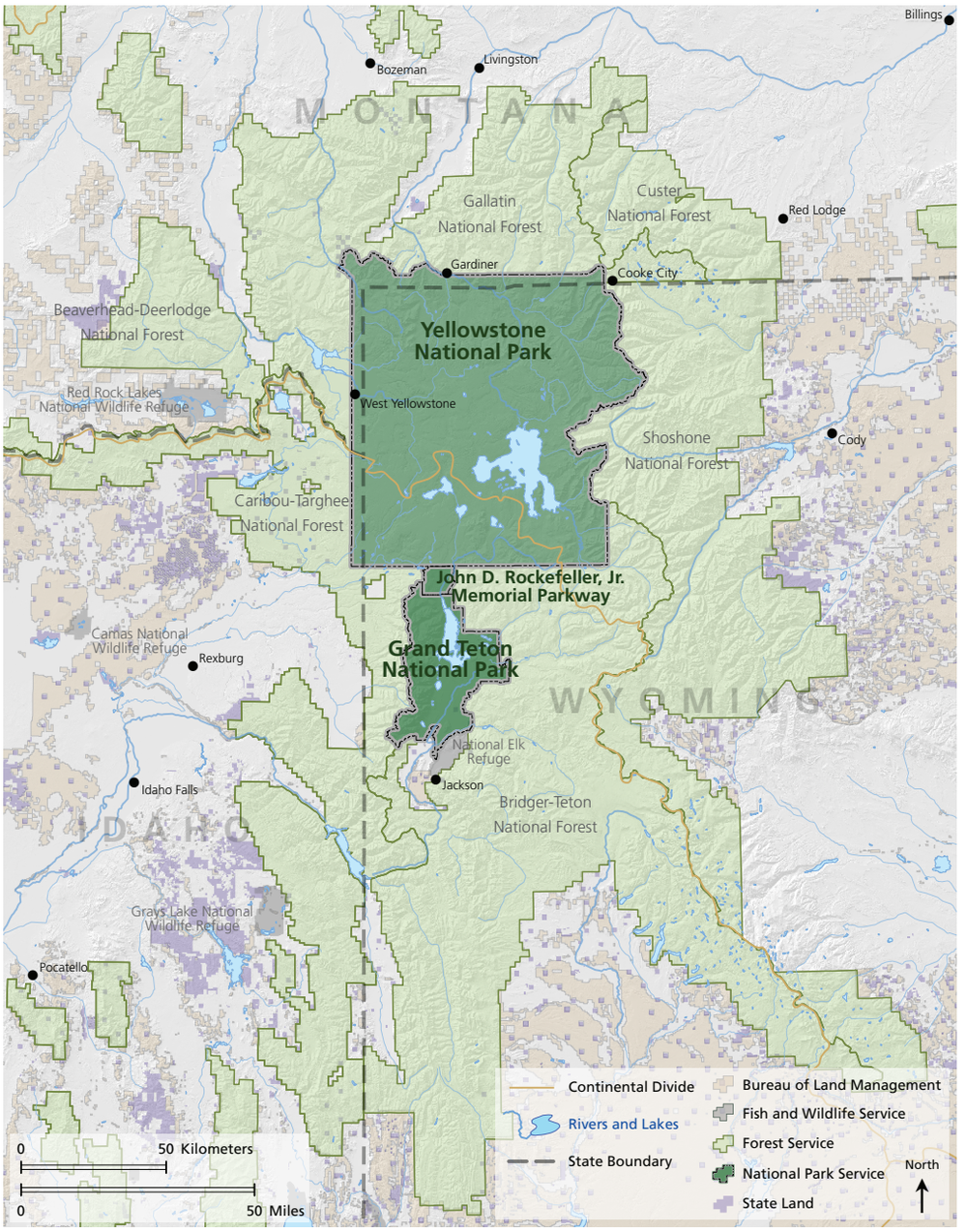
Influence of Geology

Geological characteristics form the foundation of an ecosystem. In Yellowstone, the interplay between volcanic, hydrothermal and glacial processes, and the distribution of flora and fauna, are intricate. The topography of the land from southern Idaho northeast to Yellowstone probably results from millions of years of hot-spot influence. Some scientists believe the Yellowstone Plateau itself is a result of uplift due to hot-spot volcanism. Today's landforms even influence the weather, channeling westerly storm systems onto the plateau where they drop large amounts of snow.

The volcanic rhyolites and tuffs of the Yellowstone Caldera are rich in quartz and potassium feldspar, which form nutrient-poor soils. Thus, areas of the park underlain by rhyolites and tuffs generally are characterized by extensive stands of lodgepole pine, which are drought-tolerant and have shallow roots that take advantage of the nutrients in the soil.

In contrast, andesitic volcanic rocks that underlie the Absaroka Mountains are rich in calcium, magnesium, and iron. These minerals weather into soils that can store more water and provide better nutrients than rhyolitic soils. These soils support more vegetation, which adds organic matter and enriches the soil. You can see the result when you drive over Dunraven Pass or through other areas of the park with Absaroka rocks. They have a more diverse flora, including mixed forests interspersed with meadows. Lake sediments deposited during glacial periods, such as those underlying Hayden Valley, form clay soils that allow meadow communities to outcompete trees for water. The patches of lodgepole pines in Hayden Valley grow in areas of rhyolite rock outcrops.

Because of the influence rock types, sediments, and topography have on plant distribution, some scientists theorize that geology also influences wildlife



The Greater Yellowstone Ecosystem. Description of an ecosystem's size, boundaries, and characteristics can vary greatly.

distribution and movement. Whitebark pine nuts are an important food source for grizzly bears during autumn. The bears migrate to whitebark pine areas such as the andesitic volcanic terrain of Mount Washburn. Grazing animals such as elk and bison favor the park's grasslands, which grow best in soils formed by sediments in valleys such as Hayden and Lamar. The many hydrothermal areas of the park, where grasses and other food remain uncovered by snow, provide sustenance for animals during winter.

Air Quality

The Clean Air Act Amendments of 1977 designated Yellowstone and Grand Teton among the 156 national parks and wilderness areas as Class I airsheds, requiring the most stringent air-quality protection within and around their boundaries. Yellowstone and Grand Teton are in compliance with federal air quality standards for human health. However, air-quality trends may be affecting other aspects of the ecosystem. Even at relatively low levels, such as those found in the Greater Yellowstone Ecosystem, air pollution and the subsequent deposition of pollutants in water and soil can leach nutrients from the Earth, injure vegetation, and acidify and over-fertilize lakes and streams.

The thin soils, sparse vegetation, short growing seasons, and snow-based water supply of these high elevation areas limit the amount of nitrogen that plants can effectively use. These conditions make the area more vulnerable to the effects of acidification and nutrient enrichment from nitrogen deposition. For example, nitrogen in precipitation has increased at many western sites as a result of fertilizer use and feedlots. Although nitrogen is a nutrient needed for plant growth, too much nitrogen disrupts native plant communities that are adapted to low-nitrogen conditions; high nitrogen levels can advance the spread of nonnative species that increase fire frequency. Acidification of high-alpine lakes from sulfur and nitrogen deposition can cause the loss of macroinvertebrates and fish. Long-term changes in the composition of algae in several alpine lakes in Yellowstone and Grand Teton are correlated with increased nitrogen.

Naturally occurring ozone in the upper atmosphere protects life by absorbing the sun's ultraviolet rays, while low-level ozone is a pollutant that forms when nitrogen oxides from vehicles, power plants, and other sources combine with volatile organic compounds. Ozone concentrations in Yellowstone typically peak in spring rather than summer, indicating that human influences are less significant than changes in atmospheric circulation and lengthening daylight. Nonetheless, in addition to potentially causing respiratory problems in people, ozone levels during the growing season may be high enough to prevent sensitive species, such as aspen, from reaching full growth potential.

Sources of Particulate Matter

The largest source of particulate matter in Greater Yellowstone is smoke from wildland fires, which is considered part of the area's "natural background conditions" and is taken into consideration in establishing the threshold for "good" visibility. Emissions from prescribed fires have been relatively insignificant. Because of prevailing winds, Wyoming oil and gas development has not had a detectable effect on air quality in Yellowstone.

Soundscapes

The Greater Yellowstone Ecosystem has many biological sounds with important ecological functions for reproduction and survival. Birds, mammals, amphibians, and insects often need to hear or produce sounds to attract mates, detect predators, find prey, and/or defend territories. The occurrence of sounds in a particular area forms the soundscape.

The natural soundscape of the Greater Yellowstone Ecosystem delights visitors during the fall elk rut, during birds' spring choruses, along streams, and in the still and profoundly quiet winter days and nights. Natural soundscapes are a resource and are protected by National Park Service policies. Many visitors come to national parks to enjoy serenity and solitude and to hear sounds of nature. Sounds associated with human activity, including road traffic, aircraft, and snowmobiles, often impact these natural soundscapes and are a growing concern. Aircraft noise, the most widespread human-caused sound in the park, is heard on average for less than 10 percent of the day. Yellowstone and Grand Teton initiated a soundscape monitoring program in 2003.

More Information

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National Park Service Air Resources Division: https://www.nps.gov/orgs/1971/index.htm

Recordings of Yellowstone's Soundscape: https://www.nps.gov/yell/learn/management/yellowstone-soundscapes-program.htm

Yellowstone waters provide essential moisture to much of the American West and water resources provide recreational opportunities, plant and wildlife habitat, and scenic vistas.

Water

The water flowing through Yellowstone and the Greater Yellowstone Ecosystem (GYE) is a vital national resource. The headwaters of seven great rivers located here flow from the Continental Divide across the nation to the Pacific Ocean, and the gulfs of California and America. Rain and snow in the mountains and plateaus of the Northern Rockies flow through stream and river networks to provide essential moisture to much of the American West. Together, Yellowstone's streams and rivers support an abundance of fish and wildlife, provide numerous recreational opportunities, and offer a lifeline for downstream agricultural users and municipalities.

Water also drives the complex geothermal activity in the region and fuels the largest collection of geysers on Earth. Precipitation and groundwater seep down into geothermal "plumbing" over days, and millennia, to be superheated by the Yellowstone Volcano and rise to the surface in the form of hot springs, geysers, mudpots, and fumaroles.

Yellowstone contains some of the most significant, near-pristine aquatic ecosystems found in the United States. More than 600 lakes and ponds comprise approximately 107,000 surface acres in Yellowstone—94 percent of which can be attributed to Yellowstone, Lewis, Shoshone, and Heart lakes. Some 1,000 rivers and streams make up approximately 2,500 miles of running water. Thousands of small wetlands—habitats that are intermittently wet and dry—make up a small (approximately 3%), fraction of the Yellowstone landscape.

Waters of Yellowstone

Area of Yellowstone National Park	3,472 mi² (8,991 km²)
Water surface area[2,3]	~5% of park area
Number of named lakes[1]	150
Surface area of named lakes[1]	24.7 mi² (63.9 km²)
Number of lakes with fish[2]	~45
Number of named streams[3]	278
Total stream length[3]	2,172.52 mi (3,496,329 m)
Number of streams with fish[2]	~200

[1]Yellowstone Spatial Analysis Center data.
[2]Varley and Schullery 1998.
[3]GRYN Water Quality Report 2009.

Lakes

Yellowstone's inland lakes are essential aquatic habitat for resident species. They are largely protected from many of the environmental stresses to which waters outside the park boundaries may be victim. These lakes maintain freshwater biodiversity, support elaborate food webs, and underpin plant and animal communities. Understanding the complexities of Yellowstone's lake ecosystems allows park managers to successfully conserve Yellowstone's lake resources in the face of nonnative invasive species, climate change, and pollution.

Yellowstone Lake

Yellowstone Lake is the largest high-elevation lake (above 7,000 ft) in North America, covering up to 139 square miles, with an average depth of 138 feet, and just over 12,000,000 acre-feet of water. The lake is covered by ice from mid-December to May or June.

Yellowstone Lake Quick Facts

- Elevation: 7,731 feet (2,357 m)
- Surface area: 131.8–135.9 mi² (341–352 km²)
- Perimeter (Shoreline): 141 miles (227 km)
- Deepest point is due east of Stevenson Island at 430 feet (131 m)

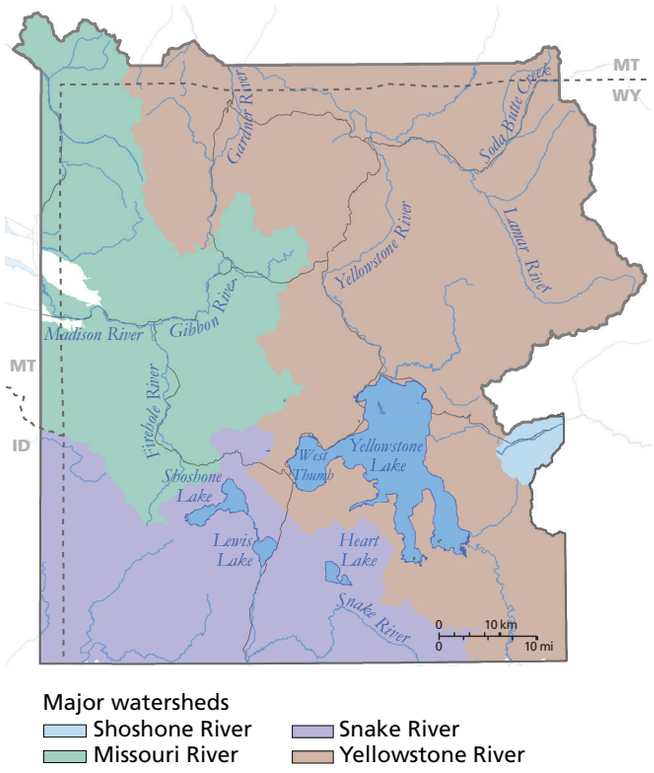
Entering Yellowstone Lake are more than 141 tributaries, but only one river. The Yellowstone River, which enters at the south end of the southeast arm, dominates the inflow of water and sediment flows out. The only outlet of the lake is at Fishing Bridge, where the Yellowstone River flows north and discharges 2,000–9,000 cubic feet per second.

Powerful geologic processes in Yellowstone National Park have contributed to the unusual shape of Yellowstone Lake, which straddles the southeast margin of the Yellowstone caldera. A smaller caldera-forming event about 174,000 years ago, comparable in size to Crater Lake, Oregon, created the West Thumb basin. Several significant glacial advances and recessions continued to shape the lake and overlapped the volcanic events. Glacial scour deepened the central basin of the lake and the faulted south and southeast arms. More recent dynamic processes shaping Yellowstone Lake include currently active fault systems, development of a series of postglacial shoreline terraces, and postglacial hydrothermal-explosion events, which created the Mary Bay crater complex and other craters. (See "Yellowstone Lake Geology" in chapter four, for more information.) Many of the area's 1,000 to 3,000 annual earthquakes occur under Yellowstone Lake, causing uplift and subsidence events which continually reshape the shoreline of the lake.

Yellowstone Lake is also the site of one of the most extensive conservation efforts in the National Park Service. Lake trout (*Salvelinus namaycush*), which were illegally introduced to Yellowstone Lake, have jeopardized the survival of the native population of cutthroat trout (*Oncorhynchus clarkii bouvieri*). See "Native Fish Species" and "Lake Trout" in the wildlife chapter for more information.

Lewis and Shoshone Lakes

Lewis Lake is fed by the Lewis River and other tributaries. Shoshone Lake, the park's second largest lake, is located at the head of the Lewis River southwest of West Thumb. Shoshone Lake is a valuable wilderness resource. Only accessible by foot, or by boat through the Lewis River Channel, one of the park's amazing geyser basins lies near the northwest shore. Shoshone Lake is 205 feet at its maximum depth, has an area of 8,050 acres, and contains lake trout, brown trout (*Salmo trutta*), and Utah chub (*Gila atraria*). 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. The US Fish and Wildlife Service believes that Shoshone Lake may be the largest lake in the lower 48 states that cannot be reached by road.

Heart Lake

Heart Lake is located at the south end of the park near the base of Mt. Sheridan. It sits in prime bear habitat, and there are several thermal areas along the northwest shore.

Rivers

Watersheds, or drainage basins, represent the surface area that contributes runoff to a particular river. The boundaries of a watershed are ridges or elevated areas which determine the direction surface water will flow. Any rain or snow that falls within the watershed will flow downstream to the basin's mouth, unless it is removed from the flow by evaporation, freezing, absorption as groundwater, or diversion for human use.

Yellowstone River

The Yellowstone River is 671 miles long. It is the longest undammed river in the lower 48 states. The headwaters of the Yellowstone are outside the

Yellowstone River delta

southeast park boundary on Younts Peak (Wyoming) and flow into Yellowstone Lake. It leaves the lake at Fishing Bridge, and continues north-northwest until it leaves the park near Gardiner, Montana. The Yellowstone River continues north and east through Montana and joins the Missouri River just across the North Dakota state line. Its watershed drains one-third of the state of Montana. It carves out the Grand Canyon of the Yellowstone in the middle of the park and runs over the Upper and Lower Falls and is home to Yellowstone cutthroat trout.

The Yellowstone River is among the top recreational river destinations in the US and provides opportunities for boating and fishing enthusiasts, birders, and for other forms of recreation. Additionally, the Yellowstone River serves many downstream communities (e.g., Billings, Montana) and is recognized regionally and nationally for economic importance to agriculture, industry, and municipalities.

Lamar River

The Lamar River originates on the east side of the park. Park boundaries were adjusted in 1929 to include the entire Lamar watershed in order to protect this major tributary of the Yellowstone River. The Lamar River is joined by Soda Butte Creek as it flows across the northern range to the outflow of Yellowstone Lake. The Lamar River Valley is home to wild pronghorn, bison rutting, bear habitat, the most consistent viewing of wild wolves in the world, and first-rate fly fishing.

Gardner River

The Gardner River originates in the northwest corner of the park and flows to the Missouri River. The Gardner flows into the Yellowstone first, joining near Rattlesnake Butte at the north entrance to the park.

Snake River

The Snake River—a major tributary of the Columbia River—originates in Yellowstone National Park, and then turns south, passing through the John D. Rockefeller, Jr., Memorial Parkway into Grand Teton National Park. The river flows through Idaho and joins the Columbia River in Washington. The Snake River is 1,040 miles long (1,674 km); 42 miles (68 km) of it are in Yellowstone National Park. The river feeds Jackson Lake—a natural lake augmented by a dam, resulting in regulated downstream flows since 1907.

Visitors enjoy a multitude of recreational opportunities on the river such as rafting, fishing, and photography. The river is home to a wide variety of riparian and aquatic species, including the native Yellowstone cutthroat trout and an endemic variety, the Snake River fine-spotted cutthroat trout (*Oncorhynchus clarkii behnkei*). The 2009 Snake River Headwaters Legacy Act designated the river above Jackson Lake as a Wild and Scenic River. The Lewis River is a tributary of the Snake River.

Firehole River

Home to several species of trout, the Firehole River is a favored fly fishing spot. Most of the outflow from the park's geyser basins empties into the Firehole River causing it to be warmer with larger concentrations of

FREQUENTLY ASKED QUESTION

Does the Missouri River begin here?

No, but its three tributaries begin in the greater Yellowstone area. The Jefferson River begins in the Centennial Mountains, west of the park. The Madison River forms inside the park at Madison Junction, where the Gibbon and Firehole rivers join. The Gallatin River also begins inside the park north of the Madison River. It flows north through Gallatin Canyon and across the Gallatin Valley, joining the Madison and Jefferson rivers at Three Forks, Montana, to form the Missouri River.

Fishing on the Firehole River.

dissolved minerals (chemically richer) than other watersheds. The Gibbon and Firehole rivers join to form the Madison River. The Madison flows to Hebgen Lake, joins the Jefferson River and eventually the Missouri River on its way to the Gulf of America.

Water Quality

The quality of the nation's waters is protected by laws and policy at local, state, and federal levels. To understand and maintain or improve water quality and aquatic ecosystems, resource managers take inventory and actively monitor water resources throughout the region. Water quality in a national park may reflect activities taking place upstream of the park's surface waters as well as within the park. The water quality in Grand Teton and Yellowstone national parks, where most of the watersheds originate on federally protected land, is generally very high. However, it is vulnerable to impacts such as road construction, recreational activities, and deposition from atmospheric pollutants.

All Yellowstone waters are classified as Outstanding National Resource Waters, which receive the highest level of protection for surface waters under the Clean Water Act. Because of the relatively pristine nature of the park's surface waters, they are often used to establish reference conditions for the northern Rocky Mountain region. Although most of the park's watersheds originate within its boundaries and are minimally affected by human activities, they are vulnerable to impacts such as road construction, dewatering, atmospheric deposition, sewage spills, climate change, and runoff from mining activities outside park boundaries.

A volunteer collects a water sample at Soda Butte Creek. Collection of water quality data has continued at fixed sites since 2002.

Long-term Water Quality Monitoring

Monitoring water quality continues to be a high priority for Yellowstone, with standardized data collected at fixed sites since 2002. This long-term data is used to evaluate overall ecosystem health, ascertain impacts of potential stressors (e.g., upstream impacts from legacy mines), identify changes that may be associated with water quality degradation, and guide resource management decisions related to water quality.

The characteristics of Yellowstone's surface waters are influenced by season, elevation, precipitation, surrounding vegetation, and wildfire. Some waters are also affected by the park's geothermal features, generally resulting in warmer temperatures and higher dissolved ion concentrations.

Most waters in Yellowstone meet or surpass national and state water quality standards. Geothermal influence on some park waters can result in failure to meet state drinking or recreational water quality standards. For example, arsenic levels in the Madison River at West Yellowstone exceeded the State of Montana's criteria on most sampling occasions. Arsenic in the Madison River is likely naturally occurring from geothermal geology in the watershed.

Park staff also monitor three sites on the park boundary where stream segments in the Yellowstone River drainage have been listed as impaired by the State of Montana.

Reese Creek

Irrigation by landowners north of the park has often reduced the lowermost reach of the stream during

mid-summer and fall. The water flow becomes unsuitable for sustaining native trout and overall biological integrity. The adjudicated water rights stipulate that the creek is to have a minimum flow of 1.306 ft^3/sec from April 15 to October 15. A stakeholder group of federal agencies, private citizens, and conservation organizations are working together on projects to maintain the flows in the main channel.

Soda Butte Creek

Soda Butte Creek is located near the park boundary, approximately 5 miles (8 km) downstream of the former location of the McLaren Mill and Tailings site. As a result of metal contamination from previous mining activity, dissolved and total metals (arsenic, copper, iron, and lead) persist in the floodplain. State and federal agencies completed a three-year effort to relocate mine tailings away from the floodplain and to reconstruct the former channel in 2014. Results from 2015 and 2016 monitoring activities in Soda Butte Creek downstream of the reclamation work show that iron levels associated with the former tailing site have been dramatically reduced.

The resulting data from recent monitoring also led to a determination in November 2017 by the Montana Department of Environmental Quality (DEQ) that metals conditions in Soda Butte Creek support designated beneficial uses. On November 27, 2018, the Montana DEQ officially removed Soda Butte Creek from the state's impaired waters [303(d)] list. The reclamation of McLaren Mill and Tailings site and subsequent removal from the 303(d) list represent important milestones in the restoration of Soda Butte Creek.

Yellowstone River at Corwin Springs

Similar to prior years, water samples were collected on the Yellowstone River from mid-April to mid-November 2019 and indicated that samples requlary exceeded the EPA drinking water standard of 0.01 mg/L total arsenic but not the aquatic life criterion (0.15 mg/L). The higher total arsenic values in this drainage may be due to natural geological or geothermal influences on water chemistry.

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The ecological diversity of the Greater Yellowstone Ecosystem contributes to its value, and its controversy. Yellowstone's northern range has been the focus of debate since the 1930s.

Cycles and Processes

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

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

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

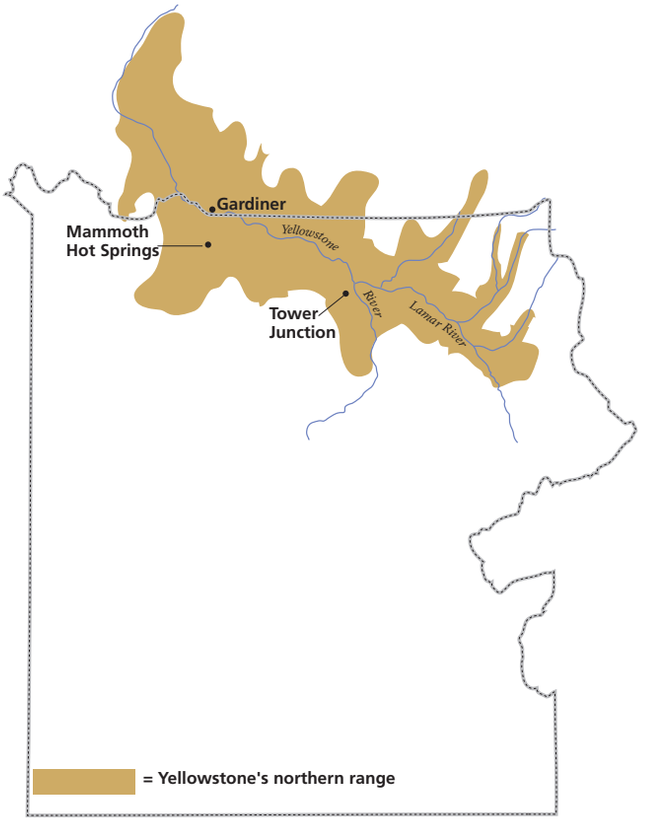
These cycles and processes are easily and frequently observed on Yellowstone's northern range, which refers to the broad grassland that borders the Yellowstone and Lamar rivers in the northern portion of the park and into Montana. This area sustains one of the largest and most diverse communities of 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 are clear of snow, a result of wind and sun. Animals take advantage of this lack of snow, finding easier access to forage.

As a result of its incredible biodiversity, relatively complete ecosystem integrity, and year-round access, research conducted on the northern range has informed much of our current scientific understanding of native species and the ecological processes that sustain them.

Biodiversity

Each species—no matter how small—has an important role to play in a functioning ecosystem. They all participate in various ecosystem processes like transferring energy, providing nutrient storage, or breaking down pollutants. That is why biological diversity, or biodiversity, is a benchmark for measuring the health of an ecosystem. Biodiversity can be measured in many ways, including the number of different species (also called richness) and the abundance of each species (also called evenness).

The biodiversity and ecological processes that are protected in the park support a healthy ecosystem. Significantly, greater Yellowstone's natural diversity is essentially intact. The region appears to have retained or restored its full historical complement of vertebrate wildlife species—a condition unique in the wildlands of the contiguous 48 states. The extent of wildlife diversity is due, in part, to the different habitats found in the region, ranging from high alpine areas to sagebrush country, from hydrothermal areas, to forests, meadows, and other habitat types. All of these are connected, by landforms, through links provided by streams and rivers that course through the changing elevations, and by the air that circulates between them.



The northern range is a broad grassland that borders the Yellowstone and Lamar rivers in the northern portion of Yellowstone and into Montana.

Biodiversity also supports the resilience of an ecosystem. When a variety of organisms contributes to ecosystem processes, an ecosystem can be more flexible through dynamic events like floods or fire. Knowledge of the park's biodiversity expanded in 2009 with Yellowstone's first bioblitz.

Intricate Layers

The reintroduction of the wolf to Yellowstone restored an important element of ecological completeness in the Greater Yellowstone Ecosystem (GYE). This region now contains every large wild mammal, predator or prey, that inhabited it when Europeans first arrived in North America, though not necessarily in the same numbers or distribution. But the wolf is only one factor in the extremely complex and dynamic community of wild Yellowstone. Since wolves were restored, scientists have discovered layers of complexity reaching far beyond the large mammals. For example, the carcasses of elk, bison, and other large mammals each become ecosystems of their own. Researchers have identified at least 57 species of beetle associated with these ungulate carcasses on the northern range. Only one of those species eats ungulate meat. The rest prey on other small scavengers, especially the larvae of flies and beetles. Others consume carcass by-products such as microscopic fungal spores. In this very busy neighborhood, thousands of appetites interact until the carcass melts away and everybody moves on.

Thus, the large predators point us toward the true richness, messiness, and subtlety of wild Yellowstone. For a wolf pack, an elk is dinner waiting to happen; for beetles, flies, and many other small animals, the elk is a village waiting to happen.

Trophic Cascade

Wolf reintroduction created the chance to observe how a top predator influences its plant-eating prey and how changes in those prey influence plants. By reducing the abundance of herbivores or changing their feeding behavior, predators can indirectly influence the degree to which plants are consumed. This series of effects is called a "trophic cascade."

Accumulated studies show that the loss of top predators like wolves and cougars from the food web on the northern range in the 1930s led to a loss of willows and other woody plants due to excessive grazing by elk. Most researchers agree that reintroduced wolves have contributed to fewer elk and changes in elk behavior. Initial studies of woody plant communities in the park offered promising evidence for the occurrence of a trophic cascade following wolf recovery, but debate soon ensued about whether trophic cascades were behaviorally mediated, and whether they were happening at all. Some studies have shown a correlation between the presence of wolves and increased growth in willows. However, not all scientists agree that this relationship is causal. For example, some researchers say elk don't linger in willow or aspen areas where visibility is poor and that this behavioral change prevents them from eating as much willow or aspen. Other scientists argue that fluctuations in the availability of ground water explain much of the growth patterns in woody vegetation. Documented changes in precipitation and effects of global climate change are also affecting vegetation growth.

More recently, scientists have provided evidence that the entire suite of predators (e.g., wolves, cougars, grizzly bears, black bears, and human hunters), along with climate effects, have all contributed to the decline in elk abundance which has reduced browsing pressure on some woody browse communities,

contributing to some increased growth. With increased abundance of bison, who can also browse some of these plant communities, it is unknown if some of the changes will persist. Changes have and are happening; it is the magnitude and extent of effects over time that are unknown. Ongoing, long-term scientific research will continue to examine the complex fabric of the GYE.

Predators and Prey

For the visitor, this community's complexity has been highlighted primarily through the large predators and their prey species. This ecological "suite" of species provides a rare display of the dramatic pre-European conditions of wildlife in North America.

Consider the northern Yellowstone elk herd, which decreased in numbers from 1994–2010. Computer models prior to wolf recovery predicted a decline in elk and the decline has exceeded those predictions. However, prey populations that share their habitat with more species of predators are now thought to fluctuate around lower equilibria, and wolf recovery occurred simultaneously with increased grizzly bear and mountain lion populations, sustained human hunting of elk (especially female or "antlerless") north of the park, and an extended drought. In fact, human hunting and climate were the primary drivers of the decline in elk abundance in the northern herd over the first decade of wolf recovery.

Elk are subject to predation by many species in the ecosystem, including bears, wolves, coyotes, and mountain lions. Also, the northern Yellowstone elk population is subject to several human hunts each year. Elk that migrate out of the park may be legally hunted during an archery season, early season backcountry hunt, general autumn hunt, and in past years a Gardiner, Montana, late hunt, all of which are managed by the Montana Department of Fish, Wildlife and Parks. The primary objective of the Gardiner late hunt was to regulate the northern Yellowstone elk population that migrated outside the park during winter and limit grazing of crops on private lands. During 1996–2002, approximately 5–19% (mean approximately 11%) of the adult female portion of counted elk were harvested each year during the late hunt. However, the hunt has not been held since 2009 due to decreased elk numbers. In more recent decades, the suite of large carnivores all are likely to play a more regulatory role in elk abundance, as still do humans and climate variation (e.g., severe winters and summer droughts). Increasing bison abundance has contributed importantly to wolf diet in recent years, offsetting predation pressure on elk. Cougars are utilizing deer more in recent years, offsetting predation impacts on elk. These changes in predators' relationship with prey are part of ongoing studies.

The processes of predation, scavenging, and eventual decomposition are just some of the ways that nutrients cycle in a dynamic ecosystem.

Animal populations are not static and do not always stay at levels pleasing to humans. Instead, a more dynamic variability is present, which probably characterized this region's wildlife populations for millennia. 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 reduce elk numbers and recruitment (elk calf survival). Nature does have balances, but they are fluid rather than static, flexible rather than rigid, and experience dynamic fluctuation as opposed to a steady state.

While some people delight in the chance to experience the new completeness of the Yellowstone ecosystem, others are alarmed and angered by the changes. But with so few places remaining on Earth where we can preserve and study such ecological completeness, there seems little doubt about the extraordinary educational, scientific, and even spiritual values of such a wild community.

Grazing and Migration

Grasses are an important part of the diet of most ungulates (hoofed animals) in Yellowstone. Bighorn sheep, bison, and elk rely on grasses for 50–80% of their food. Since newly emerging plants provide the best forage, ungulates migrate with the wave of spring green-up from lower to higher elevations, returning to lower elevations in autumn as deep snow begins to cover the high country.

Some sections of the northern range are fenced, as shown above, to study the long-term effects of grazing by fencing out large herbivores. The results indicate shrubs pruned by animals outside the fence stay healthy.

Intense grazing can degrade plant communities by removing vegetation, compacting soils, and reducing the diversity of plants. Dense ungulate populations can also shift the composition and structure of plant communities. Studies of the northern range began to address the issue of overgrazing in the 1960s and have continued to the present. Early studies identified some over-browsing of riparian plants but found no clear evidence of overgrazing.

The results of years of research and analysis published in *Ecological Dynamics on Yellowstone's Northern Range* (2002) concluded that "the best available scientific evidence does not indicate ungulate populations are irreversibly damaging the northern range." The northern range is healthy and elk do not adversely affect the overall diversity of native animals and plants. It was also determined that ungulate grazing actually enhances grass production in all but drought years, and grazing also enhances protein content of grasses, yearly growth of big sagebrush, and establishment of sagebrush seedlings.

There is some indication that the dynamic northern grassland system is in a state of flux. The density of northern Yellowstone elk decreased to approximately 3 to 5 per square kilometer during 2006 through 2011 from a high of 12 to 17 per square kilometer in the late 1980s and early 1990s before wolf reintroduction. Fewer elk resulted in less forage consumed and less intense feedbacks by elk on soil and plant processes, which likely contributed to lower plant production and forage quality.

Recently published findings from a 10-year study of bison migration reveal that bison change the way spring happens across Yellowstone's vast grasslands. As bison move and graze, they create big changes. They alter the composition of plant communities by changing the relative abundance of species with different physical traits. Intense grazing keeps plants low and dense, improving their forage quality by 50–90%. Removing large amounts of plant material accelerates early plant growth the next year by improving the availability of sunlight. Enhanced leaf tissue nitrogen during the growing season increases photosynthetic activity, prolonging plant growth. All this amounts to an up to 40% increase in plant productivity, with increased bison grazing of the same grasslands over time causing them to green up faster, more intensely, and for a longer duration.

Yellowstone's large, healthy, valued bison population is unique in North America. Given room to roam, they engineer their ecosystem from the bottom up.

Seasons and Weather

A warming climate could influence the diet, nutrition, and condition of Yellowstone wildlife. Likely scenarios suggest a 1–3 degrees Celsius increase in average temperature during the 21st century, with a corresponding increase in annual rainfall—though it is unknown precisely how precipitation patterns will change and how those changes will affect the Yellowstone system.

"Too Many" or "Too Few"

The northern range has been the focus of one of the most productive, if sometimes bitter, dialogues on the management of a wildland ecosystem. For more than 80 years this debate focused on whether there were "too many" elk on the northern range. Although early counts of the elk in the park, especially on the northern range, are highly questionable, scientists and managers in the early 1930s 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 in 1914. Due to these concerns about overgrazing and overbrowsing, park managers removed ungulates—including elk, bison, and pronghorn—from the northern range by shooting or trapping from 1935 to the late 1960s. More than 26,000 elk were culled or shipped out of the park to control their numbers and to repopulate areas where over-harvesting or poaching had eliminated elk. Hunting outside the park removed another 45,000 elk during this period. These removals reduced the annual elk counts from approximately 12,000 to fewer than 4,000 animals.

As the result of public and political pressure, park managers ended elk removals in the late 1960s. There was a transition in management approach over the next several decades to reduce human intervention and rely more on the "natural regulation" of elk through ecological processes, such as competition for food, and environmental conditions, such as summer precipitation, forage production, and snow cover that limit forage availability. In addition, park managers reintroduced wolves to Yellowstone in the mid-1990s, which coincided with the continued recovery of populations of grizzly bears and cougars. Predation, in combination with continued liberal harvests of antlerless elk in Montana and occasional severe weather, substantially decreased the numbers of elk in northern Yellowstone by 2011.

The restoration of wolves into Yellowstone and their rapid increase changed the debate from concerns about "too many" elk to speculation about "too few" elk because of wolf predation. Elk are the most abundant ungulate on the northern range and composed more than 89% of documented wolf kills during winters from 1997 to 2008. Also, from 2002 to 2008, elk-calf survival (recruitment) and total number of the northern elk herd declined. Many factors (e.g., other predators, drought, winterkill, hunting) contributed to the low recruitment and decreased elk numbers. These trends cause some people to think wolves are killing off elk, despite the fact that elk continue to populate the northern range at relatively high density compared to other areas.

Opinions about "too many" or "too few" assume there is an ideal, static ecosystem state to which we compare current conditions. Scientifically, no such condition exists. But in the scope of human values, everyone has an idea about how things "ought to be." Controversy arises when those different experiences and values conflict. For example, many urban dwellers live among intensively managed surroundings (community parks and personal gardens and lawns) and are not used to viewing wild, natural ecosystems. Livestock managers and range scientists, on the other hand, tend to view the landscape in terms of the number of animals that a unit of land can optimally sustain. Range science has developed techniques that allow intensive human manipulation of the landscape for this goal, which is often economically based. Furthermore, many ecologists and wilderness managers have come to believe that the ecological carrying capacity of a landscape is different from the concept of range or economic carrying capacity. They believe variability and change are the only constants in a naturally functioning wilderness ecosystem.

Yellowstone's largest elk herd winters along and north of the park boundary. After decades of debate over whether this range was overgrazed by too many elk, some concern has shifted to the herd's small size.

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Staff Reviewers

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Though the wildlife and plants of Greater Yellowstone are adapted to its cold, snowy winters, surviving the winter season can be a struggle.

Winter Ecology

As remarkable as Greater Yellowstone and Yellowstone National Park are during the rest of the year, in winter the park is a magical place: steam and boiling water erupt from natural cauldrons in the park's ice-covered surface, snow-dusted bison exhale vaporous breaths as they lumber through drifts of white, foxes and coyotes paw and pounce in their search for prey in the deep snow, and gray wolves bay beneath the frozen moon.

Yellowstone in winter also is a place of vulnerability. Wildlife endure extremes of cold, wind, and the absence of ready food. Their tracks through deep snow tell of tenacious struggles through the long winter. Park conditions in this most severe of seasons become critical to the mortality of wildlife and even to survival of park species.

No wonder the park is so popular in this magical, vulnerable season with those who have enjoyed its charms. It is often said among park staff who live in Yellowstone that winter is their favorite season. Many park visitors who try a winter trip to Yellowstone come back for more.

Animal Adaptations

Deep snow, cold temperatures, and short days characterize winter in the Greater Yellowstone Ecosystem. Resident plants and animals are adapted to these conditions. For example, conifers retain their needles through the winter, which extends their ability to photosynthesize. Aspens and cottonwoods contain chlorophyll in their bark, enabling them to photosynthesize before they produce leaves.

Behavioral

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

FREQUENTLY ASKED QUESTIONS:

Is Yellowstone open in winter?

Yes, though not all roads are open to cars. You can drive into the park through the North Entrance year-round. The winter season of services, tours, activities, and ranger programs typically spans from mid-December to mid-March.

At Mammoth, you can take self-guiding tours of Fort Yellowstone and the Mammoth Terraces, join a guided walk or tour, cross-country ski, snowshoe, ice skate (sometimes), rent a hot tub, watch wildlife, attend ranger programs, and visit the Albright Visitor Center. You can also arrange for oversnow tours to Norris Geyser Basin, Old Faithful, and the Grand Canyon of the Yellowstone River.

From Mammoth, you can drive past Blacktail Plateau, through Lamar Valley, and on to Cooke City, Montana. You may see coyotes, bison, elk, wolves, eagles, and other wildlife along the way. You can also stop to cross-country ski or snowshoe a number of trails along this road.

The interior of the park is open to various oversnow vehicles. Tours can be arranged through the park concessioner or operators at the various gates.

You can also stay at Old Faithful Snow Lodge, from which you can walk, snowshoe, or ski around the geyser basin, take shuttles to cross-country ski trails, or join a tour to other parts of the park such as West Thumb, Hayden Valley, and the Grand Canyon of the Yellowstone River.

How cold is Yellowstone in winter?

Average winter highs are 20–30°F (–6 to –1°C); average lows are 0–9°F (–17 to –13°C). The record low was –66°F (–54°C) at Riverside Ranger Station, near the West Entrance, on February 9, 1933.

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

- Bison, elk, geese, and other animals find food and warmth in hydrothermal areas.

Morphological and Physical

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

Biochemical and Physiological

- Mammals and waterfowl exhibit counter-current heat exchange in their limbs that enables them to stand in cold water: cold temperatures cause surface blood vessels to constrict, shunting blood into deeper veins that lie close to arteries. Cooled blood returning from extremities is warmed by arterial blood traveling towards the extremities, conserving heat.
- At night, chickadees' body temperature drops from 108°F to 88°F (42–31°C), which lessens the sharp gradient between the temperature of their bodies and the external temperature. This leads to a 23% decrease in the amount of fat burned each night.
- Chorus frogs tolerate freezing by becoming severely diabetic in response to cold temperatures and the formation of ice within their bodies. The liver quickly converts glycogen to glucose, which enters the blood stream and serves as an antifreeze. Within eight hours, blood sugar rises 200-fold. When a frog's internal ice content reaches 60–65%, the frog's heart and breathing stop. Within one hour of thawing, the frog's heart resumes beating.

Winter Soundscapes

Yellowstone's soundscape is the aggregate of all the sounds within the park, including those inaudible to the human ear. Some sounds are critical for animals to locate a mate or food, or to avoid predators. Other sounds, such as those produced by weather, water, and geothermal activity, may be a consequence rather than a driver of ecological processes. Human-caused sounds can mask the natural soundscape. The National Park Service's goal is to protect or restore natural soundscapes where possible and minimize human-caused sounds while recognizing that they are generally more appropriate in and near developed areas. The quality of Yellowstone's soundscape therefore depends on where and how often non-natural sounds are present as well as their levels.

Human-caused sounds that mask the natural soundscape relied upon by wildlife and enjoyed by

The howl of wolves contributes to the winter soundscape of Yellowstone National Park. Here, a wolf howls on a glacial erratic at Little America Flats.

park visitors are, to some extent, unavoidable in and near developed areas. However, the potential for frequent and pervasive high-decibel noise from oversnow vehicles has made the winter soundscape an issue of particular concern in Yellowstone. Management of the park's winter soundscape is important because oversnow vehicles are allowed on roads in much of the park.

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Oversnow vehicles have become much cleaner and quieter under the park's new winter-use regulations. Here, a snowmobile guide checks in at the West Entrance in 2015.

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Staff Reviewer

Ann Rodman, Yellowstone Center for Resources

Managers from local, state, and federal agencies across the Greater Yellowstone Ecosystem make efforts to coordinate the management of public land and cross-boundary issues, and seek scientific guidance.

Beyond Boundaries

Managing Resources and Impacts Across Political Lines

Despite the size of the ecosystem, Greater Yellowstone's biodiversity is not guaranteed. Many of its plant and animal species are rare, threatened, endangered, or of special concern, including more than 100 plants, hundreds of invertebrates, six fish species, several amphibian species, at least 20 bird species, and 18 mammal species. These are estimates because comprehensive inventories have not been completed. A healthy Yellowstone is important for meeting the park's mandate to preserve resources and values in a manner that provides for their enjoyment by people. At the same time, a healthy Yellowstone enhances the lives of people living outside the park by providing sustainable resources such as clean water, wildlife populations, and vegetation communities.

Several factors strongly influence the Greater Yellowstone Ecosystem (GYE) and its management:

- The GYE spans different climate regimes and vegetation zones, crosses multiple jurisdictional boundaries, and is the last remaining large, intact native ecosystem in the contiguous United States.
- The park's geographic location also attracts humans who want to occupy increasing amounts of space in the ecosystem. This leads to habitat modification, which poses a serious threat to biodiversity and ecosystem processes. For example, when homes are built close to wilderness boundaries, they fragment habitats and isolate populations of plants and animals, cutting them off from processes necessary for survival.
- Yellowstone National Park was created before the surrounding states existed, which makes its relationship to its neighbors different from those of many national parks. This park has exclusive jurisdiction over managing wildlife within the park boundary; wildlife management is driven by National Park Service (NPS) mission and federal mandates, rather than by state wildlife management objectives. However, the NPS recognizes ecological boundaries do not match the social and political boundaries established in the ecosystem. Thus, most managers in the park have established relationships with neighboring agencies to coordinate actions that, in some cases, are quite different on each side of the park boundary. The park works with the states on most issues, including wolf and bison management.
- Time also affects how this ecosystem changes and at what pace. What are the intervals between volcanic eruptions? Between fires? How has forest composition changed in the past 100 years? How is climate change altering these patterns? These are the types of "time" questions that influence management of Yellowstone.

Ecosystem managers face these challenges by addressing the whole ecosystem, including preserving individual components and their relationships and linkages between them. Maintaining healthy, functioning ecosystems preserves species more effectively than do emergency measures to bring back threatened species from the brink of extinction.

Partners

Effective management also requires strong partnerships. Several management and research partnerships exist among state, federal, and tribal agencies to help focus resources and provide collaborative problem-solving on regional issues. Many of these partnerships include academic and non-profit institutions as well.

Greater Yellowstone Network

The Greater Yellowstone Network (GRYN) was established by the National Park Service Inventory and Monitoring Program in 2000 to help enhance the scientific basis for stewardship and management of natural resources in Bighorn Canyon National Recreation Area, Grand Teton National Park (including John D. Rockefeller, Jr. Memorial Parkway), and Yellowstone National Park. The GRYN is one of 32 units nationwide that group some 270 national parks into networks based on geographic similarities, common natural resources, and resource protection challenges. This collective approach to inventory and monitoring helps to facilitate collaboration and information sharing between the parks and with other natural-resource management agencies and interests. For more information about this program, visit **www.nps.gov/im/gryn/index.htm**.

Rocky Mountains Cooperative Ecosystem Studies Unit

The Rocky Mountains Cooperative Ecosystem Studies Unit brings together the region's best scientific talent and scholarship to help manage resource problems across social, cultural, economic, political, and environmental arenas. The Rocky Mountains Cooperative Ecosystem Studies Unit conducts research, education, and technical assistance on both agency-specific issues and issues concerning areas of mixed ownership. This information is made available to those who need it, including land managers and political and industry leaders. For more information about this program, visit **www.umt.edu/cooperative-ecosystem-studies**.

Greater Yellowstone Coordinating Committee

In 1964, the managers of the national parks and national forests in the GYE first signed a Memorandum of Understanding to form the Greater Yellowstone Coordinating Committee (GYCC) to seek solutions to common issues. One of the nation's earliest land-management partnerships, the GYCC now includes managers from two national parks, five national forests, two national wildlife refuges, the Bureau of Land Management in Wyoming, Montana, and Idaho, and the fish and wildlife departments of Wyoming, Montana, and Idaho.

During its six decades, the GYCC has provided a forum for information exchange and voluntary cooperation between key agencies for managing the GYE. The GYCC managers set priorities for interagency coordination and allocate staff and funding to advance these priorities. Interagency staff and partners collaborate on topic-specific subcommittees to address priority issues and to coordinate operations such as wildfire management. GYCC subcommittees include: clean air partnership, hydrology, wildlife, native fish, terrestrial invasive species, aquatic invasive species, whitebark pine, wildland fire management, and climate change adaptation. GYCC priorities are:

1. Maintain Resilient Landscapes within the Greater Yellowstone Ecosystem
   - Understand and Respond to Climate Change
   - Combat Nonnative Species
   - Improve and Maintain Ecosystem and Wildlife Health
2. Respond to Increased Visitor Use
   - Understand and Respond to Impacts of Increasing Visitation
   - Develop Cross-Boundary Solutions that Improve Recreational and Visitor Experiences
   - Share Best Practices
3. Strengthen Coalitions, Partnerships, and Communications
   - Strengthen Public Communication and Support
   - Improve Communication and Support within the GYCC

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Staff Reviewer

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Tom Olliff, NPS IMR Chief, Landscape Conservation and Climate Change, retired

Yellowstone National Park issues and manages between 130 and 180 research permits annually—one of the highest volumes in the National Park Service.

Research in the Park

In part because Yellowstone National Park was established by Congress in 1872, early in the European American history of the West, the park is one of the last, nearly intact, natural ecosystems in the temperate zone of Earth. Natural processes operate in an ecological context that has been less subject to human alteration than most others throughout the nation and throughout the world. This makes the park not only an invaluable natural reserve, but a reservoir of information valuable to humanity.

In Yellowstone, scientists conduct research ranging from large studies of landscape-level changes affecting the local ecosystem to studies of tiny organisms that have the potential to change the lives of people the world over. Yellowstone also has a rich history that includes an archeological record of more than 11,000 years of human use. As the world's first national park, Yellowstone's modern history is no less significant; the park's Heritage and Research Center houses materials documenting the development of the national park idea, the history of science in the park, and major efforts in American wildlife conservation, as well as the park's broader natural and human history.

A Long History of Scientific Study

As a research location, Yellowstone has long attracted scientists. In any given year, 130–200 scientific researchers use study sites in the park, and many more conduct research at the park's Heritage and Research Center. Yellowstone is one of the most high-profile research locations in the National Park Service and has one of the most active research programs. Researchers from universities, other agencies, and the National Park Service come to Yellowstone to conduct scientific studies.

Some of the first written accounts about the wildlife and thermal features of the greater Yellowstone area were in journals and letters from settlers, trappers, Indian scouts, and the military. These early accounts brought about expeditions to explore Yellowstone in the 1860s and 1870s (see also: *History*). It is in these explorations that the history of

Research in Yellowstone

Number in Yellowstone
2023: 131 permits were issued.

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

Types of Research
In 2023, permitted research included

- Physical Sciences: 9%
- Biology (wildlife, vegetation): 27%
- Microbiology: 19%
- Ecology: 14%
- Geology: 24%
- Social Science: 8%

Conducting Research

- Research permits are required for studies and collections (except for archival research conducted at the Heritage and Research Center facility). The Research Permit Office (in the Yellowstone Center for Resources) is responsible for issuing and tracking research permits. It also provides support to permitted researchers in the park.
- Each permit application undergoes a formal, standard process for research permit review and issuance.
- All researchers are required to submit an annual report of their study progress and results. These annual reports are available online at https://irma.nps.gov/rprs.
- Publications resulting from research may be on file in the Yellowstone Heritage and Research Center Library.

science in Yellowstone formally began with the expeditions of geologist Ferdinand V. Hayden, who led official government expeditions to the Yellowstone area in the 1870s.

Modern Research

By the 1960s, scientific research in Yellowstone had extended beyond the study of the park itself. Yellowstone was also a place where researchers advanced techniques for scientific study. The National Park Service changed its permitting policy at this time, requiring researchers to demonstrate their projects directly benefited park managers and would help them make important decisions. As a result, many permits were denied. This gave some permit-seekers the impression that research in the park was not as welcome as it had been in the past. Around this time, the National Park Service also adopted a goal to host mission-oriented research, and managers sometimes

WILLIAM H. JACKSON

In one of the earliest scientific studies of Yellowstone, the 1871 Hayden Expedition determined Yellowstone Lake was less than 300 feet deep.

History of Science in Yellowstone

- 1871–1878: Expeditions of US Geological Survey Geologist Ferdinand Hayden to the Yellowstone area.
- 1877–1882: Park Superintendent Philetus Norris establishes scientific inquiry as an important aspect of park management and argues for employing a resident scientist in the park.
- 1935: Eugene Thomas Allen and Arthur Lewis Day publish *Hot Springs of the Yellowstone National Park* (Carnegie Institution), the definitive literature on the park's thermal environment for many decades.
- 1959–1971: A team of researchers led by John and Frank Craighead use the park to pioneer the field of radio telemetry in their ground-breaking studies of Yellowstone's grizzly bears. The Craigheads are also at the forefront of technological innovation in other methods of identifying and classifying grizzly bears.
- 1967–1971: Park managers differ with the Craigheads over some of their scientific conclusions and are disinclined to implement most of their recommendations. The Craigheads conclude their work in the park. The disagreements were so well-publicized in the news media that a widespread, enduring mythology developed that the National Park Service was generally anti-research, especially when it came to outside researchers.
- 1960s: The National Park Service changes its research permitting policy, only permitting projects that are of direct benefit to park managers and would help make important decisions.
- 1966: Park researcher Dr. Thomas Brock discovers *Thermus aquaticus* in a Yellowstone hot spring. An enzyme discovered in the microorganism is eventually used to rapidly replicate DNA.
- 1968: Yellowstone begins "natural regulation" management. The resource management philosophy has been highly controversial over the years, and has itself become a major focus of scientific study in Yellowstone.
- 1970s and 1980s: Evolving management priorities—in which the need for scientific research becomes progressively more compelling both politically and practically—combined with increasing attention and interest in Yellowstone by the scientific community is reflected in an increase in the volume of research.
- 1984: Total research permits exceed 100 for the first time.
- 1987: Total research permits exceed 200.
- 1990s–2000s: Total research permits average about 250 annually.
- 1993: The Yellowstone Center for Resources is established as a separate operational division, further elevating the formal recognition of research as an essential element of management.
- 2001: The Yellowstone Volcano Observatory forms to strengthen the long-term monitoring of volcanic and earthquake unrest in the Yellowstone region. Member organizations include the USGS, Yellowstone National Park, Montana State University, the University of Utah, the University of Wyoming, UNAVCO, and the geological surveys of ID, MT, and WY.
- 2018: The National Ecological Observatory Network (NEON) constructs a monitoring tower as part of a 30-year national effort to monitor ecological changes.
- 2009–2018: Total research permits are approximately 150 annually.
- 2019–2024: An average of 149 permits are issued each year (between 131 and 185 permits).

felt free to suggest researchers adjust their proposals accordingly to meet that goal.

As important as wildlife science has been in Yellowstone's history, the park's hot springs have demonstrated immeasurable scientific value. In 1966, researcher Thomas Brock discovered *Thermus aquaticus*, a microorganism capable of surviving in temperatures extreme enough to kill most other living organisms, in a Yellowstone hot spring. In 1985, the Cetus Corporation obtained a sample of *T. aquaticus* for use in developing the Polymerase Chain Reaction (PCR) process for rapidly replicating DNA.

Aerial surveillance of moose on the northern range.

Amplifying a segment of DNA to a billion exact copies in a few hours gives a scientist enough material to study seriously. The use of an enzyme discovered in *T. aquaticus*, called Taq polymerase (which does not break down at the high temperatures required in the PCR process), made PCR practical and is seen as the biggest advance in PCR. Today, PCR is still the main process used to study nucleic acids, and DNA sequencing is a multibillion-dollar business. More than 53 patents involve research from Yellowstone.

Research studies provide valuable information to the park. Dozens of comprehensive studies were completed in the 20 years following the 1988 fires. The restoration of wolves in 1995 lead to increased research interest on the complex interactions on the northern range and continues today. The active volcanic ecosystem also fuels a wide variety of geologic studies. Many of these scientific studies have ramifications far beyond Yellowstone National Park.

Research Projects in Yellowstone

Today, permitted researchers study everything from archeology to zoology. Current research examples include

- Evaluating the effects of winter recreation on air quality, wildlife, and natural soundscapes.
- Understanding prehistoric and historic use of the park, with emphasis on Yellowstone Lake and developed areas in the park.
- Monitoring plant and animal populations and physical parameters that are, or may be, affected by changing climatic conditions.
- Studying the interrelationship among carnivores, herbivores, and vegetation on Yellowstone's northern range.
- Conducting detailed population ecology studies on mammals such as wolves, elk, bison, grizzly bears, bighorn sheep, mountain goats, and moose.
- Understanding the effects of landscape-scale disturbances (such as fires, insect outbreaks, and disease outbreaks) on the park's forests.
- Surveying rare, unusual, or thermally adapted flora.
- Monitoring of various geophysical systems that provide indicators of change within the Yellowstone Caldera (e.g., seismicity; heat, chemical, or gas flux; ground deformation; subsidence and uplift).
- Monitoring geochemical cycling in hot springs and thermally-influenced waterways.
- Identifying new microbial species (and their survival mechanisms) found in the park's numerous and diverse thermal features.
- Studying the ecology and life-history strategies of nonnative plants and aquatic species to better understand ways to control or eradicate them.
- Using tree-ring data, pollen records, and charcoal evidence to understand past climatic patterns.

NEON–National Ecological Observatory Network

From floods and wildfires to land use and invasive species, our ecosystems are constantly changing. The National Science Foundation's National Ecological Observatory Network (NEON), is designed to collect standardized scientific data at field sites across the United States to help us better understand how these ecosystems are changing over time. Field sites are strategically located in terrestrial

and freshwater aquatic ecosystems including two field sites in Yellowstone National Park's northern range. NEON's aquatic site in Yellowstone is located in Blacktail Deer Creek while NEON's terrestrial sampling locations are distributed throughout the northern range with an instrument tower on Blacktail Plateau. At each field site, NEON uses a combination of automated instruments, observational sampling and airborne remote sensing technologies to collect data on plants, animals, soils, nutrients, freshwater and atmosphere. The NEON project, operated by Battelle, will help scientists study our nation's ecosystems by providing a wealth of open data and a continental-scale infrastructure for research studies. Learn more at **neonscience.org**.

Bioprospecting: Innovation Through Science

Yellowstone's extremophiles, especially thermophiles, have been the subject of scientific research and discovery for more than 100 years. The discovery of *Thermus aquaticus* bacteria in the 1960s has had scientific and economic benefits far beyond what anyone could have imagined and has played into the growing scientific interest in bioprospecting and extremophiles—calling greater attention to the research potential of Yellowstone.

Today, several scientific research projects sponsored by universities, federal agencies, and corporations are underway in the park to investigate extremophiles. Some of their discoveries have helped researchers create inventions suitable for commercial

Bioprospecting and Benefits-sharing in Yellowstone

The Issue
Many different extremophiles have been studied. A few extremophile researchers have also created inventions that might be used commercially, which can be the basis of benefits-sharing for Yellowstone and the National Park Service.

Researchers who study material obtained under a Yellowstone National Park research permit are required to enter into benefits-sharing agreements with the National Park Service before using their research results for any commercial purpose.

Definitions

- **Bioprospecting** is the discovery of useful scientific information from genetic or biochemical resources. It does not require large-scale resource consumption typical of extractive industries associated with the term "prospecting," such as logging and mining.
- **Benefits-sharing** is an agreement between researchers, their institutions, and the National Park Service that returns benefits to the parks when results of research have potential for commercial development.
- **Extremophile:** A microorganism living in extreme conditions such as heat and acid, and cannot survive without these conditions.
- **Thermophile:** Heat-loving extremophile.

History in Yellowstone

- 1980s: Yellowstone National Park first becomes aware that biological specimens from the park are potentially being studied for commercial applications and that patent applications are being made involving study of park organisms. In 1989, *Taq polymerase*, a commercial enzyme discovered in a Yellowstone extremophile and reproduced in the laboratory, becomes *Science* magazine's first-ever "Molecule of the Year."
- 1995: The National Park Service begins work on prototype contracts between the park and industry. A conference convened by Yellowstone, "Biodiversity, ecology and evolution of thermophiles," draws 180 attendees from industry, universities, and agencies and includes a roundtable on bioprospecting and benefit sharing.
- 1998: Yellowstone and Diversa, a biotechnology research firm that had been performing permitted research in Yellowstone since 1992, enter into a benefits-sharing agreement promising that a portion of Diversa's future profits from research in Yellowstone National Park will go toward park resource preservation.
- 1998: The National Parks Omnibus Management Act of 1998 increased the emphasis on scientific research activities in the national parks. The law authorizes "negotiations with the research community and private industry for equitable, efficient benefits-sharing arrangements" in connection with research activities conducted in units of the National Park System.
- 1999: A legal challenge freezes implementation of the agreement between Yellowstone and Diversa until an environmental analysis (EA or EIS) is completed.
- 1999–2012: Many Yellowstone extremophiles are under study, some of them are grown in researchers' laboratories so they can be studied for decades. Research on a few microbes developed from specimens collected as early as 1986 leads to about a dozen patented inventions with potential for commercial use.
- 2010: The National Park Service decides to adopt benefits-sharing following the completion of the Benefits-Sharing Environmental Impact Statement.

purposes. When this happens, we call it bioprospecting. Bioprospecting does not require the sort of grand-scale resource consumption required by the kinds of extractive industries typically associated with the term "prospecting," such as logging and mining. In this case, the "prospecting" is for new knowledge. Research is encouraged in Yellowstone if it does not adversely impact park resources and visitor use and enjoyment. Importantly, only research results, i.e., information and know-how gained during research on park specimens, may be commercialized—not the specimens themselves.

Park Science Informs Inventing

Yellowstone's geology provides a wide variety of high-temperature physical and chemical habitats that support one of the planet's greatest concentrations of extremophilic biodiversity. Research on these extremophiles can discover new enzymes that can withstand harsh manufacturing processes better than inorganic catalysts, improving efficiency, which saves energy. In some cases, using enzymes instead of inorganic chemicals can also help reduce toxic industrial by-products. Research on these extremophiles has recently helped scientists invent a wide variety of potential commercial applications, from methods for improving biofuel production to helping agricultural crops withstand drought and high temperatures.

Biggest Innovation from Yellowstone, So Far

Until the 1980s, our ability to study DNA was limited. Things we take for granted today such as DNA fingerprinting to identify criminals, DNA medical diagnoses, DNA-based studies of nature, and genetic engineering did not exist. But in 1985, the polymerase chain reaction (PCR) was invented. PCR is an artificial way to do something that living things do every day—replicate DNA. PCR is the rocket ship of replication, because it allows scientists to make billions of copies of a piece of DNA in a few hours.

Without PCR, scientists could not make enough copies of DNA quickly enough to perform their analyses. However, the heat necessary to do the PCR process inactivated the enzymes, making the process extremely slow and expensive. They found the solution to this problem in one of the hot spring organisms, *Thermus aquaticus*, isolated from Yellowstone by park researcher Thomas Brock in the 1960s. An enzyme discovered in *T. aquaticus*—called Taq polymerase—made PCR practical. Because it came from an extremophile, Taq polymerase can withstand the heat of the PCR process without breaking down like ordinary polymerase enzymes. Many laboratory-made versions of this enzyme are still in use, allowing DNA studies to be practical, effective, and affordable. Companies that sell the Taq enzymes have earned profits, but Yellowstone National Park and the United States public receive no direct benefits even though this commercial product was developed from the study of a Yellowstone microbe.

Benefits Sharing

Federal legislation authorizes the National Park Service to negotiate benefits-sharing agreements that provide parks a reasonable share of profits when park-based research yields something of commercial value. The National Park Service examined benefits-sharing options and decided to require it for new inventions made through study of park resources. Servicewide procedures for benefits sharing have been developed and can be viewed in the Benefits-Sharing Handbook at **https://parkplanning.nps.gov/**.

More Information

https://www.nps.gov/subjects/science/benefits-sharing.htm

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National Park Service Research Permit and Reporting System: https://irma.nps.gov/rprs

Staff Reviewer

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Jake White, Senior Field Ecologist, NEON

Exurban development (top right) and forest dieback (bottom left) in the Gallatin Valley of Montana, in the Greater Yellowstone Ecosystem.

Land Use

How land is used outside the park can disrupt ecological processes within the park. The region's human population resides in towns, small cities, and surrounding rural residential developments, usually on or near large river floodplains and serviced by roads and airports. The population across the 20 counties of the Greater Yellowstone Ecosystem (GYE) more than doubled during 1970–2021 (140% increase), housing density tripled, and both are projected to double again by 2050. Developed lands covered 31% of the GYE in 2016. Potential stressors on the GYE have intensified dramatically in recent decades. The natural amenities, high quality of life, and other attributes of the region have attracted large numbers of new residents.

Private land in the GYE is primarily located in valley bottoms and flood plains, which generally have longer growing seasons and higher plant productivity than the higher-elevation areas that are protected as public land. In addition, new homes have been disproportionately located in areas that are important for biodiversity, particularly grizzly bear habitat, bird hot spots, and riparian zones. The percentage of the GYE used for agriculture remained relatively constant from 1920 to 1990 but has declined slightly since then, to about 18%. Agriculture is still a significant use of the land. In 2007, the percentage of agricultural crop land in the counties in and near the GYE ranged from less than 5% to more than 50%.

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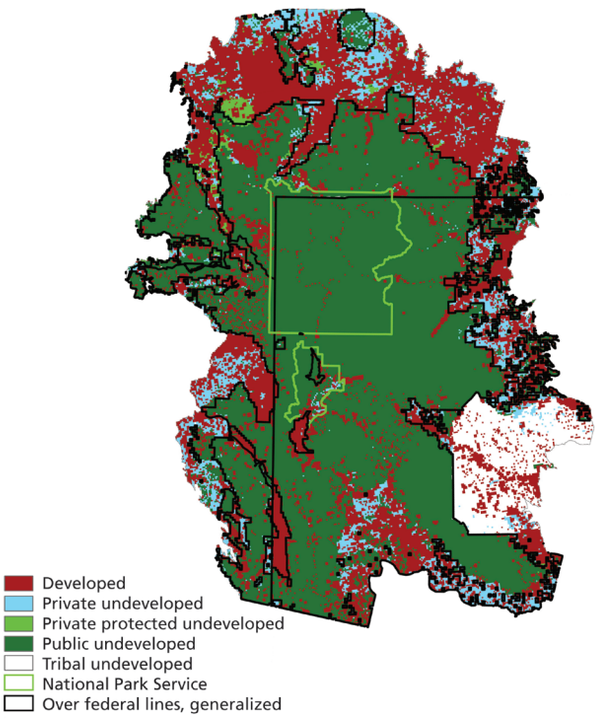

Locations within the Greater Yellowstone Ecosystem that are considered "developed" (red) and public and private land allocation classes. Data are from Hansen and Phillips (2016).

Of Yellowstone's 2.2 million acres, a little more than 2 million are recommended for federal designation as wilderness. Though Congress has not acted on this recommendation, the land is managed as wilderness.

Wilderness

Yellowstone National Park has always managed its backcountry to protect natural and cultural resources and to provide visitors with the opportunity to enjoy a pristine environment within a setting of solitude. Yet none of the park is designated as federal wilderness under the Wilderness Act of 1964.

In 1972, in accordance with that law, the Secretary of the Interior recommended 2,016,181 acres of Yellowstone's backcountry be designated as wilderness. Although Congress has not acted on this recommendation, all lands that fall within Yellowstone's Recommended Wilderness are managed to maintain their natural wilderness character so as not to preclude wilderness designation in the future. The last Yellowstone wilderness recommendation sent to Congress was for 2,032,721 acres.

Wilderness in the National Park System

Congress specifically included the National Park Service in the Wilderness Act and directed the National Park Service to evaluate all its lands for suitability as wilderness. Lands evaluated and categorized as "designated," "recommended," "proposed," "suitable," or "study area" in the Wilderness Preservation System must be managed in such a way as to (1) not diminish their suitability as wilderness, and (2) apply the concepts of "minimum requirements" to all management decisions affecting those lands, regardless of the wilderness category. Some activities that are typically prohibited under the Wilderness Act are motorized or mechanized equipment use and the installation of structures.

Director's Order 41

In 1999, Director's Order 41 was issued to guide National Park Service efforts to meet the 1964 Wilderness Act, directing that recommended wilderness must be managed to protect wilderness resources and values.

Revised in 2013, Director's Order 41 provides clearer guidance on contemporary issues in wilderness stewardship and management . It provides accountability, consistency, and continuity to the National Park Service's Wilderness Stewardship Program, and guides the National Park Service efforts to meet the letter and spirit of the 1964 Wilderness Act. Instructions include:

- "The NPS will apply the guidance contained in [Director's Order 41] to all of its wilderness stewardship activities. For the purpose of

Quick Facts

The Issue
In 1972, 90% of Yellowstone National Park was recommended for federal wilderness designation. Congress has not acted on this recommendation.

Backcountry Statistics
- Approximately 1,000 miles of trail.
- 72 trailheads within the park; 20 trailheads on the boundary.
- 299 designated campsites.
- Approximately 13% of users travel with boats, 6% with stock.
- In 2023, 38,262 visitors camped in the backcountry.

Management Concerns
- Accommodating established amount of visitor use.
- Protecting natural and cultural resources.
- Managing administrative and scientific use.
- Monitoring wilderness character.
- Educating users in Leave No Trace practices.

Current Status
Yellowstone does not have an approved wilderness management plan.

FREQUENTLY ASKED QUESTION:

Does Yellowstone include a federally designated wilderness?

No. Most of the park was recommended for this designation in 1972, but Congress has not acted on the recommendation.

applying guidance, unless specifically noted, the term "wilderness" includes the categories of eligible, proposed, recommended, and designated. Potential wilderness may be identified within the proposed, recommended, or designated categories."

- "For every designated wilderness, a Wilderness Stewardship Plan will guide management actions to preserve wilderness character . . . Parks with lands determined eligible, proposed, or recommended should also develop plans to preserve wilderness character ... Preservation of wilderness character will be incorporated into appropriate sections of park planning and management documents."

Minimum Requirement Analysis

National Park Service Management Policies (6.3.5) requires park superintendents to implement a Minimum Requirement Policy to evaluate proposed management actions within recommended wilderness areas, stating "all management decisions affecting wilderness must be consistent with the minimum requirement concept." This concept allows managers to assess:

1. If the proposed management action is appropriate or necessary for administering the area as wilderness and does not impact wilderness

Proposed wilderness (light gray) in Yellowstone National Park. Ninety percent of the park is recommended as federally designated wilderness. Areas near roads, around major visitor areas, around backcountry ranger cabins, and in previously disturbed areas are not included.

significantly. (Why must the activity occur in recommended wilderness?)
2. Which techniques and types of equipment are needed to minimize impacts to the wilderness resource. (If the project is necessary to conduct in wilderness, what is the appropriate means to conduct it that will cause the minimum impact to the wilderness resource, character, and experience that will still get the job done?)

Superintendents apply the minimum requirement concept to all administrative practices, proposed special uses, scientific activities, and equipment use in wilderness. They must consider potential disruption of wilderness character and resources before, and give significantly more weight than, economic efficiency and convenience. If the wilderness resource or character impact is unavoidable, the only acceptable actions are those preserving wilderness character or having localized, short-term adverse impacts.

Wilderness Designation and Current Practices

Yellowstone's Backcountry Management Plan and environmental assessment were drafted in 1994 but were never signed. Though unofficial, both began to provide management guidance to park managers. As managers consider wilderness in Yellowstone today, they must determine how current practices in the park will be handled within areas that are managed as wilderness:

- Protecting natural and cultural resources while also maintaining the wilderness character of the park's lands managed as wilderness.
- Managing administrative and scientific use to provide the greatest contribution with the minimum amount of intrusion on lands managed as wilderness.
- Monitoring wilderness character to develop and enact long-range strategies to better protect wilderness resources and enhance visitor experiences.
- Minimizing visitor wilderness recreation impacts by educating users in Leave No Trace outdoor skills and ethics that promote responsible outdoor recreation and stewardship.
- Evaluating the impacts to wilderness resources among other parameters for all research projects that will take place on lands managed as wilderness in Yellowstone.

Outlook

Yellowstone managers will continue to steward lands managed as wilderness in such a way that sustains the wilderness resource and wilderness character while providing wilderness recreational opportunities for park visitors. If or when Congress acts upon the recommendation to designate much of Yellowstone as wilderness, park managers will continue to manage those areas accordingly.

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Staff Reviewer

Ivan Kowski, Backcountry Program Manager

Visitor Use

The history of human presence in the Greater Yellowstone Area is long and varied. The land now defined as Yellowstone National Park has been visited, traversed, and enjoyed for millennia. Archeological evidence documents the lives and activities of people in Yellowstone going back more than 11,000 years. Each wave of human tenure in the park has been accompanied by changes in subsistence, habitation, transportation, communication, and significance. Archeological sites and historic objects inform us about past human activities in the region, illuminating the stories of people in Yellowstone.

Park managers use archeological and historical studies to help us understand how people lived and travelled here in the past. However, research is also conducted to learn how people continue to affect and be affected by this place, many parts of which have been relatively protected from human impacts. Some alterations to the landscape, such as the construction of roads and other facilities, are generally accepted as necessary to accommodate the needs of visitors today. Information on the possible consequences of modern human activities, both inside and outside the parks, is used to determine how best to preserve Yellowstone's natural and cultural resources, and the quality of the visitors' experience.

Game Changer: The Automobile

In 1905, the masterpiece of engineering known as the Belt Line (Grand Loop Road), and its accompanying bridges and approach roads, was completed under Captain Hiram Chittenden of the Army Corps of Engineers.

However, transportation patterns and methods were beginning to change. During that year only 78,000 automobiles existed in the United States, and nearly all of them were in the cities. Most of the country's roads were traversed by steel-wheeled, horse-drawn wagons. Over the following decade, the production of safer, cheaper automobiles led to a dramatic increase in their range and appeal. By 1915, there were 2.33 million automobiles on American roads, (nearly double that by 1918) and private vehicles were finally authorized to enter national parks on August 1, 1915. It soon became evident that the roads in Yellowstone were unsafe for combined stock and automobile travel. Severe injuries to animals, passengers, and motorists prompted park managers and concessioners to act decisively. By just two years later, concessions companies had completely replaced their horse-drawn stages with autos.

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Tourism and Visitation

Yellowstone National Park was designated in 1872 as the world's first national park. The explicit mission of Yellowstone, is "…to provide for the benefit and enjoyment of the people." Yet, at the time of this designation, Idaho, Montana, and Wyoming were not yet states. The total population of US Territories was only 720,000. To fulfill this mandate and truly serve the nation, Yellowstone had to develop with tourism and visitors in mind.

Infrastructure

Since its designation as a national park, infrastructure development in Yellowstone has continued to evolve. From Superintendent Philetus Norris and the first stretches of the historic Grand Loop Road, to the recently constructed Canyon lodges, approximately two percent of the park area has been developed and devoted to the accommodation and service of visitors. This infrastructure both facilitates and limits the number of visitors that the park can hold. Currently, lodging and campgrounds in the park can accommodate only about 14,300 overnight visitors during the summer. However, daily visitation during July averages around 37,700. Most of those visitors concentrate at the park's points of interest along 392 miles of paved road—mostly the same historic Grand Loop Road built more than a century ago for wagons and stage coaches, rather than RVs and tour busses.

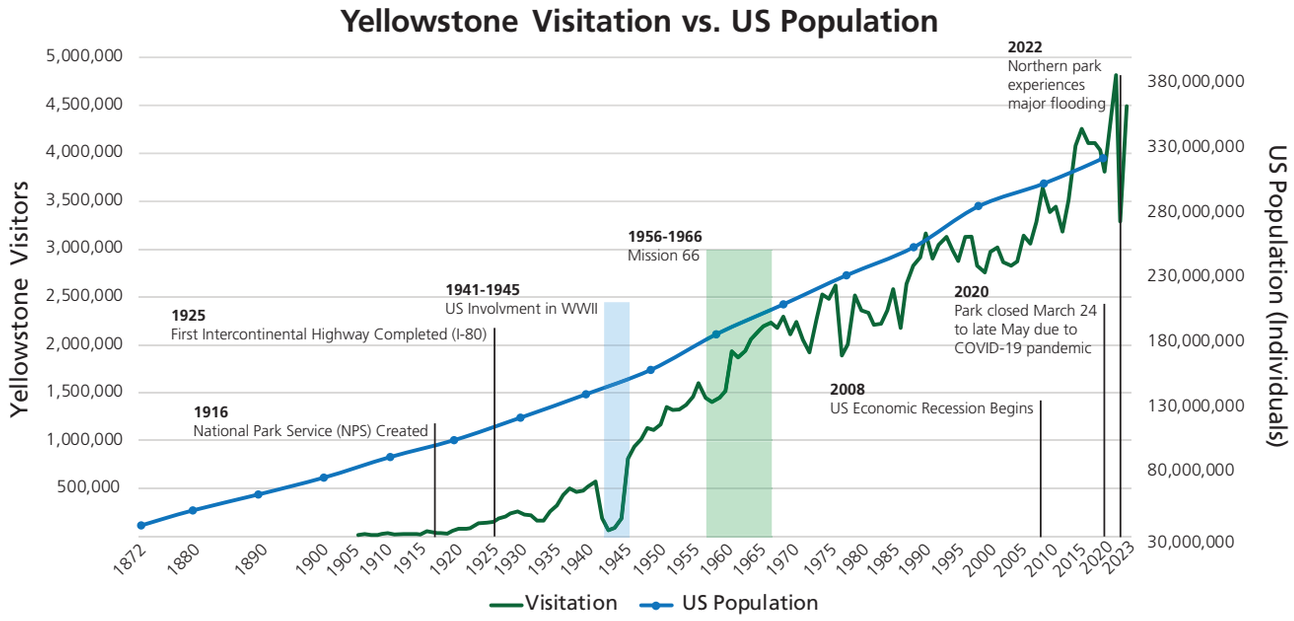
Population

Yellowstone provides a place where people can glimpse primitive America. A place where humans get the increasingly rare experience of sharing an open landscape with thousands of wild animals, including bison, bears, elk, and wolves. A precious place where a volcano's hidden power rises up in colorful hot springs, mudpots, and geysers. A place where people can see all of these things with relative ease thanks to a road system that connects five entrances with many popular destinations.

There are more people on Earth than ever before, and more and more of them want to experience Yellowstone. Visitors come to the park throughout the year but not in equal distribution. About 70% of the visitation occurs from June through August. Fall visitation has increased since the 1980s and now comprises about 21% of annual use; winter visitation has always been minimal and has never accounted for more than 6% of the annual total.

Changing Types and Timing of Visitation

In 1992, visits to Yellowstone National Park exceeded 3 million for the first time. After that, annual visitation at Yellowstone fluctuated between 2.8 and 3.1 million until new records were set in 2009 (3.3 million) and 2015 (more than 4 million). Visitation peaked in 2021 at 4,860,242. Since 2008, annual visitation to Yellowstone increased by more than



There are more people on Earth than ever before, and more and more of them want to experience Yellowstone.

40% over the previous decade. The shoulder seasons have seen the most dramatic increase in visitation on a percentage basis. From 2014 to 2016, visitation increased 44% in May, 25% in June, 16% in July, 9% in August, and 24% in October.

- Similar to trends at other western parks, overnight backcountry use in Yellowstone peaked in 1977 at more than 55,000 nights spent in the backcountry. Since the mid-1990s backcountry use has remained fairly steady, ranging between 37,000 and 46,000 person use nights annually.
- Yellowstone has seen a 130% increase in tour buses between 2012–2017 and a 267% increase in tour buses at the West Entrance since 2008.
- A 2018 study showed that approximately 30% of visitors to Yellowstone National Park are international visitors. North American visitors to Yellowstone make up 77% of all visitors followed by visitors from Europe at 13% (Germany, France, Switzerland, and UK make up the top 4) and Asia at 8% of all visitors (89% of Asian visitors are from China).

Cultural differences and language barriers can lead to communication challenges about critical park information, and even conflicts among visitors. Yellowstone has added additional Mandarin-speaking rangers and publications in Mandarin to accommodate this growing user group.

Use Impact

The impact of human beings on any landscape is complex, and our values and priorities color much of how we interpret that impact. In 2018, 4.1 million visitors to Yellowstone National Park generated $43.9 million in funding for park operations. Just a portion of this revenue funded educational programs for more than 260,000 people in the park, and more than 27,500 school children and teachers. Money collected through fees was also used to monitor (or remove) some of our 225 species of invasive plants; to study the 285 species of birds and watch them for impacts of climate change; and to provide opportunities for hundreds of thousands of visitors to view wild wolves in their natural habitat.

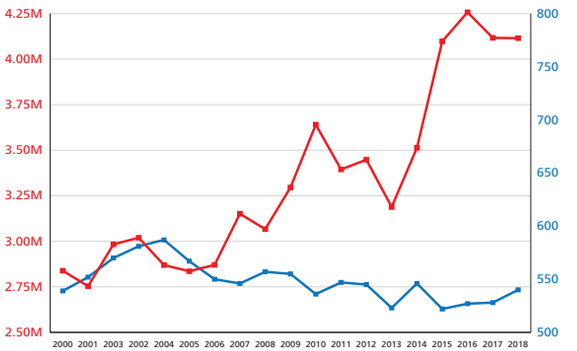
In 2022, 3.3 million park visitors spent an estimated $452 million in local gateway regions while visiting Yellowstone National Park. That spending supported 6,234 jobs in the local area (for a cumulative benefit to the local economy of $600 million). Park supporters donated an additional $1.7 million for research internships, historic preservation, and projects to protect and learn about native species like Yellowstone cutthroat trout, golden eagles, black bears, and cougars.

Use by visitors is both a primary reason for the establishment of national parks and a factor in the condition of many of the natural and cultural resources that the parks are intended to protect. Visitors do much to support the preservation and operation of parks but not all impacts are positive. To some degree, ongoing visitor activities and associated infrastructure affect many park resources, including:

- air and water quality and the natural soundscape;
- wildlife habitat, distribution and habituation;
- the spread of nonnative plants, diseases, and aquatic organisms;
- the preservation of archeological sites and other cultural artifacts.

However, the Greater Yellowstone Ecosystem remains one of the most intact ecosystems in the US. The relationship between visitation and impacts to resources is complex, and while park managers continue to monitor this relationship, no population or system-wide impairment appears to be occurring from current visitation levels.

Operationally, increased annual visitation to Yellowstone sometimes causes overflowing parking lots, traffic jams, roadside soil erosion and vegetation trampling, and unsanitary conditions around busy bathrooms. In just two years (2014 to 2016) Yellowstone saw a twenty percent increase in visitation over the previous decade. This arrived coupled with an even greater rise in motor vehicle accidents



While visitation has climbed dramatically, the number of full-time National Park Service employees has not changed significantly.

(+90%), ambulance use (+60%), and search and rescue efforts (+130%). Meanwhile, staffing levels and funding have remained flat over the last ten years.

Visitor Use Management

Yellowstone is not undertaking a formal parkwide planning process for visitor use management, as impacts are site specific. The park has been working to understand the impacts of increasing visitation. Below are details about past and current work.

Upcoming Work

- Pilot Projects—The park continues to test a range of pilot projects around the park, such as altering traffic, parking, and visitor flow configurations and adding staff to highly congested areas to improve resource protection, safety, operations, and the visitor experience.

Past Work

Visitor Use Studies

- Visitor Use Study (2016): The park commissioned a survey of summer visitors to better understand who comes to Yellowstone, how they plan their trips, what they come to see, their perceptions of the park (including attitudes about access and transportation), and level of satisfaction with park services and facilities.
- Visitor Use Study (2018): Researchers conducted a study to explore how people experience and move through the park in real-time and how their experiences vary across the season (May–September).
- Visitor Use and Behavior at Attraction Sites: In 2017, the park began an on-going monitoring project in partnership with Oregon State University and the Youth Conservation Corp (YCC) to better understand visitor volumes and behaviors at high-use attraction sites. YCC Crews monitor numbers and density of people, how they use the area, and instances of resource impacts. This monitoring occurs at Old Faithful, Midway Geyser Basin, the Fairy Falls trail to the Grand Prismatic Overlook, and Norris.

Transportation Studies

- Transportation and Vehicle Mobility Study, Phase I (2016): Researchers collected data in 2016 to describe traffic, parking, capacity, and visitor flow patterns throughout the park.
- Transportation and Vehicle Mobility Study, Phase 2 (2018): Researchers used the 2016 data to model traffic conditions and demand specifically on the West Yellowstone to Old Faithful Corridor.
- In 2018, a graduate student conducted a study to explore the feasibility of a shuttle system between West Yellowstone and Old Faithful.

Wildlife Jams (2018)

Employees worked with University of Montana students to examine how humans and animals interact with one another at wildlife jams.

Visitor and Employee Safety (2018)

Two graduate students from the NPS Business Plan Internship program worked with the park to study the relationship between increasing visitation, human safety, and impacts on employees and operations in the Resource and Visitor Protection Division.

Resource Impacts

Employees monitored the creation and expansion of social trails, which are unwanted and unofficial trails made by visitors that damage soil and plants.

More Information

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Staff reviewer

Christina White, Outdoor Recreation Planner

The enjoyment of Yellowstone and its unique resources during the wintertime has drawn deep and passionate interest in the park since the 1930s. Here, skiers pass bison on Slough Creek trail.

Winter Use

The National Park Service (NPS) mission is a dual mandate: preserve Yellowstone's resources and make the park available and accessible for enjoyment and appreciation. The ways in which visitors access Yellowstone in winter can affect the park's plants, animals, and wild character in ways more profound—and potentially more damaging—than at other times of the year. To meet its mission, the NPS has worked carefully to develop a long-term plan for winter use in Yellowstone that both protects the park's resources and provides outstanding opportunities "for the benefit and enjoyment of the people."

For years, the National Park Service managed the park in winter with interim management plans in the face of repeated courtroom challenges over snowmobiles and other winter operations. The final rule, published in October 2013, established long-term management of winter use in Yellowstone and concluded more than 15 years of planning efforts and litigation.

History of the Debate

The popularity of visiting the park in winter, coupled with concerns over impacts to resources from visitation, has made winter use planning for Yellowstone one of the most contentious issues for park managers and visitors. The debate spans more than 80 years, with each participant asking: should the park be accessible in winter? If so, what type of transportation has the least harmful impact on resources, while providing for meaningful visitor experiences?

In the early 1930s, communities around the park began asking the NPS to plow Yellowstone's roads year-round so tourist travel and associated spending in the area would be stimulated. The NPS resisted these requests, citing non-winterized buildings, harsh weather conditions, and roads too narrow for snow storage. Meanwhile, snowbound entrepreneurs in West Yellowstone began experimenting with motorized vehicles capable of traveling over snow-covered roads. In 1949, they drove the first motorized winter vehicles, known as snowplanes, into Yellowstone.

Quick Facts

The Issue

National Park Service Regulation 36 CFR 2.18 prohibits snowmobile use in national parks when there is no specific rule authorizing their use. This is known as the "closed unless open rule"—without a specific rule, oversnow vehicles would be prohibited from entering Yellowstone.

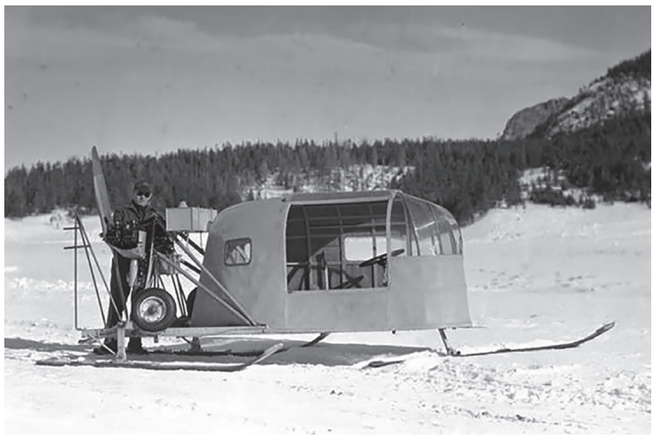
Winter Use Management Goals

- Provide a high-quality, safe, and educational winter experience
- Provide for visitor and employee health and safety
- Protect wilderness character and values
- Preserve pristine air quality
- Preserve natural soundscapes
- Mitigate impacts to wildlife
- Coordinate with partners and gateway communities

Concerns Raised by the Public

- Overcrowding
- Visitor impacts on natural resources
- Noise and air pollution
- Availability of facilities and services
- Restricting snowmobiles, including requiring guides
- Importance of winter visitation to the local and regional economy
- Wildlife using groomed roads
- Displacing wildlife
- Health and human safety

Updates: www.nps.gov/yell/learn/management/winter-use-management.htm



Snowplane on Swan Lake Flat, c. 1945. These winter vehicles consisted of passenger cabs set on skis and blown about (without becoming airborne) with a rear-mounted airplane propeller and engine.

Snowcoaches first entered the park in 1955.

In 1955, visitors began touring the park on snowcoaches, enclosed oversnow vehicles (OSV) capable of carrying about 10 people. Finally, in 1963, the first visitors on modern snowmobiles entered Yellowstone. Not long after, snowmobiling became the dominant way to tour the park in winter.

Still, pressure to plow park roads persisted, and Yellowstone authorities knew that they could not accommodate both snowmobiles and automobiles. They thought snowmobiles offered a way to accommodate visitors while preserving the wintertime experience. By 1968, an OSV program was formalized. In 1971, park managers began grooming snowmobile routes to provide smoother, more comfortable touring, and also opened Old Faithful Snow Lodge so visitors could stay overnight at the famous geyser.

Throughout the 1970s, 80s, and early 90s, visitation by snowmobile grew consistently. This brought unanticipated problems such as air and noise pollution, conflicts with other users, and wildlife harassment. Meanwhile, in 1972, President Nixon signed Executive Order 11644, which described how off-road vehicles, including snowmobiles, should be managed. This Executive Order requires each agency to establish policies and provide for procedures that will ensure that the use of off-road vehicles on public lands will be controlled and directed so as to protect the resources of those lands; to promote the safety of all users of those lands; and to minimize conflicts among the various uses of those lands.

In 1990, park managers completed the Winter Use Plan Environmental Assessment for Yellowstone and Grand Teton national parks and the John D. Rockefeller, Jr. Memorial Parkway to address known and developing problems with snowmobile use. This plan formalized the park's existing winter use program and included a commitment to examine the issue further if winter visitation exceeded the threshold of 140,000 visitors. That threshold was exceeded in the winter of 1992–1993, eight years earlier than the plan predicted.

In accordance with the 1990 plan, a final report was published in 1999. Based on scientific studies, visitor surveys, and public comments analyzing the issues or problems with winter use, the report made many recommendations to park and forest managers and summarized the state of knowledge regarding winter use at that time.

Unfortunately, the assessment did not change conditions in the parks. By the late 1990s, an average of 795 snowmobiles entered the park each day. All were two-stroke machines, which used a mix of oil and gas for combustion, resulting in high levels of pollution. Carbon monoxide pollution was especially severe, coming close to violating the Clean Air Act's standards at the West Entrance in one event. Air particulate and some hydrocarbon levels were also high. Two-stroke machines were also loud, making it difficult on many days to experience natural silence in the Firehole Valley. Moreover, many visitors traveling by snowmobile lacked the experience necessary to pass bison and other wildlife without causing harassment.

Planning and Litigation

The winter of 1996–1997 was one of the harshest winters of the 1990s, with abundant snow, cold temperatures, and a thick ice layer in the snowpack. Unable to access the forage under the ice, more than 1,000 bison left the park and were shot or shipped to slaughter amid concerns they could transmit

Plowing the high mountain roads in Yellowstone is both costly and dangerous.

brucellosis to cattle in Montana (see also: *Brucellosis p. 193*). Concerned that groomed roads increased the number of bison leaving the park and being killed, the Fund for Animals and other groups filed suit in the US District Court for the District of Columbia against the NPS in May 1997. The groups alleged that the NPS had failed to examine the environmental impacts of winter use. In 1999, the Bluewater Network filed a legal petition with the NPS to ban snowmobiles from all national park units nationwide. These two actions inaugurated more than 15 years of winter use planning and associated lawsuits, and catapulted the issue into one of the NPS's most visible and enduring environmental controversies.

As part of a court-mediated settlement, the NPS produced a draft EIS (in 1999) that proposed plowing the road from West Yellowstone to Old Faithful. Since that initial EIS, other environmental compliance documents have proposed addressing winter-use impacts using a combination of new technologies, limits on vehicle numbers, mandatory guiding, and monitoring winter-use impacts on park resources. All of these environmental compliance planning documents have proposed allowing a combination of snowmobiles and snowcoaches, with the snowmobile numbers decreasing from plan to plan and snowcoach numbers remaining relatively consistent.

By 2002, snowmobiles which used new technology to dramatically reduce emissions and somewhat reduce noise (what we now refer to as "Best Available Technology," or BAT) were commercially available. Requiring visitors to tour with snowmobile guides or in commercially guided snowcoaches reduced the conflicts with wildlife. Resource monitoring allowed the NPS to gauge the effects of these actions and take further protective actions. These changes aimed to eliminate the problems of the past.

Each of the subsequent winter use plans was litigated. Certainly, the litigation is one of the factors accounting for the protracted nature of the winter use debate. In each decision against it, the National Park Service has responded by addressing the concerns of the courts.

Beginning in 2009, winter use was managed with an interim plan. In 2011, the NPS released a draft Environmental Impact Statement (EIS) for public review on the potential effects of the plan for motorized oversnow travel in the park. After months of public comment and review, the NPS decided additional study was needed before putting a long-term plan in place, and the planning process was extended for another year.

Management by "Transportation Events"

In 2012, the NPS released a draft Supplemental EIS, the seventh environmental document since 2000. This document introduced the idea of managing oversnow vehicles by "transportation events." Previous management alternatives were based on managing by absolute numbers of OSVs. Through analysis of monitoring data and computer simulations, the park discovered that by packaging traffic into transportation events (i.e., groups) and limiting the total number of transportation events allowed into the park each day, the park would be able to lessen disturbances to wildlife and improve natural soundscape conditions, in addition to allowing more visitors to see the park in winter. Based on monitoring data, the NPS demonstrated that snowmobile and snowcoach transportation events have comparable impacts on Yellowstone's resources and values.

In February 2013, the NPS published a final Winter Use Plan/Supplemental EIS to guide the future of winter use in Yellowstone National Park with management by transportation events as the preferred alternative. A proposed rule was published in the Federal Register in April 2013, and the Record of Decision, which officially concludes the SEIS process by selecting management by transportation events as the final alternative, was signed in August 2013.

A Final Rule for Winter Use in Yellowstone

National Park Service Regulation 36 CFR 2.18 prohibits snowmobile use in national parks when there is no specific rule authorizing their use. This is known

as the "closed unless open rule"—without a specific rule, oversnow vehicles would be prohibited from entering Yellowstone

The final Rule authorizing OSV use in Yellowstone was published in the Federal Register on October 23, 2013, and was based upon the environmental analyses contained within the 2013 SEIS and Record of Decision. The final Rule provides mechanisms to make the park cleaner and quieter than previously authorized; provides greater flexibility for OSV commercial tour operators; rewards new oversnow technologies; and allows for increases in public visitation. Specific parameters established by the final Rule for winter use in Yellowstone include:

- Up to 110 daily transportation events.
- 46 events reserved for commercially guided snowmobiles,
- 4 reserved for non-commercially guided snowmobiles.
- No fewer than 60 events reserved for snowcoaches.
- New "best available technology" (New BAT) is required for snowmobiles.
- BAT is required for all snowcoaches.
- One non-commercially guided group of up to five snowmobiles is permitted to enter through each of the four park entrances every day.
- OSVs may continue to use Sylvan Pass; however, the pass may be closed at any time due to avalanche danger or mitigation efforts.
- Park managers are collaborating with the public by implementing an Adaptive Management Program to combine science with public input.

Adaptive Management Program

The final Rule authorizes an adaptive management program to inform and improve winter-use management. Adaptive management is a three-step process: management, monitoring, and evaluation improve resource protection by blending science and public engagement. It enables natural-resource managers to acknowledge uncertainties in the management of natural systems and to respond to changing conditions while working with the public and interested stakeholders. Collaborative adaptive management, the approach Yellowstone is taking, emphasizes joint learning and an active partnership among managers, scientists, and other stakeholders, including the public. The objectives of the program are to

- Evaluate the impacts of OSV use and help managers implement actions that keep impacts within the range predicted under the final Plan/SEIS.
- Gather additional data to compare impacts from a group of snowmobiles versus a snowcoach.
- Reduce impacts on park resources after implementation of the final Rule by gathering additional data on the overall social and ecological impacts of winter use.

To meet these objectives, the NPS has collaborated with the public and other partners to develop a long-term, sustainable adaptive management plan for winter use in Yellowstone National Park, released in December 2016. Members of the public participate in working groups around six topics: wildlife, soundscapes and acoustic resources, air quality, human dimensions, operations and technology, and the Non-Commercially Guided Snowmobile Access Program. The NPS leads for each of these working groups publish monitoring and study data, and working group members provide public feedback.

Improvements to winter use management are made through the adaptive management process. For example, input from commercial snowcoach operators suggested that low-pressure tires should be explored as an alternative to traditional mattracks. Following a study to assess the impacts of low-pressure tires on safety, the park, and visitor experience, coupled with a pilot program, low-pressure tires are now widely used. The implementation of low-pressure tires has led to snowcoaches that are significantly quieter, more fuel efficient, less part and labor intensive, and provide a smoother ride for visitors.

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Staff Reviewer
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FREQUENTLY ASKED QUESTION:

Do winter use regulations effectively protect park resources?

Recent studies on winter use indicate park resources are in very good condition. Research shows that snowmobiles and snowcoaches contribute similarly to the impacts of winter use. The perception that snowmobiles contribute to the vast majority of observed effects, and that those effects would greatly diminish by limiting travel to snowcoaches only, is not supported. When managed, both modes of transportation provide opportunities for visitors to enjoy the park offering different winter experiences for visitors.

Wildlife

The impact of oversnow vehicles (OSV) on wildlife is a key issue in winter use policies. OSVs are required to stay on groomed roads, but the roads are often situated where wildlife may concentrate in winter. Research indicates that disturbance by winter visitors is not a primary influence on the distribution, movements, or population size and composition of bison, trumpeter swans, elk, coyotes, and bald eagles.

Monitoring OSV use in Yellowstone shows that nearly all OSV users remain on groomed roads and behave appropriately toward wildlife, rarely approaching unless animals are on or adjacent to the road. In most encounters observed between people on OSVs and wildlife, the animals either had no apparent response or looked and then resumed what they were previously doing.

Road grooming does not increase bison migration out of the park. Data on bison road use and off-road travel collected from 1997 to 2005 found bison on the road less often from December to April when the roads were groomed than during the rest of the year, and found no evidence that bison preferentially used groomed roads during winter.

Compared to similar studies in other places, the relatively low intensity of wildlife responses in Yellowstone suggests that because the encounters near roads are predictable and apparently not harmful to the animals, some habituation to OSVs and associated human activities may be occurring.

Making all visitors use a guide has nearly eliminated wildlife harassment. Guides enforce proper touring behaviors, such as passing wildlife on or near roads without harassment and ensuring that wildlife do not obtain human food. Monitoring indicates that snowcoaches have a slightly higher probability of disturbing wildlife than do snowmobiles.

Air Quality

Winter air quality in Yellowstone depends primarily on proximity to roads, parking areas, employee housing, and visitor lodging. Although visitation is far lower in the winter than in the summer, OSVs produce more emissions than autos. Levels of carbon monoxide and particulates fell dramatically after 2002 with conversion to BAT snowmobiles and reduced OSV numbers. Hydrocarbon and air toxin concentrations are also no longer a concern. Carbon monoxide, nitrogen dioxide, and particulate matter are monitored at the West Entrance and Old Faithful, where OSVs are most concentrated.

In general, the requirements of the managed use era (the 2004-2005 season and beyond) have had a very positive affect on winter air quality. This includes BAT requirements, a reduction in time OSVs spend idling, and the requirement that guides accompany groups when they tour the park. Analysis of the data shows that levels of carbon monoxide, particulate matter, and hydrocarbons have all been reduced since 2002. When the older values are compared to current values, the improvement is even more dramatic. Monitoring of nitrogen dioxide has only occurred since 2009, but the data indicates that ambient levels are well below those of the National Ambient Air Quality Standards. BAT snowmobiles and snowcoaches produce a similar amount of air pollution on a per passenger basis. Under the Clean Air Act Amendments of 1977, Yellowstone is designated as Class I airsheds, a classification that requires the most stringent protection.

Soundscapes

Noise levels have also fallen somewhat with the conversion to BAT OSVs, mandatory commercial guiding, and limited numbers of snowmobiles. Although snowmobiles and snowcoaches are commonly heard during certain periods of the day, their noise is absent during other times—even in developed areas like Old Faithful.

During the day, OSVs can be heard, on average, about half the time at Madison Junction and approximately 62% of the time at Old Faithful, but much less often in areas of the park with lower OSV activity. The maximum sound levels of groups of snowmobiles measured at 100 feet are generally in the 60s dBA and occasionally reach into the 70s dBA for some individual snowcoaches. Most operators have since reached enhanced BAT and new low pressure tires introduced more recently have made snowcoaches 5-6 times quieter.

Incidents

With guiding has come a 50% reduction of law enforcement incidents, even when accounting for the drop in visitation. Arrests have virtually disappeared. Calls for medical assistance are the only statistic that has increased since the conversion to mandatory guiding.

Yellowstone National Park strives to demonstrate and promote sound environmental stewardship. Through these efforts, more than 5,000 small propane cylinders are crushed and redeemed as steel each year.

Sustainable and Greening Practices

The National Park Service (NPS) mission articulates a clear ethic for environmental stewardship and Yellowstone's sustainability program extends this commitment to minimizing the environmental impacts from its own operations. Though Yellowstone has been working toward becoming a greener park for many years, sustainability is made more urgent by a changing climate resulting in impacts to natural resources both locally and globally.

Increases in visitation as well as aging facilities and infrastructure create an additional challenge and a need for the park to continue to improve and expand sustainability efforts. The Green Parks Plan provides guidance for reductions in energy, water, waste, and greenhouse gas emissions for all National Park units in the US.

Yellowstone's size and complexity create challenges that require collaboration among park managers and partners. The Yellowstone Environmental Coordinating Committee (YECC) works to ensure a comprehensive approach to sustainability. This team consists of representatives from the National Park Service, Xanterra, Delaware North, Medcor, Yellowstone Park Service Stations, and Yellowstone Forever. The YECC team is constantly working to identify projects that reduce energy and water use and improve waste management throughout the park.

Sustainable and Greening Practices in Yellowstone

The Issue
Demonstrating and promoting sound environmental stewardship through regional and national partnerships.

History

- 1997: Park celebrates 125th anniversary and "greening" efforts increase.
- 2002: The park's diesel fleet converts to biodiesel blend; the Greater Yellowstone/Teton Clean Energy Coalition receives federal designation.
- 2003: Regional composting facility opens; park demonstrates the first fuel cell in a national park; park begins testing prototype alternatively-fueled vehicles.
- 2004: Park employees begin using hybrid vehicles; Xanterra employee housing receives LEED designation.
- 2005: The Energy Policy Act addresses US energy production.
- 2007: Park completes a greenhouse gas inventory, leading to initiatives to reduce greenhouse gas emissions.
- 2011: Corporate partners participate in "Greening Yellowstone Symposium."
- 2012: Green Parks Plan articulates the overarching vision for NPS sustainability.
- 2013: Yellowstone becomes a Climate Friendly Park.
- 2015: Executive Order 13693, Planning for Federal Sustainability in the Next Decade, signed.
- 2017: 44 KW solar and 2.5 kilowatt micro-hydro system online at Lamar Buffalo Ranch.
- 2018: Executive Order 13834, Efficient Federal Operations, signed revoking E.O. 13693 of 2015.

Park Waste Diverted from Landfills
Latest data from 2018: 51.6% of waste diverted (34% recycled, 18% compost).

- newspapers, magazines, office paper: 61 tons
- aluminum and steel: 36.5 tons
- glass: 133 tons
- plastics: 58 tons
- cardboard: 363 tons
- food waste and other garbage composted: 722 tons
- manure: 257 tons

Energy Conservation

Yellowstone is the largest consumer of energy in the NPS. Though most of Yellowstone's energy comes from electricity generated at coal-fueled power plants and other fossil fuels used directly, the park is reducing energy use by making facilities more energy efficient and increasing the use of renewable energy where possible.

Electricity is used for lighting, appliances, computers, tools and some heating and cooling. Improving the efficiency of these applications is one of the most productive steps we can take toward energy conservation. North-Western Energy (Yellowstone's electricity provider) is also increasing its renewable energy portfolio further reducing the emissions from electricity production.

Most of Yellowstone's building heating and cooling systems rely on fuel: either diesel (fuel oil) or propane. Other common users of fuel for direct heat and power are water heaters, kitchen appliances and generators. Renovating Yellowstone's buildings presents opportunities for reducing fuel use. Heating systems are being updated where possible and efforts are being made throughout the park to improve building envelopes such as adding insulation and installing better storm windows. Yellowstone's housing initiative is also focused on installing energy efficient appliances and using best building practices for energy smart housing.

Approximately 2.2 billion dollars in global energy consumption is wasted annually from artificial lighting at night. Yellowstone has more than 5,000 outdoor lights throughout developed areas of the park, ranging from historic lampposts to garage flood lights. Each of these lights must adhere to the strict lighting guidelines which reduce energy use and light pollution. Unfortunately, most lights were installed before these guidelines existed and even before negative effects of artificial light were considered. Yellowstone's staff is working retroactively to identify and remove any unnecessary or excess lights, replace all bulbs with high-efficiency LEDs, and install fully shielded fixtures that direct light only where needed allowing for a lower wattage bulb.

New construction and major renovations provide opportunities to implement energy efficient designs. Many buildings in Yellowstone now have LEED (Leadership in Energy and Environmental Design) certification including the Old Faithful Visitor Education Center, Old Faithful Haynes Photoshop, Canyon Lodges, and several employee housing dormitories.

Photovoltaic (PV) solar energy systems have been a great success, particularly at locations that do not have main line electric power. At Bechler, a portable trailer with a 9 kW solar panel array meets 90% of the electrical needs in the summer season and several arrays now exist on newer buildings that are tied into the electrical grid.

The Buffalo Ranch in Lamar Valley has the largest solar array in Yellowstone. The off-grid ranch has a 44 kW solar panel system and microhydro turbine that together meet over 90% of electrical needs averaged throughout the year. Each building's energy

This portable photovoltaic system at Bechler provides power during the summer season, meeting 90% of the site's electrical needs.

The irrigation system used to water the historic lawns of Fort Yellowstone and Mammoth Hot Springs, pictured here in 1916, was upgraded to include smart controllers which measure moisture levels.

use is monitored so that occupants can see their use and energy savings can be tracked which can be used to make better informed efficiency decisions in the future.

In 2012, a microhydro generator was installed on an existing piped water supply in Mammoth Hot Springs, providing renewable electric power to the grid. The generator produces about 1.4 million kW-hours for the park annually, saving approximately $95,000 in electricity costs and 900 metric tons of greenhouse gas emissions each year. Solar hot water systems on concession buildings have also been successful at Old Faithful and Grant. Using thermal energy from the ground or from natural hot water is not being considered by park managers as the effects could be detrimental to the park's hydrothermal features and other sensitive resources.

Water Conservation

As the Rocky Mountain West becomes warmer and drier with the effects of climate change, and with more than four million annual visitors, it is important that Yellowstone minimizes water use and our impact on natural water resources.

Currently, over 250 million gallons are used for hydrating, flushing, and washing each year. Continued education of our visitors and staff is important, but changing people's habits is one of the toughest challenges for lessening water (and energy) use.

Updating old infrastructure and installing water-smart technology and design is the best way to keep our water use and impact down. Small, hidden leaks in underground pipes can release thousands of gallons of drinking water a day. To identify unseen weaknesses, we perform leak detection surveys on potable water pipes in some developed areas using acoustic sensor technology. Other water saving initiatives include updating water fixtures to low flow and installing smart controllers on irrigation systems.

Yellowstone has seen a slight decrease in overall water use in recent years. Continued vigilance in updating our water infrastructure should keep this trend going.

Fleet and Transportation

The NPS is working toward reducing fossil fuel consumption from fleet vehicles by decreasing the size of our fleet, replacing the existing fleet with more fuel-efficient vehicles, and choosing the most efficient vehicles for each job. Approximately 19% of the vehicles used for work in Yellowstone are hybrid vehicles.

In 2011, Yellowstone diverted approximately 72% of its waste from landfills, including 235 tons of aluminum and steel.

The set speed limit throughout most of the park is 45 mph, which is also the speed range vehicles have the highest gas mileage. However, traffic jams are all too common and increase greenhouse gas (GHG) emissions if engines are not turned off. Studies show that idling for just 10 seconds in modern vehicles uses more fuel than restarting the engine. Yellowstone has partnered with Yellowstone–Teton Clean Cities on several fuel-reduction projects including an idle-reduction campaign and the installation of electric vehicle (EV) charging stations for both fleet and visitors. Level 2 EV charging is now available free to the public at all the major developed areas through Xanterra Travel Collection.

Yellowstone also operates a ride-share program for employees who live north of the park with a single 45-seater bus. Not only does this reduce fuel and emissions by taking many cars off the road but it is a safer solution for staff working ten hour days and traveling 50 miles each way.

Environmental Purchasing and Waste Reduction

Yellowstone is striving to divert 75% of the solid waste produced in the park from landfills. The YECC, We Recycle Montana (Yellowstone's recycling contractor), and the West Yellowstone Compost Facility aggregate solid waste statistics to determine the total amount diverted annually. In 2018, park employees, visitors, and partners diverted 51.6% through recycling and composting initiatives, as well as by purchasing environmentally preferred products. Items with minimal packaging, biodegradable

Bear spray canisters are now recyclable throughout the Greater Yellowstone Ecosystem.

In 2018, park employees, visitors, and partners diverted approximately 52% of waste from the landfill through recycling and compost initiatives.

and recovered materials, and without toxic chemicals as well as those requiring minimal energy to produce and transport are preferred. For example single-use plastic water bottles are being reduced by providing water bottle filling stations throughout the park and alternate containers such as cans for water. The recycling program in Yellowstone accepts glass, 1 and 2 plastic, paper, aluminum, steel and cardboard as well as bear spray and 1 pound or smaller camping gas cylinders.

A Commitment from Yellowstone Concessions

Yellowstone National Park's major concessioners have more interaction with visitors through food service, lodging, fuel and automotive services, and retail operations than any National Park Service facilities.

Concession partners have made corporate commitments to use environmental management systems that meet international business standards for sustainability and further the success of Yellowstone's sustainable operation goals. They work hard to minimize waste from the services they provide to visitors and make it a priority for their operations. Both Xanterra Parks and Resorts and Delaware North Services have won awards for their green initiatives.

Xanterra Travel Collection

Xanterra Travel Collection provides lodging and other guest services in the park and is a huge proponent of sustainability in Yellowstone. Their environmental commitment includes solid waste diversion, energy and water conservation, and environmental purchasing. Xanterra has several new and longstanding green initiatives and awards including:

- The green housekeeping program "Our Softer Stay" gives guests the opportunity to opt out of housekeeping services, offering a $5 incentive to participate.
- The "Choose to be Straw Free" campaign made a commitment in 2018 to purchase only compostable straws, eliminating hundreds of thousands of plastic straws each year.
- Continuing to discourage the use of plastic water bottles by partnering with Phillipsburg Brewing Company and Montana Silver Springs for locally-sourced canned water.
- Installing a sanitizing system that creates environmentally friendly, safe, and affordable sanitizing products by electrochemically activating water.
- NPS Environmental Achievement Award for the sustainable design and construction of the Canyon Area Lodging Development.
- Near-Zero Waste Award by the Green Restaurant Association for Mammoth Hotel Dining Room.

Delaware North

Delaware North operates twelve general stores in the park and practices an award winning sustainability system focused on environmental management, community involvement, facilities and asset protection, healthy living, and interpretation and education. Successful programs and initiatives include:

- The "Last Straw" campaign where straws are no longer provided with drinks and compostable straws are available upon request, resulting in 25,000 less straws used in 2018 than previous years.

- GBCI's TRUE Zero Waste certification for the West Yellowstone warehouse—the first and only within the NPS to obtain this award. In 2018, the warehouse diverted over 97% of waste through composting and recycling.
- Installing free water-filling stations to reduce the production, shipping, and use of approximately 35,000 plastic water bottles.
- Using renewable energy at Grant Village dormitory for water heating.

Sustainability Challenges

Even though Yellowstone strives to constantly reduce energy and water use as well as decrease unnecessary waste, reaching goals made twenty years ago has been challenging. Exponential increases in visitation and an extended busy season puts stress on Yellowstone's infrastructure and energy use has only continued to increase. Challenges with composting and recycling facilities have also caused waste diversion to decrease since 2017. Education is a top priority but convincing people to change their habits is often difficult. The YECC staff is vigilant in pursuing new ideas and technology to incorporate green practices into everyday activities, making Yellowstone sustainable from the ground up.

Sustainability and You

Though sustainable practices face many challenges, it is really easy to get involved and help make positive changes towards Yellowstone's energy, water, and waste conservation efforts. Reduce, reuse, recycle, refuse, and rethink are strategies staff and visitors should keep in mind.

- Reduce: Turn off the lights, limit shower times, and unplug appliances. These are simple ways to reduce energy use. Turning off the car while in a traffic jam or pull-off reduces gas consumption and air pollution.
- Reuse: Carrying a refillable water bottle and coffee tumbler eliminates plastic waste. Reusing hotel towels minimizes water and energy use from washing and drying.
- Recycle: Yellowstone is home to countless recycling centers and waste stations where glass, plastic, metal, and cardboard are recycled and compost is collected. There are also recycling centers for bear spray and propane canisters.
- Refuse: Saying no can be difficult, but consider if you're really going to read that pamphlet or drink that last refill with your meal. Yellowstone says yes to recycled products and green packaging.
- Rethink: Technology is constantly improving and new ideas come about daily. Rethinking how we go about everyday tasks and incorporate sustainable practices in daily activities is key to creating a more sustainable Yellowstone and preserving this unique ecosystem.

Yellowstone's major concessioners have made corporate commitments to incorporating sustainability into their operations. This water filling station is located in the Tower Fall Delaware North store.

More Information

National Park Service Green Parks Plan: www.nps.gov/greenparksplan

Yellowstone's sustainable practices: http://www.nps.gov/yell/getinvolved/sustainability.htm

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GreenPath at Delaware North: http://www.delawarenorth.com/about/values/greenpath

Staff Reviewers

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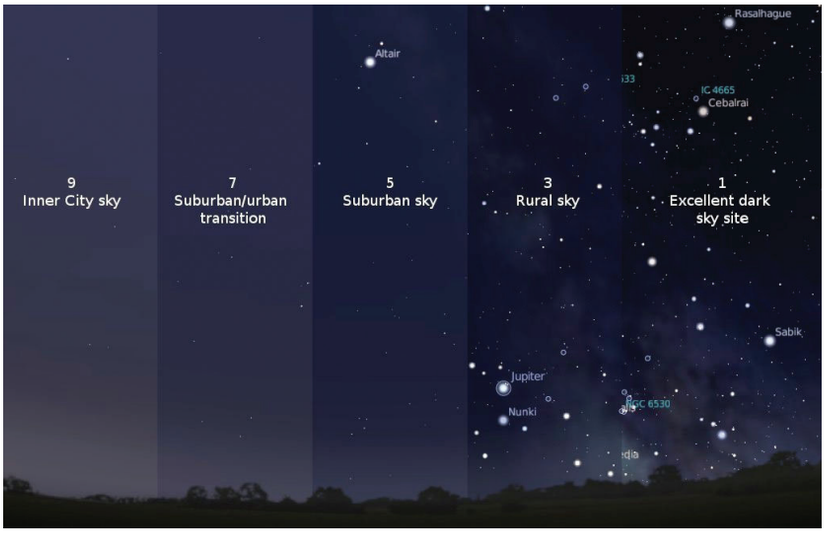
Dark Skies

Light pollution, the inappropriate or excess use of artificial light, is eliminating dark night skies as *skyglow* increases. Skyglow is the brightening of the night sky from artificial light and creates a glow that diminishes visibility of the natural night sky. Inefficient use of technology and the resulting light pollution is a growing concern. Limiting artificial light is crucial to protecting the dark night sky and the health of Yellowstone's wilderness environment.



The Bortle scale is a nine-level numeric scale that measures the night sky's brightness of a particular location. It quantifies the astronomical observability of celestial objects and the interference caused by light pollution.

Effects on Human Health and Wildlife

Daily light-dark cycles are necessary for maintaining human health and wildlife activity. Artificially lit areas create light pollution which masks these cycles. Artificially lighted areas disrupt behavior, reproduction, nourishment cycles, and predator-prey relationships in wildlife. In Yellowstone, this manifests in negative impacts particularly to insects, bats, amphibians, and birds. In humans, excessive light levels are known to impact behavior, melatonin production, sleep patterns, anxiety, and may contribute to the development of various types of cancer.

Yellowstone by Night

Most of Yellowstone is free of artificial light. This allows the viewing of cosmic events like meteor showers, comets, and even the Aurora Borealis. However, in developed areas throughout the park there are more than 5,000 light fixtures. Visitors often encounter bright light fixtures illuminating parking areas and access to buildings making it difficult to view the natural night sky. Often these lights create glare and are too bright making it difficult to see. Yellowstone is addressing this false sense that more light is safer with better lighting design, incorporating fully shielded lights that direct light only downward and are also low wattage, energy saving LEDs. Currently, only 46% of light fixtures are on at night and 75% those are fully shielded; helping to further preserve nighttime wilderness.

Quick Facts

Good Lighting Design Should:

- Avoid all upward light, glare, and sideways light.
- Be no brighter than necessary and light only areas where light is needed.
- Use uniform lighting so eyes can adjust easily and create smooth, gentle transitions from light to dark.
- Use lights in the yellow end of the spectrum (less than 3000K), not blue light which replicates daylight.
- Be energy efficient.

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Staff Reviewer

Lynn Chan, Landscape Architect

The landscape of Yellowstone National Park is the result of many geological processes. Here, glacial erratics (foreground), ground moraines (midground), and Cutoff Mountain (background) appear near Junction Butte.

Geology

The landscape of the Greater Yellowstone Ecosystem is the result of 150 million years of geological processes. Here, Earth's crust has been compressed, pulled apart, glaciated, eroded, and subjected to volcanism. This geologic activity formed the mountains, canyons, plateaus, and hydrothermal features that define the natural wonder that is Yellowstone.

While these mountains and canyons may appear to change very little during our lifetime, they are still highly dynamic and variable. Some of Earth's most active volcanic, hydrothermal (water and heat), and earthquake systems make this national park a priceless treasure. In fact, Yellowstone was established as the world's first national park primarily because of its extraordinary geysers, hot springs, mudpots, and steam vents, as well as other wonders such as the Grand Canyon of the Yellowstone River.

What Lies Beneath

Yellowstone's geologic story provides examples of how geologic processes work on a planetary scale. The foundation to understanding this story begins with the structure of the Earth and how this structure shapes the planet's surface.

Earth is frequently depicted as a ball with a central core surrounded by concentric layers that culminate in the crust or outer shell. The distance from Earth's surface to its center or core is approximately 4,000 miles. The core of the earth is divided into two parts. The mostly iron and nickel inner core (about 750 miles in diameter) is extremely hot but solid due to immense pressure. The iron and nickel outer core (1,400 miles thick) is hot and molten. The mantle (1,800 miles thick) is a dense, hot, semi-solid layer of rock. Above the mantle is the relatively thin crust, three to 48 miles thick, forming the continents and ocean floors.

In the key principles of Plate Tectonics, Earth's crust and upper mantle (lithosphere) is divided into

Yellowstone's Geologic Significance

Yellowstone continues today as a natural geologic laboratory of active Earth processes.

- One of the most geologically dynamic areas on Earth due to a shallow source of magma and resulting volcanic activity.
- One of the largest volcanic eruptions known to have occurred in the world, creating one of the largest known calderas.
- More than 10,000 hydrothermal features, including approximately 500 geysers—the most undisturbed hydrothermal features left in the world.
- The largest concentration of active geysers in the world—more than half of the world's total.
- Mammoth Hot Springs is one of the world's largest active travertine terraces.
- Site of many petrified trees formed by a series of andesitic volcanic eruptions 45 to 50 million years ago.

many plates, which are in constant motion. Where plate edges meet, they may slide past one another, pull apart, or collide. When plates collide, one plate is commonly driven beneath another (subduction). Subduction is possible because continental plates are made of less dense rocks (granites, which have a similar rock composition to the rhyolites and tuffs from the Yellowstone volcano) and, thus, "ride" higher than the basaltic oceanic plates. At divergent plate boundaries, such as mid-ocean ridges, the upwelling of magma pushes plates apart from each other.

Many theories have been proposed to explain crustal plate movement. Scientific evidence shows that convection currents in the partially molten asthenosphere (the zone of mantle beneath the lithosphere) move the rigid crustal plates above. The volcanism that has so greatly shaped today's Yellowstone is a product of plate movement combined with convective upwellings of hotter, semi-molten rock we call mantle plumes.

At a Glance

Although a cataclysmic eruption of the Yellowstone volcano is unlikely in the foreseeable future, real-time monitoring of seismic activity, volcanic gas concentrations, geothermal activity, and ground deformation helps ensure public safety. Yellowstone's seismograph stations, monitored by the University of Utah for the Yellowstone Volcano Observatory, detect several hundreds to thousands of earthquakes in the park each year. Scientists continue to improve our capacity to monitor the Yellowstone volcano through the deployment of new technology.

In the early 2000s, scientists implemented very precise Global Positioning Systems (GPS), capable of accurately measuring vertical and horizontal groundmotions to within a centimeter (0.4 in), and satellite radar imagery of ground movements called InSAR. These measurements indicated that parts of the Yellowstone caldera were rising at an unprecedented rate of up to seven centimeters (2.75 in) per year (2006) while an area near the northern caldera boundary started to subside. The largest vertical movement was recorded at the White Lake GPS station, inside the caldera's eastern rim, where the total uplift from 2004 to 2010 was about 27 centimeters (10.6 in). The caldera began to subside during the first half of 2010, entered into a renewed period of uplift from 2014 to 2015, and has since returned to subsidence. Episodes of uplift and subsidence have been correlated with changes in the frequency of earthquakes in the park.

On March 30, 2014, an earthquake of magnitude 4.8 occurred four miles north-northeast of Norris Geyser Basin. The M4.8 earthquake was felt in Yellowstone; Gardiner and West Yellowstone, Montana; and throughout the region. This was the largest earthquake in Yellowstone since the early 1980s. Analysis of the M4.8 earthquake indicates a tectonic origin (mostly strike-slip motion), but it was also involved with unusual ground uplift of 7 centimeters (2.75 in) at Norris Geyser Basin that lasted 6 months.

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Between 542 and 66 million years ago—long before the supervolcanic eruptions became part of Yellowstone's geologic story—the area was covered by inland seas.

Geologic History of Yellowstone

Most of Earth's history (from the formation of the earth 4.6 billion years ago to approximately 541 million years ago) is known as the Precambrian time. Rocks of this age are found in northern Yellowstone and in the hearts of the nearby Teton, Beartooth, Wind River, and Gros Ventre mountain ranges. During the Precambrian and the subsequent Paleozoic and Mesozoic eras (541 to 66 million years ago), the western United States was covered at times by oceans, sand dunes, tidal flats, and vast plains. From the end of the Mesozoic through the early Cenozoic, mountain-building processes formed the Rocky Mountains.

During the Cenozoic era (approximately the past 66 million years of Earth's history), widespread mountain-building, volcanism, faulting, and glaciation sculpted the Yellowstone area. The Absaroka Range along the park's north and east sides was formed by numerous volcanic eruptions about 50 million years ago. This period of volcanism is not related to the present Yellowstone volcano.

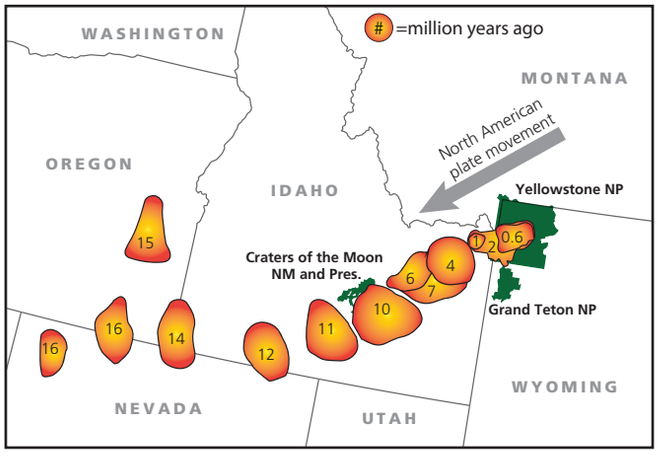
Approximately 30 million years ago, vast expanses of today's West began stretching apart along an east–west axis. This ongoing stretching process increased about 17 million years ago and created the modern basin and range topography (north–south mountain ranges with long north–south valleys) that characterizes much of the West, including the Yellowstone area.

About 16.5 million years ago, an intense period of volcanism initiated near the borders of present-day Nevada, Oregon, and Idaho. Subsequent volcanic eruptions can be traced across southern Idaho towards Yellowstone. This 500-mile trail of more than 100 calderas was created as the North American Plate moved in a southwestern direction over a shallow body of magma. About 2.1 million years ago, the movement of the North American plate brought the Yellowstone area closer to the shallow magma body. This volcanism remains a driving force in Yellowstone today.

Yellowstone Geologic History

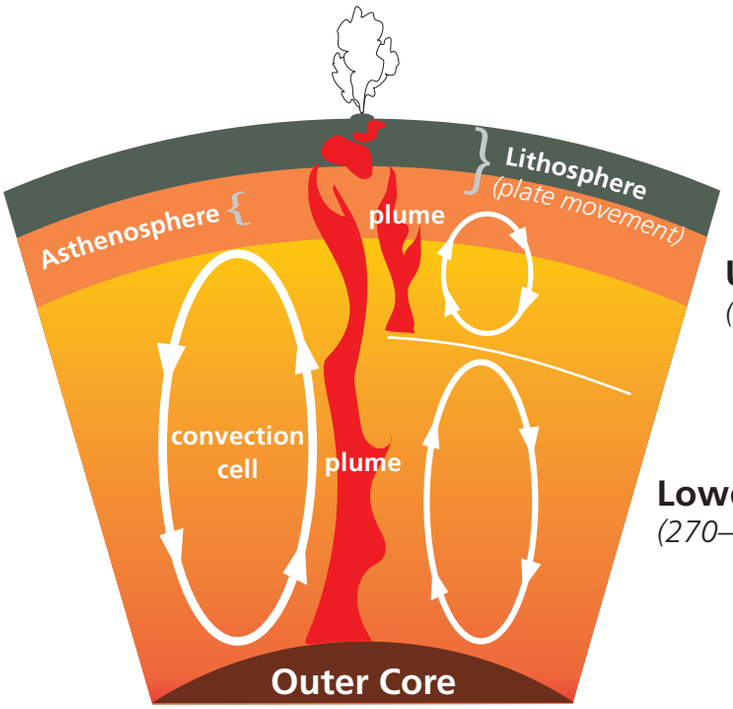
21 to 16 ka	Pinedale Glaciation maximum
160 to 151 ka	Bull Lake Glaciation underway
174 ka	West Thumb eruption
631 ka	3rd Yellowstone super-eruption
1.3 Ma	2nd Yellowstone super-eruption
2.1 Ma	1st Yellowstone super-eruption
16 Ma	Volcanism begins again in present-day Nevada and Idaho
30 Ma to present	"Basin and Range" forces creating Great Basin topography
50 to 40 Ma	Absaroka volcanics
542 to 66 Ma	Area covered by inland seas

Ma = mega annum, or millions of years ago
ka = kilo annum, or one thousand years ago



Ages in millions of years of major calderas formed by the movement of the North American plate over the deep hot spot.

ADAPTED FROM SMITH AND SIEGEL, 2000; AND HUANG ET AL., 2015.



Crust
(0–35 km)

Upper Mantle
(35–270 km)

Lower Mantle
(270–2,890 km)

Molten rock, or magma, rises in convection cells like water boiling in a pot. A hot spot may arise from a heated plume originating from the mantle-core boundary (left), or one originating from higher up in the mantle (right). The magma reservoirs of the Yellowstone hot spot originate at a much shallower depth than the mantle plume.

FREQUENTLY ASKED QUESTIONS:

Is Yellowstone a volcano?

Yes. Within the past two million years, some volcanic eruptions have occurred in the Yellowstone area—two of them super-eruptions.

What is the caldera shown on the park map?

The Yellowstone Caldera was created by a massive volcanic eruption approximately 631,000 years ago. Later lava flows filled in much of the caldera, which now measures 30 x 45 miles. Its rim can best be seen from the Washburn Hot Springs overlook, south of Dunraven Pass. Gibbon Falls, Lewis Falls, Lake Butte, and the Flat Mountain arm of Yellowstone Lake are part of the rim.

When did the Yellowstone volcano last erupt?

Approximately 174,000 years ago, creating what is now the West Thumb of Yellowstone Lake. The last of the 60–80 post-caldera lava flows were about 70,000 years ago.

Is Yellowstone's volcano still active?

Yes. The park's many hydrothermal features attest to the heat still beneath this area. Earthquakes—700 to 3,000 per year—also reveal activity below ground. The University of Utah Seismograph Station tracks this activity closely at http://quake.utah.edu.

What is Yellowstone National Park doing to stop or prevent an eruption?

Nothing can be done to prevent an eruption. The temperatures, pressures, physical characteristics of partially molten rock, and immensity of the magma chamber are beyond human ability to impact—much less control.

What is a supervolcanic eruption?

An eruption is supervolcanic when it ejects more than 240 cubic miles of magma. Two of Yellowstone's three major eruptions met this criteria.

Will the Yellowstone volcano erupt soon?

Another caldera-forming eruption is theoretically possible, but it is very unlikely in the next thousand or even 10,000 years. Scientists have also found no indication of an imminent smaller eruption of lava in more than 30 years of monitoring.

How do scientists know the Yellowstone volcano won't erupt?

Scientists from the Yellowstone Volcano Observatory watch an array of monitors in place throughout the region. These monitors would detect sudden or strong earthquake activity, ground shifts, and volcanic gases that would indicate increasing activity. No such evidence exists at this time.

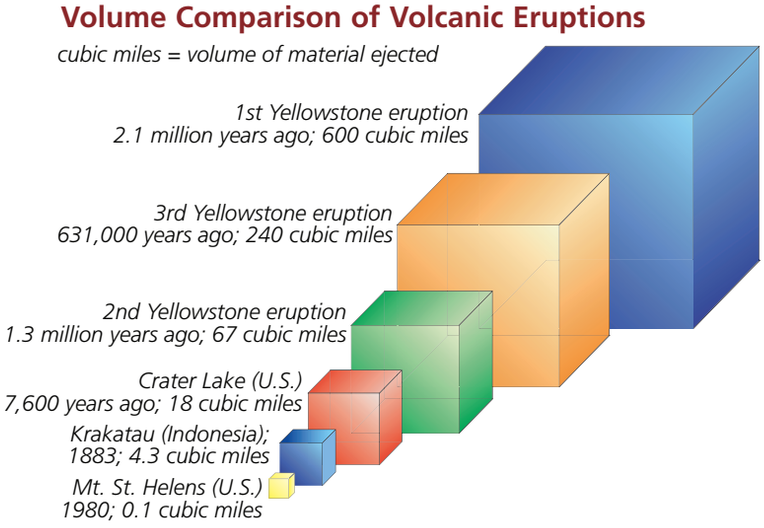
In addition, Yellowstone Volcano Observatory scientists collaborate with scientists from all over the world to study the hazards of the Yellowstone volcano. To view current data about earthquakes, ground movement, and stream flow, visit volcanoes.usgs.gov/yvo/.

If Old Faithful Geyser quits, is that a sign the volcano is about to erupt?

All geysers are highly dynamic, including Old Faithful. We expect Old Faithful to change in response to the ongoing geologic processes associated with mineral deposition and earthquakes. Thus, a change in Old Faithful Geyser will not necessarily indicate a change in volcanic activity.

Magma, Hot Spots, and the Yellowstone Volcano

Magma (molten rock from below Earth's crust) is close to the surface in the greater Yellowstone area. This shallow body of magma is caused by heat convection in the mantle. Plumes of magma rise through the mantle, melting rocks in the crust and creating magma reservoirs of partially molten, partially solid rock. Mantle plumes transport heat from deep in the mantle to the crust and create what we call "hot spot" volcanism. Hot spots leave a trail of volcanic activity as tectonic plates drift over them. As the North American Plate drifted southwestward over the past 16.5 million years, the hot spot that now resides under the greater Yellowstone area left a swath of volcanic deposits across Idaho's Snake River Plain.



Volume comparison of global volcanic eruptions.

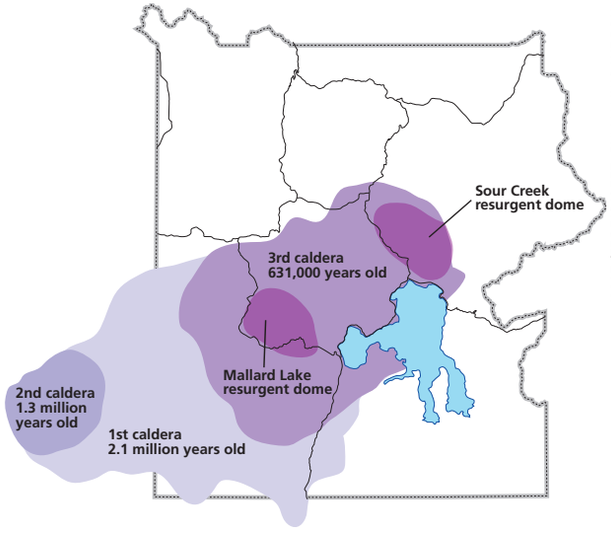
ADAPTED WITH PERMISSION FROM *WINDOWS INTO THE EARTH* BY ROBERT SMITH AND LEE J. SIEGEL, 2000.

Heat from the mantle plume has melted rocks in the crust and created two stacked magma chambers of partially molten, partially solid rock near Yellowstone's surface. Heat and increased pressure from the shallowest magma chamber caused an area of the crust above it to expand and rise. Stress on the overlying crust resulted in increased earthquake activity along newly formed faults. Eventually, these faults reached the magma reservoir, and magma oozed through the cracks. Escaping magma released pressure within the chamber, which also allowed volcanic gasses to escape and expand explosively in a massive volcanic eruption. The eruption spewed copious volcanic ash and gas into the atmosphere and produced fast, super-hot debris flows (pyroclastic flows) over the existing landscape. As the underground magma chamber emptied, the ground above it collapsed and created the first of Yellowstone's three calderas.

This eruption 2.1 million years ago—among the largest volcanic eruptions known to humans—coated about 6,000 square miles with ash, as far away as Missouri. The total volcanic material ejected is estimated to have been 6,000 times the volume of material ejected during the 1980 eruption of Mt. St. Helens, in Washington.

A second significant, though smaller, volcanic eruption occurred within the western edge of the first caldera approximately 1.3 million years ago. The third and most recent massive volcanic eruption 631,000 years ago created the present 30-by-45-mile-wide Yellowstone Caldera. Since then, 80 smaller eruptions have occurred. Approximately 174,000 years ago, one of these created what is now the West Thumb of Yellowstone Lake. During and after these explosive eruptions, huge flows of viscous rhyolitic lava partially filled the caldera floor and surrounding terrain. The youngest of these lava flows is the 70,000-year-old Pitchstone rhyolite flow in the southwest corner of Yellowstone.

Since the last of three caldera-forming eruptions, pressure from the shallow magma body has formed two resurgent domes inside the Yellowstone Caldera. Magma may be as little as 3–8 miles beneath Sour Creek Dome and 8–12 miles beneath Mallard Lake Dome, and both domes inflate and subside as the volume of magma or hydrothermal fluids changes



The locations of Yellowstone's three calderas and two resurgent domes.

ADAPTED WITH PERMISSION FROM *WINDOWS INTO THE EARTH* BY ROBERT SMITH AND LEE J. SIEGEL, 2000.

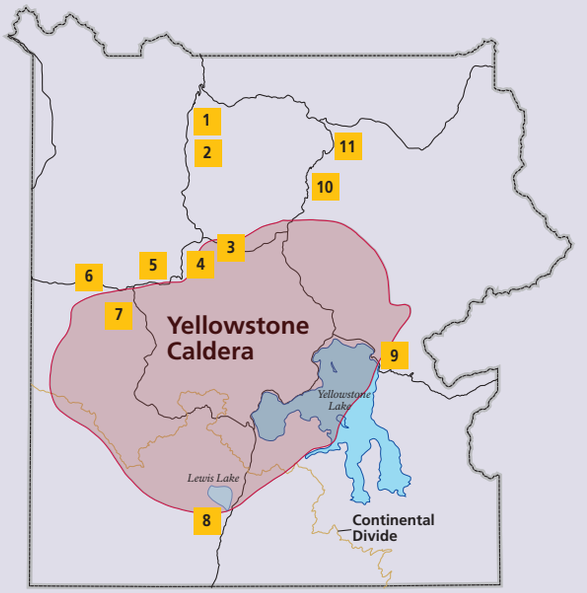
beneath them. The entire caldera floor lifts up or subsides, too, but not as much as the two domes. In the past century, the net inflation has tilted the caldera floor toward the south. As a result, Yellowstone Lake's southern shores have subsided, and trees now stand in water, and the north end of the lake has risen into a sandy beach at Fishing Bridge.

Recent Activity

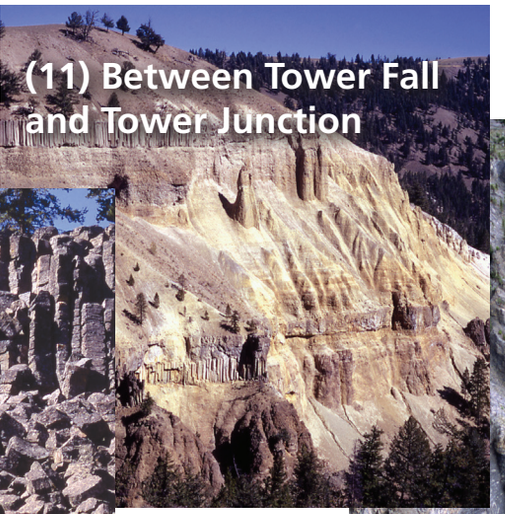
Remarkable ground deformation has been documented along the central axis of the caldera between Old Faithful and White Lake in Pelican Valley in historic time. Surveys began in 1975 measuring vertical motion of benchmarks. By 1985, the surveys documented unprecedented uplift of the entire caldera in excess of a meter (3 ft). Later GPS measurements revealed that the caldera went into an episode of subsidence (sinking) until 2005 when the caldera returned to an episode of extreme uplift. The largest vertical movement was recorded at the White Lake GPS station, inside the caldera's eastern rim, where the total uplift from 2004 to 2010 was about 27 centimeters (10.6 in).

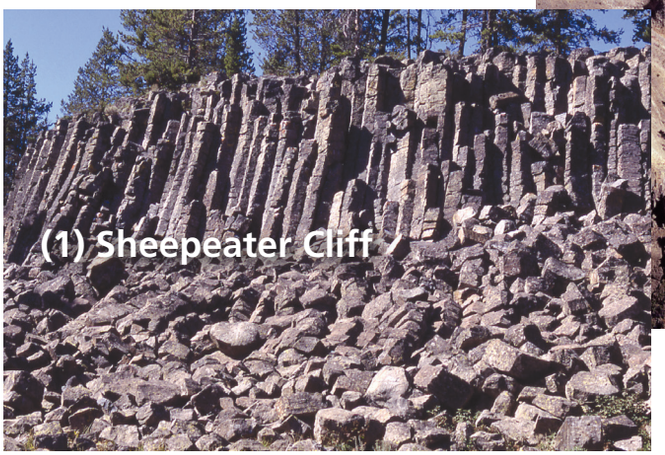
The rate of rise slowed in 2008, and the caldera began to subside again during the first half of 2010. The uplift is believed to be caused by the movement of deep hydrothermal fluids or molten rock into the shallow crustal magma system at a depth of about 10 km (6.2 mi) beneath the surface. A caldera may undergo episodes of uplift and subsidence for thousands of years without erupting. Notably, changes in uplift and subsidence have been correlated with increases of earthquake activity. Lateral discharge of these fluids away from the caldera—and the accompanying earthquakes, subsidence, and uplift—relieve pressure and could

Where to See Volcanic Flows



1. Sheepeater Cliff: columnar basalt
2. Obsidian Cliff: lava
3. Virginia Cascades: ash flow
4. Gibbon Falls: near caldera rim
5. Tuff Cliff: ash flow
6. West Entrance Road, Mt. Haynes, and Mt. Jackson: columnar rhyolite, Lava Creek tuff
7. Firehole Canyon: lava
8. Lewis Falls: near caldera rim
9. Lake Butte: on edge of caldera, overall view of caldera
10. Washburn Hot Springs Overlook: overall view of caldera
11. Between Tower Fall and Tower Junction: columnar basalt





Yellowstone Volcano Observatory

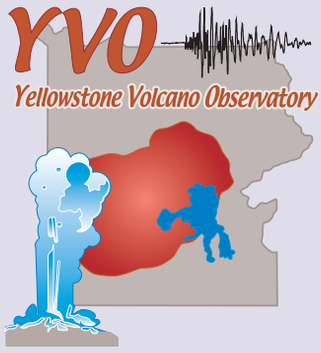
Increased scientific surveillance of Yellowstone has detected significant changes in its vast underground volcanic system. The system is centered on an enormous caldera that is characterized by geologically infrequent but very large volcanic eruptions.

To strengthen the ability of scientists to track and respond to changes in Yellowstone's activity, the Yellowstone Volcano Observatory (YVO) was created here in 2001. YVO is a cooperative partnership among the US Geological Survey, National Park Service, University of Utah, University of Wyoming, University NAVSTAR Consortium, and State Geological Surveys of Wyoming, Montana, and Idaho. The observatory is a long-term, instrument-based monitoring program designed for observing volcanic and seismic activity in the Yellowstone National Park region.

The principal goals of the Yellowstone Volcano Observatory are to

- assess the long-term potential hazards of volcanism, seismicity, and explosive hydrothermal activity in the region;
- provide scientific data that enable reliable and timely warnings of significant seismic or volcanic events and related hazards in the Yellowstone region;
- notify the NPS, local officials, and the public in the event of such warnings;
- improve scientific understanding of tectonic and magmatic processes that influence ongoing seismicity, surface deformation, and hydrothermal activity; and
- effectively communicate the results of these efforts to responsible authorities and to the public.

Current real-time-monitoring data are online at volcanoes.usgs.gov/yvo/monitoring.html.



act as a natural pressure-release valve, balancing magma recharge and keeping Yellowstone safe from volcanic eruptions.

Future Volcanic Activity

Will Yellowstone's volcano erupt again? Over the next thousands to millions of years? Probably. In the next few hundred years? Not likely.

The most likely activity would be lava flows, such as those that occurred after the last major eruption. A lava flow would ooze slowly over months and years, allowing plenty of time for park managers to evaluate the situation and protect people. No scientific evidence indicates such a lava flow will occur soon.

To monitor volcanic and seismic activity in the Yellowstone area, the Yellowstone Volcano Observatory (YVO) was established in 2001. YVO is a partnership of scientists from the US Geological Survey, National Park Service, University of Utah, University of Wyoming, Montana State University, University NAVSTAR Consortium (UNAVCO), and the state Geological Surveys of Wyoming, Montana, and Idaho. YVO scientists monitor the Yellowstone volcano with a real-time and near real-time monitoring network of 40 seismic stations, 16 GPS receivers, and 11 stream-gauging stations. Scientists also collect information on temperature, chemistry, and gas concentrations at selected hydrothermal features and chloride concentrations in major rivers. A monthly activity summary, real-time monitoring of seismicity and water flow, and near real-time monitoring of ground deformation can be found at the Yellowstone Volcanic Observatory website.

More Information

A field trip guide to the petrology of Quaternary volcanism on the Yellowstone Plateau: https://pubs.er.usgs.gov/publication/sir20175022Q

Caldera Chronicles: https://volcanoes.usgs.gov/volcanoes/yellowstone/article_home.html?vaid=251

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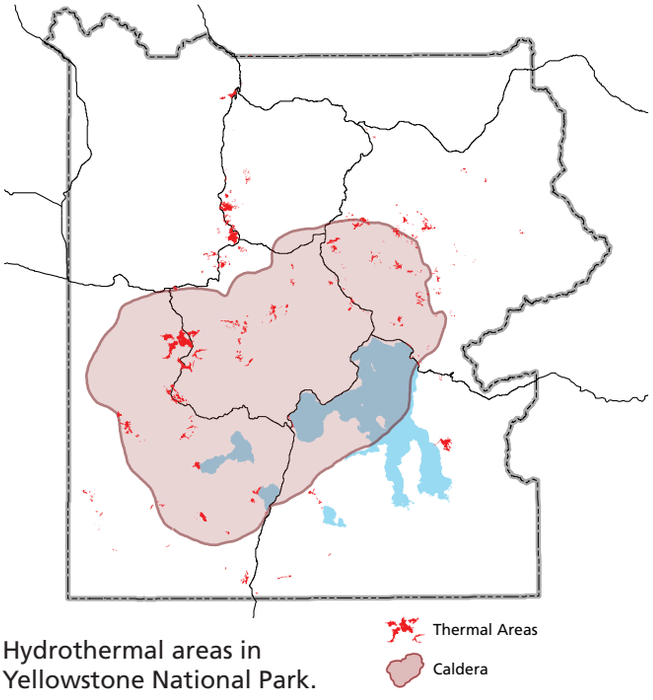
Grand Prismatic Spring is one of more than 10,000 thermal features in Yellowstone. Research on heat-resistant microbes in the park's hydrothermal areas has led to medical, forensic, and commercial uses.

Hydrothermal Systems

Yellowstone was set aside as the world's first national park because of its hydrothermal wonders. The park contains more than 10,000 thermal features, including the world's greatest concentration of geysers as well as hot springs, mudpots, and steam vents. Research on heat-resistant microbes in the park's thermal areas has led to medical, forensic, and commercial uses. Oil, gas, and groundwater development near the park, and drilling in "Known Geothermal Resources Areas" identified by the US Geological Survey in Island Park, Idaho, and Corwin Springs, Montana, could alter the functioning of hydrothermal systems in the park. So in 1994, the National Park Service and State of Montana established a water-rights compact and controlled-groundwater area to protect those areas from development.



Hydrothermal areas in Yellowstone National Park.

Under the Surface

The park's hydrothermal system is the visible expression of the immense Yellowstone volcano; it would not exist without the underlying partially molten magma body that releases tremendous heat. The system also requires water, such as ground water from the mountains surrounding the Yellowstone Plateau. There, snow and rain slowly percolate through layers of permeable rock riddled with cracks. Some of this cold water meets hot brine directly heated by the shallow magma body. The water's temperature rises well above the boiling point, but the water remains in a liquid state due to the great pressure and weight of the overlying water. The result is superheated water with temperatures exceeding 400°F.

The superheated water is less dense than the colder, heavier water sinking around it. This creates convection currents that allow the lighter, more buoyant, superheated water to begin its journey back to the surface following the cracks and weak areas through rhyolitic lava flows. This upward path is the natural "plumbing" system of the park's hydrothermal features.

As hot water travels through this rock, it dissolves some silica in the rhyolite. This silica can precipitate in the cracks, increasing the system's ability to withstand the great pressure needed to produce a geyser.

At the surface, silica precipitates to form siliceous sinter, creating the scalloped edges of hot springs and the seemingly barren landscape of hydrothermal basins. The siliceous sinter deposits, with bulbous or cauliflower-like surfaces, are known as geyserite.

Hydrothermal Activity

The park's hydrothermal areas are dispersed across 3,472 square miles (8,991 km^2) making it challenging to coordinate a systematic monitoring program. Thus, geologists use remote sensing, groundwater

flow studies, measurements from individual features, and collaboration with other researchers to gather reproducible data over many years. The variety and duration of monitoring helps to distinguish human influences from natural changes, and define the natural variability of the hydrothermal system. This distinction is essential for Yellowstone to successfully protect the integrity of the system as a whole.

Hydrothermal variability is easiest to see in individual features. On March 15, 2018, Steamboat Geyser began a period of more frequent eruptions after three and a half years of dormancy. The world's tallest active geyser erupted 32 times in 2018, 48 in 2019 and 2020, 20 in 2021, 11 in 2022, 9 in 2023, and 6 in 2024. Eruption intervals ranged from three to 89 days. The Upper Geyser Basin also experienced increased activity around the Geyser Hill area in the fall of 2018. This includes new erupting vents splashing water on the boardwalks, surface fractures, and a rare eruption of Ear Spring on September 15, 2018. The eruption ejected a variety of foreign objects: coins and trash dating back to the 1930s. The Old Faithful eruption typical interval is 102 minutes (+/- 10 minutes) as of January 2025.

These highly visible changes receive public attention, but do not necessarily represent changes in the entire hydrothermal system. New research methods and technology enhance our understanding. Work continues to progress documenting the status of the hydrothermal system by measuring the total amount of thermal water and the total heat output for selected geyser basins. Thermal infrared images taken by aircraft are used to document changes in the hydrothermal areas. Research measuring seismic activity in the Upper Geyser Basin and Norris Geyser Basin used "harmonic tremors" preceding eruptions

FREQUENTLY ASKED QUESTIONS:

Why are geysers in Yellowstone?

Yellowstone's volcanic geology provides the three components necessary for the existence of geysers and other hydrothermal features: heat, water, and a natural "plumbing" system. Magma beneath the surface provides the heat; ample rain and snowfall seep deep underground to supply the water; and underground cracks and fissures form the plumbing. Hot water rises through the plumbing to surface as hydrothermal features.

What exactly is a thermal basin?

A thermal basin is a geographically distinct area containing a "cluster" of hydrothermal features that may include geysers, hot springs, mudpots, and fumaroles. These distinct areas often, but not always, occur in low places because hydrothermal features tend to be concentrated around the margins of lava flows and in areas of faulting.

Where can I see mudpots?

Small mudpot areas occur at West Thumb Geyser Basin, Fountain Paint Pot, and Artists' Paintpots. The largest group of mudpots can be found at Mud Volcano, at the southern end of Hayden Valley.

What is the oldest thermal area in the park, active or inactive?

Terrace Mountain, near Mammoth Hot Springs, is evidence of carbonate hot spring deposits up to 406,000 years old.

What is the most active thermal area in the park?

Norris Geyser Basin is the hottest and most dynamic of Yellowstone's active hydrothermal areas. The highest temperature yet recorded in any Yellowstone hydrothermal area was measured in a scientific drill hole at Norris: 459°F (237°C) just 1,087 feet below the surface. Norris shows evidence of having had hydrothermal activity prior to the last great ice age. The features change often, with frequent disturbances from seismic activity and water fluctuations. Norris is so hot and dynamic primarily because it sits at the intersection of three major faults, two of which intersect with a ring fracture zone from the Yellowstone Caldera eruption of 631,000 years ago.

Is Yellowstone's geothermal energy used to heat park buildings?

Yellowstone National Park's hydrothermal resources cannot be tapped for geothermal energy because such use could destroy geysers and hot springs, as it has done in other parts of the world.

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

Dogs have died diving into hot springs. They also disturb wildlife and are prohibited from all park trails. In the few places pets are permitted, they must be leashed at all times. Ask at a visitor center where you can walk a pet.

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

YES. Geyser basins are constantly changing. Boiling water surges just under the thin crust of most geyser basins, and many people have been severely burned when they have broken through the fragile surface. Some people have died. You may not be able to be detected thin crust above hot waters or acid vapors just by looking.

Why can't I smoke in the geyser basins?

Cigarette butts quickly accumulate where smoking is allowed, and they—like any litter—can clog vents, thus altering or destroying hydrothermal activity.

Hydrothermal Features in Yellowstone

Fumaroles, or steam vents, are the hottest hydrothermal features in the park. The limited amount of water flashes into steam before reaching the surface. At places like Roaring Mountain (above), the result is a loud hissing of steam and gases.

Travertine terraces, found at Mammoth Hot Springs (above), are formed from limestone (calcium carbonate). Water rises through the limestone, carrying high amounts of dissolved carbonate minerals. At the surface, carbon dioxide is released and carbonate minerals like calcite are deposited, forming travertine, the chalky white rock of the terraces. Due to the rapid rate of deposition, these features change constantly and quickly.

Mudpots, such as those near Mud Volcano (above), are acidic features with a limited water supply. Some microorganisms use hydrogen sulfide, which rises from deep within the earth, as an energy source. They help convert the gas to sulfuric acid, which breaks down rock into clay minerals. Various gases escape through the wet clay mud, causing it to bubble. Mudpot consistency and activity vary with the seasons and precipitation.

Cone geysers, such as Riverside in the Upper Geyser Basin (left), erupt in a narrow jet of water. **Fountain geysers**, such as Great Fountain in the Lower Geyser Basin (right), shoot water in various directions, typically from a pool.

Hot springs, such as this one at West Thumb (above), are the most common hydrothermal features in the park. Their plumbing has no constrictions. Superheated water cools as it reaches the surface, sinks, and is replaced by hotter water from below. This process, called convection, prevents water from reaching the temperature needed to set off an eruption.

How Geysers Erupt

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

to create three-dimensional images of geyser reservoirs and plumbing systems. This produced the first three-dimensional seismic images of the Old Faithful and Steamboat plumbing systems.

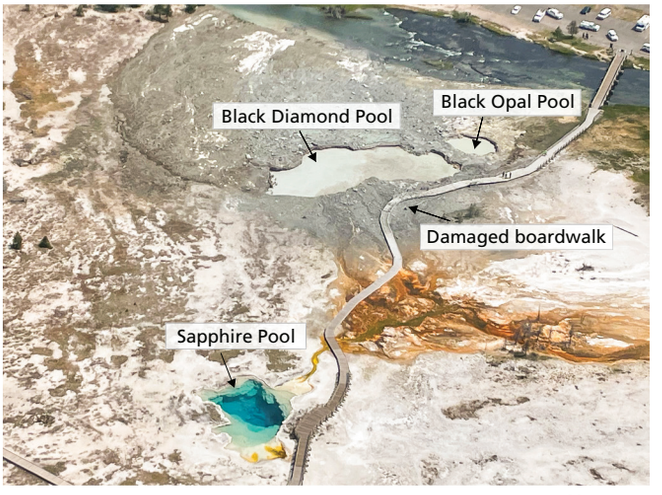
Hydrothermal Explosions

The rapid transition of water to steam in the subsurface is the phenomenon that drives both geyser eruptions and hydrothermal explosions. This rapid transition happens all the time in established geyser systems, like Old Faithful Geyser or Steamboat Geyser, where well-defined conduit systems allow that steam and hot water to rapidly escape to the surface and result in a geyser eruption.

When the energy released during the liquid to steam transition exceeds the confining force of the subsurface conduit and reservoir system, the pressure due to the expansion of steam bubbles overcomes the strength of the rock, and an explosion occurs. The explosion fragments the surrounding rock and creates jets of steam, water, and pieces of rock that vary from silt-sized particles to large boulders that can be strewn about hundreds of meters from the source vent.

On July 23, 2024, a hydrothermal explosion occurred when waters violently flashed to steam beneath Black Diamond Pool in Biscuit Basin. Multiple explosive jets sent steam and debris hundreds of feet into the air, destroyed the nearby boardwalk and ejected grapefruit-sized rocks tens to hundreds of feet from the source. Some blocks closest to the explosion site are about 3 feet (1 meter) wide and weigh hundreds of pounds. The explosion was largely directed to the northeast toward the Firehole River, and the largest blocks of debris fell in that direction. Geologists are collecting data from the explosion debris to better understand the exact conditions at the time of the event.

A section of boardwalk near the hydrothermal explosion at Biscuit Basin was destroyed. Although visitors were present at the time of the event, no injuries were reported.



Black Diamond Pool and Black Opal Pool were affected by the explosion but remain distinct features, although the shape of Black Diamond has changed somewhat.

Similar, although smaller, hydrothermal explosions took place in 1989 at Porkchop Geyser in Norris Geyser Basin, and on April 15, 2024, from the Porcelain Terrace Area of Norris Geyser Basin. A small hydrothermal explosion occurred from Wall Pool, in Biscuit Basin, in 2009. Significant hydrothermal explosions, probably similar in size to that of July 23, 2024, occurred in the 1880s at Excelsior Geyser, in Midway Geyser Basin.

Hydrothermal explosions typically occur in the park one to a few times per year, but often in the backcountry where they may not be immediately detected.

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The geology below Yellowstone Lake reflects shaping by lava flows where the lake lies within the caldera and shaping by glacial and other processes in the southern half of the lake that lies outside the caldera.

Yellowstone Lake Geology

Until the late 1990s, few details were known about the geology beneath Yellowstone Lake. In 1996, researchers saw anomalies on the floor of Bridge Bay as they took depth soundings. They deployed a submersible remotely operated vehicle (ROV) equipped with photographic equipment and sector-scan sonar. Large targets appeared on the sonar image, then suddenly very large, spire-like structures appeared in the photographic field of view. These structures looked similar to hydrothermal structures found in deep ocean areas, such as the Mid-Atlantic Ridge and the Juan de Fuca Ridge. The structures also provided habitat for aquatic species such as fresh-water sponges and algae.

Lake-bottom Surveys

From 1999 to 2007, scientists from the US Geological Survey and a private company, Eastern Oceanics, surveyed the bottom of Yellowstone Lake using high-resolution, multi-beam swath sonar imaging, seismic-reflection profiling, and a ROV. The survey confirmed the northern half of the lake is inside the 631,000-year-old Yellowstone Caldera and mapped previously unknown features such as large hydrothermal explosion craters, siliceous spires, hundreds of hydrothermal vents, and craters and fissures. The survey also mapped young, previously unmapped faults, landslide deposits, and submerged, older lake shorelines. These features are part of an undulating landscape shaped by rhyolitic lava flows that filled the caldera. The southern half of the lake lies outside the caldera and has been shaped by glacial and other processes. The floor of the Southeast Arm has many glacial features similar to the glacial terrain seen on land in Jackson Hole, south of the park.

These new surveys give an accurate picture of the geologic processes shaping Yellowstone Lake and

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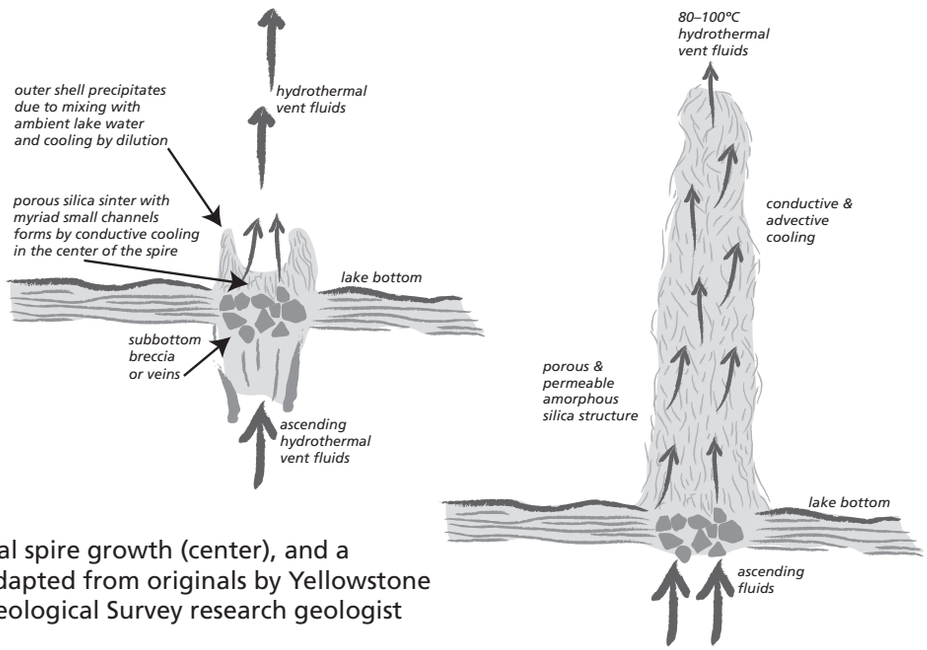
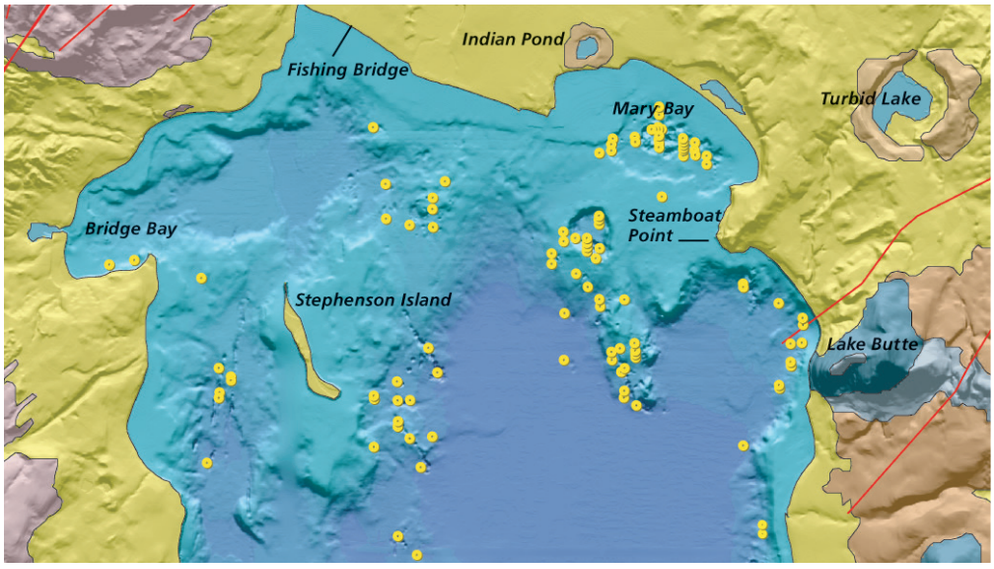
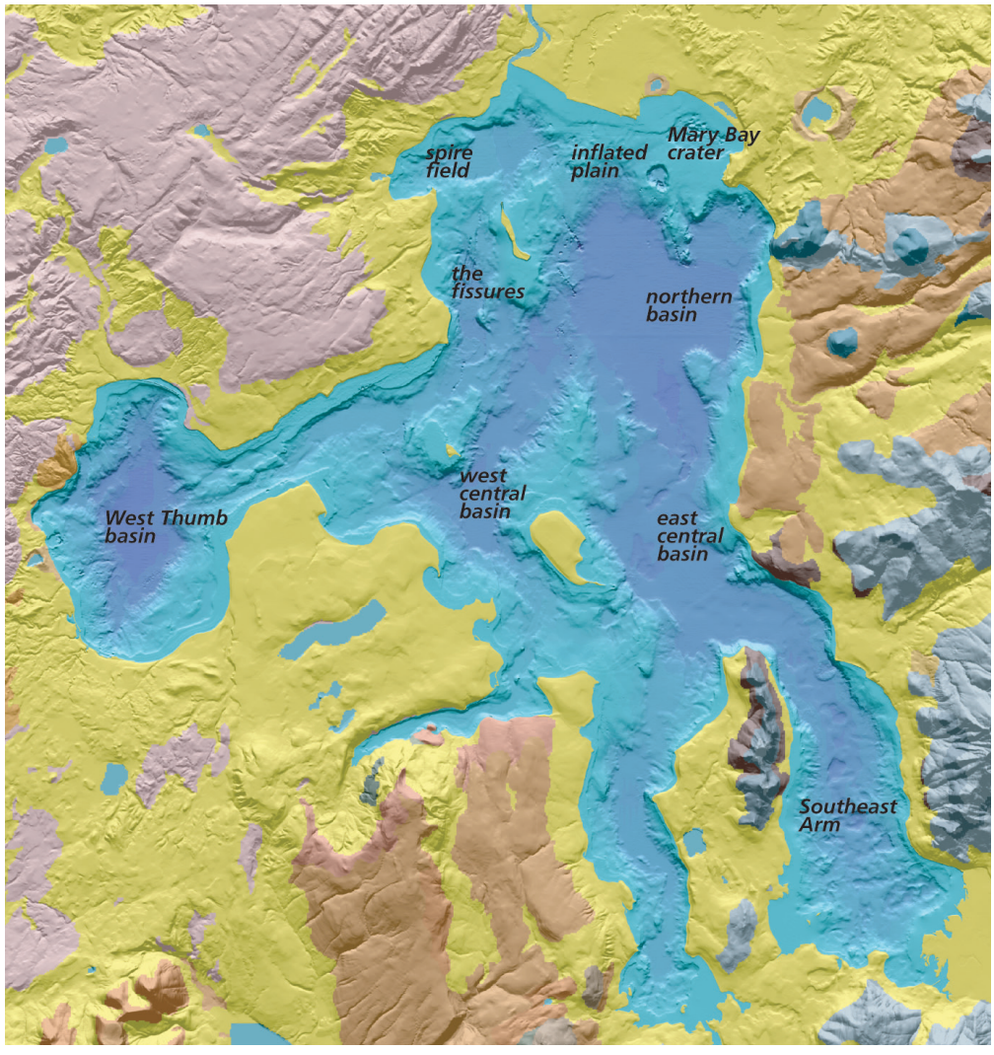


A photo of a Bridge Bay spire, initial spire growth (center), and a mature spire (right). Illustrations adapted from originals by Yellowstone National Park researcher and US Geological Survey research geologist Lisa Morgan.



USGS/ LISA MORGAN



USGS/ LISA MORGAN

Yellowstone Lake has existed since the end of the Pinedale glaciation. The lake drains north from its outlet at Fishing Bridge into the vast Atlantic Ocean drainage via the Yellowstone River. The elevation of the lake's north end does not drop substantially until LeHardys Rapids, which is considered the northern geologic boundary of the lake. The top map shows locations of hydrothermal vents in northern Yellowstone Lake; the map below shows the geologic features of the lake bottom. Both maps resulted from the five-year survey project.

determine geologic influences affecting the present-day aquatic biosphere. For example, hydrothermal explosions formed craters at Mary Bay, Turbid Lake, and Indian Pond. Spires may form similarly to black smoker chimneys, which are hydrothermal features associated with oceanic plate boundaries.

Spire Analysis

With the cooperation of the National Park Service, scientists from the University of Wisconsin–Milwaukee collected pieces of spires and a complete small spire for study by several teams. They conducted a CAT scan of the spire, which showed structures seeming to be conduits, perhaps for hydrothermal circulation. When they cut open the spire, they confirmed the presence of conduits and also saw a layered structure.

Tests by the US Geological Survey show that the spire is about 11,000 years old, which indicates it was formed after the last glaciers retreated. In addition to silica, the spire contains diatom tests (shells) and silica produced by underwater hydrothermal processes. The spire's interior shows evidence of thermophilic bacteria. Scientists say this suggests that silica precipitated on bacterial filaments, thus playing an important role in building the spire.

These and other research projects are expanding our understanding of the geological processes at work beneath Yellowstone Lake. Additional study of the spires and other underwater features will continue to contribute to our understanding of the relationship between these features and the aquatic ecosystem.

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Anywhere from 700 to 3,000 earthquakes occur each year in the Yellowstone area; most are not felt. The 1959 Hebgen Lake earthquake (7.3 *M*) caused significant damage to park roads, shown here near Gibbon Falls.

Earthquakes

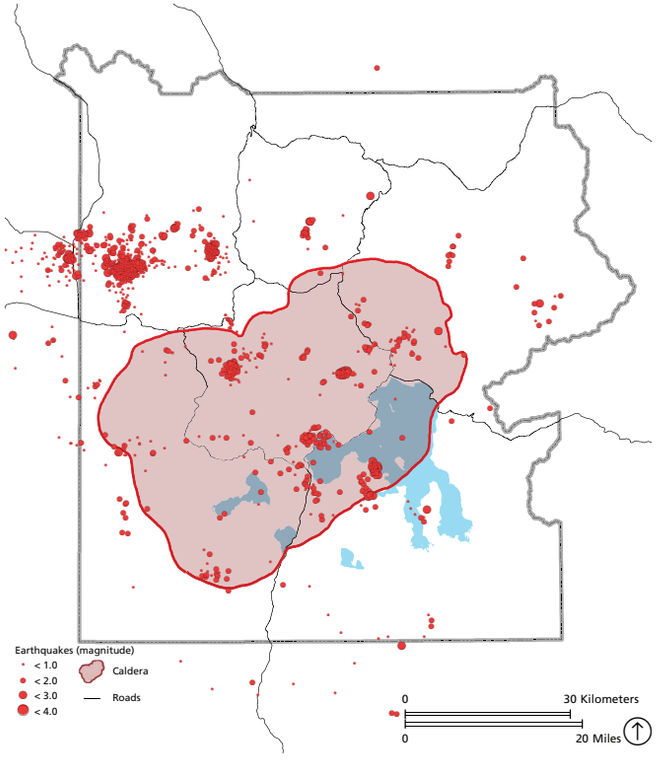
Yellowstone is one of the most seismically active areas in the United States. Approximately 700 to 3,000 earthquakes occur each year in the Yellowstone area; most are not felt. They result from the extensive network of faults associated with the volcano and surrounding tectonic features. Yellowstone earthquakes tend to occur in swarms—close together in time and space. This phenomenon is related to transport of volcanic fluids along the many small fractures in the shallow rocks over the magma, a pattern that has been noted in volcanos around the world.

Earthquakes occur along fractures in the crust where stress from crustal plate movement and volcanic activity build to a significant level. The rock along these faults becomes so strained that eventually it slips or breaks. Energy is then released as shock waves (seismic waves) that reverberate throughout the surrounding rock. Once a seismic wave reaches the surface of the Earth, it may be felt. Surface waves affect the ground, which can roll, crack open, or be vertically and/or laterally displaced. Structures are susceptible to earthquake damage because of both horizontal and vertical ground motion.

In Yellowstone, earthquakes help to maintain hydrothermal activity by keeping the "plumbing" system open. Without periodic disturbance from relatively small earthquakes, the small fractures and conduits that supply hot water to geysers and hot springs might be sealed by mineral deposition. Some earthquakes generate changes in Yellowstone's hydrothermal systems. For example, the 1959 Hebgen Lake (7.3 *M*) and 1983 Borah Peak (6.9 *M*) earthquakes caused measurable changes in Old Faithful Geyser and other hydrothermal features.

Yellowstone commonly experiences "earthquake swarms"—a series of earthquakes over a short period of time in a localized area. The largest swarm occurred in 1985, with more than 3,000 earthquakes recorded during three months on the northwest side of the park. Hundreds of quakes were recorded during swarms in 2009 near Lake Village and 2010 between Old Faithful area and West Yellowstone, MT. Scientists posit these swarms are due to shifting and changing pressures in the Earth's crust that are caused by migration of hydrothermal fluids, a natural occurrence of volcanoes.

The Maple Creek Swarm began on June 12, 2017, and persisted until October. A cluster of more than 2,475 earthquakes was recorded in the area six miles



Approximately 1,950 earthquakes with magnitudes greater than 0.0 occurred in and directly outside of Yellowstone in 2018. Earthquake data provided courtesy of University of Utah Seismograph Stations Network.

north of West Yellowstone, Montana, and on the west side of the park. Earthquake sequences like these are common and account for roughly 50% of the total seismicity in the Yellowstone region

Earthquakes help us to map and to understand the sub-surface geology around and beneath Yellowstone. The energy from earthquakes travels through hard and molten rock at different rates. Scientists can "see" the subsurface and make images of the magma reservoir and the caldera by "reading" the seismic waves emitted during earthquakes. An extensive geological monitoring system is in place to aid in that interpretation.

On June 16, at 6:48 PM Mountain Daylight Time, the largest earthquake of 2017 occurred. The magnitude 4.4 quake was located about nine miles north-northwest of West Yellowstone, Montana. The earthquake was reported felt in the towns of Gardiner and West Yellowstone, Montana. It was the largest quake since the 4.8 *M* that occurred on March 30, 2014. This earthquake was part of an energetic swarm in the same area.

Beginning in the fall of 2015, the University of Utah, in collaboration with the University of Texas El Paso and Yellowstone National Park began deploying seismic instrumentation around Old Faithful and the Upper Geyser Basin. Repeat deployments have been done in 2016, 2017, and 2018 as well. The goals of this work are to image the subsurface of the geyser basin and in particular, the plumbing system of Old Faithful, as well as to record seismic signals related to hydrothermal activity that can shed light on how these systems work. In total, they have installed around 980 nodal seismometers in and around the Upper Geyser Basin. They have revealed the plumbing system of Old Faithful down to about 80 meters (~260 feet).

Starting in 2018, and continuing into 2019, due to the increased activity of Steamboat Geyser, they started doing similar deployments in the Norris Geyser Basin. These deployments have focused on recording major eruptions of Steamboat Geyser and imaging the subsurface connection between Steamboat Geyser and Cistern Pool (which drains shortly after major eruptions of Steamboat). These data provide an unprecedented look into the Steamboat Geyser (the tallest active geyser in the world) eruption process during this historic run of activity.

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Real-time earthquake data: www.seis.utah.edu

University of Utah Yellowtone Research: www.uusatrg.utah.edu/

Yellowstone Volcano Observatory: volcanoes.usgs.gov/yvo

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Much of Yellowstone was shaped by glaciers. Glacial erratics are scattered across Yellowstone's landscape, as shown here alongside a glacially formed pond in the Lamar Valley.

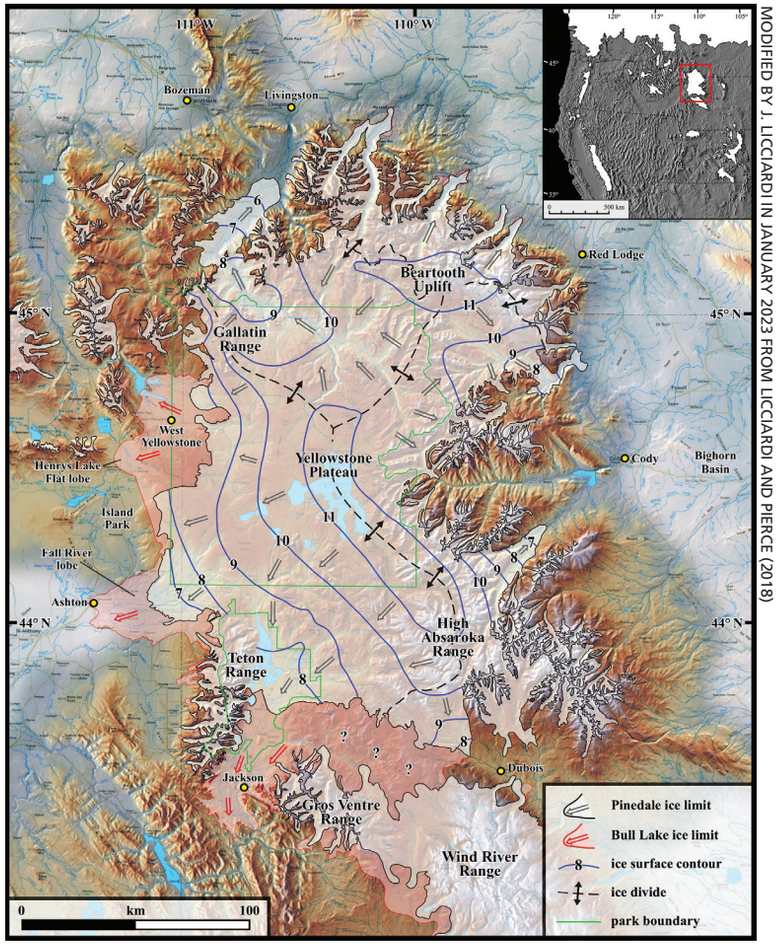
Glaciers

Glaciers result when, for a period of many years, more snow falls in an area than melts. Once the snow reaches a certain depth, it turns into ice and begins to move under the force of gravity or the pressure of its own weight. During this movement, rocks are picked up and carried in the ice, and these rocks grind and sculpt Earth's surface. Once the glacier eventually melts and recedes, rocks and sediments are released from the ice or transported by meltwater streams, and deposited on the surface. Large U-shaped valleys, ridges of debris (moraines), and out-of-place boulders (erratics) are evidence of a glacier's passage across a landscape.

Yellowstone and much of North America have experienced numerous periods of glaciation during the last 2.6 million years. Succeeding periods of glaciation have destroyed most surface evidence of previous glacial periods, but scientists have found evidence of them in sediment cores taken on land and in the ocean. In Yellowstone, a glacial deposit near Tower Fall dates back 1.3 million years. Evidence of such ancient glaciers is rare.

About 150,000 to 140,000 years ago, glaciers covered the Yellowstone region in an episode known as the Bull Lake glaciation. Evidence exists that this glacial episode extended farther south and west of Yellowstone than the subsequent glaciation, known as the Pinedale, but little surface evidence of it is found to the north and east. This indicates that the Pinedale glaciation covered or eroded surface evidence of Bull Lake glaciation in these areas.

The Yellowstone region's last major glaciation, the Pinedale, is the most thoroughly studied. Its beginning has been hard to pin down because field evidence is missing or inconclusive and dating techniques are inadequate. Ages of the Pinedale maximum vary around the Yellowstone Ice Cap from 20,000 years ago on the east to 18,000 years ago on



MODIFIED BY J. LICCIARDI IN JANUARY 2023 FROM LICCIARDI AND PIERCE (2018)

Light shaded areas bounded by black and red lines indicate the areas covered during the Pinedale and Bull Lake glaciations, respectively. Blue lines are contours in thousands of feet on the reconstructed Pinedale glacier surface. Black dashed lines with double-pointed arrows indicate main ice divides. Yellowstone and Grand Teton National Park boundaries are shown by green outlines.

the north and possibly as young as 16,000–15,000 years ago on the south. Most of the Yellowstone Plateau became ice-free between 15,000–14,000 years ago.

During the Pinedale glaciation, glaciers advanced and retreated from the Beartooth Plateau, altering the present-day northern range. During glacial retreat, meltwater flowed through and covered Hayden Valley, depositing various sediments. Glacial dams also backed up water in the Lamar Valley; when the dams failed, catastrophic floods helped to form the modern landscape around the North Entrance of the park.

During the peak of the Pinedale glaciation, the center of the Yellowstone Plateau was covered by an ice cap that was over 3,500 feet thick. Mount Washburn was completely covered by ice. This ice cap was not part of the continental ice sheet extending south from Canada. A large ice cap formed on the Yellowstone volcanic plateau, in part, because the Yellowstone hot spot caused uplift of this region, and the resulting high elevations allowed large amounts of snow to accumulate.

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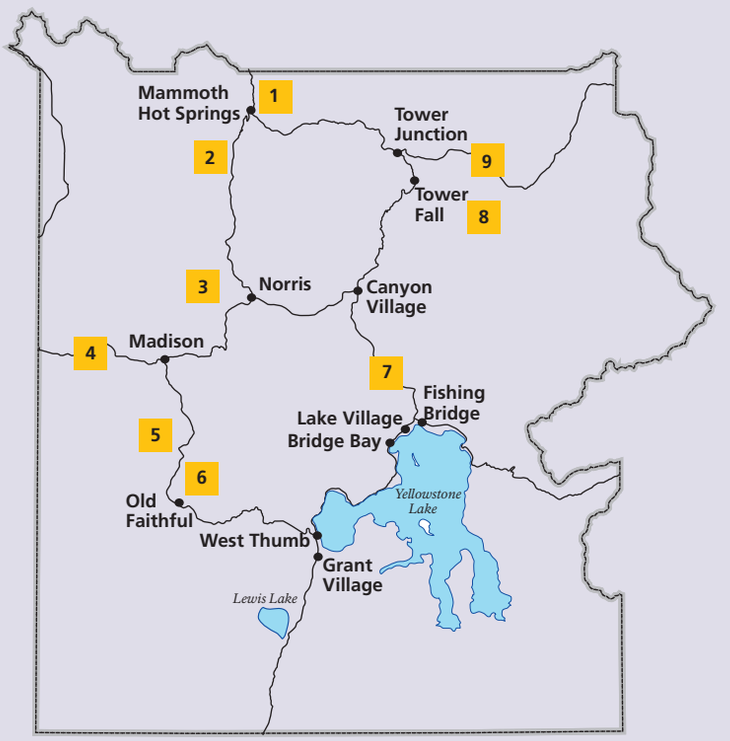
Where to See Evidence of Glaciers



1. Mammoth Hot Springs: Thermal kames (steep-sided mounds of sand and gravel deposited by melting ice sheets) exist in this area. Mount Everts and Bunsen Peak were both overridden by ice. The top of Sepulcher Mountain peeked above the Pinedale ice.
2. Swan Lake Flat: These meadows and wetlands formed after the glaciers retreated. Electric Peak, to the northwest, was also sculpted by glaciers.
3. Norris Geyser Basin: Several high peaks in the Gallatin Mountains stood above the Pinedale ice cap.
4. Madison Valley, west of Seven Mile Bridge: Glacial moraines, glacial outwash, and recent Madison River deposits can be seen.
5. Fountain Flats: The Porcupine Hills and Twin Buttes are thermal kames.
6. Upper Geyser Basin: Volcanic rocks and ice-water contact deposits are present here. Deposits underlying this and other geyser basins in the area store the water necessary for geysers to occur and allow the water to percolate up from depth.
7. Hayden Valley: The valley is floored with glacial lake sediments that formed when Pinedale ice dammed the Yellowstone River and created a lake. The valley also has a variety of large boulders, known as glacial erratics, that were carried here by ice that flowed south from the Beartooth Mountains. The glacial lake sediments contain an abundance of fine grain sizes, including clay, that do not allow water to percolate quickly into the ground. Thus, Hayden Valley is marshy.
8. Tower Fall area: North of Tower Fall, sediments between layers of basalts may show evidence of the oldest known glaciation in Yellowstone. Plus, huge glacial erratics from the last major glaciation rest atop the youngest basalt.
9. Lamar Valley: Huge boulders and ponds between the Lamar and Yellowstone rivers were left by melting glaciers, as were several moraines. Other ponds have formed within post-glacial landslides.

Sedimentation and erosion actively shape Yellowstone's landscape. Here, the Lamar River erodes its banks and transports the sediment for deposition elsewhere.

Sedimentation and Erosion

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

Sedimentary sandstones and shales, deposited by seas during the Paleozoic and Mesozoic eras (approximately 540 million to 66 million years ago) can be seen in the Gallatin Range and Mount Everts. Sedimentary rocks in Yellowstone tend to erode more easily than the Precambrian rocks.

Weathering breaks down earth materials from large sizes to small particles, and happens in place. The freeze/thaw action of ice is one type of weathering common in Yellowstone. Agents of erosion—wind, water, ice, and waves—move weathered materials from one place to another.

When erosion takes place, sedimentation—the deposition of material—also eventually occurs. Through time, sediments are buried by more sediments and the material hardens into rock. This rock is eventually exposed (through erosion, uplift, and/or faulting), and the cycle repeats itself. Sedimentation and erosion are "reshapers" and "refiners" of the landscape—and they also expose Yellowstone's past life as seen in fossils like the petrified trees.

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Staff Reviewers

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Left: The Beartooth Mountains northeast of Yellowstone are actually an uplifted block of Precambrian rock. Right: Mt. Everts, near Mammoth, exposes sedimentary rock, which erodes easily and often tumbles or slides into Gardner Canyon.

Petrified trees in Yellowstone are the result of volcanic debris flows that occurred about 50 million years ago. This piece of petrified wood shows annual rings.

Fossils

The fossil record of Yellowstone is one of the most diverse in the NPS. Fossils of plants, invertebrates, vertebrates, and trace fossils have been identified from more than 40 stratigraphic units (rock layers of known age and origin) spanning more than 540 million years from the Cambrian to the Quaternary.

Paleontological resources, or fossils, are any remains of past life preserved in geologic context. Yellowstone contains the two main types of fossils: body fossils and trace fossils. Body fossils are the physical remains of an actual organism (shells, bones, teeth, plant leaves, trees, stumps, etc.), while trace fossils (burrows, coprolites, footprints, trackways, etc.) preserve indirect evidence of an organism's activity or behavior. Best known in Yellowstone are the fossil forests of Specimen Ridge, where the remains of hundreds of 50-million-year-old trees stand exposed on a steep hillside, with trunks up to eight feet in diameter and some more than 20 feet tall.

Although the park's paleontologic resources are extensive and scientifically valuable, it is estimated that only 3% of the park's potentially fossil-bearing units have been assessed. Erosion is the key to discovery of nearly all paleontological specimens; however, once exposed, fossils are subjected to physical and chemical forces that can quickly become destructive to them.

Fossils are a non-renewable resource. Road construction, other infrastructure development, and illegal collecting can also impact fossil-bearing units. Due to the fragility of most fossils, it is necessary to inventory and document fossil localities to evaluate existing fossil material and obtain baseline information so that appropriate management decisions can be made about these areas.

Yellowstone fossils have long been studied and have already contributed to important scientific findings. Research in the park by Charles Walcott on trilobites in the late 1800s influenced his theory of the "Cambrian Explosion," a term he used to describe the relatively sudden appearance of complex multi-cellular life possessing "hard parts" such as phosphatic or calcitic exoskeletons.

Sediment cores from the bottom of Yellowstone's lakes contain fossils of pollen deposited during the Late Pleistocene. These pollen records show which plants were present at that time and allow researchers to infer climate conditions. The pollen in sediment layers illustrates the changes in vegetation and climate over time, providing a model of regional reforestation and climate history.

Paleontologists have also devoted much attention to the Eocene fossil plant material in the park, using it to inform regional studies of the paleoclimate and paleoecology of that period. Much could be gained in understanding current global climate change by studying Eocene times, which include an episode of rapid and intense warming when our planet was at its hottest in the past 70 million years.

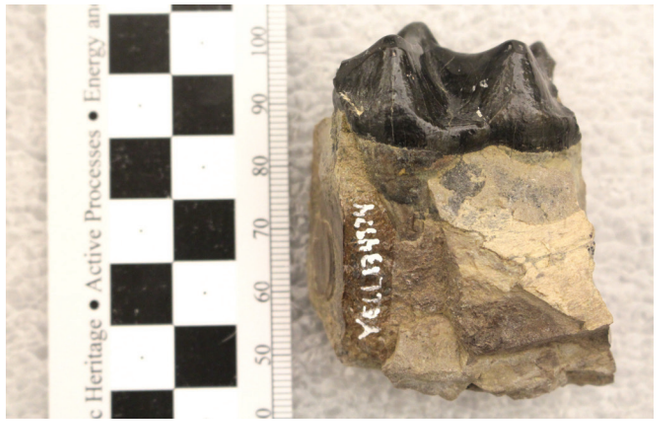
Paleobotany

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

Most petrified wood and other plant fossils come from Eocene deposits about 50 million years old, which occur in many sites in the northern parts of the park. The first fossil plants from Yellowstone were collected by the early Hayden Survey parties. In his

A fossil cone of *Pinus macrolepis*, collected in the Lamar River Valley. This rare fossil cone gives new insight into the plants of the Eocene.

This trilobite, *Tricrepicephalus yellowstonensis*, is about 500 million years old. Every year, new species of trilobites are being discovered all over the world.



The second molar of a brontothere. The tooth is black, set in the gray-white fragment of the jaw bone.

1878 report, William Henry Holmes made the first reference to Yellowstone's fossil "forests."

In 1889, F. H. Knowlton identified 147 species of fossil plants from Yellowstone, 81 of them new to science. He also proposed the theory that the petrified trees on the northwest end of Specimen Ridge were forests petrified in place.

Additional studies and observations informed a modification of Knowlton's original hypothesis. Andesitic volcanic eruptions such as the 1980 eruption of Mount St. Helens showed that trees are uprooted by rapidly flowing volcanic debris flows. The volcanic debris flows not only transported trees to lower elevations, but research shows that approximately 10–15% of the trees were deposited in an upright orientation. Thus, with increased scientific knowledge, our understanding of Yellowstone's fossil forests has changed.

Cretaceous marine and nonmarine sediments are exposed on Mount Everts and other areas in Yellowstone. Similar to Cretaceous rocks throughout the Rocky Mountains, fossil leaves, ferns, clam-like fossils, shark teeth, and several species of vertebrates have been found. In 1994, fossil plants were discovered in Yellowstone during the East Entrance road construction project, which uncovered areas containing fossil sycamore leaves and petrified wood.

Fossil Invertebrates

Fossil invertebrates are abundant in Paleozoic rocks, especially the limestones associated with the Madison Group in the northern and south-central parts of the park. As far back as the first expedition in Yellowstone National Park, invertebrate fossils have been documented. Fossil invertebrates give insight into the paleoenvironment and paleoclimate of an area.

Brachiopods were common during the Paleozoic era (between about 540 and 250 million years ago). They had hard shells and a valve that kept them anchored to the sea floor, and they liked to live in calmer ocean locations. The presence of this fossil in Yellowstone means that the area was home to an inland sea at various times during the Paleozoic.

Long before fish occupied the seas and dinosaurs roamed the land, planet Earth was home to numerous marine invertebrates including trilobites. Trilobites thrived during the Paleozoic era as well. Trilobites were once so abundant, they could be found in nearly every sea and ocean. Today, their fossil distribution helps us understand Earth's history. With more than 20,000 described specimens, trilobites are considered the single most diverse class of extinct organism and can be found in Paleozoic rocks all over the world.

At least 38 national parks have documented trilobites, including Yellowstone National Park. Late 1800s explorer William Henry Holmes recognized large trilobite deposits and gave "Trilobite Point" on Mount Holmes its name. Trilobites reveal fascinating facts about our planet; because of their great diversity, trilobites can offer insights into paleoenvironments, paleoclimate, biostratigraphy, and evolutionary biology associated with the greater Yellowstone area.

Yellowstone fossil invertebrates include corals, bryozoans, brachiopods, trilobites, gastropods, and crinoids. Trace fossils, such as channeling and burrowing of worms, are found in some petrified tree bark.

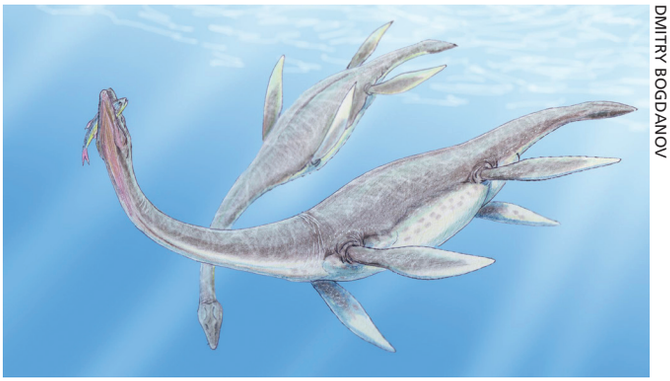
Fossil Vertebrates

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

- Fish: Middle Mississippian and Early Permian shark teeth and spines, Early Permian bony fish teeth, cranial plates, and isolated scales; Middle Cretaceous bony fish scales and a hybodont shark spine.
- Horse: possible Pleistocene horse, reported in the 1890s from now-missing fossils.
- Other mammals: Holocene mammals recovered from Lamar Cave; brontothere tooth and mandible found on Mt. Hornaday in 1999.

A partial tooth and jaw segment was found in Early Eocene (49–47 million years ago) volcanic sediments on Mount Hornaday in 1998 by a USGS wildlife biologist. This fossil represents the early brontothere Palaeosyops, a tapir-sized relative to horses, rhinos, and tapirs. These herbivores would evolve to be some of the largest mammals on the planet by the end of Eocene, living in both dense forests and open woodlands, before going extinct 34 million years ago.

Plesiosaurs were large aquatic reptiles that existed from the late Triassic through the Cretaceous Period. These aquatic marine reptiles once dominated the seas, and the largest plesiosaurs were among the biggest predators of all time. The skeleton of what may be a Cretaceous plesiosaur was discovered in Yellowstone National Park nearly two decades ago.



DMITRY BOGDANOV

Potential plesiosaur bone fragments were discovered in 1996.

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National Park Service Reviewer

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Thermophiles, or heat-loving microscopic organisms, are nourished by the extreme habitat at hydrothermal features in Yellowstone National Park. They also color hydrothermal features shown here at Clepsydra Geyser, either through the pigments that they make or by minerals that they precipitate.

Life in Extreme Heat

The hydrothermal features of Yellowstone are magnificent evidence of Earth's volcanic activity. Amazingly, they are also habitats in which microscopic organisms called thermophiles—"thermo" for heat, "phile" for lover—survive and thrive.

Grand Prismatic Spring at Midway Geyser Basin is an outstanding example of a hydrothermal system that is teaming with thermophilic microbial life. Visitors marvel at its size and brilliant colors. Yet, those colors are due to the microbes and upclose examples can be readily seen on the boardwalk that crosses a vast habitat for thermophilic microbes. Nourished by energy and chemical building blocks available in the hot springs, microbes construct vividly colored communities. Living with these microscopic life forms are larger examples of life in extreme environments, such as mites, flies, spiders, and plants.

For thousands of years, people have likely wondered about these extreme habitats. The color of Yellowstone's superheated environments certainly caused geologist Walter Harvey Weed to pause, think, and even question scientists who preceded him. In 1889, he (Weed, 1889) wrote:

> *There is good reason to believe that the existence of algae of other colors, particularly the pink, yellow and red forms so common in the Yellowstone waters, have been overlooked or mistaken for deposits of purely mineral matter.*

However, he could not have imagined what a fantastic world exists in these waters of brimstone. Microorganisms, single-celled organisms smaller than the width of a human hair, thrive in waters as acidic as the liquid in your car battery and hot enough to blister your skin. Some create layers that look like molten wax on the surface of steaming

Words to Know

Extremophile: A microorganism living in extreme conditions such as heat and acid, that cannot survive without these conditions.

Thermophile: Heat-loving extremophile.

Microorganism: Single- or multi-celled organism of microscopic or submicroscopic size. Also called a microbe.

Microbes in Yellowstone: In addition to the thermophilic microorganisms, millions of other microbes thrive in Yellowstone's soils, streams, rivers, lakes, vegetation, and animals. Some of them are discussed in other chapters of this book.

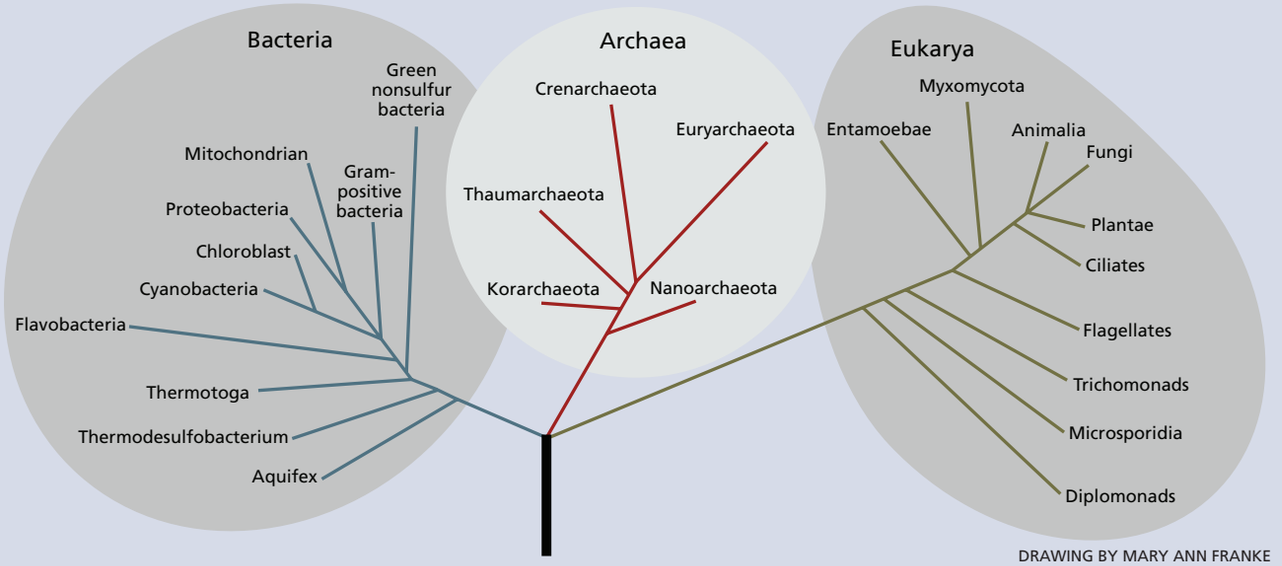
Bacteria (Bacterium): Single-celled microorganisms without nuclei, varying in shape, metabolism, and ability to move.

Archaea (Archaeon): Single-celled microorganisms without nuclei and with membranes different from Bacteria. Once thought to be Bacteria.

Viruses: Non-living parasitic microorganisms consisting of a piece of DNA or RNA coated by protein.

Eukarya (Eukaryote): Single- or multi-celled organisms whose cells contain a distinct membrane-bound nucleus.

Thermophiles in the Tree of Life



DRAWING BY MARY ANN FRANKE

Yellowstone's hot springs contain species from the circled groups on this Tree of Life. Jack Farmer conceived of this version of the tree of life, which first appeared in *GSA Today,* July 2000 (used with permission).

In the last few decades, microbial research has led to a revised tree of life, far different from the one taught before. The new tree combines animal, plant, and fungi in one branch. The other two branches consist solely of microorganisms, including an entire branch of microorganisms not known until the 1970s—the Archaea.

Dr. Carl Woese first proposed this "tree" in the 1970s. He also proposed the new branch, Archaea, which includes many microorganisms formerly considered Bacteria. The ancestor of the Bacteria, Archaea, and Eukarya is inferred to be where the blue, red, and green lines connect. Organisms that branch closest to this ancestor are hyperthermophiles, which thrive in water above 176°F (80°C), indicating life may have arisen in hot environments on the young Earth.

Relevance to Yellowstone
Among the earliest organisms to evolve on Earth were microorganisms whose descendants are found today in extreme high-temperature, and in some cases acidic, environments, such as those in Yellowstone. Their history exhibits principles of ecology and ways in which geologic processes might have influenced biological evolution, and how this, in turn, influenced geology.

alkaline pools. Still others, apparent to us through the odors they create, exist only in murky, sulfuric caldrons that stink worse than rotten eggs.

Today, many scientists study Yellowstone's thermophiles. Some of these microbes are similar to the first life forms capable of oxygenic photosynthesis—the process of using sunlight to convert water and carbon dioxide to oxygen, sugars, and other by-products. These life forms, called Cyanobacteria, began to create an oxygen-rich atmosphere that would eventually support human life. Cyanobacteria are found in some of the colorful mats and streamers of Yellowstone's hot springs and are typically responsible for the orange colored sponge-like mats in alkaline springs, like Grand Prismatic. The production of oxygen by Cyanobacteria forever changed Earth and created numerous new opportunities for life to evolve, including animals (us) that require oxygen.

About Microbes

Other life forms—the Archaea—predated Cyanobacteria and other photosynthesitic organisms. Archaea can live in the hottest, most acidic conditions in Yellowstone; their ancestors are considered among the very earliest life forms to have evolved on Earth.

Yellowstone's thermophiles and their environments provide a living laboratory for scientists, who continue to explore these extraordinary organisms. Researchers know that many mysteries of Yellowstone's extreme environments remain to be revealed.

Regardless of scientific advances, visitors and explorers in Yellowstone can still relate to something else written about Yellowstone, more than a century ago (Weed, 1889):

The vegetation of the acid waters is seldom a conspicuous feature of the springs. But in the alkaline waters that characterize the geyser

basins, and in the carbonated, calcareous waters of the Mammoth Hot Springs, the case is otherwise, and the red and yellow tinges of the algae combine with the weird whiteness of the sinter and the varied blue and green of the hot water to form a scene that is, without doubt, one of the most beautiful as well as one of the strangest sights in the world.

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Reviewers

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Jefferson Hungerford, Park Geologist

The travertine terraces in Mammoth Hot Springs host thermophilic Cyanobacteria.

Thermophilic Bacteria

The word "Bacteria" is often associated with disease, but only a few kinds of Bacteria (species) cause problems for humans. The other millions of bacterial species, although all simple organisms, play a complex role in Earth's ecosystems. In fact, Cyanobacteria were responsible for the oxygenation of our atmosphere. They were the first photosynthesizers, converting light energy into oxygen more than 2.4 billion years ago. Without Bacteria, in particular Cyanobacteria, humans would not be able to breathe and we would therefore not be here.

While some Bacteria perform photosynthesis, others depend on chemical energy that is released when unusual compounds like hydrogen, arsenic, or sulfur react with oxygen. This energy is then used to convert carbon dioxide into biomass (chemosynthesis). For example, the bacterium, *Thermus*, may also be able to oxidize arsenic into a less toxic form to humans.

Individual Bacteria may be rod or sphere shaped, but they often join end to end to form long strands and streamers (filaments) that are often seen in the outflow channels of hot springs. These strands help form thermophilic mats, forming a vast community or mini-ecosystem. Other groups of Bacteria form layered structures resembling tiny towers, that can trap sand and other organic materials.

Thermophilic Bacteria in Yellowstone National Park

Name	pH and Temperature	Description	Location
Cyanobacteria *Calothrix*	pH 6–9 30–45°C (86–113°F)	Color: dark brown mats Metabolism: photosynthesis by day; fermentation by night	• Mammoth Hot Springs • Upper, Midway, and Lower geyser basins
Phormidium	pH 6–8 35–57°C (95–135°F)	Color: orange mats Metabolism: photosynthesis	• Mammoth Hot Springs • Upper, Midway, and Lower geyser basins
Oscillatoria	pH 6–8 36–45°C (96–113°F)	Color: orange mats Metabolism: photosynthesis; oscillating moves it closer to or away from light sources.	• Mammoth Hot Springs • Chocolate Pots
Synechococcus	pH 7–9 52–74°C (126–165°F)	Color: green mats Metabolism: photosynthesis by day; fermentation by night	• Mammoth Hot Springs • Upper, Midway, and Lower geyser basins
Green Sulfur *Chlorobium*	pH 6–9 32–52°C (90–126°F)	Color: dense, dark green mats Metabolism: anoxygenic photosynthesis—produces sulfate and sulfur, not oxygen.	• Mammoth Hot springs • Calcite Springs
Green non-sulfur *Chloroflexus*	pH 7–9 35–85°C (95–185°F)	Color: green mats Metabolism: anoxygenic photosynthesis—use organic compounds during photosynthesis.	• Mammoth Hot Springs • Upper, Midway, and Lower geyser basins
Aquificales *Hydrogeno-baculum*	pH 3–5.5 55–72°C (131–162°F)	Color: yellow and white streamers Metabolism: reacts hydrogen, hydrogen sulfide, elemental sulfur, or arsenic with oxygen to generate energy.	• Norris Geyser Basin • Amphitheater Springs
Aquificales *Thermocrinis*	pH 5–9 40–79°C (104–174°F)	Color: bright pink or orange streamers; contains carotenoid pigments that act as sunscreen.	• Lower Geyser Basin

Archaea are the most extreme of all extremophiles, and some scientists think they have not changed much from their ancestors. Grand Prismatic Spring at Midway Geyser Basin contains Archaea.

Thermophilic Archaea

Archaea are the most extreme of all extremophiles—some kinds live in the frigid environments of Antarctica; others live in the boiling acidic springs of Yellowstone. Like Bacteria, single-celled Archaea have no nucleus but have a unique, tough outer cell wall. This tough membrane segregates molecules and enzymes from the acidic external environment, allowing those cells to live in environments with a pH 3 or less. (For example, most vinegar has a pH of less than 3.) Archaea also have protective enzymes within their cells to keep them from becoming too acidic.

Some scientists think present-day Archaea are highly reminiscent of their ancestors, in particular those that inhabit circumneutral to alkaline pH hot springs. This may be due to the extreme environments in which they live, which limit the successful changes that would allow them to diversify out of these environments. If this is so, modern Archaea may not be much different from the earliest forms of life, thus their study can provide important clues into how life was supported on early Earth.

Once thought to be members of the domain Bacteria, Archaea are now known to represent their own domain and share many characteristics with eukaryotic organisms, which includes plants and animals. Many kinds of Archaea live in the hydrothermal waters of Yellowstone. For example, Grand Prismatic Spring at Midway Geyser Basin contains abundant members of the Archaea. However, they are most well-known in the superheated acidic features of Norris Geyser Basin and the muddy roiling springs of the Mud Volcano area

Whenever you see a hot, muddy, acidic spring, you are probably seeing the results of a thriving community of archaeal cells called *Sulfolobus*. This is the archaeon most often isolated and most well-known to scientists. In sulfuric hydrothermal areas, *Sulfolobus* oxidizes sulfur into sulfate or sulfuric acid, which helps dissolve the rocks into mud. The *Sulfolobus* community in Congress Pool (Norris) is providing interesting new research directions for scientists: it is parasitized by viruses never before known on Earth.

Archaea can be found in the Mud Volcano area, among other places in Yellowstone National Park.

Thermophilic Archea found in Yellowstone National Park

Name	pH and Temperature	Description	Location
Domain Archaea	pH 0.9–9.8 upper temp.: 92°C (197.6°F)	Color: cream or yellow-colored Metabolism: chemosynthesis, using hydrogen, sulfur, aresenic Form: unicellular, tough cell membrane	• In many of Yellowstone's hydrothermal features
Sulfolobus is the genus most often isolated	pH 0–4, ~50–80°C (104–131°F)	Color: cream or yellow-colored Metabolism: chemosynthesis	• Norris Geyser Basin • Lemonade Creek

Microscopic Eukarya in the extreme environments of Yellowstone. Norris Geyser Basin is one of the best places in Yellowstone to see thermophilic algae.

Thermophilic Eukarya

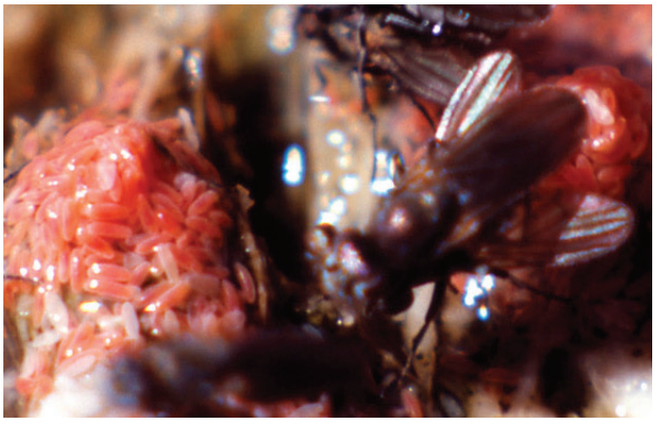
Plants, animals, and mushrooms are the Eukarya most of us know. However, millions of unseen, microscopic members of this kingdom exist throughout our world, including in the extreme environments of Yellowstone.

Norris Geyser Basin is one of the best places to see thermophilic algae, where they form robust bright green microbial mat communities. Bright green *Cyanidioschyzon* algae grows on top of orange-red iron mineral deposits around Whirligig and Echinus geysers and their runoff channels. Waving streamers of darker green *Zygogonium* algae are especially easy to see in Porcelain Basin, in cooler regions of spring runoff channels, where their dark colors contrast with the white surface.

From the boardwalk crossing Porcelain Basin, you can also see larger Eukarya, such as ephydrid or stratiomyid flies. They live among the thermophilic mats and streamers, and their larvae eat algae, among other things. The species that lives in the waters of Geyser Hill, in the Upper Geyser Basin, lays its eggs in pink-orange mounds, sometimes on the firm surfaces of the mats. Part of the thermophilic food chain, ephydrid flies become prey for spiders, beetles, and birds.

Some microscopic Eukarya consume other thermophiles. A predatory protozoan called *Vorticella* thrives in the warm, acidic waters of Obsidian Creek, which flows north toward Mammoth Hot Springs, where it consumes thermophilic bacteria.

Thermophilic eukarya include one form that is dangerous to humans: *Naegleria*, a type of amoeba that can cause disease and death in humans if inhaled through the nose.



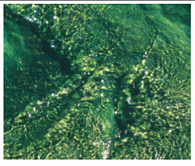
THERMAL BIOLOGY INSTITUTE, MONTANA STATE UNIVERSITY

Counterclockwise from top: Ephydrid flies lay eggs in pink-orange mounds, sometimes on the firm surfaces of the mats; waving streamers of *Zygogonium* are easy to see in Porcelain Basin; the fungi *Curvularia protuberata* lives in the roots of hot springs panic grass.

Although they aren't visible like mushrooms, several thermophilic fungi thrive in Yellowstone. *Curvularia protuberata* lives in the roots of hot springs panic grass. This association helps both organisms survive higher temperatures than each could alone. In addition, researchers have recently discovered a virus inside the fungus that is also essential to the grass's ability to grow on hot ground.

Of all the thousands, if not millions, of thermophilic species thriving in Yellowstone's extreme environments, the Eukarya are the group that bridges the world of thermophilic microbes with the larger life forms—such as geese, elk, and bison—that thrive in ecological communities beyond the hot springs.

Thermophilic Eukarya found in Yellowstone National Park

Name		pH and Temperature	Description	Location
Red algae *Cyanidio-schyzon*		pH 0–4 40–55°C (104–131°F)	Color: bright green Metabolism: photosynthetic Form: coating on top of formations; mats	• Norris Geyser Basin • Lemonade Creek • Nymph Creek
Green algae *Zygogonium*		pH 0–4 <32°C (90–131°F)	Color: appears black or dark purple in sunlight Metabolism: photosynthetic Form: filaments and mats	
Protozoa				
Naegleria (amoeba)		Warm Alkaline	Predator of Bacteria; can infect humans when ingested through nose	• Huckleberry Hot Springs • Boiling River
Vorticella (ciliate)			Consumer; single-celled ciliate (feathery appendages swirl water, bringing prey)	• Obsidian Creek
Euglenids *Mutablis*		pH 1–2 <43°C (109°F)	Single-celled; photosynthetic; moves by waving one or two strands called flagella	
Fungi (*Curvularia protuberata*)		≤65°C (149°F) with panic grass <55°C (131°F) without	Grows in roots of hot springs panic grass (*Dichanthelium lanuginosum*), enabling both to survive high temperatures; the plant also produces sugars that the fungus feeds on	
Ephydrid fly (*Ephydra* sp.)		>pH 2 <43°C (109°)	Nonbiting insect that eats microscopic algae as larvae and adult; prey for spiders, beetles, dragonflies, killdeer	• Norris, especially Porcelain Basin • Upper Geyser Basin, especially Geyser Hill • Mammoth Hot Springs
Ross's bentgrass (*Agrostis rossiae*)		38°C (100°F)	One of Yellowstone's three endemic plant species; may bloom in winter; dries out in summer's hot air temperatures	• Banks of Firehole River • Near Shoshone Lake
Warm springs spike rush, with some Tweedy's rush		Warm Acidic	Forms thick floating mats, which also provide habitat for thermophilic algae and other thermophiles	• Obsidian Creek

Note: Algae and Warm springs spike rush photos by Carolyn Duckworth. Fungi photo by Russell Rodriguez and Joan Henson. Ross's bentgrass photo by NPS/Jennifer Whipple.

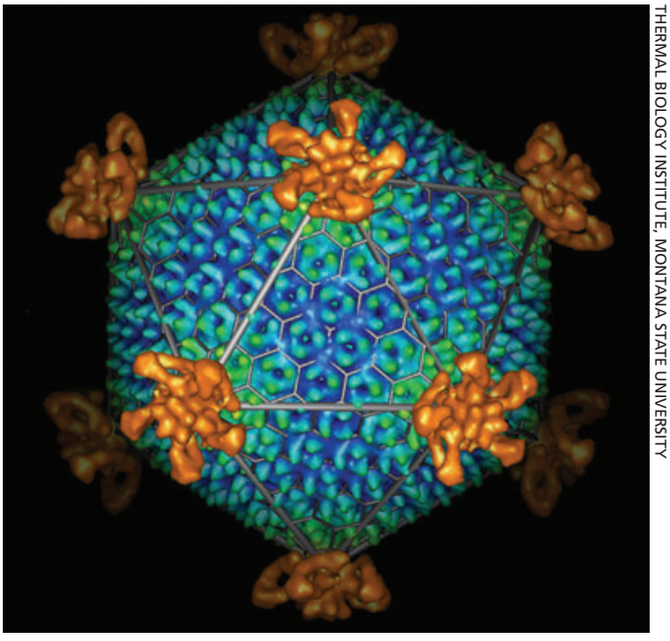
A virus was discovered in Congress Pool, shown here, at Norris Geyser Basin. It was infecting the archaean *Sulfolobus*.

Thermophilic Viruses

Like Bacteria, the word "virus" often conjures up images of sickness and death. However, relatively few viruses cause problems for humans. None of the thermophilic viruses in Yellowstone should cause problems for human health—our bodies are too cold for them to reproduce in, for one thing.

Unlike microorganisms in the three domains, viruses are not considered to be alive, yet they are still called "life forms." They have no cell structure, only a protein "envelope" that encloses genetic material. They cannot reproduce on their own. Instead, a virus inserts itself into a host cell and uses that cell's nutrients and metabolism to produce more viruses.

Scientists suspect many viruses exist in Yellowstone's hydrothermal features because they would be a logical part of the thermophilic ecosystem. One kind was discovered in Congress Pool, at Norris Geyser Basin. It was infecting the archaeon *Sulfolobus*. Another kind of virus has been identified in pools near Midway Geyser Basin.



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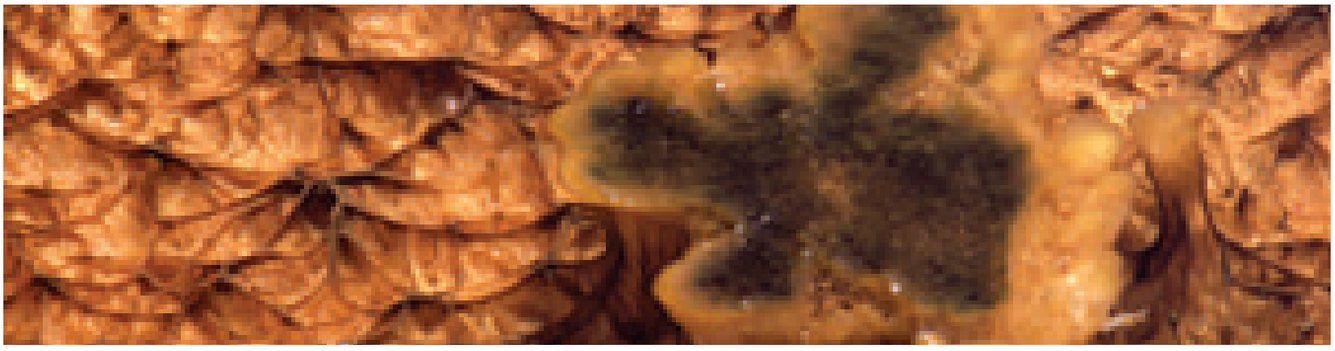
This virus parasitizes *Sulfolobus*.

Thermophilic Viruses found in Yellowstone National Park

Name	pH and Temperature	Description	Location
Viruses (not in a domain)	pH 0.9–5.8; optimum 2–3 55–80°C (131–176°F) optimum 70–75°C	• Protein coats a core of genetic material • Cannot reproduce by itself • Reproduces by using the host cell's metabolism • Not considered living • Predators of other microbes	• In many of Yellowstone's hydrothermal features
Unnamed	Acidic Boiling	• Shape very similar to viruses that infect Bacteria and animals, which could mean this group of viruses existed early in the development of life on Earth	• Unnamed pool near Midway Geyser Basin
Unnamed	Acidic Boiling	• Parasitizes the archaean, *Sulfolobus*	• Norris, Congress Pool



Channels formed with water runoff from geysers create bacterial columns such as this one, located where the runoff channels from Pinwheel and Whirligig geysers meet.

Thermophilic Communities

Thermophilic communities are as diverse as the communities that humans live in. Community formations, colors, and locations vary depending on the types of microbes, the pH, and the temperature of their environments. Here, we discuss the microbe communities most easily seen in Yellowstone.

Millions of individual microbes can connect into long strands called filaments. Some Bacteria and algae form thin and delicate structures in fast moving water such as the runoff channels of hot springs and geysers. Other microbes form thick, sturdy structures in slower water or where chemical precipitates quickly coat their filaments.

A bacterium called *Thermocrinis* forms structures and grows by eating hydrogen gas or sulfur compounds. Its filaments entwine, forming mats. Flowing water carries other microbes, organic matter, and minerals that become caught in the streamers and add to the mat.

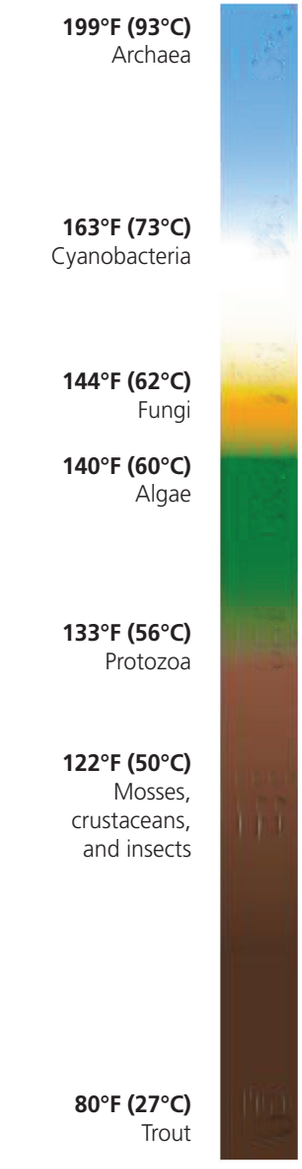
Photosynthetic activity of Cyanobacteria such as *Lyptolyngbya* form columns or pedestals. Oxygen bubbles rise in the mat, forcing the microbes upward. The higher formations capture more organic matter and sediment than the lower mats, which help build the columns. Called stromatolites or microbialites, these structures are similar to ancient microbial communities preserved in formations (dated to >3.0 billion years old) around the world.

Mats can be as thin as tissue paper or as thick as lasagna. Multiple layers of microorganisms make up inch-thick mats. Dozens of types of microbes from all three domains can exist in these layers. Each layer is a community, and each layer interacts with the other layers, forming a complex, larger ecosystem full of millions of microorganisms and their life processes.

Changes in Communities

Visible and invisible changes occur in thermophile communities as light, temperature, and chemical concentrations change—both short term (within one day) and long-term (seasonally). As day brightens to noon, Cyanobacteria sensitive to light may move away from the surface; microbes less sensitive to light may move to the top layers of the mat. When light levels cause shifts in organisms, the community is responding to a light gradient.

Temperature and chemical gradients most often affect thermophilic communities in runoff channels of geysers and in shallow outflows from hot springs. The runoff channels from Pinwheel and Whirligig geysers meet. The outer edges of both are too hot for visible thermophile communities to develop. But as Pinwheel's water cools in the shallower channel edge, *Cyanidioschyzon* (an alga) can grow, forming a bright green



Thermophilic community inhabitants are controlled, in part, by water temperature and pH. The chart provides general guidelines for maximum for each type.

community. Whirligig's runoff is hotter, which prevents *Cyanidioschyzon* from growing, but another type of thermophile thrives by oxidizing the abundant iron in the water, thereby forming the orange/red (rust, also a form of oxidized iron) colored community.

At the Chocolate Pots, which you can see from pullouts along the Gibbon River just north of Gibbon Meadows, iron-rich water flows from the vents. Cyanobacteria—such as *Synechococcus*, and *Oscillatoria*—thrive in this feature. The bacterial filaments form mats, in which orange-red iron oxide (rust) is captured. The iron may also be caught on the Bacteria as the microbes move about within the mat. An olive green color indicates where

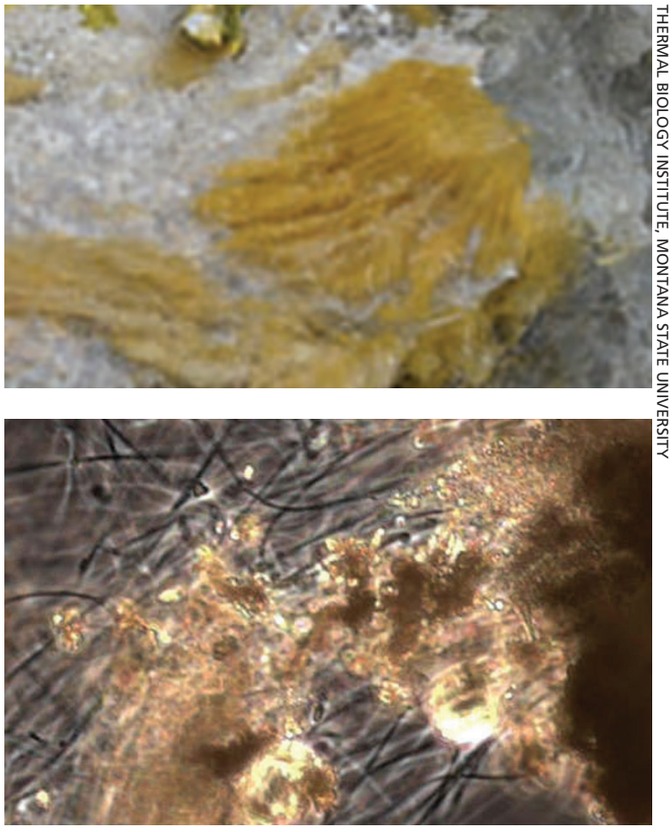
COURTESY CAROLYN DUCKWORTH

Bison and elk find food and warmth on the less extreme edges of thermophilic environments in winter.

Thermophiles by Place and Color in Yellowstone National Park

Location	Characteristics	Thermophiles by Temperature	Thermophiles by Color
Upper, Middle, and Lower Geyser Basins and West Thumb Geyser Basin			
	• pH 7–11 (alkaline) • underlain by rhyolitic rock • water rich in silica, which forms sinter and geyserite deposits	• >75°C (167°F), Bacteria and Archaea • >75°C (167°F), *Thermocrinis* and other bacteria form streamers of pink, yellow, orange, or gray • <75°C (167°F), *Synechococcus*, *Lyptolyngbya*, and *Calothrix* (cyanobacteria) plus *Roseiflexus* (filamentous green bacterium) form mats that line cooler hot springs and runoff channels	• Pink, yellow, orange, gray filaments—*Thermocrinis* bacteria • Orange mats—Cyanobacteria, especially on sunny summer days (carotenoids protect the organisms from the bright sun) • Olive-green mats—Cyanobacteria
Norris Geyser Basin and Mud Volcano Area			
	• pH 0–5 (acidic) • underlain by rhyolite rock	• >75°C (167°F), *Sulfolobus*, an archaean, and viruses that parasitize *Sulfolobus* • >60°C (140°F), filamentous bacteria in yellowish streamers and mats • <60°C (140°F), filamentous bacteria and archaea form red brown mats • <56°C (133°F), *Zygogonium*, other algae, and fungi form mats in runoff channels	• Pink–pinkish-orange mats and streamers—*Thermus aquaticus* and other *Thermus* sp. • Green streamers and mats—*Cyanidium* • Orange—iron and/or arsenic, oxidized by thermophiles • Gray, muddy pools—*Sulfolobus*
Mammoth Hot Springs			
	• pH 6–8 (neutral to slightly acidic) • underlain by ancient limestone deposits • water rich in calcium carbonate and sulfur	• 66–75°C (151–167°F), *Aquificales* (Bacteria) filaments near hot springs vents • <66°C (151°F), *Chloroflexus* (green nonsulfur bacteria) and Cyanobacteria mats, and filamentous bacteria streamers • <58°C (136°F), *Chromatium* (Bacteria) form dark mats (uncommon) • 25–54°C (77–129°F), *Chlorobium* (Bacteria) mats; *Calothrix* streamers; *Synechococcus*	• Orange—*Chloroflexus* and Cyanobacteria in summer • Green—*Chloroflexus* and Cyanobacteria in winter; *Chlorobium* in cooler water • Cream—filamentous bacteria

Note: Photos by Carolyn Duckworth.



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Top: Structures formed by the bacteria *Thermocrinis.* Bottom: Millions of individual microbes can connect into long strands called filaments, shown here with the help of a microscope.

the orange iron and green bacteria are enmeshed. Darker streaks indicate the presence of manganese. Scientists think that mixing of iron-rich waters with shallow precipitation-derived waters creates the unique conditions that give rise to the large iron and manganese oxide mounds at Chocolate Pots. These formations are not commonly encountered in the park.

Communities formed by thermophilic microbes sustain communities of larger organisms within Yellowstone's hydrothermal areas. These communities in turn affect even larger communities of the park's mammals. For example, bison and elk find food and warmth on the less extreme edges of high temperature environments in winter. In turn, coyotes, wolves, and bears seek prey in these areas—especially in late winter and early spring when bison and elk are weaker than at any other time of year.

Whether it's the strike of a grizzly's paw or a shift in heat beneath the Earth, new hot springs can emerge from the subsurface while others change through both common and strange processes. Biologists continue to discover more about the individuals involved in thermophilic communities, and ecologists follow the threads of these intricate webs.

Thermophiles in Time and Space

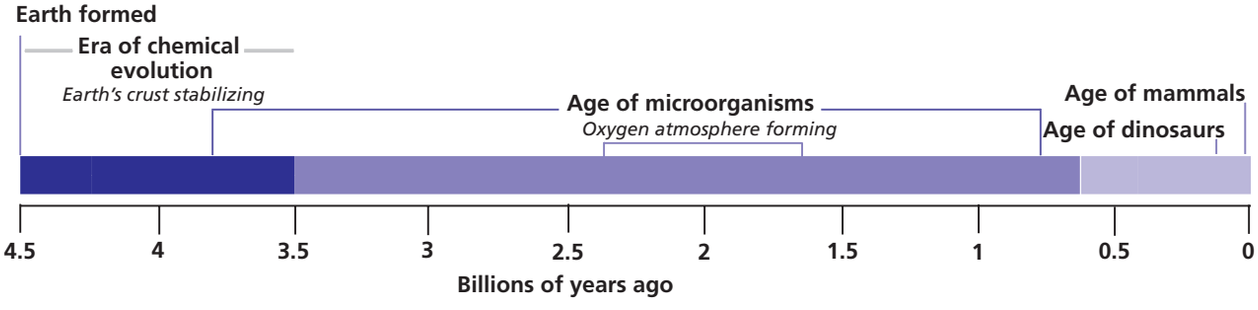
To Mars—and Beyond?

The hydrothermal features of Yellowstone and their associated thermophilic communities are studied by scientists searching for evidence of life on other planets. The connection is extreme environments. If life began in the extreme conditions thought to have been widespread on ancient Earth, it may well have developed on other planets with similar conditions—and these conditions might still exist today.

The chemosynthetic microbes that thrive in some of Yellowstone's extreme hot spring environments do so by metabolizing inorganic chemicals, a source

What's the Connection?

- Yellowstone's hydrothermal features contain modern examples of Earth's earliest life forms, both chemo- and photosynthetic, and thus provide a window into Earth's ancient past.
- Yellowstone's hydrothermal communities reveal the extremes life can endure, providing clues to environments that might harbor life on other worlds.
- Yellowstone's environments show how mineralization preserves biosignatures of thermophilic communities, which could help scientists recognize similar signatures elsewhere.
- Based on life on Earth, the search for life on other planets seems more likely to encounter evidence of microorganisms than of more complex life.

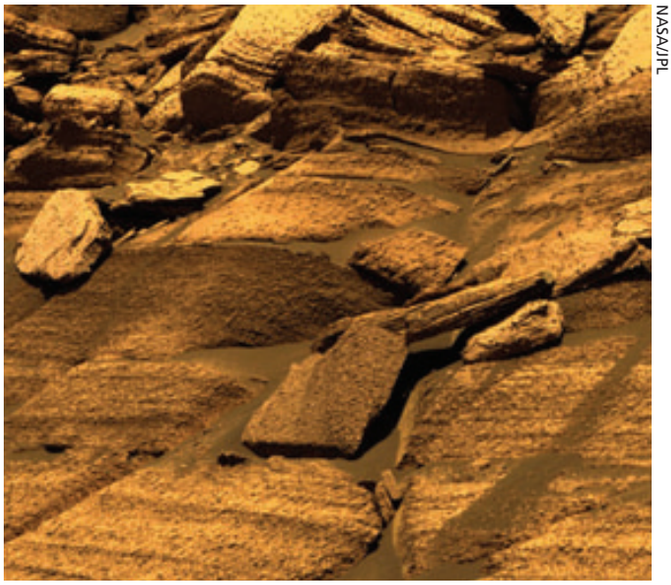


of energy that does not require sunlight. Such chemical energy sources provide the most likely habitable environments for life on Mars or on the moons of Jupiter—Ganymede, Europa, and Callisto—where uninhabitable surface conditions preclude photosynthesis. Chemical energy sources, along with extensive groundwater systems (such as on Mars either today or in its distant past) or oceans beneath icy crusts (such as on Jupiter's moons) could provide habitats for life.

Similar Signatures

Thermophile communities leave behind evidence of their shapes as biological "signatures." For example, at Mammoth Hot Springs, rapidly depositing minerals entomb thermophile communities. Scientists compare these modern signatures to those of ancient deposits elsewhere, such as sinter deposits in Australia that are 3.5 billion years old. These comparisons help scientists better understand the environment that supported life on early Earth, and give them an idea of what to look for on other planets.

Yellowstone National Park will continue to be an important site for studies of the physical and chemical limits of survival. These studies will give scientists a better understanding of the conditions that give rise to and support life, and of how to recognize signatures of life in ancient rocks and on distant planets.



NASA/JPL

These layers of rock on Mars have minerals and features developed by interactions between liquid water and rocks over time. This evidence does not prove life developed on Mars, but it brings the possibility one step closer to reality. Photo and caption adapted from www.nasa.gov, image by NASA/JPL.

Reviewers

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Jefferson Hungerford, Park Geologist
Annie Carlson, Research Permit Coordinator

Roughly 1,491 plant taxa occur in Yellowstone National Park. The whitebark pine, shown here and found in high elevations in the Greater Yellowstone Ecosystem, is an important native species in decline.

Vegetation

The vegetation communities of Yellowstone National Park include overlapping combinations of species typical of the Rocky Mountains and the Great Plains to the east and the Intermountain region to the west. The exact vegetation community present in any area of the park reflects the underlying geology, ongoing climate change, substrates and soils, and disturbances created by fire, floods, landslides, blowdowns, insect infestations, and the arrival of nonnative plants.

Today, the roughly 1,491 native taxa in the park represent the 1,404 species that have historically persisted in the area that recolonized after glaciers, lava flows, and other major disturbances. Yellowstone is home to three endemic plant species, all of which are tightly tied to the park's thermal features. Most vegetation management in the park is focused on minimizing human-caused impacts to native plant communities where feasible.

Vegetation Communities

There are several vegetation communities in Yellowstone: higher- and lower-elevation forests and the understory vegetation associated with them, sagebrush-steppe, wetlands, and hydrothermal.

Quick Facts

Number in Yellowstone

Native plant taxa: 1,491:

- Hundreds of wildflowers.
- Trees: nine conifers (lodgepole pine, whitebark pine, Engelmann spruce, white spruce, subalpine fir, Douglas-fir, Rocky Mountain juniper, common juniper, limber pine) and some deciduous species, including quaking aspen and cottonwood.
- Shrubs: include common juniper, sagebrush (many species), Rocky Mountain maple.
- Three endemic species (found only in Yellowstone): Ross's bentgrass, Yellowstone sand verbena, Yellowstone sulfur wild buckwheat.

Nonnative plant taxa: 238.

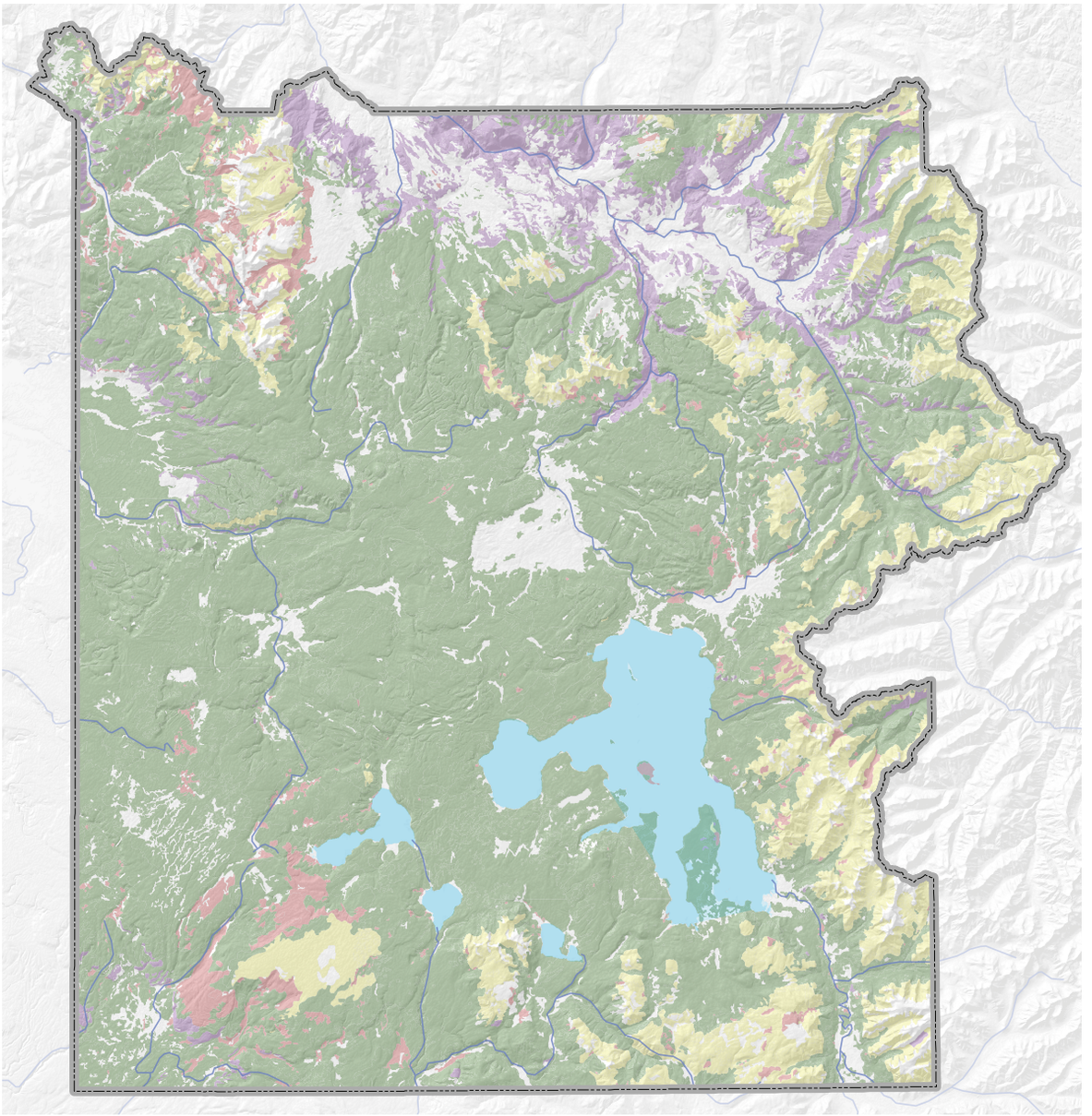
Characteristics

- Vegetation in Yellowstone is typical of the Rocky Mountains.
- Elements of the Great Plains and Great Basin floras mix with Rocky Mountain vegetation in the vicinity of Gardiner and Stephen's Creek.
- Hydrothermal areas support unique plant communities and rare species.

Management Issues

- Controlling nonnative species, which threaten native species, especially near developed areas; some are spreading into the backcountry.
- Park partners are monitoring whitebark pine, white pine blister rust, and forest insect pests.
- Biologists survey areas for sensitive or rare vegetation before a disturbance such as constructing a new facility.
- Park managers are restoring areas of disturbance.

Vegetation Communities in Yellowstone National Park



Lodgepole pine forests
Dominate more than 80% of the total forested area.
Can be seral (developing) or climax.
Climax forests underlain by rhyolite.

Spruce-fir forests
Engelmann spruce/subalpine fir dominate older forests.
Usually found on moist and/or fertile substrates.
Climax forests underlain by andesitic soils.

Whitebark pine forests
Major overstory component above 8,400 feet.
Major understory component of lodgepole-dominated forests from 7,000 to 8,400 feet.
Seeds are ecologically important food for a variety of wildlife species.

Douglas-fir forests
Associated with the Lamar, Yellowstone, and Madison river drainages below 7,600 feet.
Often fewer than 20 inches annual precipitation.
More frequent historic fire interval (25–60 year) than other forest communities in the park.

Non-forest
Includes grasslands, sagebrush, alpine meadows, talus, and hydrothermal environments.
Encompasses the moisture spectrum from dry sagebrush shrublands to wet alpine meadows.
Provides the winter and summer forage base for ungulates.

Other communities not shown on map
Aspen—found in small clones interspersed among the sagebrush/forest ecotone (transition zone) along the Yellowstone, Madison, and Snake river drainages.
Wetland—Wetlands include wet meadows, forested wetlands, springs, and seeps comprised of woody vegetation, forbs, rushes, sedges, and grasses. Some are thermally influenced.
Riparian—typically streamside vegetation includes cottonwoods, willows, and various deciduous shrubs.

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Staff Reviewers

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Steven Bekedam, Vegetation Program Lead

Douglas-fir forests occur at lower elevations and are associated with the Lamar, Yellowstone, and Madison river drainages in Yellowstone National Park.

Forests

Forests cover roughly 80% of the park. Lodgepole pine, Engelmann spruce, subalpine fir, whitebark pine, and limber pine are the most common tree species encountered.

Though ubiquitous throughout the park, Douglas-fir is particularly abundant in the northern region. Their thick bark enables them to tolerate low-intensity fire. Some of the trees in these forests are estimated to be several hundred years old and exhibit fire scars from a history of low-intensity ground fires. In contrast, lodgepole pine trees have very thin bark which makes this species more susceptible to mortality from ground fires.

In high elevation areas where andesite volcanic rock is prevalent, older forests are dominated by Engelmann spruce and subalpine fir. Historically, these areas were likely dominated by lodgepole pine. However in the absence of fire, Englemann spruce and subalpine fir thrived, replacing lodgepole as the main overstory species. In present-day lodgepole forests, Englemann spruce and subalpine fir are a common understory component.

Lodgepole is dominant on rhyolitic soils which are poor in nutrients essential for subalpine fir and Engelmann spruce. At higher elevations, such as the Absaroka Mountains and the Washburn Range, whitebark pine is a significant forest component. In the upper subalpine zone, whitebark pine, Engelmann spruce, and subalpine fir often co-occur in island stands of timber separated by subalpine meadows. In treeline environments where conditions are extreme, whitebark pine take on a krumholtz, or stunted, shrub-like growth form where most of the "tree" is protected below the snow from winter's wind and desiccating effects.

Common Conifers

Higher-Elevation Species

Lodgepole Pine *(Pinus contorta)*
- Most common tree in park, 80% of canopy
- Needles in groups of two
- Up to 75 feet tall

Engelmann Spruce *(Picea engelmannii)*
- Often along creeks, or around wet areas
- Sharp, square needles grow singly
- Cones hang down and remain intact with no bract between scales
- Up to 100 feet tall

Subalpine Fir *(Abies lasiocarpa)*
- Only true fir in the park
- Blunt, flat needles
- Cones grow upright, disintegrate on tree
- Up to 100 feet tall

Limber Pine *(Pinus flexilis)*
- Needles in groups of five
- Young branches are flexible
- Cones green in color
- Often on calcium-rich soil
- Up to 75 feet tall

Whitebark Pine *(Pinus albicaulis)*
- Grows above 7,000 feet
- Needles in groups of five
- Cones deep purple in color
- Up to 75 feet tall

Lower-Elevation Species

Douglas-Fir *(Pseudotsuga menziesii)*
- Resembles fir and hemlock, hence its generic name Pseudotsuga, which means "false hemlock"
- Cones hang down and remain intact, with three-pronged bract between scales
- Up to 100 feet tall

Rocky Mountain Juniper *(Juniperus scopulorum)*
- Needles scale-like
- Cones are small and fleshy
- Up to 30 feet tall

Lodgepole Pine (*Pinus contorta*)

The lodgepole pine is by far the most common tree in Yellowstone. Early botanical explorers first encountered the species along the West Coast where its wind-contorted stature earned it the name *Pinus contorta*. The Rocky Mountain variety, which grows very straight, is *Pinus contorta* var. *latifolia*. Some American Indian tribes used this tree to make the frames of their tipis or lodges, hence the name "lodgepole" pine.

Description

Lodgepoles are the only pine in Yellowstone whose needles grow in bundles of two. The bark is typically somewhat brown to yellowish and a grayish-black fungus often grows on the shady parts of the bark, giving the tree a dark hue.

The species is shade intolerant, as such, when growing in large, dense stands, branches in the shade below the canopy will wither and fall off the tree. When growing individually, branches often remain to the base of the trunk given the full-tree exposure to sunlight.

Reproduction

Like all conifers, lodgepole pines have both male and female cones. The male cones produce huge quantities of yellow pollen in June and July. This yellow pollen is often seen in pools of rainwater around the park or at the edges of lakes and ponds.

The lodgepole's female cone takes two years to mature. In the first summer, the immature cones look like tiny, ruby-red miniature cones near the end of the branches. The following year, after fertilization, the cone starts to grow rapidly and turns a conspicuous green hue. Female cones will either open at maturity and subsequently release their seeds, or they remain closed. Cones that remain closed—a state known as serotiny—can hang on the branches for years until they are subjected to high heat such as a forest fire. Shortly after the tree ignites, the cones open, seeds are released over the charred area, and the forest has been in effect, replanted. Trees lacking serotinous cones (Engelmann spruce, subalpine fir, Douglas-fir, whitebark pine, and limber pine) rely on wind, animals, or other agents to distribute their seeds to other locations.

Lodgepole pine forests are the most common in Yellowstone. A lodgepole's serotinous cones need to be exposed to the high heat of a forest fire for the seeds to be released. Cones that do not disperse their seeds as a direct result of fire, open at the end of their second summer when seeds are mature.

Habitat

Lodgepole pines prefer slightly acidic soil and will grow quickly in mineral soils disturbed by fire or humans, such as road openings in the forest. Their roots spread out sideways and do not extend deeply into the soil—an advantage in Yellowstone where the topsoil is only about 6 to 12 inches deep, but a disadvantage in high winds. Lodgepole pines are vulnerable in windstorms, especially individuals that are isolated or in the open.

In addition to reseeding effectively after disturbance, lodgepole pines can grow in conditions ranging from very wet ground to very poor soil prevalent within the Yellowstone Caldera. This flexibility allows the species to occur in habitats that are inhospitable to other forest species.

Lodgepole pine are dependent on sunny conditions for seedling establishment and survival. In the Yellowstone region where soils are well-developed, lodgepole pine forests are often succeeded by more shade-tolerant seedlings of subalpine fir and Englemann spruce. In lodgepole pine forests growing on nutrient-poor soils, subalpine fir and Englemann spruce are typically minor components of the forest. Here, aging, overstory lodgepole pine are commonly replaced by young, understory lodgepole pine.

Whitebark Pine (*Pinus albicaulis*)

Whitebark pine occur at high elevations in subalpine communities in the northern Rocky Mountains and the Pacific Northwest. This hardy tree grows in areas with poor soils, high winds, and steep slopes that are inhospitable to other tree species. Whitebark pine is an important conifer in these upper ranges where it retains snow and reduces erosion, acts as a nurse plant for other subalpine species, and produces seeds that are an important food for birds, grizzly bears, and other wildlife. Whitebark pine produce wingless seeds and rely primarily on Clark's nutcrackers (*Nucifraga Columbiana*) for seed dispersal.

Substantial mortality in whitebark populations has been documented throughout its range. Decreases are attributed to the introduced pathogen white pine blister rust (*Cronartium ribicola*); native mountain pine beetle (*Dendroctonus ponderosae*); historic wildand fire suppression resulting in more frequent, larger, and hotter wildfires; and projected environmental factors associated with climate change. These agents, both individually and collectively, pose a significant threat to the persistence of healthy whitebark pine populations on the landscape. As a result, whitebark pine was listed as threatened under the Endangered Species Act in January of 2023.

A reported 27–42% of whitebark pine trees taller than 1.4 meters are infected with blister rust in the Greater Yellowstone region. As of 2023, 1,953 of the more than 5,500 monitored trees had died, including 60% of those in the >10 cm in diameter size classes. In addition, the Greater Yellowstone Network has estimated that by the end of 2023, 29% of whitebark pine trees >1.4 meters tall had died.

Aerial surveys, which measure the spatial extent of mortality rather than the percentage of individual dead trees counted on the ground, have generally produced higher whitebark pine mortality estimates in the Greater Yellowstone Ecosystem. This could be because larger trees, which occupy more of the area in the forest canopy visible from the air, are more likely to be attacked by beetles, which prefer larger trees for laying their eggs. In 2013, an aerial survey method called the Landscape Assessment System was used to assess mountain pine beetle-caused mortality of whitebark pine across the region. Results of the one-time study indicate that nearly half (46%) of the GYE whitebark pine distribution showed severe mortality, 36% showed moderate mortality, 13% showed low mortality, and 5% showed trace levels of mortality.

The needles of a whitebark pine are clustered in groups of five.

Despite the high percentage of large trees that have died, trees are continuing to produce cones, and regeneration is still occurring. The network estimated an average growth of 63 small trees per 500 m^2 by the end of 2023.

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Staff Reviewer

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Understory Vegetation

Understory vegetation differs according to precipitation, forest type, and substrate. Lodgepole pine forest is often characterized by a very sparse understory of mostly elk sedge (*Carex geyeri*) or grouse whortleberry (*Vaccinium scoparium*). Pinegrass (*Calamagrostis rubescens*) occurs frequently under Douglas-fir forest but is also common under other forest types, especially where the soil is better developed or more moist. In some areas of the park, such as Bechler and around the edges of the northern range, a more obviously developed shrub layer is composed of species such as Utah honeysuckle (*Lonicera utahensis*), snowberry (*Symphoricarpos* spp.), and buffaloberry (*Shepherdia canadensis*).

Forest Insect Pests

Coniferous trees of Yellowstone currently face one fungal and five insect threats. The fungus is a nonnative species while the insects are native to this ecosystem. Both fungus and insects have been present and active in cycles, probably for centuries. A scientist studying lake cores from the park has found insect remains in core samples, indicating their existence even millions of years ago. However, in the last 10 years, all five insects have been extremely active as a result of climate change.

The primary cause of tree mortality in Yellowstone is native bark beetles. Beetles damage trees in similar ways: their larvae and adults consume the inner bark. If the tree is girdled, it dies. Their feeding activity can girdle a tree in one summer, turning the crown red by the following summer. The needles usually drop within the next year, leaving a standing dead tree (snag). Scattered throughout the park, isolated pockets of red-needled trees lend testament to past and present beetle activity.

Pest Activity

The severity of insect-caused tree mortality has been considerable throughout the West for over a decade. These damaging insects have spread to previously unaffected plant communities. Several native bark beetle species in the Scolytidae family have altered extensive areas within the Greater Yellowstone. Forest structure, tree health, and climate are the major factors in determining whether an outbreak expands; drought and warmer temperatures can make forests more vulnerable to infestation.

Although activity by both Douglas-fir beetle and Engelmann spruce beetle has declined to endemic (natural to Yellowstone) levels since 2000, other forest insects of ecological significance remain active. Mountain pine beetle activity was largely confined to the northwest portion of the park, in high-elevation whitebark pine and lower-elevation lodgepole pine, peaking in 2009 with annual decreases in mortality since. Defoliation of Douglas-fir and Engelmann spruce by the western spruce budworm is present in the park throughout the lower Lamar and along the

Forest Insect Pests

Number in Yellowstone
Five forest pests and one forest pathogen.

Mountain Pine Beetle (*Dendroctonus ponderosae*)
- Affects whitebark, lodgepole, and limber pine.
- The tree defends itself by increasing resin (pitch) production, which can "pitch out" the insect from the tree and seal the entrance to others.
- Look for globs of resin, often mixed with wood borings, on the bark.
- Adults emerge in mid-summer.

Engelmann Spruce Beetle (*Dendroctonus rufipenni*)
- Affects Englemann spruce, rarely lodgepole pine.
- Larvae feed for two years.
- Look for reddish dust on the bark and at the base of the tree in early summer.

Douglas-Fir Beetle (*Dendroctonus pseudotsugae*)
- Affects Douglas-fir.
- Larvae also consume outer bark.

Western Balsam Bark Beetle (*Dryocoetes confusus*)
- Affects subalpine fir.

Western Spruce Budworm (*Choristoneura occidentalis*)
- Affects Douglas-fir, true firs, spruce.
- Larvae defoliate trees and can destroy cones and seeds.
- Look for clumps of chewed needles on branch tips.

White Pine Blister Rust
- A nonnative disease caused by the fungus *Cronartium ribicola*.
- Affects whitebark and limber pines.
- The disease affects the tree's ability to transport nutrients and produce cones, and may eventually kill the tree.
- Look for cankers on the bark.

Management Issues
- Research will investigate the interactions between insect infestations and wildfire.
- Participate in a national strategy to conserve whitebark pine.

Yellowstone and Lamar river valleys. However, in recent years, budworm infestation and damage have decreased. These trends continued in 2011 when the park was partially surveyed.

Future of Insect Outbreaks in Yellowstone

Landscape-scale drought and the availability of suitable host trees have contributed to insect outbreaks. Healthy trees can defend themselves from beetle attack by "pitching out" adult females as they try to bore into the tree. Extreme winter temperatures can kill off overwintering broods, and cooler, wet summer weather impedes the insects from invading additional trees. Insect activity also decreases as the larger and more susceptible trees are killed off. Spruce beetles have likely declined as a result of insufficient preferred food sources (spruce trees more than 10 inches in diameter).

Recent and ongoing studies supported by the National Park Service are investigating the interaction between insect infestations and wildfire. Researchers have focused on how bark beetle epidemics may affect fire behavior in lodgepole-dominated forests and are comparing the resulting fire hazard with that in Douglas-fir forests.

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Other vegetation communities in Yellowstone include sagebrush-steppe, wetlands, and hydrothermal communities. Sagebrush-steppe occurs in the northern range in Yellowstone.

Other Vegetation Communities

Sagebrush-steppe

This vegetation type occurs in the northern range; in Hayden, Pelican, and Madison valleys; on Swan Lake Flats; and along many of the rivers and creeks. Mountain big sagebrush (*Artemisia tridentata* var. *vaseyana*) dominates, along with several other kinds of sagebrush. Several grass species, such as Idaho fescue (*Festuca idahoensis*), also dominate sagebrush-steppe. Other species found in sagebrush-steppe include mountain brome, needlegrasses, yampah, sticky geranium, and several species of upland sedges. The northern range can be spectacular with wildflowers in late June and early July.

In 2015, a long-term sagebrush-steppe monitoring program was inititated to track the changes in plant cover and species composition over many years with an emphasis on invasive species. Data loggers will be used to assist staff with correlating any changes in the vegetation with climate change.

Wetlands

Where to See
Some wetlands located near roads:

- **Northeast Entrance Road**, beginning east of Yellowstone Picnic Area: look for sandhill cranes and ducks in the glacial ponds throughout the Lamar Valley.
- **Firehole Lake Drive:** listen for frogs and look for elephant's head flowers in hydrothermal wetlands where the road begins.
- **Dunraven Pass area:** look for abundant wildflowers in high-elevation seep wetlands near the road.
- **Norris Geyser Basin**, Back Basin: near Puff 'n' Stuff Geyser, look for dragonflies.
- **All thermal areas:** look for seaside arrow grass, and warm springs spike-rush, ephydrid flies, thermophiles, and other life forms.

Wetlands

Yellowstone's wetlands include lakes, rivers, ponds, streams, seeps, spring mounds, marshes, fens, wet meadows, forested wetlands, and hydrothermal pools. They occupy more than 357 square miles (924 km^2): 44% are lakes and ponds larger than 20 acres or having water deeper than 6.6 feet at low water; 4% rivers and streams; and 52% shallow water systems that dry up most years. Roughly 38% of the park's plant species—including half of the rare plants—are associated with wetlands, and 11% grow only in wetlands. Each type of wetland has a different suite of plants. Wetland flora put on a nice bloom, are widely distributed, and from June to September include the park's wildflower, fringed gentian (*Gentianopsis thermalis*). Wetlands in the park harbor much of the park's sedge biodiversity with 57 of the park's 82 sedge species known to occur in wetlands. Wetlands provide essential habitat for Yellowstone's rare plants, thermal species, reptiles, and amphibians; and for numerous insects, birds, and fish.

Hydrothermal Communities

Yellowstone is the best place in the world to see hydrothermal phenomena such as geysers and hot springs. Fascinating and unique plant communities have developed in the expanses of thermally heated ground. Many of the species that occur in the geyser basins are actually species that tolerate tremendously different conditions and thus grow all over the western United States. Other species, however, are typical of the central Rockies or are regional endemics.

Hydrothermal plant communities demonstrate in very short periods of time that change is fundamental in any natural system. In a few days, the ground can heat up, perhaps triggered by an earthquake, and kill plants, while an adjacent area may cool, allowing plants to invade a previously inhospitable place.

NPS/D. RENKIN

Fringed gentian (*Gentianopsis detonsa*), the park wildflower. The appearance of wildflowers announces spring in the park. Enjoy the wildflowers, but don't pick them.

Wildflowers

Wildflowers such as lupine (*Lupinus argenteus*) and arnica (*Arnica cordifolia*) often grow under the forest canopy, but the most conspicuous wildflower displays occur in open meadows and sagebrush-steppe. The appearance of springbeauties (*Claytonia lanceolata*), glacier lilies (*Erythronium grandiflorum*), and steer's head (*Dicentra uniflora*) announce spring in the park. Soon colors splash the slopes, especially on the northern range—yellow from arrowleaf balsamroot (*Balsamorhiza sagittata*), white from phlox (*Phlox multiflora*), reds and oranges from paintbrush (*Castilleja*), and blue from penstemon (*Penstemon montanus*) and lupine. Goldenrod (*Solidago multiradiata*) and purple asters indicate the coming of fall.

Finding Flowers

Elevation, relative temperatures, soil types, and precipitation patterns all play a role in what you find blooming in various areas at different times of the year. In addition, far-reaching events such as fires can cause spectacular blooms of species that thrive on the conditions these events create.

Remember that many of Yellowstone's wildflowers are also very important parts of animal diets. The bulbs of springbeauty and glacier lily, for example, are vital spring foods of the grizzly bear. Wild strawberries are collected by ground squirrels and chipmunks; the seeds of most wildflowers are used by birds and insects. Even the petals of many flowers are eaten by animals. Bees and other insects collect nectar and pollen.

Invasive Species

Exotic plants—escaped domestics and "weeds"—can be found in Yellowstone. Look for them in disturbed sites such as roadsides where they have little initial competition and frequent redisturbance. Dalmation toadflax (*Linarea dalmatica*), yellow sweetclover (*Melilotus officinalis*), ox-eye daisy (*Leucanthemum vulgare*), and other exotics compete with native plants. For this reason, and for the continued integrity of the Yellowstone ecosystem, these exotics are controlled. Currently 229 nonnative species have been documented in the park. Of those, nine are native to North American and not native to Yellowstone.

Dalmation toadflax (*Linarea dalmatica*) is an invasive species common along trails and roads. Improper removal techniques can actually spread infestations further.

More Information

Occasional wildflower sightings are posted on http://www.nps.gov/yell/learn/nature/wildflowers.htm and https://www.facebook.com/YellowstoneNPS

Staff Reviewer

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Yellowstone is home to three endemic plant species, or species that occur only in Yellowstone and nowhere else in the world. Yellowstone sand verbena, shown here, is only found along the shore of Yellowstone Lake.

Rare Plants

The Greater Yellowstone region has few endemic plant species, or species that occur only in Yellowstone and nowhere else in the world. Endemic species occur in unusual or specialized habitats such as hydrothermal areas. Within Yellowstone, only three endemic species occur: Ross's bentgrass (*Agrostis rossiae*), Yellowstone sand verbena (*Abronia ammophila*), and Yellowstone sulfur wild buckwheat (*Eriogonum umbellatum* var. *cladophorum*).

Several other unusual species live in the Greater Yellowstone Area: warm springs spike rush, which grows in warm water; and Tweedy's rush, sometimes the only vascular plant growing in acidic hydrothermal areas.

Ross's Bentgrass (*Agrostis rossiae*)

Yellowstone's geothermally influenced plant communities contain species that must be able to tolerate a wide range of conditions. Although most of these species are widespread in range and occur at diverse elevations, not all of them are common. A unique grass of the geyser basins is Ross's bentgrass. This species is highly restricted in range. It grows in "vapor dominated" sites in the thermal areas, such as crack systems, the walls of thermal springs, or geothermally influenced depressions. Together, the widespread species and the local endemic form an interesting plant community in geothermal areas.

Distribution

Ross's bentgrass grows only in the geyser basins in the Firehole River drainage and at Shoshone Geyser Basin. Even within the thermal areas of Yellowstone's geyser basins, the right conditions to support Ross's bentgrass are rare and highly scattered. Thermal habitats are distinguished primarily by their elevated soil temperatures, and heat stress is the primary factor controlling the distribution of plants within them. This species seems to require locations providing the right combination of moisture and warmth that create a natural greenhouse. As a result, this grass is one of the first plants to green up in warm pockets of geyserite—sometimes as early as January.

In the right conditions, Ross's bentgrass can grow profusely, sometimes with several hundred plants in a very small area. Although Ross's bentgrass is considered a poor disperser of seed, this trait may be adapted to thermal habitats that tend to be small and scattered. A seed bank in the thermal area may be more advantageous to a thermal species than dispersing seed into habitat where the plant is unlikely to survive. Most of the known sites of Ross's bentgrass, fewer than 12 acres of occupied habitat in total, have been mapped using the Global Positioning System (GPS).

Life History

Because the seeds of Ross's bentgrass germinate from December to January, the plants are a conspicuous green presence in the thermal areas by late winter. Flowers are produced in May and early June when the plants reach their maximum size of 1.5–7.8 inches (4–20 cm), after which they dry out and die as the soil temperature rises. Flowers may be present in February and March, but the plants typically do not produce viable seed that early. Full bloom occurs in late May and early June. As soon as temperatures rise in the early summer, the plants dry out due to the sun's heat from above and the thermal heat from below. Ross's bentgrass is already dead and hard to find by July.

Life in Thermal Areas

Although the temperature an inch beneath Ross's bentgrass can be 100°F, it does not appear to be

Ross's bentgrass is native to the geyser basins along the Firehole River.

especially heat tolerant. It survives only in thermal areas because their lethal summer temperatures impose a short growing season advantageous to annual plants with precocious flowering and prevent competition from slower growing perennials.

Any plant growing in thermal areas must be able to deal with constant change. A successful plant in the geyser basins must be able to shift location relatively easily, because one major thermal change, or several smaller changes, could eradicate the entire population. Apparently, Ross's bentgrass deals with this problem efficiently. Its seed-dispersal mechanism probably includes traveling on the muddy hooves of bison and elk who inhabit thermal areas during the winter. Nonnative species, such as cheatgrass, pose the only known threat; as they spread in thermal areas, they eventually may out-compete Ross's bentgrass.

Research

Recent genetic research indicates that another *Agrostis* found in thermal areas, which was previously considered the same species as the perennial *A. scabra* (ticklegrss), is actually an annual more closely related to *A. rossiae* as well as to *A. scabra* var. *geminata* in Lassen Volcanic National Park and *A. pauzhetica* from the Kamchatka Peninsula of Russia. The thermal *Agrostis* complex needs to be more closely investigated to determine the taxonomy and correct scientific name for this other annual bentgrass in Yellowstone's thermal areas.

Sometimes both of the thermal *Agrostis* occur in the same area, but generally they do not grow directly adjacent to each other. While Ross's bentgrass occurs only along the Firehole River drainage and Shoshone Geyser Basin, the other *Agrostis* is commonly encountered at thermal areas throughout the park. Both *Agrostis* are typically surrounded on cooler ground by non-thermal ticklegrass, which is common in the park interior and reproductively isolated from the thermal plants by its later flowering time.

The primary threat to Ross's bentgrass is fast-growing, invasive annual species such as cheatgrass, bluegrass, and chickweeds. These species are restricting the presence of *A. rossiae* at several locations in the Upper Geyser Basin.

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Yellow Monkeyflower

Unlike Ross's bentgrass, the yellow monkeyflower (*Mimulus guttatus*, also known as *Erythranthe guttata*) occurs abundantly throughout western North America. However, like bentgrass, some monkeyflowers are specialized to thrive in the extreme habitats created by hydrothermal activity. In thermal areas in Yellowstone, monkeyflowers exhibit an annual life cycle, germinating during Fall, growing throughout the winter, and flowering as early as March and April to set seed before they are killed by the hot and dry soils of summer. In contrast, monkeyflowers in nonthermal habitats in the park (e.g., riversides and bogs) are long-lived perennials that only flower in the summer and spend most of the year under snow. Remarkably, these two types occur within meters of each other within the park and are in the early stages of speciation.

Yellowstone Sand Verbena (*Abronia ammophila*)

Yellowstone sand verbena occurs along the shore of Yellowstone Lake. Taxonomists debate the relationship of this population to other sand verbenas. It may be distinct at the subspecific level and is certainly reproductively isolated from the closest populations in the Bighorn Basin of Wyoming east of the park.

The presence of a sand verbena at 7,700 feet elevation in the northern Rockies is unexpected, as most members of this North American genus occur in the warmer climates of the Southwest and Pacific Coast. One speculation by botanists is that the warmth provided by the geothermal activity in the area enabled a genus which had evolved in a warmer climate to gradually adapt to conditions in Yellowstone. Today, Yellowstone sand verbena tolerates long, cold winters and uses the brief summer to bloom and reproduce.

Distribution

The entire occupied habitat of Yellowstone sand verbena plants is 1.48 acres. Herbarium specimens of Yellowstone sand verbena indicate that the species was previously more widely distributed along the lake shore. These early collections provide evidence that Yellowstone sand verbena has been extirpated at several sites (including near Fishing Bridge museum and the Lake Hotel) since 1900. In the past 30 years, an additional site has been extirpated, suggesting that as much as half of the population has been lost, probably due to trampling.

In 1998, about 8,326 plants were documented along the lake shore. The previous two years had been very wet, resulting in a high level of recruitment with many young plants, some of which would probably not survive drier conditions. In 2023, the population was estimated at 2,703 plants. Possible reasons for this decrease include natural fluctuations in population size, cumulative effects of many years of drought, and increased thermal activity. Other potential threats include trampling by humans and invasion by nonnative plants, particularly cheatgrass (*Bromus tectorum*).

Current work

In 2019, NPS began treating cheatgrass (manually and chemically) around the North Shore populations. Bumper logs were installed to discourage off-trail travel in 2021 and educational signs about protecting plant species have also been installed.

In 2021, NPS began working with a researcher to begin restoration of Yellowstone sand verbena at Pelican Point. Seed was collected from the North Shore population and grown in a greenhouse. Ninety-six individuals were planted in 2021 and 143 in 2022; 311 individuals were observed in 2023 and 149 in 2024.

Yellowstone sand verbena in the park is isolated from other populations.

Life History

The Yellowstone sand verbena grows close to the sand, rarely rising more than three inches from the surface. Some individuals occur near warm ground, so the thermal activity in Yellowstone may be helping this species survive. The foliage is sticky, which defends against herbivorous insects. White flowers bloom from mid-June until a killing frost.

Although the species was once thought to be an annual, it has a significant taproot that in mature plants extends at least several feet deep. Sand verbenas as a group are known to be sensitive to disturbance, suggesting that increased activity on the lake shore may have contributed to the species's decline as the result of wildlife and humans walking across the area. An area adjacent to Storm Point Trail has been closed to off-trail travel to protect the species.

Research has shown that the plants are capable of self-pollination as well as out-crossing using insect pollinators. Self-pollination may sustain Yellowstone sand verbena in the absence of pollinators, but it may lead to inbreeding depression. Many types of insects visit the flowers, but pollination occurs primarily from moths and bumblebees. Insect visitation is sporadic and adversely impacted by precipitation and turbulent winds. Genetic exchange among the sites is unlikely due to the significant distance between them and the low numbers at three of the sites. The

location of nearly all of the plants on the lake's north shore places the species at risk of extinction due to random events affecting the population.

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Yellowstone Sulphur Flower (*Eriogonum umbellatum* var. *cladophorum*)

Approximately 250 species of wild buckwheat are found in the world, with most of the species occurring in arid regions of the western United States. The group has undergone rapid evolution, leading to numerous closely related taxa. The sulfur buckwheats (*Eriogonum umbellatum*), of which there are 41 recognized varieties in the West, exemplify this rapid speciation. Several varieties of sulfur buckwheat live in the park, but the variety endemic to the park, Yellowstone sulphur flower, is found only in the Firehole River drainage.

Description

Yellowstone sulphur flower has bright yellow flowers and very hairy, somewhat gray looking leaves, distinguishing it from the more common varieties. The other bright yellow buckwheat in the area, Piper's wild buckwheat (*Eriogonum flavum* var. *piperi*), blooms early in the summer, well before Yellowstone sulphur flower, and on close examination the flowers are hairy on the exterior.

The close relative of Yellowstone sulphur flower has creamy yellow flowers without hairs, greenish leaves, and blooms before Yellowstone sulphur flower. Even though these two taxa are considered members of the same species, there has been no sign of interbreeding or hybridization. Growing on mildly geothermally influenced ground, this plant community includes several species that are more commonly encountered at lower elevations or as components of the Great Basin flora. Superficially, these areas in the vicinity of the park's geyser basins look relatively barren, but the plant species representing different areas of the West form a unique plant community that can be found nowhere else.

Distribution

Yellowstone sulphur flower is adapted to survive on barren, slightly geothermally influenced open areas. It apparently does not tolerate any shading, so it is a conspicuous component of relatively dry plant communities adjacent to the park's thermal areas. The geographic range of this variety is highly restricted, having been found only from the Upper, Midway, and Lower geyser basins to the vicinity of Madison Junction. Adaptation to life in a geothermal setting means that this taxon has to be able to move with changes in the geothermal system. Yellowstone sulfur buckwheat is capable of recolonizing disturbed areas, as demonstrated by its presence near the Old Faithful Inn and Visitor Education Center, and other locations in the Upper Geyser Basin.

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Staff Reviewer

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Yellowstone sulphur flower wild buckwheat is only found in Yellowstone National Park.

Yellowstone works to prevent the spread of invasive plant species, which can displace native species, change vegetation communities, affect fire frequency, and impact food for wildlife.

Invasive Plants

Invasive nonnative plants can displace native plant species, including some endemic to the park's geothermal habitats, change the nature of vegetation communities and affect fire frequency and the distribution, foraging activity, and abundance of wildlife. These changes can profoundly affect the entire ecosystem. For example, nonnatives that are unpalatable to wildlife may replace preferred native plants, leading to changes in grazing activity. In turn, this stresses plants not adapted to grazing.

Invasive plants have altered views of the park's cultural landscapes and historic districts. Seeds may be spread by people and their vehicles, wild and domestic animals, and sand and gravel used for construction and maintenance work. The most vulnerable areas have been disturbed by human use: along the roads, trails, and rivers— though they are spreading from developed areas to the backcountry. Restoring native plants in an area that has become infested is extremely difficult.

In addition to about 1,491 native plant taxa, 229 nonnative species have been documented in the park through ongoing survey efforts. Not all of these nonnative species are still present in the park, but most of them are.

Managing Invasive Plants

Controlling all the invasive plants—some well-established—is unrealistic. Staff prioritize treatments based on the threat they pose to native plant communities and the likelihood for successful control.

Quick Facts

Number in Yellowstone
229 species

Canada Thistle (*Cirsium arvense*)
- Throughout the park and adjacent national forests.
- Airborne seeds enable it to spread widely throughout the park, invading wetlands. Forms dense monocultures, thus radically changing an area by forcing out native vegetation.

Dalmatian Toadflax (*Linaria dalmatica*)
- Northern portions of the park, especially around Mammoth.
- Highly invasive, replaces native plants.

Houndstongue (*Cynoglossum officinale*)
- Primarily found in Mammoth and at the East Entrance.
- May have been introduced by contaminated hay used by both the National Park Service and concessioners in their horse operations.
- Seeds easily attach to the coats of animals, and thus spread along animal corridors.
- Highly invasive.

Leafy Spurge (*Euphorbia esula*)
- Small patches in Bechler and along roadsides, so far being successfully controlled but spreading actively in Paradise Valley north of the park and outside Bechler on the Caribou-Targhee National Forest.
- Becomes a monoculture.
- Extremely hard to control because of deep underground stems (up to 30 feet) and dense vegetation.

Ox-eye Daisy (*Leucanthemum vulgare*)
- Mammoth and Madison areas.
- Can become dominant in meadows, is unpalatable to elk and other wildlife.
- Control efforts have substantially curtailed infestation; monitoring and evaluation continue.

Spotted Knapweed (*Centaurea maculosa*)
- Along roadsides and in the vicinity of Mammoth.
- Aggressive species that, once established, forms a monoculture.
- Aggressive control efforts underway to prevent a catastrophic change in park vegetation.

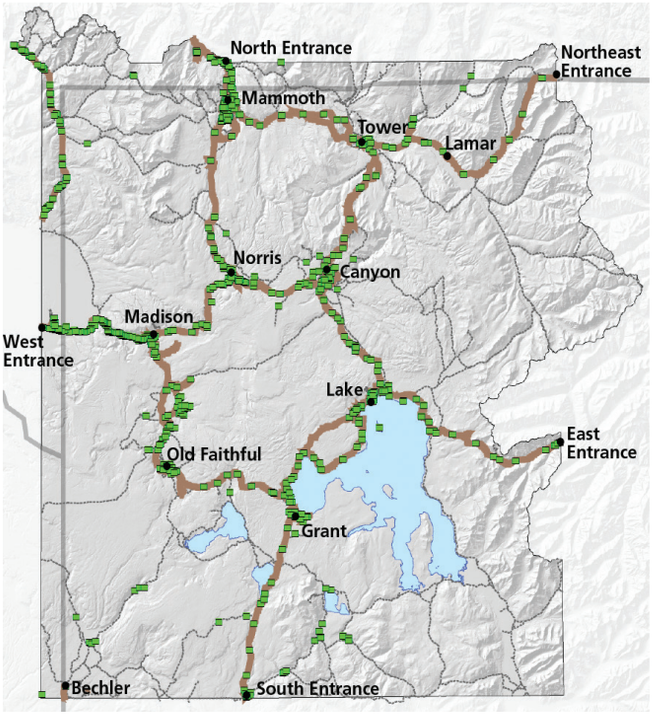
Management Issues
Resource managers target the most invasive species for control or removal.

Words to Know

Native species have occurred, now occur, or may occur in a given area as a result of natural processes. Native plants evolve within their own ecological niche in concert with other native plants.

Nonnative species (also known as exotic, foreign, non-indigenous, alien, or weeds) live outside their natural range and arrived there by human activity, either deliberate or accidental. Nonnative species typically have few biological controls to keep their populations in check.

Invasive species have the potential to thrive and spread aggressively outside their natural range, and can include native species. A naturally aggressive plant may be especially invasive when it is introduced into a new habitat. An invasive species that colonizes a new area often has an ecological advantage because the insects, diseases, and foraging animals that naturally keep its growth in check in its native range are not present in its new habitat. An invasive plant that sustains itself outside cultivation is considered naturalized and has not "become" native.



A total of 120 acres (green circles) of invasive plants were treated in 2015. Most treatment areas are along roadways and in developed areas, though trails and some backcountry areas were also treated.

Some infestations can be eradicated if the species is treated when the outbreak is still small; other species, such as spotted knapweed (*Centaurea maculosa*), are so common that stopping them from spreading is the primary goal. This strategy has helped prevent high-priority invasive species from moving into wilderness areas where control is more difficult.

Nonnative vegetation was found occurring on 18,440 acres inventoried in 2022. Sometimes exotic plants are found in pure populations with few native plants, but are most often mixed within native plant

Keep Invasive Plants Out of Yellowstone National Park

- Don't transport them. Be diligent at removing debris (especially seeds) and mud from boots, gear, pets and your vehicle after recreational activities.
- Report "suspicious" looking plants to the park botanist. To report a plant, just take a photo and note the location (coordinates such as UTMS are even better if you have access to a GPS unit). Please email photo and location to Heidi_Anderson@nps.gov. Our best hope of keeping a native flora intact is catching small populations before they expand.
- When removing seeds from clothing and pets dispose of them properly when you find them. If you are unfamiliar with a seed attached to your clothing wait untill you're back at the trailhead to dispose of it; this can stop the spread of invasive plants into the backcountry.
- Use trailhead boot brushes when available to stop the spread of weeds. Yellowstone National Park installed eight trailhead boot brushes in 2019. This is a quick way to remove seeds possibly hiding on the bottom of your shoes and a good time to stop and inspect pets and clothing before venturing further down the trail.
- Stay on designated routes, roads, and trails when possible. New social trails help spread weeds to new locations.
- Park in designated pull offs or on a hardened surface whenever possible. Parking on the vegetation not only kills the existing plants but also introduces new weed species.
- If you are a frequent visitor to the park, please consider adopting a weed patch or helping collect native seed for restoration projects in the park by contacting the park botanist at Heidi_Anderson@nps.gov.
- Please photograph and observe the plants, but do not pick the flowers.

Together we can keep areas weed free and stop invasive plant species from disrupting native plant communities. Early detection can also be extremely helpful, so the more you know the more you can help.

Park managers sometimes restore disturbed areas infested by invasive nonnative plants to native vegetation. The area enclosed by this sturdy fence was an irrigated field; park managers are restoring native plants here.

communities. Based on program priorities for species, the equivalent of 103 acres of pure non-native plant populations was treated during 2022. Physical removal is the preferred method of control when feasible, but pulling or cutting of some of the perennial species serves to stimulate new growth, and the use of herbicides becomes necessary to control aggressive species over large areas. Manual pulling efforts in 2022 totaled three acres as these efforts were limited to small, isolated patches along road corridors and in bison brucellosis quarantine facilities. Most of the 36 species targeted for treatment are listed by the states of Idaho, Montana, or Wyoming as "noxious weeds," which means they are detrimental to agriculture, fish and wildlife, aquatic navigation, or public health.

Preventing the Spread of Invasive Plants

Prevention efforts include control of construction materials entering the park, equipment inspections at park entrances, allowing only certified weed-free hay to be transported through the park, restricting the use of hay in the backcountry, and planting native species where ground disturbance has occurred.

To improve nonnative plant management throughout the region, park staff work with land managers from other government agencies, the Greater Yellowstone Coordinating Committee's Weed Subcommittee, and the National Park Service's Rocky Mountain Exotic Plant Management Team. The park uses Integrated Pest Management—chemical, biological, sociological, and mechanical methods—to control some of the nonnative plants. The park also cooperates with adjacent state and county Weed Control Boards to share knowledge and technology related to nonnative plant detection and control.

More Information

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Restoring Native Plants

In 1932, President Hoover added more than 7,000 acres of land to Yellowstone National Park to provide low-elevation winter wildlife habitat near Gardiner, Montana. The addition included 700 acres of irrigated agricultural fields.

Park managers stopped irrigating the fields and planted a nonnative perennial grass, crested wheatgrass (*Agropyron cristatum*), that they hoped would tolerate the arid conditions and provide wildlife forage. It thrived for many decades but was never suitable forage. Eventually, another, more aggressive nonnative plant—an annual mustard, desert alyssum (*Alyssum desertorum*)—moved in. Alyssum germinates very early and uses up most of the soil moisture before other species even get started. It also exudes a chemical that inhibits soil bacteria needed by native plants.

Park managers are restoring native vegetation to this area, following recommendations of arid-land-restoration specialists. In 2008 and 2009, they fenced four pilot plots totaling 50 acres, where they are controlling nonnative plants with herbicides and growing cover crops to increase soil organic matter and moisture-holding capacity and to restore soil microbial communities. Since 2014, the areas within the fences, as well as some areas outside of the

fencing, have been drill and broadcast seeded with a mix of native grasses and forbs. Spot-spraying with herbicides in the seeded areas will continue to help the native species establish.

In 2022, the last section of restoration fencing was removed to allow wildlife to have access to all revegetated areas. Restoration of native plants will continue in the Gardiner Basin without the use of exclosure fencing. Future restoration efforts continue to follow a "broadcast herbicide-plant native seed-spot treat with herbicide" method, and in 2022, approximately 35 additional acres were treated in this manner south of Rescue Creek along the northern boundary of Yellowstone National Park. Nearly 20 acres of Landslide Creek, initially treated in 2020, were also selectively herbicide-treated and reseeded from 2021–2022.

Greater Yellowstone is a fire-adapted ecosystem. Smoke may be visible from ongoing fires during the fire season, typically July through September.

Fire

Fires are a natural part of the Greater Yellowstone Ecosystem (GYE). Native plant species have evolved to thrive after periodic fires. Evidence of pre-1872 fires found in soil profiles, charcoal, and old-growth trees indicates fires have occurred in Yellowstone for over 14,000 years. The ecosystem's processes, such as nutrient cycling and plant community composition, are heavily influenced by the natural process of fire. However, fire suppression by European Americans altered these natural fire regimes. Without regular fires, biodiversity declined, and leaf litter accumulated faster than nutrients can return to the soil. Now, the National Park Service (NPS) aims to restore fire's natural role in parks where feasible.

In Yellowstone, lightning often ignites numerous forest fires during summer, with most extinguishing naturally. Occasionally, large wind-driven fires can impact millions of acres—a fire of this magnitude occurred in Yellowstone in 1988. The fire season typically lasts from July to September, influenced by climate, suppression efforts, and weather conditions.

Ignition

Afternoon thunderstorms that release little precipitation occur frequently in the northern Rockies. Yellowstone receives thousands of lightning strikes in a typical summer, but most do not result in fires. A snag struck by lightning may smolder for several days and then burn out because surrounding fuels are too moist to sustain combustion or too sparse to allow the fire to spread. Most of the park's forests have few shrubs; understory fuels are predominantly young trees. The moisture content of both live and dead vegetation tends to drop as summer progresses, temperatures increase, and relative humidity decreases. Fuels have often dried out enough to ignite the first wildfire of the year by July.

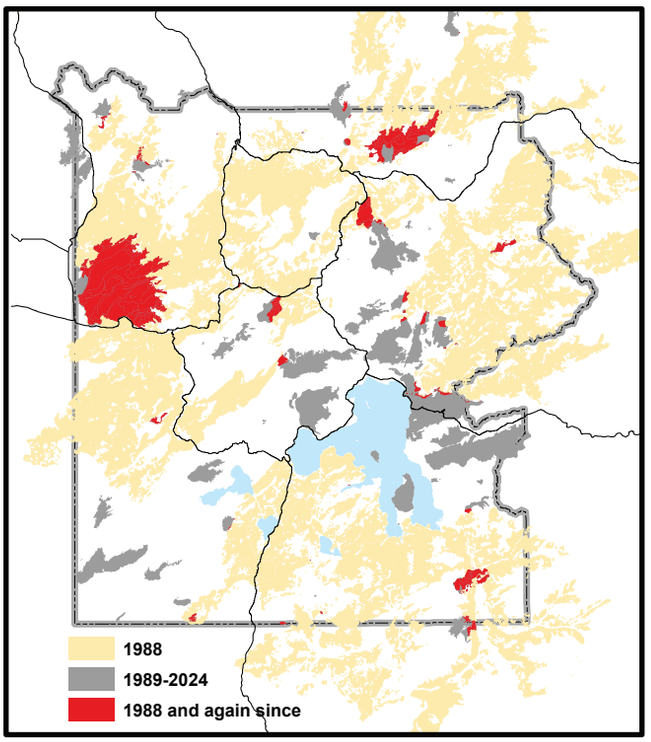
A forested area that has burned recently enough to contain only young stands of trees usually doesn't have enough combustible fuel to carry a fire, except under extreme weather and climate conditions. But as the years pass, trees that don't survive the competition for light and other resources die and eventually fall over. On living trees, older branches die and fall off as they are shaded by new foliage growing above. As a stand grows older and taller, the canopy becomes more broken. This allows enough light to reach the forest floor for a shade-tolerant understory to be established. The accumulation of fuel on the forest floor, and the continuity of fuels from forest floor to understory to canopy, make older stands more vulnerable to fire. Some forests in Yellowstone may not have burned in at least 300 years and may be particularly prone to lightning ignition.

Fire Behavior

Nearly all of Yellowstone's plant communities have burned at one time or another, but their varied characteristics cause fires to behave differently. To quickly assess a fire start and its potential to spread, park staff

use different vegetation communities as indicators of fuel load, dominant vegetation, and time since the last fire or other disturbance.

The moisture content of dead and downed woody debris, climate, and weather trends are the main factors that determine the severity of a given fire season. While fires can occur no matter the fuel moisture, many times conditions are too wet for fires to spread. In fact, 88% of all fires burn fewer than 10 acres in the park. However, in Yellowstone, when 1,000-hour fuel moistures fall below 12%, fires can grow quickly. If extreme drought continues, most forest types and ages are likely to burn.



Burned areas in Yellowstone from 1988 to 2024. Until 2016, the large fires of the 2000s were burning in areas largely unaffected by the 1988 fires. In 2016 alone, 42,425 acres burned in 1988 fire scars.

To determine how much water is in the fuel, Yellowstone fire monitoring staff weigh and oven-dry fuel samples to determine the moisture content. In a normal fire season, 1,000-hour fuels within the park may average 14–20% fuel moisture. (Dead fuels are classified according to size, and how long they take to dry out when completely soaked; "1,000-hour fuel moisture" refers to the moisture in large fuels such as downed timber that would generally dry out within 42 days. Kiln-dried lumber is 12%.)

Fire behavior is generally not observed until 1,000-hour fuel moisture contents are less than 18%, and only minimal areas are burned until moisture levels drop to 12%. At that point, a fuel moisture threshold is crossed; lightning strikes in forested areas can quickly result in observable smoke and, if fuel and vegetation conditions are right, the fire spreads. Below 12% fuel moisture, younger and more varied forest types may burn, especially when influenced by high winds. During extreme drought years, 1,000-hour fuel moistures may drop as low as 5%.

Quick Facts

Numbers in Yellowstone

- In 2024, 5.6 acres burned from 9 known wildfire starts. All but one were lightning caused and the largest was the Riverside Fire at 4 acres.
- Since 1972, when reliable fire records began, the park has averaged 24 fires, and 5,466 acres burned per year. The number of fires has ranged from five to 78 each year, and acres burned has ranged from one to 793,880 each year.
- The most active fire year since 1988 was 2016, with 70,285 acres in Yellowstone burned.
- In Yellowstone, approximately 78% of fires are caused by lightning, and 22% are human-caused.
- During the last 30 years (1994–2024), Yellowstone has averaged fewer fires per year, but more acres burned per year, than in previous decades.
- About 76% of fires in Yellowstone never reach more than 0.1 hectares (0.25 acres) in size.
- About 92% of fires in Yellowstone never burn more than 40 hectares (100 acres).

Characteristics

- Yellowstone's landscape has been shaped by naturally caused fire for 14,000 years. Factors affecting fire size and severity include: vegetation type; location; time since the last fire; moisture in the dead and down logs; length of drought; temperature; humidity; and wind.

Management Issues

- The park is required to protect human life as well as the approximately 2% of Yellowstone's 2.2 million acres that are considered developed from the threat of fire—while at the same time letting fire carry out its ecological role as much as possible.

Depending on the forest type, fuel moisture, weather, and topography, fires can grow in size by isolated or frequent torching and spotting (transport of burning material by wind and convection currents), or by spreading from tree crown to crown. Fires in Yellowstone's subalpine forests seldom spread significantly through ground fuels only. Like weather, terrain can be either an ally or adversary in suppressing unwanted wildfires. A few natural barriers such as the ridge from Electric Peak south to Mt. Holmes; Yellowstone Lake; and the Absaroka Mountains along the eastern boundary of the park are likely to prevent the spread of a low-to-moderate-intensity fire, but high-intensity fires may cross these features by spotting two to three miles ahead.

Fire managers may be able to predict a fire's behavior when they know where the fire is burning (vegetation, topography) and the fuel moisture content. However, predicting fire is much more difficult during prolonged drought periods, such as those in 1988, 2003, and 2016.

Ongoing research in Yellowstone is also showing that forests experiencing stand-replacing fires can affect fire behavior for up to 200 years. When a fire encounters a previously burned forest, its intensity and rate of spread decrease, except under prolonged drought conditions. In some cases, the fire moves entirely around the burned area. Thus, fire managers have another tool for predicting fire behavior: they can compare maps of previous fires with a current fire's location to predict its intensity and spread.

Ecological Consequences of Fire

In the first years after a major fire, new vistas appear while the lush growth of new, young trees emerges from the burned ground. Today, decades after the 1988 fires, those young trees are renewed forests, once again filling in vistas. Some visitors still feel the Yellowstone they knew and loved is gone forever. But Yellowstone is not a museum—it is a functioning ecosystem in which fire plays a vital role.

Vegetation

Some of the vegetation in the GYE has adapted to fire and, in some cases, is dependent on it. Certain plant communities require the removal of the forest canopy to become established. They are the first to inhabit sites after a fire. Other plants growing on the forest floor are adapted to survive at a subsistence level for long periods of time until fires open the canopy. Fire creates a landscape more diverse in age, which reduces the probability of disease or fire spreading through large areas.

Serotinous cones are one of the two types of cones produced by lodgepole pines, which make up nearly 80% of the park's forest. Serotinous cones will not release their seeds until the resin sealing them melts, requiring a temperature of at least 113°F (45°C). This adaptation helps ensure the seeds do not disperse until fire creates conditions that favor the establishment of lodgepole pine seedlings: diminished litter on the forest floor and plenty of sunlight through an open canopy.

Of the fires that occur in Yellowstone National Park, 76% are less than 0.25 acres and another 12% range from 0.25 to 9.9 acres. These smaller, less intense fires play a role in this ecosystem by helping to thin out smaller trees and brush, and boost the decay process that provides nutrients to the soil.

Some fires burn with higher intensity and rapid rates of spread. These large, fast-moving fires send plumes of smoke thousands of feet into the air and receive much of the public's attention. These large fires (>100 acres) only occur 8% of the time in the park.

Fire can limit trees in the meadows of Yellowstone. For example, Douglas-fir seeds require conditions that exist only in rare microhabitats in these meadows. If a seed reaches such a microhabitat during a favorable year, a seedling may develop. Once the tree is growing, it begins to influence the immediate environment. More tree habitat is created and a small forest island eventually appears. Periodic fire kills the small trees before they have a chance to become islands, thus maintaining the open meadow.

The thick bark on mature Douglas-fir trees resists damage from surface fires. Historically, in areas like the park's northern range, frequent surface fire kept most young trees from becoming part of the overstory. The widely scattered, large, fire-scarred trees in some of the dense Douglas-fir stands in the northern range are probably remnants of these communities.

Although Engelmann spruce and subalpine fir have thin bark, they grow in cool, moist habitats where conditions that enable fires to burn are infrequent. In 1988, 28% of the park's whitebark pine burned, though it grows in open, cold, high-altitude habitats that accumulate fuel very slowly and have only a short season between snowmelt and snowfall during which fires can ignite and carry. Caches of whitebark pine seeds collected by red squirrels and Clark's nutcrackers and the hardiness of whitebark pine seedlings on exposed sites give this tree an initial advantage in burned areas over conifers dependent on wind to disperse seeds. However, this slow growing and long-lived tree is typically more than 60 years old before reaching full cone production, and young trees may die before reproducing if the interval between fires is too short or if faster-growing conifers outcompete them.

Some soils respond quickly after fires, but other soil types may continue to support less vegetation.

Tree seedlings sprout and grow at variable rates between the surviving trees and the fallen and standing snags. As root systems of standing dead trees decay and lose their grip on the soil, the trees fall— sometimes hundreds at once in the presence of a strong wind. However, many trees remain upright for more than a decade after dying by fire or other causes.

Fires may stimulate regeneration of certain species of shrubs and trees, but their growth is also affected by other influences such as climate and wildlife browsing. Aspen have thin bark, but the clones are connected by a network of underground roots that can survive even very hot surface and crown fires. Although the above-ground stems may be killed, fire stimulates the sprouting of suckers from the roots, and fire leaves bare mineral soil suitable for the establishment of aspen seedlings.

Soils in Yellowstone that support little vegetation have been largely unaffected by fire. Soils that have dense, diverse vegetation before a fire are likely to respond quickly after the fire with a variety of species and nearly complete cover. Though above-ground parts of grasses and forbs are consumed by fire, the below-ground root systems typically remain unharmed, and for a few years after a fire these plants commonly increase in productivity because fire rapidly releases nutrients from wood and forest litter.

Trees in greater Yellowstone are adapted to fire. This serotinous cone from a lodgepole pine tree was opened by fire, allowing it to release its seeds.

The regrowth of plant communities begins as soon as moisture is available, which may be within days at some sites.

Wildlife

Wildfires do not significantly affect the abundance of most wildlife species in Yellowstone. Relatively few animals died as a direct result of the large fires in 1988, and most of those deaths were caused by smoke inhalation. Of Yellowstone's seven native ungulate species, only the moose experienced a population decline after 1988. Although moose population estimates are imprecise, it appears that with less willow and subalpine fir available for winter browse, and snow accumulating more deeply with many forest canopies gone, moose winter mortality increased in 1989.

Mortality in all ungulate species was unusually high in the winter after the fires, but it is difficult to know how much of that was the result of burned forage rather than drought, large herd sizes, and the relatively severe winter. Elk, bison, and deer populations soon rebounded.

Of the 38 grizzly bears wearing radio transmitters when the fires began, 21 had home ranges burned by one or more of the fires. Thirteen of those bears moved into burned areas after the fire front had passed, three adult females without young stayed within active burns as the fire progressed, three bears remained outside the fire perimeters, one adult female was not located for another two years, and another adult female was never located again at all. Large predators such as grizzly and black bears, cougars, and wolves simply move out of the way of a fire. Bears have been observed frequently grazing in burned areas after the vegetation has started to return due to the increase in vegetation in years following a fire. Even the fires in 1988 had no discernible impact on the number of grizzly bears in the GYE.

Wildlife continue to use burned areas after fires.

Rodents probably have the highest fire-related mortality of any mammals. Although many can escape fires in burrows, they can die of suffocation as fires come through. They also become more exposed to predators because they temporarily lose the cover of grasses and other plants. But, because of their capacity to have multiple litters with many young per year, rodents quickly repopulate burned areas.

Most birds are not directly harmed by fires, and some benefit. Raptors hunt rodents fleeing a fire, but young still in their nests may die. Post fire habitat changes help some birds. Cavity-nesting birds, such as Barrow's goldeneye, flickers, and bluebirds have many dead trees for their nests. Robins and flickers find ants and worms more easily. Boreal owls, however, may lose some of the mature forests they need.

History of Fire Management

Fire suppression in Yellowstone began with the arrival of the US Army, which was placed in charge of protecting the park in 1886. The Army, which was in Yellowstone until 1918, successfully extinguished some fires in the belief that suppression would help save the forests. However, it is difficult to determine how much effect a small group of men could have had on overall fire size or the extent of fires in a large park without motorized vehicles or good roads. Fire suppression was most successful on the northern range, which is relatively accessible from the park headquarters in Mammoth Hot Springs.

More effective fire fighting techniques and airplanes became available after World War II, but even then, fire suppression did not result in a significant increase in fuel loads except perhaps on the northern range. Records indicate fire was almost completely excluded (suppressed) from the Douglas-fir, sagebrush steppe, and aspen communities on the northern range from 1886 until 1987.

By the 1940s, ecologists recognized fire was a natural and unavoidable change agent in many ecosystems, including relatively arid portions of the Rocky Mountains. In the 1950s and 1960s, other parks and forests began to experiment with controlled burns. In 1972, Yellowstone became one of several national parks to initiate programs that allowed some lightning-caused fires to burn. Two backcountry areas in

History of Fire Management in Yellowstone

For the first 100 years of the park's existence, managers believed fires had to be extinguished to preserve park resources. Subsequent 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 vegetation patterns of the landscape,
- fire is a part of the ecosystem park managers want to preserve, and
- suppressing fires alters the natural landscape and diminishes diversity.

History

- 1886–1918: US Army suppresses fire in Yellowstone.
- 1940s: More effective fire suppression techniques become available after World War II. Around the same time, ecologists recognize fire is a natural and unavoidable change agent in many ecosystems.
- 1972: Yellowstone begins allowing some natural fires.
- 1972–1987: 235 natural, unsuppressed fires burned 33,759 acres—mostly in two dry years: 1979 and 1981.
- Spring 1988: Approval of a new fire management policy for Yellowstone is suspended.
- 1988: 793,880 acres burn in Yellowstone, sparking an increase in the public understanding and acceptance of the role of fire in wildland areas.
- 1989: A national policy review team reaffirms the importance of natural fire policies in national parks and wilderness areas.
- 1992: Yellowstone issues a new fire management plan incorporating the 1989 review team's recommendations.
- 2004: Yellowstone's fire management plan is revised.
- 2009: Yellowstone begins operating under the 2009 Federal Wildland Fire Policy, which allows the park to manage fires for multiple objectives.
- 2014: Yellowstone's fire management plan is revised.

the park totaling 340,000 acres, Mirror Plateau and Two Ocean Plateau, were designated as locations where natural fires could burn.

After three years, during which 10 fires burned a total of 831 acres in the two fire zones, the non-suppression area was expanded to include most of the park, except for developed areas and a buffer zone on the park boundary. Starting with Yellowstone National Park and Bridger Teton National Forest in 1976, cooperative agreements were adopted among all greater Yellowstone federal lands that by 1986 allowed natural fires to burn across shared public land boundaries.

From 1972 to 1987, 235 fires were allowed to burn 33,759 acres in Yellowstone. The summers of 1982–1987 were wetter than average, which may have contributed to the relatively low fire activity during that period. Yellowstone's fire managers began revising the park's fire management plan. The new plan permitted some lightning-caused fires to burn under natural conditions; provided for suppressing fires that threatened human life, property, special natural features, and historic and cultural sites; and recommended prescribed burns when and where necessary and practical to reduce hazard fuels. It was in the final stages of approval in spring 1988.

However, Yellowstone's "new" fire management plan was suspended in July 1988 as a consequence of the large fires that occurred that summer. After these fires, a national policy review team examined the national fire policy again and reaffirmed the importance of natural fire policies in national parks and wilderness areas. However, the report also offered recommendations, including the establishment of more specific criteria to determine under what circumstances fires are permitted to burn and more reduction of hazard fuels near developed areas. These recommendations were incorporated into Yellowstone's 1992 fire management plan. Other revisions occurred to the park's fire management plan in 2004 and 2014.

Monitoring fire behavior and weather on the Maple Fire, 2016.

Fire Management

Our Goals

- **We let wildfire carry out its ecological role while protecting people and structures.** Yellowstone National Park operates under the 2009 Federal Wildland Fire Policy. These guidelines allow fire personnel to manage a lightning-caused fire for multiple objectives. For example, fire personnel can suppress one side of a fire to protect structures and people, while allowing another side to burn to achieve natural fire benefits.
- **We work across boundaries to manage fires.**
- Wildfire is a great example of interagency cooperation and coordination. Federal agencies, state and local governments, and private contractors all play a role in managing fire in the park.
- **We work to reduce hazardous fuels near developed areas.** Fuels management includes both planned prescribed burns and other mechanical treatments to change and/or reduce wildland fuels. The goal of Yellowstone National Park's fuels management program is to reduce hazardous fuel loads near developed areas.
- **We monitor the effects of planned fire management actions**. The Yellowstone fire effects monitoring crew collects information on the long-term effects of fire and fire management activities. The crew collects data on fuel loads, plant populations, tree regeneration, nonnative species and other aspects of the park's ecosystems. Monitoring is a major component of the adaptive management process.

Managing a Natural Process

The National Park Service may allow lightning-ignited fires to burn in Yellowstone provided they are not a threat to human life and property. In an average year, Yellowstone has approximately 24 fires, 80% of which are caused by lightning. The park protects human life as well as the approximately 2% of Yellowstone's 2.2 million acres that are considered developed (e.g., roads, buildings, and other infrastructure), which includes almost 2,000 buildings, from the threat of fire while at the same time letting wildfire carry out its ecological role in the landscape as much as possible.

The Antelope Fire of 2010 was an example of managing a fire for multiple objectives. It was suppressed on its west flank to protect people using the roads and other values at risk. It was monitored, but not suppressed, as it moved south and east away from developed areas.

Working Across Boundaries

Fire management requires interagency cooperation and coordination. For example, the NPS sometimes relies on Forest Service smokejumpers to assist with the park's remote fires. In return, the National Park Service sends its helicopter or engine to the Silver Gate or Cooke City areas, which are located on or adjacent to the Custer Gallatin and Shoshone national forests. Programmable radios ensure communication between NPS and Forest Service dispatch, which improves firefighter safety. The NPS also works with its partners to develop community wildfire protection plans to help plan and prepare for a wildfire that may threaten homes.

Wildland Fire Program

Dispatch

Yellowstone's Wildland Fire and Aviation Dispatch Center handles fire reports from lookouts, visitors, and park employees, and dispatches appropriate resources to the scene. If additional resources are needed, the dispatch office fills requests with park resources or forwards them to the Billings Interagency Dispatch. The office also manages requests for Yellowstone resources to be dispatched outside the park. Besides tracking all resources for park incidents and areas just outside its boundaries, the dispatch office oversees search and rescue operations, special incidents, flight-following for various aircraft, and ordering and tracking medevac flights for medical emergencies.

Engines

Yellowstone has one wildland fire engine staffed from May through October. The engine supports local fire management and large firefighting efforts nationwide. Engine crews handle initial attacks near roads but can also reach remote fires by hiking or flying in. They assist with fireline production, structure protection, and helicopter operations, using water to create wetlines that minimize vegetation impact and erosion. For structure protection, the crew conducts structure triage, uses sprinklers, foil wrap, and fuel

reduction techniques. Yellowstone also maintains a variety of pumps and water handling equipment for different firefighting needs.

Helitack

The Yellowstone Helitack Crew is a ten-person crew that responds to wildfires as well as search and rescue operations (SAR). They manage and staff a Type 3 Helicopter based at Mammoth Hot Springs, seven days a week from mid-June until October.

Our helitack crew is trained in all aspects of safe helicopter operations, including size-up and initial attack of wildfires as well as passenger and cargo transport by short haul and longline.

When fire activity in Yellowstone is low, the helicopter and crew assist other forests and parks all over the United States with wildfire and SAR operations. When not working on wildfires or assisting with search and rescue operations, crew members assist with fuels projects, hazard tree removal, and assisting the many other park operations where their skills and unique talents are needed.

Lookouts

The Yellowstone Fire Management Office maintains two fire lookout stations located on Mt. Washburn (10,219 feet) and Mt. Sheridan (10,308 feet). Only Mt. Washburn is continuously staffed from mid-June until the end of the fire season in the fall.

The lookouts serve two primary functions: fire detection and fire monitoring. Each lookout tower is staffed with a trained fire lookout who is provided with cell phones, radios, and high-quality optical equipment. Additionally, each station has a conventional Osborne fire finder—a sighting device used to calculate azimuth and range.

Fuels Management

Yellowstone National Park's fuels management program aims to reduce hazardous fuel loads near developed areas through planned prescribed burns and mechanical treatments. Fuels include all plant material that can ignite, influencing fire behavior and its effects on ecosystems. By reducing hazardous fuels, the program enhances firefighter safety, protects structures during wildfires, and mitigates the risk of severe fire to human communities while preserving the health of the Yellowstone ecosystem.

Effects Monitoring

The National Park Service's Fire Effects Monitoring Program in Yellowstone focuses on assessing the impacts of planned fire management activities. The dedicated crew collects data on fuel loads, plant populations, tree regeneration, and non-native species to understand the long-term effects of fire. This monitoring aids in adaptive management. Additionally, the crew provides crucial information on weather and fuel conditions through a network of weather stations and monitors precipitation, drought indices, and lightning occurrences to gauge fire danger. During wildfires, they gather data on fire behavior, fuels, vegetation, and weather to assist fire managers in predicting fire dynamics.

A summary of fire seasons is available at **https://www.nps.gov/yell/learn/management/fire-management.htm**

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Staff Reviewers

John Cataldo, Fire Management Officer

Yellowstone National Park has abundant and diverse wildlife. A wolf chases ravens and magpies from an elk carcass killed by the Slough Creek wolf pack near the Lamar River.

Wildlife

Yellowstone's abundant and diverse wildlife are as famous as its geysers. Habitat preferences and seasonal cycles of movement determine, in a general sense, where a particular animal may be at a particular time. Early morning and evening hours are when animals tend to be feeding and are more easily seen. But remember that the numbers and variety of animals you see are largely a matter of luck and coincidence.

Wild animals, especially females with young, are unpredictable and dangerous. Keep a safe distance from all wildlife. Each year a number of park visitors are injured by wildlife when approaching too closely. Approaching on foot within 100 yards (91 m) of bears or wolves, or within 25 yards (23 m) of other wildlife is prohibited. Please use roadside pullouts when viewing wildlife. Use binoculars or telephoto lenses for safe viewing and to avoid disturbing wildlife.

By being sensitive to its needs, you will see more of an animal's natural behavior and activity. If you cause an animal to move, you are too close. It is illegal to willfully remain near or approach wildlife, including birds, within any distance that disturbs or displaces the animal.

FREQUENTLY ASKED QUESTION:

Where can I see wildlife?

It helps to know the habits and migration patterns of the animals you want to see and the habitats in which they live. For example, bighorn sheep are adapted to live on steep terrain, so you might see them on cliffs in the Tower area. Osprey eat fish, so you would expect to see them along rivers. Bison graze on grasses and sedges, and mate in August, so you are likely to see them in big, noisy herds in the Hayden and Lamar valleys.

Hydrothermal basins provide important habitat for wildlife. For example, some bison live in the Old Faithful area year-round. In the winter, they take advantage of the warm ground and thin snow cover. Both black and grizzly bears visit these areas during the spring when winter-killed animals are available. Rangers at the visitor centers can tell you where wildlife have been seen recently.

Yellowstone is home to the largest concentration of mammals in the lower 48 states. Here, bison, pronghorn, and elk (in the far distance) graze on the northern range.

Mammals

Yellowstone is home to the largest concentration of mammals in the lower 48 states. In addition to having a diversity of small animals, Yellowstone is notable for its predator–prey complex of large mammals, including eight ungulate species (bighorn sheep, bison, elk, moose, mountain goats, mule deer, pronghorn, and white-tailed deer) and seven large predators (black bears, Canada lynx, coyotes, grizzly bears, mountain lions, wolverines, and wolves).

The National Park Service's goal is to maintain the ecological processes that sustain these mammals and their habitats while monitoring the changes taking place in their populations. Seasonal or migratory movements take many species across the park boundary where they are subject to different management policies and uses of land by humans.

Understanding the links between climate change and these drivers will be critical to informing the ecology and management of Yellowstone's wildlife in the years to come.

Quick Facts

Yellowstone is home to the largest concentration of mammals in the lower 48 states.

- 67 different mammals live here, including many small mammals.
- Approximately 1,030 grizzly bears live in the Greater Yellowstone Ecosystem.
- Black bears are common.
- Gray wolves were restored in 1995. As of January 2025, at least 108 live primarily in the park.
- Wolverine and lynx, which require large expanses of undisturbed habitat, live here.
- Seven native ungulate species—elk, mule deer, bison, moose, bighorn sheep, pronghorn, and white-tailed deer—live here.
- As of August 2024, there were approximately 5,400 bison.
- Nonnative mountain goats have colonized northern portions of the park.

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Bears

Yellowstone is home to two species of bears: grizzly bears and black bears. The Greater Yellowstone Ecosystem is one of few areas south of Canada where these two bear species coexist. Grizzly bears are more aggressive than black bears and more likely to rely on their size and aggressiveness to protect themselves and their cubs from predators and other perceived threats. Their evolution diverged from a common ancestor more than 3.5 million years ago, but their habitats only began to overlap about 13,000 years ago.

People who visited Yellowstone prior to the 1970s often remember seeing bears along roadsides and within developed areas of the park. Although observing these animals was very popular with park visitors, it was not good for people or bears. 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 and property damage. The measures included installing bear-proof garbage cans and closing garbage dumps in the park.

Visitors should be aware that all bears are potentially dangerous. Park regulations require that people stay at least 100 yards (91 meters) from bears (unless safely in your car as a bear moves by). Bears need your concern, not your food; it is against the law to feed any park wildlife, including bears. All

Yellowstone is home to both grizzly bears (above) and black bears. Safe traveling in bear country begins before you get on the trail.

of Yellowstone is bear habitat – from the deepest backcountry to the boardwalks around Old Faithful. Prepare for bear encounters no matter where you go by learning more about bear safety.

Grizzly Bears

Compared to black bears, grizzly bears have a much smaller range across the United States. The grizzly bear is typically larger than the black bear and has a large muscle mass above its shoulders; a concave, rather than straight or convex, facial profile; and much more aggressive behavior. The grizzly bear is a subspecies of brown bear that once roamed large swaths of the mountains and prairies of the American West. Today, the grizzly bear remains in a

Grizzly Bears

Number in Yellowstone
Approximately 150–200 with home ranges wholly or partially in the park.

Approximately 1,030 estimated in greater Yellowstone.

Where to See
Dawn and dusk in the Hayden and Lamar valleys, on the north slopes of Mt. Washburn, and from Fishing Bridge to the East Entrance.

Size and Behavior

- Males weigh 200–700 pounds, females weigh 200–400 pounds; adults stand about 3½ feet at the shoulder.
- May live 15–30 years.
- Grizzly bears are generally 1½ to 2 times larger than black bears of the same sex and age class within the same geographic region, and they have longer, more curved claws.
- Lifetime home range: male, 800–2,000 square miles, female, 300–550 square miles.
- Agile; can run up to 40 mph.
- Can climb trees, but curved claws and weight make this difficult.
- Adapted to life in forest and meadows.
- Food includes rodents, insects, elk calves, cutthroat trout, roots, pine nuts, grasses, forbes, and large mammals.
- Mate in spring, but implantation of embryos is delayed until fall; gives birth in the winter to 1–3 cubs.
- Considered super hibernators.

Status

- Currently listed as a Threatened Species under the Endangered Species Act.
- Scientists and managers believe the grizzly population is doing well. Grizzlies are raising cubs in nearly all portions of the greater Yellowstone area and dispersing into new habitat. Currently, they occupy 27,066 square miles in the Greater Yellowstone Ecosystem.
- The states of Wyoming, Montana, and Idaho have all petitioned the US Fish and Wildlife Service to consider removing GYE grizzlies from Threatened Species status.

few isolated locations in the lower 48 states, including Yellowstone. In coastal Alaska and Eurasia, the grizzly bear is known as the brown bear.

The Greater Yellowstone Ecosystem and northwest Montana are the only areas south of Canada that still have large grizzly bear (*Ursus arctos horribilis*) populations. Grizzly bears were federally listed in the lower 48 states as a threatened species in 1975 due to unsustainable levels of human-caused mortality, habitat loss, and significant habitat alteration. Grizzly bears may range over hundreds of square miles, and the potential for conflicts with human activities, especially when human food is present, makes the presence of a viable grizzly population a continuing challenge for its human neighbors in the Greater Yellowstone Ecosystem.

Population

The estimated Greater Yellowstone Ecosystem grizzly bear population increased from 136 in 1975 to a peak of 1,030 (estimated) in 2024. The bears have gradually expanded their occupied habitat by more than 50%. As monitored by the Interagency Grizzly Bear Study Team, the criteria used to determine whether the population within the Greater Yellowstone Ecosystem has recovered include estimated population size, distribution of females with cubs, and mortality rates.

Description

The grizzly bear's color varies from blond to black, often with pale-tipped guard hairs. In the Greater Yellowstone Ecosystem, many grizzly bears have a light-brown girth band. However, the coloration of black and grizzly bears is so variable that it is not a reliable means of distinguishing the two species.

Bears are generally solitary, although they may tolerate other bears when food is plentiful. Grizzlies have a social hierarchy in which adult male bears dominate the best habitats and food sources, generally followed by mature females with cubs, then by other single adult bears. Subadult bears, who are just learning to live on their own away from mother's protection, are most likely to be living in poor-quality habitat or in areas nearer roads and developments. Thus, young adult bears are most vulnerable to danger from humans and other bears, and to being conditioned to human foods. Food-conditioned bears are removed from the wild population.

FREQUENTLY ASKED QUESTIONS:

Where are the bears?

People who visited Yellowstone prior to the 1970s often remember seeing bears along roadsides and within developed areas of the park. Although observing these bears was very popular with park visitors, it was not good for people or bears. 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 and property damage. The measures included installing bear-proof garbage cans and closing garbage dumps in the park.

Bears are still seen near roads and they may be seen occasionally in the wild. Grizzly bears are active primarily at dawn, dusk, and night. In spring, they may be seen around Yellowstone Lake, Fishing Bridge, Hayden and Lamar valleys, Swan Lake Flat, and the East Entrance. In mid-summer, they are most commonly seen in the meadows between Tower–Roosevelt and Canyon, and in the Hayden and Lamar valleys. Black bears are most active at dawn and dusk, and sometimes during the middle of the day. Look for black bears in open spaces within or near forested areas. Black bears are most commonly observed between Mammoth, Tower, and the Northeast Entrance.

Are grizzly bears considered threatened or endangered?

The Yellowstone grizzly population is listed as a federal Threatened Species as of a court decision on September 24, 2018. Regardless of its listing status, scientists will continue to monitor the long-term recovery goals for grizzly bears.

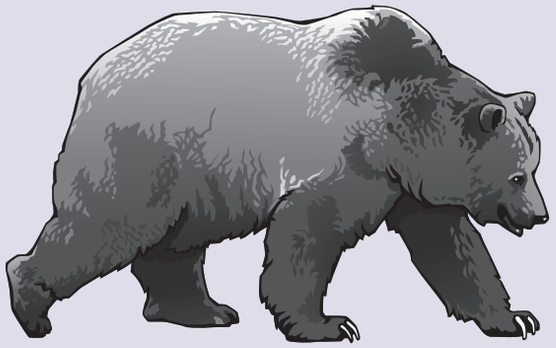
Diet

Bears are generalist omnivores that can only poorly digest parts of plants. They typically forage for plants when they have the highest nutrient availability and digestibility. Although grizzly bears make substantial use of forested areas, they make more use of large, non-forested meadows and valleys than do black bears. The longer, less curved claws and larger shoulder muscles of the grizzly bear makes it better suited to dig plants from the soil and rodents from their caches.

Grizzly bear food consumption is influenced by annual and seasonal variations in available foods. Over the course of a year, army cutworm moths, whitebark pine nuts, ungulates, and cutthroat trout are the highest-quality food items available. In total, grizzly bears in the Greater Yellowstone Ecosystem are known to consume at least 266 species of plant (67%), invertebrate (15%), mammal (11%), fish, and fungi. They will eat human food and garbage where they can get it. This is why managers emphasize that keeping human foods secure from bears increases

Identify Grizzly Bears and Black Bears

Grizzly Bear



- Rump lower than shoulders.
- Shoulder hump present.
- Long claws for digging.

Black Bear

- Rump higher than shoulders.
- No shoulder hump.
- Short, curved, claws for climbing.

the likelihood that humans and bears can peacefully coexist in greater Yellowstone.

Bears spend most of their time feeding, especially during "hyperphagia," the period in autumn when they may gain more than three pounds per day until they enter their dens to hibernate. In years and locations when whitebark pine nuts are available, they are the most important bear food from September through October. However, not all bears have access to whitebark pine nuts, and in the absence of this high-quality food, the bear's omnivory lets them turn to different food sources. Fall foods also include pondweed root, sweet cicely root, grasses and sedges, bistort, yampa, strawberry, globe huckleberry, grouse whortleberry, buffaloberry, clover, horsetail, dandelion, ungulates (including carcasses), ants, false truffles, and army cutworm moths.

From late March, when they come out of hibernation, until mid-May, a grizzly bear's diet primarily consists of elk, bison, and other ungulates. These ungulates are primarily winter-killed carrion (already dead and decaying animals), and elk calves killed by predation. Grizzly bears dig up caches made by pocket gophers. Other items consumed during spring include grasses and sedges, dandelion, clover, spring-beauty, horsetail, and ants. When there is an abundance of whitebark seeds left from the previous fall, grizzly bears will feed on seeds that red squirrels have stored in middens.

From June through August, grizzly bears consume thistle, biscuitroot, fireweed, and army cutworm moths in addition to grasses and sedges, dandelion, clover, spring-beauty, whitebark pine nuts, horsetail, and ants. Grizzly bears are rarely able to catch elk calves after mid-July. Starting around mid-summer, grizzly bears begin feeding on strawberry, globe huckleberry, grouse whortleberry, and buffaloberry. By late summer, false truffles, bistort, and yampa are included in the diet as grasses and other plants become less prominent.

Hibernation

Bears' annual denning behavior probably evolved in response to seasonal food shortages and cold weather. Most bears enter their den by mid-November; although, some males remain active through December before hibernating. Bears hibernate during the winter months in most of the world. The length of denning depends on latitude and varies from a few days or weeks in Mexico to six months or more in Alaska. Pregnant females tend to den earlier

A grizzly bear emerging from hibernation begins searching for food to replenish lost body mass.

and longer than other bears. Grizzly bear females without cubs in Greater Yellowstone den for five months on average.

Grizzly bears will occasionally re-use a den in greater Yellowstone, especially those located in natural cavities like rock shelters. Dens created by digging, as opposed to natural cavities, usually cannot be reused because runoff causes them to collapse in the spring. Greater Yellowstone dens are typically dug in sandy soils and located on the mid to upper one-third of mildly steep slopes (30–60°) at 6,562–10,000 feet (2,000–3,048 meters) in elevation. Grizzly bears often excavate dens at the base of a large tree on densely vegetated, north-facing slopes. This is desirable in greater Yellowstone because prevailing southwest winds accumulate snow on the northerly slopes and insulate dens from sub-zero temperatures.

The excavation of a den is typically completed in 3–7 days, during which a bear may move up to one ton of material. The den includes an entrance, a short tunnel, and a chamber. To minimize heat loss, the den entrance and chamber is usually just large enough for the bear to squeeze through and settle; a smaller opening will be covered with snow more quickly than a large opening. After excavation is complete, the bear covers the chamber floor with bedding material such as spruce boughs or duff, depending on what is available at the den site. The bedding material has many air pockets that trap body heat.

The body temperature of a hibernating bear remains within 12°F (22°C) of their normal body temperature. This enables bears to react more quickly to danger than hibernators who must warm up first. Because of their well-insulated pelts and their lower surface area-to-mass ratio compared to smaller hibernators, bears lose body heat more slowly, which enables them to cut their metabolic rate by 50–60%. Respiration in bears, normally 6–10 breaths per minute, decreases to 1 breath every 45 seconds during hibernation, and their heart rate drops from 40–50 beats per minute during the summer to 8–19 beats per minute during hibernation.

Bears sometimes awaken and leave their dens during the winter, but they generally do not eat, drink, defecate, or urinate during hibernation. They live off a layer of fat built up prior to hibernation. The urea produced from fat metabolism (which is fatal at high levels) is broken down, and the resulting nitrogen is used by the bear to build protein that allows it to maintain muscle mass and organ tissues. Bears may lose 15–30% of their body weight but increase lean body mass during hibernation.

Bears emerge from their dens when temperatures warm up and food is available in the form of winter-killed ungulates or early spring vegetation. Greater Yellowstone grizzly bears begin to emerge from dens in early February, and most bears have left their dens by early May. Males are likely to emerge before females. Most bears usually leave the vicinity of their dens within a week of emergence, while females with cubs typically remain within 1.86 miles (3 kilometers) of their dens until late May.

Life Cycle

Grizzly bears reproduce slowly compared to other land mammals. Females rarely breed before age four, and typically become pregnant once every three years. Grizzly and black bears breed from May through July, and bears may mate with multiple partners during a single season. Because implantation of a fertilized egg in the uterus is delayed, the embryo does not begin to develop until about one month after the mother has denned. This appears to allow her to conserve energy until she enters her den where, in late January or early February, she gives birth to one or two cubs, sometimes three, rarely four. At birth the cubs are hairless and blind, about eight inches (20 cm) long, and weigh from 8 to 12 ounces (224–336 g). They sleep next to the sow, nurse, and grow rapidly. At ten weeks, grizzly bear cubs weigh from 10–20 pounds (4.5–9.0 kg). Male bears take no part in raising cubs, and may actually pose a threat to younger bears. Grizzly bear cubs usually spend 2.5, and sometimes 3.5, years with their mother before she or a prospective suitor chases them away so that she can mate again. Females frequently establish their home range in the vicinity of their mother, but male cubs disperse farther.

Black Bears

The black bear (*Ursus americanus*) is the most common and widely distributed bear species in North America. However, the Greater Yellowstone Ecosystem (GYE) is one of the few areas south of Canada where black bears coexist with the grizzly bears. From 1910 to the 1960s, park managers allowed visitors to feed black bears along park roads, although the National Park Service officially frowned on this activity. During this time, along with Old Faithful, black bears became the symbol of Yellowstone for many people, and are still what some people think of when Yellowstone bears are mentioned. Since 1960, park staff have sought to deter bears from becoming conditioned to human foods.

In Yellowstone, about 50% of black bears are black in color, while others are brown, blond, and cinnamon.

Population

Little is known about the black bear population in Yellowstone or whether it has been affected by the increase in grizzly bear numbers and distribution since the 1970s. Black bears are commonly observed in the park, especially on the northern range and in the Bechler area of the park.

Black bears have few natural predators, although both cubs and adults are occasionally killed by their own kind or by the other large carnivores with which they compete for food—wolves, cougars, and grizzly bears. Vehicle collisions (average = 1 per year) and removals of nuisance bears (average = 1 every 5 years) are not common either. Most black bear mortality in the park is likely attributed to old age or other natural causes.

Outside the park, some black bears are killed during state regulated hunting seasons. As their access to human foods has been reduced, human injuries from black bears in the park have decreased from an average of 45 per year during the 1930s–1960s to approximately one injury every five years since 1980. Black bears are occasionally radio-collared for management and scientific reasons, with the latter focusing on research on habitat selection and multi-carnivore interactions.

Description

In Yellowstone, about 50% of black bears are black in color; others are brown, blond, and cinnamon. Black bears eat almost anything, including grass, fruits, tree cambium, eggs, insects, fish, elk calves, and carrion. Their short, curved claws enable them to climb trees, but do not allow them to dig for roots or ants as well as a grizzly bear can.

The life cycle of black bears is similar to grizzly bears. Like grizzly bears, black bears spend most of their time during fall and early winter feeding during hyperphagia. In November, they locate or excavate a den on a north-facing slope between 5,800–8,600 feet (1,768–2,621 m), where they hibernate until late March.

Males and females without cubs are solitary, except during the mating season, May to early July. They may mate with a number of individuals, but

Black Bears

Number in Yellowstone
Common

Where to See
Tower and Mammoth areas, most often.

Size and Behavior

- Males weigh 210–315 pounds, females weigh 135–200 pounds; adults stand about 3 feet at the shoulder.
- May live 15–30 years.
- Home range: male, 6–124 square miles, female, 2–45 square miles.
- Can climb trees; adapted to life in forest and along forest edges.
- Food includes rodents, insects, elk calves, cutthroat trout, pine nuts, grasses and other vegetation.
- Mates in spring; gives birth the following winter to 1–3 cubs.
- Considered true hibernators.
- Have fair eyesight and an exceptional sense of smell.

occasionally a pair stays together for the entire period. Both genders usually begin breeding at age four. Like grizzly bears, black bears also experience delayed implantation. Total gestation time is 200 to 220 days, but only during the last half of this period does fetal development occur.

Birth occurs in mid-January to early February; the female becomes semiconscious during delivery. Usually two cubs are born. At birth, the cubs are blind, toothless, and almost hairless. After delivery the mother continues to sleep for another two months while the cubs nurse and sleep.

Modern Research

Although grizzly bears in Yellowstone have been studied continuously for more than 50 years, little research has been conducted on the park's black bears since the 1960s. However, a series of black bear studies starting in the early 2000s have provided new insights on black bears, demonstrating their population has also been impacted by changes in the ecosystem, from changes in the grizzly bear population to changes in resource availability.

Recently, research studies utilizing GPS tracking collars and non-invasive DNA samples from hair snares have helped biologists learn more about the black bear population size and density, predatory rates on elk, home range sizes, movements, food habits, and habitat use. Results have shown that black bears in the northern portion of Yellowstone occur at some of the highest densities found in the Greater Yellowstone Ecosystem, which could have implications for other wildlife populations in the region. In addition, collar data has shown that the quality of spring forage influences how black bears navigate around the landscape and annual movement data found that male black bears range farther than previously thought. The results from these studies demonstrate the need to continue studying black bears in Yellowstone as they continue to play an important role in the region.

Grizzly Bears, Black Bears, and Wolves

Grizzly bears, black bears, and gray wolves have historically coexisted throughout a large portion of North America. The behavior of bears and wolves during interactions with each other are dependent upon many variables such as age, sex, reproductive status, prey availability, hunger, aggressiveness, numbers of animals, and previous experience in interacting with the other species. Most interactions between the species involve food, and they usually avoid each other. Few instances of bears and wolves killing each other have been documented. Wolves sometimes kill bears, but usually only cubs.

Wolves prey on ungulates year-round. Bears feed on ungulates primarily as winter-killed carcasses, ungulate calves in spring, wolf-killed carcasses in spring through fall, and weakened or injured male ungulates during the fall rut. Bears may benefit from the presence of wolves by taking carcasses that wolves have killed, making carcasses more available to bears throughout the year. If a bear wants a wolf-killed animal, the wolves will try to defend it; wolves usually fail to chase the bear away, although female grizzlies with cubs are seldom successful in taking a wolf-kill.

A grizzly bear sow with three cubs defends a carcass from wolves on Alum Creek in Hayden Valley, 2010. Most interactions among the grizzly bears, black bears, and wolves involve food. The species usually avoid each other.

Bear Management

Bear management in Yellowstone has changed since the early days of the National Park Service. In the past, bears ate human food at park garbage dumps and were regularly fed by park staff and visitors in campgrounds and along roads, resulting in injuries, deaths, and property damage. In 1970, the park adopted a new bear management plan focused on protecting and maintaining natural populations of grizzly and black bears while ensuring visitors could safely enjoy park resources. This approach remains in place today.

Yellowstone has installed bear-proof food storage boxes in 79% of the park's 1,917 campsites with the goal to complete the installation of bear boxes in every park campsite in 2026.

Our Goals

- **We protect and maintain natural populations of grizzly and black bears**. To do this, we preserve the processes affecting the genetic integrity, distribution, abundance, and behavior of grizzly and black bear populations within the park.
- **We educate visitors and employees about bears and how they can reduce bear-human conflicts.** By offering opportunities to learn about bear ecology and behavior, park visitors and employees can recognize the causes of bear-human conflicts and understand how they can prevent personal injuries, property damage, and bear removals.
- **We make all human food sources unavailable to bears**. Preventing bears' access to human food and garbage is one of the most significant ways to reduce bear management problems and related public safety hazards in the park.
- **We alert visitors about the presence of bears and inherent dangers of recreating in bear country.** All of Yellowstone is bear country, from the park's backcountry trails to the boardwalks around Old Faithful.
- **We provide opportunities for the public to understand, observe, and appreciate wild bears in their natural habitat.** Yellowstone is one of the best places in the world to see bears in their natural habitat, offering unique opportunities to learn and appreciate these wild animals.

Reducing Bear–Human Conflicts

The park takes many actions to prevent bear–human conflicts. The availability of human food and garbage to bears is a major potential cause of bear management problems in Yellowstone. The park aims to eliminate unnatural attractants to bears by using bear-resistant dumpsters and trash cans, monitoring developed areas for litter and food waste, scheduling garbage pickups to prevent overflow of trash cans, requiring bear-resistant food storage in campgrounds, and using bear-resistant fencing around sewage lagoons and garbage transfer stations.

Foraging bears can sometimes be seen close to park roadways, causing significant traffic jams when visitors slow down or park their vehicles on the road. Park staff manage these situations by directing traffic and ensuring visitors maintain a safe viewing distance.

Additionally, to promote human safety, park staff may remove large mammal carcasses from high-use areas, post temporary warnings and closures in areas with recent bear activity, and haze bears out of developed areas. Park staff report all bear sightings, bear signs (tracks, scats, etc.), and bear encounters, as well as bear activity reported by visitors, to the park's Bear Management Office.

The park's bear management philosophy continues to be highly successful in reducing bear–human conflicts and human-caused bear mortalities. Yellowstone is one of the few places in the Greater Yellowstone Ecosystem where most bears die of old age and other natural causes rather than by human actions.

Bear Management Areas

To protect public safety and bear habitat in backcountry areas, Yellowstone wildlife biologists establish "bear management areas" in locations where grizzly bears are known to seasonally concentrate and where there is a high density of elk and bison carcasses. In these areas, certain recreational activities are limited at specific times of year to reduce encounters between bears and humans. Restrictions may include: area closures, trail closures, a minimum group size recommendation, day-use only, or no off-trail travel.

Bear Research

Research and monitoring are also integral parts of bear management. The Interagency Grizzly Bear Study Team (IGBST), formed by the Department of the Interior in 1973, is an interdisciplinary group of scientists and biologists responsible for long-term monitoring and research efforts on grizzly bears in the Greater Yellowstone Ecosystem (GYE). IGBST members include representatives from the US Geological Survey, National Park Service, US Fish and Wildlife Service, US Forest Service, the Eastern Shoshone and Northern Arapaho Tribal Fish and Game Department, and the states of Idaho, Montana, and Wyoming. The main objectives of the team are to: (1) monitor the status and trend of the grizzly bear population in the GYE; and (2) understand the preferred habitat of bears and how human activities on the land affect their well-being.

Grizzlies & the Endangered Species Act

The Yellowstone population of grizzly bears was designated, or listed, as threatened with extinction in 1975. Various agencies and stakeholder groups hold differing opinions about the status of the population and how it should be managed in the future.

Listening for bears in the area during an Interagency Grizzly Bear Study Team bear capture operation.

In September 2018, a federal judge restored protections for grizzly bears within the Greater Yellowstone Ecosystem under the Endangered Species Act. This significant decision came after the U.S. Fish & Wildlife Service removed those protections, or "delisted" the bears, in July 2017. As always, hunting will remain prohibited inside Yellowstone National Park.

The growth and expansion of the grizzly bear population in the Greater Yellowstone Ecosystem is a remarkable conservation success story. The population has grown from 136 in 1975 to 1,030 in 2024 using a population estimate model called Chao2. Scientists think the Yellowstone area population is recovered and may have reached its capacity for resident grizzlies in many areas of the ecosystem. To restore the area effectively, it's crucial to minimize conflicts between people and bears, as well as protect habitat for bears to move around and connect with other bear populations beyond the Greater Yellowstone Ecosystem.

The conservation and management of grizzly bears inside Yellowstone and Grand Teton national parks will not change significantly through this listing and delisting process. Yellowstone and Grand Teton national parks will continue to prevent bears from obtaining human foods, preserve wilderness to minimize human-caused mortalities and disturbances, and maintain our long-term monitoring program. We value grizzlies as a dominant species in the ecosystem—and one that offers amazing wildlife viewing opportunities. Millions of people visit the park with the intention of seeing bears and connecting with the wildness of nature. Wildlife watching also brings economic benefits worth tens of millions of dollars to the region. We are proud that Yellowstone and Grand Teton national parks will continue to be the heart of the grizzly population keeping this magnificent species in the wild.

Reducing conflicts with people is the key to grizzly conservation. Employing best practices for safety in bear country doesn't just protect people, but the welfare of animals as well. When bears kill people or damage property, bears lose. To ensure grizzly bears' safety, learn how to share the landscape with them responsibly.

The US Fish & Wildlife Service is the federal agency that administers the Endangered Species Act. They make all decisions about listing and delisting in consultation with other agencies, Tribes, states, and

the public. Yellowstone will continue to be actively engaged with these partners and provide scientific data related to population estimates, habitat, genetics, and population connectivity.

History of Bear Management

During its first century, Yellowstone National Park was known as the place to see and interact with bears. Hundreds of people gathered nightly to watch bears feed on garbage in the park's dumps. Enthusiastic visitors fed bears along the roads and behaved recklessly to take photographs.

Beginning in 1931, park managers recorded an average of 48 bear-inflicted human injuries and more than 100 incidents of property damage each year in Yellowstone. In 1960, the park implemented a bear management program directed primarily at black bears and designed to reduce the number of bear-caused human injuries and property damages and to re-establish bears in a natural state. The plan included expanding visitor education about bear behavior and the proper way to store food and other bear attractants; installing bear-proof garbage cans; strictly prohibiting feeding of bears; and removing potentially dangerous bears, habituated bears, and bears that damaged property in search of food. The open-pit garbage dumps remained open.

In the early days of National Park Service management in Yellowstone, black bears could be fed along roadsides and at garbage dumps. Today, black bears in the park are wild.

After 10 years, the number of bear-caused human injuries decreased slightly to an average of 45 each year. In 1970, Yellowstone initiated a more intensive program that included eliminating open-pit garbage

Timeline of Listing & Delisting (1975–2018)

- 1975: The grizzly bear was listed as a threatened species, which required recovering the species to a self-sustaining population.
- 1993: A recovery plan is implemented with three specific recovery goals that have to be met for six consecutive years.
- 2000: Draft Conservation Strategy for the Grizzly Bear in the Greater Yellowstone Ecosystem is completed.
- 2002: Conservation Strategy is approved after public comment period—16,794 comments were received. It will be implemented when the grizzly is removed from the threatened species list.
- 2003: Recovery goals are met for the sixth year in a row.
- 2005: US Fish & Wildlife Service proposes removing the grizzly bear from the threatened species list.
- 2006: The Grizzly Bear Recovery Plan is modified to update methods of estimating population size and sustainable mortality.
- 2007: The Greater Yellowstone Ecosystem distinct population segment of grizzly bear population is removed from the threatened species list. Conservation Strategy is implemented. Several groups file lawsuits challenging the decision.
- 2009: A federal district judge overturned the delisting ruling, placing grizzly bears back on the threatened species list claiming: (1) the Conservation Strategy was unenforceable, and (2) that the US Fish & Wildlife Service did not adequately consider the impacts of the potential loss of whitebark pine nuts, a grizzly bear food source.
- 2010: The US Fish & Wildlife Service appeals the decision to keep the grizzly bear on the threatened species list.
- 2011: An appeals court rules the grizzly bear should remain on the threatened species list. They determined that the Conservation Strategy did in fact provide adequate regulatory mechanisms were in place. But the court upheld the lower court ruling that the US Fish & Wildlife Service did not sufficiently address the potential impacts from reduction of whitebark pine and other foods.
- 2013: Yellowstone Ecosystem Subcommittee, the Interagency Grizzly Bear Committee, and Interagency Grizzly Bear Study Team recommend that grizzly bears be removed from the threatened species list because alternative foods are available and the reduction of whitebark pine is not having a significant impact on bears at this time.
- 2017: US Fish & Wildlife Service removes the Yellowstone population of grizzly bears from the threatened species list.
- 2018: A US District Judge restored protections for the Yellowstone-area population of grizzly bears under the Endangered Species Act.

dumps inside the park with the intention of returning bears to a natural diet of plant and animal foods.

Bear researchers and brothers John and Frank Craighead predicted bears would range more widely and come into more conflict with humans as the bears were weaned off of human food. This prediction was realized in the first years of the revised management program: an annual average of 38 grizzly bears and 23 black bears were moved to backcountry areas, and an annual average of 12 grizzly bears and 6 black bears were removed from the population. However, the number of bear–human conflicts decreased to an annual average of 10 each year after 1972. Bear removals also decreased.

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

Listing Under the Endangered Species Act

On July 28, 1975, under the authority of the Endangered Species Act, as amended, the US Fish & Wildlife Service listed four distinct populations of grizzly bear in the lower 48 states as "threatened," in part, because the species was reduced to only about 2% 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 the Greater Yellowstone Ecosystem, where 136 grizzly bears were thought to live in the mid-1970s. The goal of an Endangered Species Act listing is to recover a species to self-sustaining, viable populations that no longer need protection. To achieve this goal, federal and state agencies:

- Stopped the grizzly hunting seasons in the Greater Yellowstone Ecosystem (outside national park boundaries).
- Established the Yellowstone grizzly bear recovery area (Yellowstone National Park, John D. Rockefeller, Jr. Memorial Parkway, portions of Grand Teton National Park, national forests surrounding Yellowstone, Bureau of Land Management lands, and state and private land in Idaho, Montana, and Wyoming).
- Created the Interagency Grizzly Bear Study Team to coordinate bear research and monitoring among the federal agencies and state wildlife managers; the team monitors bear populations and studies grizzly bear food habits and behavior.
- Established the Interagency Grizzly Bear Committee to increase communication and cooperation among managers in all recovery areas, and to supervise public education programs, sanitation initiatives, and research studies.

The Grizzly Bear Recovery Plan was established in 1993 and revised in 2006. This plan guides management when the grizzly is on the threatened species list. Bear managers will use the Grizzly Bear Conservation Strategy if the Greater Yellowstone Ecosystem population of grizzly bear is removed from the threatened and endangered species list. The Conservation Strategy is the long-term guide for managing and monitoring the grizzly bear population and assuring sufficient habitat to maintain recovery. It emphasizes coordination and cooperative working relationships among management agencies, landowners, and the public to ensure public support, continue the application of best scientific principles, and maintain effective actions to benefit the coexistence of grizzlies and humans. It incorporates existing laws, regulations, policies, and goals. The strategy has built-in flexibility:

- Grizzly–human conflict management and bear habitat management are high priorities in the recovery zone, which is known as the Primary Conservation Area. Bears are favored when grizzly habitat and other land uses are incompatible; grizzly bears are actively discouraged and controlled in developed areas.
- State wildlife agencies have primary responsibility to manage grizzly bears outside of national parks, including bears on national forests; national parks manage bears and habitat within their jurisdictions.
- State and federal wildlife managers will continue to monitor the grizzly population and habitat conditions using the most feasible and accepted techniques.
- Managers will remove nuisance bears conservatively and within mortality limits outlined

above, and with minimal removal of females; they will emphasize removing the human cause of conflict rather than removing a bear.

- Outside the Primary Conservation Area, states develop management plans that define how grizzly bears are to be managed.

Your Safety in Bear Country

On average, bears injure one person each year within Yellowstone National Park. In 2011 and 2015, in separate incidents, three people were killed by bears inside the park. Hiking in bear country takes appropriate preparation. Before you set out, ask about area closures, advisories, and seasonal food habits of local bears. Know what to do if you encounter a bear unexpectedly. Resources are available at visitor centers—where public bear spray demonstrations are offered in summer programs—and on the park website (www.nps.gov/yell/planyourvisit/safety.htm).

Statistically, you're most likely to have an encounter with bears at park roadsides. If you see a bear while driving, do not stop. Regardless of what other people may do, keep moving to the next paved pullout and park safely. If the bear is within 100 yards, watch and take pictures from inside your car. Comply with instructions of park staff on the scene.

As you venture beyond developed areas, stay clear of animal carcasses. Bears are very protective of carcasses as a food source. A single dead animal can attract and hold more than a dozen bears. Many may be bedded down nearby. Watch for gatherings of ravens, magpies, and coyotes. They can be good first indicators that a carcass is nearby. Leave the area immediately by the same route you used to get there.

Bears don't like surprises. Be vigilant about alerting unseen bears to your presence. Some trail conditions make it hard for bears to see, hear, or smell approaching hikers. Make noise by calling out and clapping your hands loudly at regular intervals. Bells are not enough. If you see a bear that hasn't noticed you, leave the area.

Know how to react. If you have a surprise encounter with a bear, do not run. Face the bear and slowly back away. If a bear charges you, stand your ground and use your bear spray. Do not drop your pack. It can help to protect your back from injury. If a bear makes contact with you, fall to the ground onto your stomach and play dead.

A sow protecting her cubs is one of the most dangerous situations you can face in nature. As cute as cubs can be, no photograph of them is ever worth risking personal injury. Always assume mother is nearby and ready to protect her young. For the safety of others, please report all bear incidents and wildlife encounters to a park ranger immediately. Before you set out to enjoy park trails be sure to learn what to do if you unexpectedly encounter a bear.

Watch for fresh tracks and scat.

Bear spray works. Know how to use it.

- **Be alert** for bears and watch for fresh tracks or scat.
- **Make noise** in areas where you can't see far around you.
- **Carry bear spray** that is readily accessible and know how to use it.
- **Hike in groups** of three or more people.
- **Do not run.** If you encounter a bear, back away slowly.

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Bison

Yellowstone is the only place in the United States where bison (*Bison bison*) have lived continuously since prehistoric times. Yellowstone bison are exceptional because they comprise the nation's largest bison population on public land. Unlike most other herds, this population has thousands of individuals that are allowed to roam relatively freely over the expansive landscape of Yellowstone National Park and some nearby areas of Montana. They also exhibit wild behavior like their ancient ancestors, congregating during the breeding season to compete for mates, as well as migration and exploration that result in the use of new habitat areas. These behaviors have enabled the successful restoration of a population that was on the brink of extinction just over a century ago.

However, some Yellowstone bison are infected with brucellosis, a livestock disease that can be transmitted to wild bison and elk as well as to cattle through contact with infected fetal tissue. To prevent conflicts with ranching and other activities outside the park, the National Park Service (NPS) works with other federal, state, and tribal agencies to manage and develop policies for bison access to habitat in Montana. Conservation of wild bison is one of the most complex of Yellowstone's resource issues. All of the interested parties bring their own wide-ranging values and objectives to the debate.

The bison is the largest land mammal in North America. Each year, bison injure park visitors who approach too closely.

Description

Bison are the largest land-dwelling mammal in North America. Males (2,000 lbs/900 kg) are larger than females (1,100 lbs/500 kg) and both are generally dark chocolate-brown in color, with long hair on their forelegs, head, and shoulders, and short, dense hair (1 in/3 cm) on their flanks and hindquarters. Calves of the year are born after 9 to 9½ months of gestation. They are reddish-tan at birth and begin turning

Quick Facts

Number in Yellowstone

- Population estimates in recent years range from 3,000 to nearly 6,000.
- The 2024 population estimate was 5,400; this includes two primary breeding herds: northern and central.

Where to See

- Year-round: Hayden and Lamar valleys.
- Summer: grasslands.
- Winter: hydrothermal areas and along the Madison River. Blacktail Deer Plateau, Tower, and the Gardiner Basin.

Size and Behavior

- Male (bull) weighs up to 2,000 pounds, female (cow) weighs up to 1,000 pounds.
- May live 12–15 years; a few live as long as 20 years.
- Feed primarily on grasses and sedges.
- Mate in late July through August; give birth to one calf in late April or May.
- Can be aggressive, are agile, and can run up to 30 miles per hour.

History

- Yellowstone is the only place in the lower 48 states to have a continuously free-ranging bison population since prehistoric times.
- In the 1800s, market hunting and the US Army nearly caused the extinction of the bison.
- By 1902, poachers had reduced the Yellowstone population to about two dozen animals.
- The US Army, who administered Yellowstone at the beginning of the 20th century, protected these bison from further poaching.
- Bison from private herds were used to establish a herd in northern Yellowstone.
- For decades, bison numbers were reduced due to belief that they, along with elk and pronghorn, were over-grazing the park.
- By 1968, herd reductions of bison ceased.
- Reductions began again in the 2000s due to increasing numbers and litigation over migration into Montana.

brown after 2½ months. Both sexes have relatively short horns that curve upward, with males' horns averaging slightly longer than those of adult females.

All bison have a protruding shoulder hump. Large shoulder and neck muscles allow bison to swing their heads from side to side to clear snow from foraging patches, unlike other ungulates that scrape snow away with their front feet. Bison are agile, are strong swimmers, and can run 35 miles per hour (55 kph). They can jump over objects about 5 feet (1.5 m) high and have excellent hearing, vision, and sense of smell.

FREQUENTLY ASKED QUESTION:

What is the difference between a bison and a buffalo?

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

Behavior

Bison are mostly active during the day and at dusk, but may be active through the night. They are social animals that often form herds, which appear to be directed by older females. Group sizes average about 20 bison during winter, but increase in summer to an average of about 200, with a maximum of about 1,000 during the breeding season (known as the rut) in July and August. Bison are sexually mature at age two. Although female bison may breed at these younger ages, older males (>7 years) participate in most of the breeding.

During the rut mature males display their dominance by bellowing, wallowing, and engaging in fights with other bulls. The winners earn the right to mate with receptive females. Once a bull has found a female who is close to estrus, he will stay by her side until she is ready to mate. Then he moves on to another female. Following courtship, mature males separate and spend the rest of the year alone or in small groups. Group sizes decrease through autumn and into winter, reaching their lowest level of the year during March and April.

The bull bellows during rutting season, while a disinterested cow continues to graze.

Diet

Yellowstone bison feed primarily on grasses, sedges, and other grass-like plants (more than 90% of their diets) in open grassland and meadow communities throughout the year. They also eat forbs (weeds and herbaceous, broad-leafed plants) and browse (the leaves, stems, and twigs of woody plants) through the year, but those usually comprise less than 5% of the diet. They typically forage for 9 to 11 hours daily. Bison are ruminants with a multiple-chambered stomach that includes microorganisms such as bacteria and protozoa to enable them to effectively digest plant material. Bison alternate between eating and ruminating, which is regurgitating partially digested food and chewing it again, to allow microorganisms to further break down plant material into volatile fatty acids and other compounds. Their large digestive tract allows them to digest lower quality foods with greater efficiency than other ungulates such as cattle, deer, or elk.

Interaction with Other Wildlife

Wolves and grizzly bears are the only large predators of adult bison. Dead bison provide an important source of food for scavengers and other carnivores. Bison will rub against trees, rocks, or in dirt wallows in an attempt to get rid of insect pests. Birds such as the magpie perch on a bison to feed on insects in its coat. The cowbird will also follow close behind a bison, feeding on insects disturbed by its steps.

Migration

Most other ungulates of the Greater Yellowstone Ecosystem follow the "green wave" of sprouting plants and grasses during spring because young plants are highly nutritious. Bison begin spring by leaving winter ranges in sync with the green wave

but let it pass them by as they migrate and graze, not reaching summer ranges until weeks after green-up. Bison can move out-of-sync with forage green-up because they engineer the ecosystem. Rather than just moving to find the best foods, bison create high-quality foods by how they move and graze. When bison let the green wave pass them by, they spend their time returning to graze the same areas repeatedly at high intensity. The behavior keeps plants growing, although the plants never appear more than a few inches tall, and allows bison to keep getting highly nutritious foods. In winter, bison will move from their summer ranges to lower elevation as snow accumulates and dense snowpack develops. Bison migrate up to 70 miles between summer and winter ranges. Most animals travel about 1,000 miles over the course of the year by repeatedly leaving and returning to the same areas. This means bison travel a greater distance than any other ungulate in the Greater Yellowstone Ecosystem.

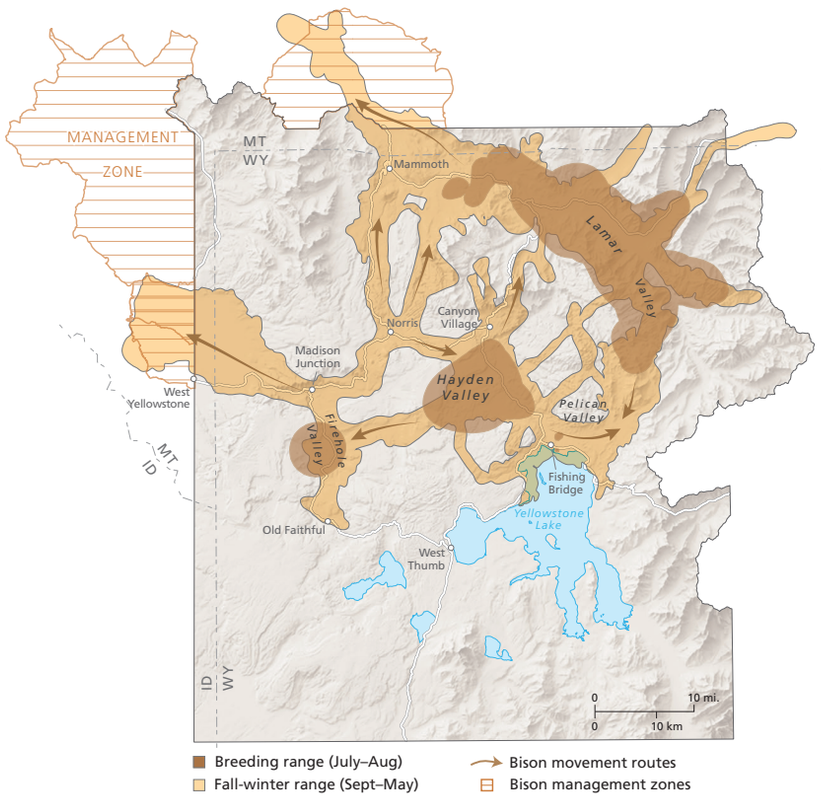
Habitat

Yellowstone bison historically occupied approximately 7,720 square miles (20,000 km2) in the headwaters of the Yellowstone and Madison rivers. Today, this range is primarily restricted to Yellowstone National Park and some adjacent areas of Montana. The bison population lives and breeds in the central and northern regions of the park. The northern breeding herd congregates in the Lamar Valley and on adjacent plateaus for the breeding season. During the remainder of the year, these bison use grasslands, wet meadows, and sage-steppe habitats in the Yellowstone River drainage, which extends 62 miles (100 km) between Cooke City and the Paradise Valley north of Gardiner, Montana. The northern range is drier and warmer than the rest of the park, and generally has shallower snow than in the interior of the park.

The central breeding herd occupies the central plateau of the park, from the Pelican and Hayden valleys with a maximum elevation of 7,875 feet (2,400 m) in the east to the lower-elevation and thermally- influenced Madison headwaters area in the west. Winters are often severe, with deep snows and temperatures reaching -44°F (-42°C). This area contains a high proportion of moist meadows composed of grasses, sedges, and willows, with upland grasses in drier areas. Bison from the central herd congregate in the Hayden Valley for breeding. Most of these bison move among the Madison, Firehole, Hayden, and Pelican valleys during the rest of the year. However, increasing numbers of bison are travelling to the northern portion of the park and mixing with the northern herd. Some of these bison do not return to the Hayden Valley for the subsequent breeding season, and instead breed and rear young on their new range.

Conservation

Yellowstone has played a key role in the conservation of wild bison in North America. In fact, they've been so successful that the challenge now is to manage a rapidly growing population of migratory bison that frequently roam beyond our borders onto private land and land managed by other agencies.



The seasonal distribution of Yellowstone bison is shown here in comparison with the Interagency Bison Management Plan management areas.

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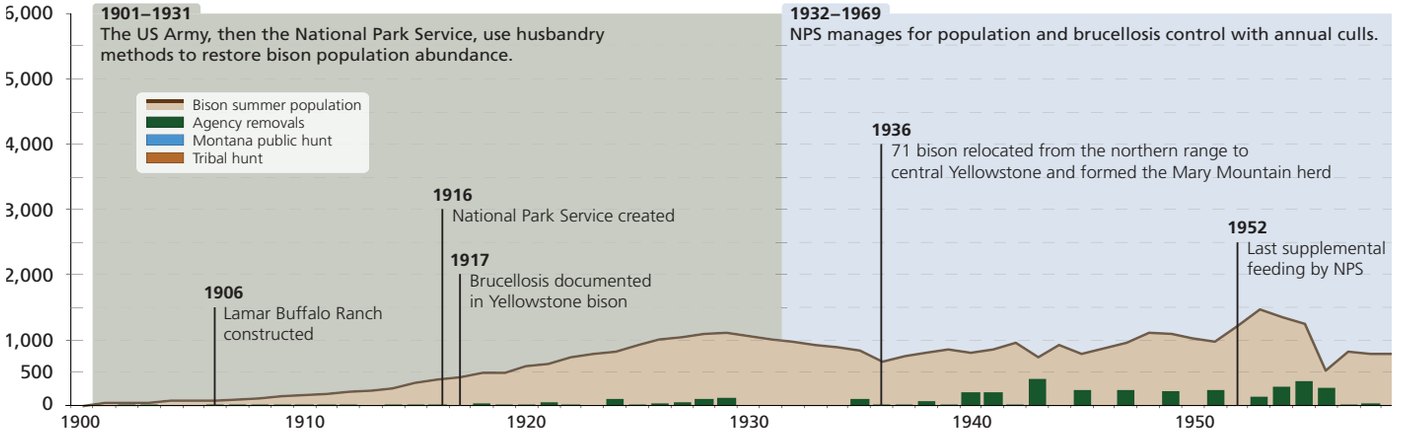


Estimated summer population and the number of bison removed the following winter, 1900–2020.

History of Bison Management

Near Extinction & Recovery

The American bison (*Bison bison*) once roamed across most of North America in numbers that reached into the tens of millions. Such abundance made the bison a critical part of Native American culture: every part of the bison provided something for their way of life. Before horses and gunpowder arrived in North America, native people hunted bison on foot. One technique involved stampeding dozens or hundreds of animals off cliffs where they would fall to their deaths. A single "jump" could sustain the members of a tribe for an entire year, providing food as well as materials for clothing, shelter, tools, and more.

As European Americans settled the west in the 1800s, the U.S. Army began a campaign to remove Native American tribes from the landscape by taking away their main food source: bison. Hundreds of thousands of bison were killed by U.S. troops and market hunters. By the late 1880s, the great herds of bison that once dominated the landscape were nearly gone. Some animals found protection on private ranches. In the Yellowstone area, their numbers dwindled to about two dozen bison that spent winter in Pelican Valley.

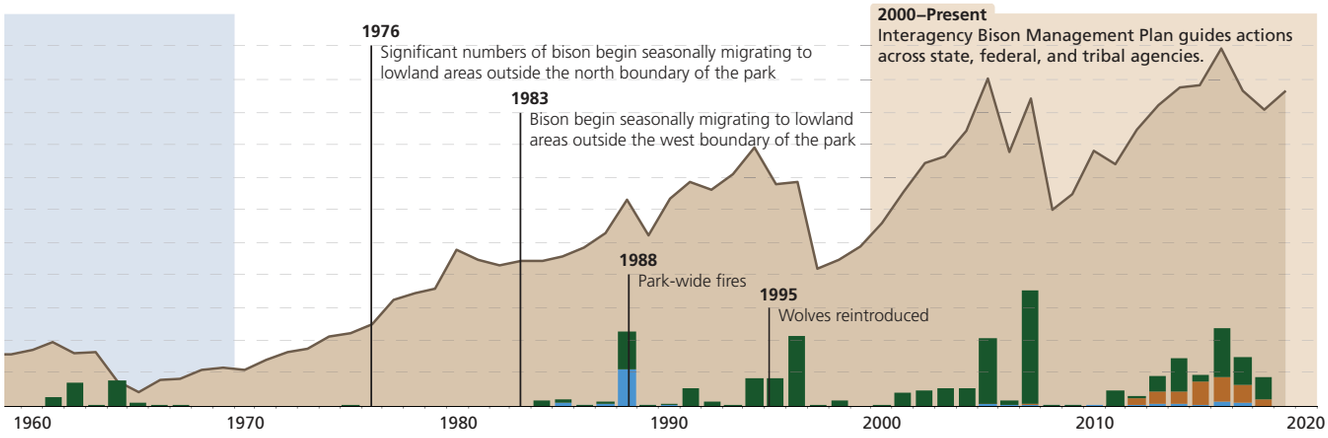
Historic bison management operations at the Lamar Buffalo Ranch.

In one of the first efforts to preserve a wild species through protection and stewardship, Yellowstone's managers set about recovering the bison population. In 1902, they purchased 21 bison from private owners and raised them in Mammoth and then at the historic Lamar Buffalo Ranch. Eventually, these animals began to mix with the park's free-roaming population and by 1954, their numbers had grown to roughly 1,300 animals.

Population Growth & Conflict

Yellowstone bison reproduce and survive at relatively high rates compared to many other large, wild mammals, so even as the population recovered managers limited its growth with frequent culling. Hundreds of animals were removed to start or supplement herds on other public and tribal lands. Even more were killed and given to Native American tribes or relief agencies. But a moratorium on culling beginning in 1969 resulted in the bison population increasing dramatically: from 500 animals in 1970 to 3,000 in 1990. At the same time, elk numbers increased to more than 19,000 animals in the late 1980s. As bison and elk numbers increased, they began to leave the park in greater numbers. Only a few bull bison left the park prior to 1975, but as bison numbers increased, groups of bison began migrating across the north and west boundaries of Yellowstone to expand their winter range and pioneer new territory.

As they left the park, bison encountered a changed world. In the century since bison roamed a continent



of open space, the grassy river valleys and plains they used to graze had been settled and developed by people, much of it for agriculture. The landscape had become a maze of fenced pastures, houses, and highways. Large groups of 1,000-pound animals searching for food create challenges for people sharing that landscape, both in terms of human safety and because bison want to eat the same grass ranchers grow to feed their livestock.

To further complicate things, bison and elk in the Greater Yellowstone Ecosystem carry brucellosis, a disease that can be transmitted to livestock and induce abortions or stillbirths in infected animals. Brucellosis has an economic impact on ranchers because it affects the reproductive rate and marketability of their animals, so park and state wildlife officials have gone to great lengths to prevent bison from mixing with cattle. Between 1985 and 2000, about 3,100 bison were killed as they tried to migrate out of the park: some were captured and shipped to slaughter, others were shot by hunters or state agents.

These actions generated a lot of controversy. Meanwhile, the bison population continued to grow, as did state and federal pressure to keep brucellosis out of livestock. In 1995, the state of Montana sued the National Park Service for allowing bison to leave the park. After five years of litigation and mediation, the state of Montana and the federal government developed the Interagency Bison Management Plan (IBMP) to guide the management of bison in and around Yellowstone. As part of this plan, five agencies and three tribal entities work to sustain a wild, wide-ranging bison population and reduce the risk of brucellosis transmission from bison to cattle.

In the decades since the IBMP was created, the bison population has ranged between 2,400 and 6,000 animals. There have been no cases of bison transmitting brucellosis directly to cattle, in part due to efforts by federal and state agencies to maintain separation between these animals. The state of Montana now allows bison to occupy some habitat adjacent to the park that was previously off-limits, including year-round in some areas, which is a major conservation advancement. However, lack of tolerance for wild bison in most areas outside Yellowstone continues to limit the restoration of this iconic species. Large parts of their historic winter ranges are no longer available due to human development, and because states only allow limited numbers of bison in areas near the park.

A Future for Bison

Many people don't like the fact that animals from a national park are sent to slaughter. We don't like it either. We'd like to see more tolerance for migrating bison on public lands in surrounding states; similar to deer, elk, and other ungulates. The park isn't big enough to let bison numbers increase without more available habitat to sustain them, but we cannot force adjacent states to tolerate more migrating bison.

We have placed some captured bison in the Bison Conservation Transfer Program so animals that repeatedly test negative for brucellosis can be used to start conservation herds elsewhere. Since 2019, bison have been transferred to the Fort Peck Assiniboine and Sioux Tribes in northeastern Montana. Afterward, bison are then transferred to the InterTribal Buffalo Council and given to other member Tribes across North America. In fall 2022, Yellowstone built a partnership with Yellowstone Forever and the Greater Yellowstone Coalition to more than double the Bison Conservation Transfer Program's capacity and lower the number of animals sent to slaughter. Using the new facility in

coordination with APHIS and their leased facility outside the park will result in transferring more bison per year to Tribes as an alternative to slaughter.

Also, we would like hunting outside the park to become a more successful management tool, as it is for other species. For this to happen, bison need to be allowed to disperse more widely and pioneer new areas away from Yellowstone. This would entail expanding tolerance for bison in Montana, reducing hunter concentrations along the park boundary, and promptly responding to conflicts to aid communities living with bison.

The state of Montana and some Native American Tribes have proposed hunting bison within Yellowstone National Park. However, the Lacey Act of 1894 prohibits hunting and the possession or removal of wildlife from the park, as well as frightening or driving wildlife from the park for hunting or other reasons. In addition, park managers oppose hunting in the park because it would affect the behavior of many different animals and drastically change the experiences of visitors.

Bison Management

The National Park Service (NPS) has sole authority to manage bison within Yellowstone National Park's boundaries. However, unlike other migratory wildlife, bison are managed differently due to Montana's limited tolerance for their presence outside the park. To address this, the NPS coordinates with other federal agencies, the state of Montana, and American Indian Tribes under the Interagency Bison Management Plan (IBMP), which was established in 2000 and signed by the secretaries of Agriculture and Interior and the governor of Montana.

In 2024, the NPS developed a new bison management plan, formalized through a Final Environmental Impact Statement and Record of Decision under the National Environmental Policy Act. This update responds to new scientific information, changing circumstances, and recent litigation. The 2024 plan outlines how the NPS will manage bison within the park and sets conditions for supporting partners' efforts outside the park, while maintaining the primary goals of the IBMP. To achieve these shared goals, the NPS will continue collaborating with federal, state, and American Indian Tribe partners under the existing IBMP framework to coordinate the plan's implementation.

A bison group on the move in Lamar Valley at sunrise.

Our Goals

- **We preserve a sustainable population of 3,500-6,000 wild, migratory bison.** Yellowstone's bison are the closest resemblance left today of the vast herds that once roamed the continent. Bison act as ecosystem engineers fundamentally designing grassland ecosystems, and they hold significant cultural importance to people, with a connection spanning thousands of years.
- **We coordinate with federal, state, and Tribal partners to manage the bison population.** Yellowstone bison must be managed because the population is growing exponentially and there is limited winter range for bison within the park. Like other wildlife, bison migrate out of the park to find food in winter, but unlike other wildlife, there is limited tolerance for them outside the park. Yellowstone works with its partners to control numbers, limit bison migrating out of the park, and help Tribes restore Yellowstone bison to their livelihoods.
- **We develop the best available science to preserve our national mammal.** Making decisions about bison population management requires contemporary research on population viability, habitat use, and the effects that bison have on grasslands to ensure a sustainable bison population and habitat.

Conserving Yellowstone Bison

Archeological evidence shows that bison have inhabited the Greater Yellowstone Area for over 10,000 years. By 1902, however, only 23 bison remained in the park—representing the last wild bison in North

Bison field crew leader collects bison DNA samples during the rut.

Bison in holding pens to prepare for transfer to Fort Peck Indian Reservation.

America. Throughout the 1900s, dedicated conservation efforts helped Yellowstone's bison population recover, making it one of the most significant conservation successes for bison worldwide. As the population rebounded, bison began migrating out of the park and into Montana, leading to one of the most complex wildlife management challenges of our time.

NPS Bison Management Plan

Multiple federal, state, and Tribal entities are involved in managing bison and hold different opinions on how bison should be managed. These opinions are intensified by each entity's varying authority over bison management, which depends on the specific lands where the bison are located—whether within Yellowstone, on adjacent US Forest Service lands, or on private lands in Montana.Yellowstone's new Bison Management Plan aims to secure a sustainable future for our national mammal by updating our tools for population control, setting a target population range, and establishing strategies for managing brucellosis within the bison population. The 2024 plan outlines three methods to control bison numbers: the Bison Conservation Transfer Program (BCTP), the Tribal Food Transfer Program (TFTP), and regulated Tribal harvests and state hunts.

Bison Conservation Transfer Program (BCTP)

The 2024 plan prioritizes the BCTP to capture, identify, and transfer brucellosis-free bison to Tribes. As bison migrate north out of the park, some are captured at Yellowstone's bison facility and enter the program. The goal is to add 100–300 animals annually, though this may vary if fewer bison migrate or if the park population falls below 3,000. About 30–40% of captured bison qualify, as eligible animals must test negative for brucellosis and be under three years of age.

Once accepted into the program, bison go through multiple testing phases. The first phase is conducted at Yellowstone quarantine facilities or on private land leased by the Animal and Plant Health Inspection Service (APHIS) near the park's northern boundary. This phase, which takes about 300 days for males and 2.5 years for females, ends with certification as brucellosis-free by APHIS and Montana animal health officials. The bison are then moved to the Assiniboine and Sioux Tribes of the Fort Peck Indian Reservation, where they undergo one additional year of testing in an assurance facility. Afterward, the Fort Peck Tribes transfer some bison to the InterTribal Buffalo Council, which distributes them to other Tribes across North America.

Tribal Food Transfer Program (TFTP)

Yellowstone transfers bison to Tribes, who then process them for their meat and hides at Tribal meat-processing facilities. This program supports Tribal food sovereignty and provides bison meat to Tribal members who may not have access to harvest opportunities outside the park.

Tribal Harvests & State Hunts

Currently, eight American Indian Tribes exercise their treaty rights to harvest bison outside Yellowstone, with each Tribe managing its own harvests. We support Tribal efforts to expand harvests outside the park, enhancing access to traditional food and cultural resources. The state of Montana also manages a smaller public hunt. Together, the harvests and hunt help manage bison populations effectively, especially under favorable weather conditions.

The migration of bison outside of Yellowstone National Park (the boundary is marked here with the 1903 arch at the North Entrance) is a challenging issue for the greater Yellowstone area.

Target Population Range & Adaptive Management

Managing wildlife populations to a static number isn't realistic or suitable for bison, as their migration patterns fluctuate with the weather, causing the number of bison exiting the park to vary significantly each year. For this reason, the Bison Management Plan sets a flexible target population range of 3,500 to 6,000 animals.

Each year's management strategy is adjusted to the current bison population and migration numbers, with specific guidelines provided to IBMP partners and Tribes each fall to help ensure that removals do not harm the population's health. The management tools applied each year depend on the following population thresholds:

- **Above 5,200:** We rely primarily on Tribal harvests and state hunts to manage numbers. If harvests and hunts are unable to reduce numbers, we commit to decreasing the population by removing additional animals through the TFTP. We prioritize the removal of brucellosis-infected bison, which stabilizes or decreases brucellosis prevalence over time.
- **Below 5,200:** We only place bison in the BCTP and utilize the TFTP to remove brucellosis-positive bison that are identified in selecting animals for the program.
- **Near 3,000:** We protect the population inside the park and encourage partners to reduce hunting outside the park.

Studying Yellowstone Bison

Each summer, bison managers conduct aerial counts of the bison population using fixed-wing aircraft. We integrate these counts with survival rates of radio-collared bison and ground surveys of male-to-female and female-to-calf ratios to estimate the population status. We then use population modeling techniques to provide management recommendations to our partners for implementing hunts in winter.

Genetic Monitoring

Bison in the park are a metapopulation or a single population with two distinct breeding groups. During the July and August breeding season, we collect genetic samples from bison using biopsy dart projectiles. From these samples, we determine gene frequencies and track genetic diversity to help ensure that we are sustaining the population.

Rangeland Monitoring & Grazing Experiments

Bison use only about 40% of the grazeable acreage in the park, but in some areas, like Lamar Valley, they graze intensively. We use small grazing exclosures throughout the high-grazing areas of the park to evaluate consumption patterns and impacts on soil health, plant productivity, and nutrient cycling. We monitor long-term exclosures to see how plant communities are changing with and without bison.

Bison Stats

- Approximately 61 bison were removed from the population during winter 2023/2024, including 5 bison placed in the BCTP, 15 bison captured by the NPS and transferred to Tribes through the TFTP, and 41 bison harvested by state hunters or Tribal members.
- The NPS counted the population in August 2024 and recommended a removal objective to the IBMP partners in fall based on the 2024 Bison Management Plan.
- Yellowstone's bison population has grown steadily over the last 50+ years: from 500 animals in 1970 to 5,400 in 2024. Yellowstone bison represent a unique source of genetic diversity.
- Designation of bison as our national mammal does not provide any special protection to bison.

Learn more about bison management at **https://www.nps.gov/yell/learn/management/bison.htm**

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Staff Reviewers

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Bighorn Sheep

Although widely distributed across the Rocky Mountains, bighorn sheep (*Ovis canadensis*) persist chiefly in small, fragmented populations that are vulnerable to sudden declines as a result of disease, habitat loss, and disruption of their migratory routes due to roads and other human activities. Between 10 and 13 interbreeding bands of bighorn sheep occupy steep terrain in the upper Yellowstone River drainage, including habitat that extends more than 20 miles north of the park. These sheep provide visitor enjoyment as well as revenue to local economies through tourism, guiding, and sport hunting. Mount Everts receives the most concentrated use by bighorn sheep year-round.

All bighorn sheep have horns. The rings on horns can be used to determine age, though it is easier to count the rings on a ram (*left*).

Population

From the 1890s to the mid-1960s, the park's bighorn sheep population fluctuated between 100 and 400. Given the vagaries of weather and disease, bighorn sheep populations of at least 300 are desirable to increase the probability of long-term persistence with minimal loss of genetic diversity. The count reached a high of 487 in 1981, but a keratoconjunctivitis (pinkeye) epidemic caused by Chlamydia reduced the population by 60% the following winter, and the population has been slow to recover. Although the temporary vision impairment caused by the infection is rarely fatal for domestic sheep that are fenced and fed, it can result in death for a sheep that must find its forage in steep places.

During the 2018 survey, a total of 345 bighorn sheep were observed, including 214 in Montana and 131 inside Yellowstone National Park. This is slightly

Quick Facts

Number in Yellowstone
345 in the northern Yellowstone area in 2018 (131 counted inside the park).

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

Behavior and Size
- Average life span: males, 9–12 years; females 10–14 years.
- Adult male (ram): 174–319 pounds, including horns that can weigh 40 pounds. The horns of an adult ram can make up 8–12% of his total body weight.
- Adult female (ewe): up to 130 pounds.
- Horn growth is greatest during the summer and early in life. Female horns grow very little after four to five years, likely due to reproductive costs.
- The horn size of bighorn sheep rams can influence dominance and rank, which affects social relationships within herds.
- Older ram horns may be "broomed" or broken at the tip, which can take off one to two years of growth.
- Mating season begins in November.
- Ram skulls have two layers of bone above the brain that function as a shock absorber, an adaptation for the collision of head-on fighting that is used to establish dominance between rams of equal horn size, especially during mating.
- One to two lambs born in May or June.

Habitat
- Feed primarily on grasses; forage on shrubby plants in fall and winter.
- Rocky Mountain bighorn sheep, found in greater Yellowstone, differ from other currently recognized subspecies in the United States: Desert bighorn sheep, which is currently listed as an endangered species, Dall sheep found in Alaska and northwestern Canada, and Stone's sheep, which are a subspecies of Dall sheep.

Management
- Early reports of large numbers of bighorn sheep in Yellowstone have led to speculation they were more numerous before the park was established.
- A chlamydia (pinkeye) epidemic in 1981–1982 reduced the northern herd by 60%.

Most bighorn sheep in Yellowstone are migratory, wintering in lower-elevation areas along the Yellowstone, Lamar, and Gardner rivers, and moving to higher-elevation ranges from May through October.

Bighorn sheep exhibit some habituation to humans. Be alert to them along the road and never feed them.

below the 10-year average of 358 sheep. Additionally, in 2018, lamb-to-ewe ratios of 20:100 were below the 10-year average (28:100), with very low lamb recruitment observed on the Cinnabar, Corwin, and Mt. Everts winter ranges.

During 2005-2015, the population increased steadily. A decline occurred in 2015 related to an all-ages pneumonia event. In spite of the 2015 decline, overall bighorn sheep numbers in the northern Yellowstone remain substantially above the long-term average.

Competition with Other Species

Bighorn sheep populations that winter at high elevations are often small, slow-growing, and low in productivity. Competition with elk as a result of dietary and habitat overlaps may have hindered the recovery of this relatively isolated population after the pinkeye epidemic. Rams may be hunted north of the park, but the State of Montana has granted few permits in recent years because of the small population size.

Although wolves occasionally prey on bighorn sheep, the population has increased since wolf reintroduction began in 1995. Longer-term data are needed to show whether sheep abundance may be inversely related to elk abundance on the northern range. The Wyoming Game and Fish Department, Montana Fish, Wildlife & Parks, the Idaho Department of Fish and Game, Montana State University, the US Forest Service, and several non-governmental organizations are cooperating with the National Park Service to study how competition with nonnative mountain goats, which were introduced in the Absaroka Mountains in the 1950s, could affect bighorn sheep there.

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Mountain Goats

Descendants of mountain goats (*Oreamnos americanus*) introduced in the Absaroka and Madison mountain ranges during the 1940s and 1950s established a population in Yellowstone National Park in the 1990s. They have reached a relatively high abundance in the northeastern and northwestern portions of the park. Investigations of paleontological, archeological, and historical records have not found evidence that the mountain goat is native to greater Yellowstone.

Many people consider the goats a charismatic component of the ecosystem, including those who value the challenge of hunting them outside the park. But the colonization has raised concerns about the goats' effects on alpine habitats. Competition with high densities of mountain goats could also negatively affect bighorn sheep, whose range overlaps that of mountain goats.

Habitat

Mountain goats live in alpine habitats. Studies of alpine vegetation in the northeast portion of the park during 2002 and 2003 suggest that ridge-top vegetation cover is lower, and barren areas along alpine ridges are more prevalent in areas that have received relatively high goat use. Studies by Idaho State University and the National Park Service during 2008–2010 suggest goats are affecting the soil chemistry of sites they inhabit by increasing the availability of soil nitrogen through deposition of urine and feces. Soil rockiness may be increasing slightly over time at sites with high goat presence, but no large-scale effects have been detected so far with respect to vegetation (species, community structure).

Mountain goats are not native to the Greater Yellowstone Ecosystem.

Colonization of suitable habitats south of The Thunderer and along the eastern park boundary within the Absaroka Mountain Range appears to be occurring. During a 2022 survey, mountain goats were observed from Notch Peak to Eagle Peak, indicating they continue to expand their range. Only males (billies) were observed; however, park biologists anticipate that the expansion southward will continue and eventually include females (ewes) and reproductive groups.

Quick Facts

Nonnative species

Number in Yellowstone

200–300 in and adjacent to Yellowstone.

Where to See

- Infrequently seen; northeastern and northwestern portions of the park in alpine habitat.
- Winter: steep, south-facing slopes, windblown ridge tops; Spring: south- and west-facing cliffs; Summer: meadows, cliffs, ravines, and forests.

Behavior and Size

- Mature male (billy) weighs 300 or more pounds; female (nanny) weighs 150 pounds.
- Young (kids) born in late May–June.
- Females usually begin to breed at 2½ years.
- Live in precipitous terrain.
- Both sexes have horns; females' horns curve less and are thinner and sometimes longer than males.

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Staff Reviewer

Travis Wyman, Biological Technician

Elk

Yellowstone provides summer range for an estimated 10,000–20,000 elk (*Cervus canadensis*) from six to seven herds, most of which winter at lower elevations outside the park. These herds provide visitor enjoyment as well as revenue to local economies through hunting outside the park. As Yellowstone's most abundant ungulate, elk comprise approximately 85% of winter wolf kills and are an important food for bears, mountain lions, and at least 12 scavenger species, including bald eagles and coyotes. Competition with elk can influence the diet, habitat selection, and demography of bighorn sheep, bison, moose, mule deer, and pronghorn. Elk browsing and nitrogen deposition can affect vegetative production, soil fertility, and plant diversity. Thus, changes in elk abundance over space and time can alter plant and animal communities in Yellowstone.

Bull elk grow antlers for the fall mating season and keep them through the winter. The antlers fall off for the new year's growth.

Description

Elk are the most abundant large mammal found in Yellowstone. European American settlers used the word "elk" to describe the animal, which is the word used in Europe for moose (causing great confusion for European visitors). The Shawnee word "wapiti," which means "white deer" or "white-rumped deer," is another name for elk. The North American elk is considered by some experts to be the same species as the red deer of Europe (*Cervus elaphus*). This is an ongoing taxonomic debate. Currently, most scientists refer to elk in North America as *Cervus canadensis*.

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

Growing antlers are covered with a thick, fuzzy coating of skin commonly referred to as "velvet." Blood flowing in the skin deposits calcium that makes the antler. Usually around early August, further hormonal changes signal the end of antler growth, and the bull begins scraping the velvet off, polishing and sharpening the antlers in the process.

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

Bulls retain their antlers through the winter.

Quick Facts

Number in Yellowstone

- Summer: 10,000–20,000 elk in six to seven different herds.
- Winter: <2,000.

Where to See

- Summer: Cascade Meadows, Madison Canyon, and Lamar Valley.
- Autumn, during "rut" or mating season: northern range, including Mammoth Hot Springs; Madison River.
- Winter: migrate north to the northern range and around Gardiner, Montana; south to the Jackson Hole Elk Refuge in Jackson, Wyoming.

Size and Behavior

- Males (bulls) weigh ~700 pounds and are ~five feet high at the shoulder; females (cows) weigh ~500 pounds and are shorter; calves are ~30 pounds at birth.
- Bulls have antlers, which begin growing in the spring and usually drop in March or April of the following year.
- Feed on grasses, sedges, other herbs and shrubs, bark of aspen trees, conifer needles, burned bark, aquatic plants.
- Mating season (rut) in September and October; single calves born in May to late June.

Elk Antlers

Antlers are usually symmetrical and occur on males and, only rarely, females.

- The average, healthy, mature bull has six tines on each antler, and is known in some parts of the US as a "six point" or "six by six."
- One-year-old bulls grow 10–20-inch spikes, sometimes forked.
- Two-year-old bulls usually have slender antlers with four to five points.
- Three-year-old bulls have thicker antlers.
- Four-year-old and older bulls typically have six points; antlers are thicker and longer each year.
- Eleven- or 12-year-old bulls often grow the heaviest antlers; after that age, the size of antlers generally diminishes.

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

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 bulls spend the winter with other bulls or with gender-mixed herds, retaining 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 and mates.

Mating Season

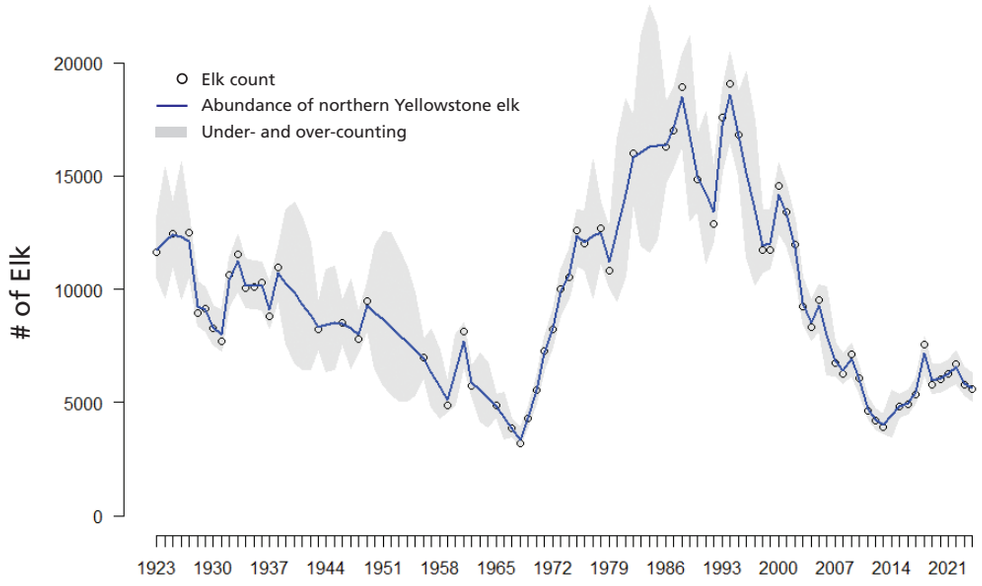
The mating season (rut) generally occurs from early September to mid-October. Elk gather in mixed herds—many females and calves, with a few bulls nearby. Bulls bugle to announce their availability and fitness to females and to warn and challenge other bulls. When answered, bulls move toward one another and sometimes engage in battle for access to the cows. They crash their antlers together, push each other intensely, and wrestle for dominance. While loud and extremely strenuous, fights rarely cause serious injury. The weaker bull ultimately gives up and wanders off.

Elk calves can walk within an hour of birth, but they spend much of their first week to 10 days bedded down between nursing sessions.

Calves are born in May and June. They are brown with white spots and have little scent, providing them with good camouflage from predators. They can walk within an hour of birth, but spend much of their first week to 10 days bedded down between nursing sessions. Soon after, they begin grazing with their mothers, and join a herd of other cows and calves. Up to two-thirds of each year's calves may be killed by predators. Elk calves are food for black and grizzly bears, wolves, coyotes, cougars, and golden eagles. Female elk can live 17–18 years. Rare individuals may live 25 years.

Population

The high elevation grasslands of the park provide summer habitat for 10,000–20,000 elk. However, fewer than 2,000 elk spend winter in the park. Climate is an important factor affecting the size and distribution of elk herds. Many ungulates migrate to increase their access to high-quality food. They prefer to feed on young plants, which are the most nutritious. In winter, colder temperatures and snowfall decrease the amount of forage that grows, which means less forage is accessible to wildlife. This forces elk to migrate to areas where forage is more available. The timing and routes of northern Yellowstone elk migration closely follow the areas of seasonal vegetation growth and changes in snow depth. After winters with high snowpack, elk delay migration. In years with lower snowpack and earlier vegetation



Abundance of the northern Yellowstone elk population, 1923–2024. Shaded area indicates uncertainty about the trend with respect to random under- and overcounting. These results underestimate the true population size because they do not account for imperfect sightability. Data from the Northern Yellowstone Cooperative Wildlife Working Group.

green-up, elk migrate earlier.

Ungulates that migrate typically give birth around periods of peak vegetation green-up to overlap with high-nutrition plant phases. Nutritious food allows mothers and calves to build up fat reserves. Changes in climate will undoubtedly impact newborn elk, but it is difficult to predict whether that impact will be positive or negative. Earlier spring could lead to a longer snow-free season where migration and access to food are not encumbered. However, a longer growing season, without increased access to high-quality forage, might have a negative impact. Warmer temperatures could increase the rate of green-up, causing the plants to complete their growth cycle faster, thus shortening the period of time that food is available and accessible. Also, earlier spring could result in a mismatch in the timing of calving and the date of peak plant nutrition, resulting in high mortality of newborn calves.

Elk on the northern range

Yellowstone's largest elk herd winters along and north of the park's winter boundary. With more moderate temperatures and less snowfall than the park interior, this area can support large numbers of wintering elk. The herd winters in the area of the Lamar and Yellowstone river valleys from Soda Butte to Gardiner, Montana. Currently, the majority of the northern herd migrates outside of the park into the Custer Gallatin National Forest and onto private land.

After decades of debate over whether this range was overgrazed by too many elk, public concern has shifted to the herd's small size. The winter count, which was approximately 17,000 when wolf reintroduction began in 1995, fell below 10,000 in 2003. It fluctuated between 6,000 and 7,000 as the wolf population on the park's northern range declined from 94 in 2007 to 50 by the end of 2015. The elk count dropped to 3,915 in early 2013, the lowest since culling ended in the park in the 1960s. However, the elk population has been increasing since 2013. There were more elk counted in 2022 (6,673) than during the final year of Gardiner Late Hunt (2010: 6,070) just north of the park's boundary. This hunt was initiated by the State of Montana in 1976 prior to carnivore recovery and designed to reduce the size of the northern herd through the removal of adult female elk. While these counts do not account for factors known to influence number of elk counted (e.g., snow cover, group size, sightability of elk across habitat types), these recent trends in minimum count estimates suggest herd size has stabilized or is even increasing. Decreased numbers have been attributed to large carnivore recovery (wolves, cougars, bears), hunter harvest, and drought-related effects on pregnancy and survival. The State of Montana has reduced the permits issued for this herd so that hunting of females now has little impact on population size.

There are some indications that elk–carnivore interactions are contributing to a release of willows and other woody vegetation from the effects of herbivory on the northern range. Carnivores play some role in altering elk behavior, group size, habitat selection, movements, and distribution; while the proportion of browsed aspen, cottonwood, and willow leaders has decreased in some areas during recent years, and

cottonwood and willow heights have increased significantly. Others argue that lower elk densities over the past two decades—resulting from the combined effects of predators (wolves, cougars, bears), human hunters, and weather—has necessarily altered the impact of elk browsing. Research is under way to determine the relative effects of climate, hydrology, carnivore predation/avoidance, and herbivory on these woody species.

A new book titled *Northern Yellowstone: Elk Resilience and Adaptation to Changes in Management Policies and the Ecosystem* is available for free download at **www.nps.gov/yell/ learn/nature/elk.htm**. This book, written by park biologists and colleagues, examines the history of elk conservation and management in the United States, compiles the latest scientific information about Yellowstone elk, and discusses both the opportunities for and challenges to elk conservation within the Greater Yellowstone Area and across their historic range.

Elk in the Interior

Only one herd lives both winter and summer inside the park. The Madison–Firehole elk herd (fewer than 100 animals) has been the focus of a research study since November 1991. Researchers are examining how environmental variability affects ungulate reproduction and survival. Prior to wolf restoration, the population was naturally regulated by severe winter conditions to a degree not found in other, human-hunted elk herds. The elk are also affected by high fluoride and silica levels in the water and plants they eat, which affect enamel formation and wear out teeth quickly—thus shortening their lives. The typical life span is 13 years; elk on the northern range regularly live to about 18 years. Information gained in this study will be useful in comparing non-hunted and hunted elk populations.

The Madison–Firehole herd is the only elk herd that lives inside the park in both winter and summer.

Elk in the Greater Yellowstone Ecosystem

The Greater Yellowstone Ecosystem is home to approximately 30,000–40,000 elk. For the last decade, the Jackson herd, which currently numbers about 10,000, has been larger than the northern Yellowstone herd. Some ranges and migratory routes overlap, and some interchange occurs among the herds. Summer range in the southern part of Yellowstone National Park is used by part of the Jackson herd as well as by elk from the North Fork Shoshone and northern Yellowstone herds. Because the wildlife responsibilities of the National Park Service, the US Fish and Wildlife Service, the US Forest Service, and state wildlife agencies coincide, elk management in Greater Yellowstone requires substantial coordination among government agencies with different priorities.

Disease in Greater Yellowstone

Brucellosis

Many elk and bison in the Greater Yellowstone Ecosystem have been exposed to the bacterium that causes brucellosis. Brucellosis is a contagious bacterial disease that originated in livestock and often causes infected cows to abort their first calves. It is transmitted primarily when susceptible animals directly contact infected birth material. No cure exists for brucellosis in wild animals. For more information about brucellosis, see “Bison.”

The prevalence of brucellosis in Yellowstone elk is low; the rate of exposure to brucellosis in 100 adult female elk captured on the park’s northern range during the winters of 2000 to 2005 was 2%; it was 3% in 130 neonatal elk on the park’s northern range during the summers of 2003–2005; and it was 3% in 73 adult female elk captured in the park’s Madison–Firehole drainages during the winters of 1996–1998. Elk are commonly observed within 100 yards of bison during late winter and spring when brucellosis-induced abortion or calving occurs in Yellowstone.

Because of their high densities, elk that are fed in winter have sustained high levels of brucellosis; winter feeding on the northern range stopped more than 50 years ago. Elk are fed during the winter at the National Elk Refuge in Jackson, Wyoming, in

addition to 22 Wyoming-run feed grounds. The feed grounds were created in the 1900s to maintain Wyoming's elk herds and limit depredation as migratory routes from summer range to lower elevation winter ranges became blocked by settlement in the Jackson area. Transmission of brucellosis from feed ground elk, where an average of 30% have tested positive for exposure to the bacteria, was the apparent source of infection in Wyoming cattle in 2004.

Chronic Wasting Disease

Elk, deer, and moose in and near Yellowstone National Park are at risk for infection by chronic wasting disease (CWD). This fatal infection, transmitted by animal contact or through the environment, has increasingly spread in Wyoming and Montana. Yellowstone National Park and the Wyoming Game and Fish Department confirmed the presence of CWD in the carcass of an adult mule deer buck found near Yellowstone Lake in the southeastern section of the park in October 2023. This is the first confirmed positive detection of the disease in Yellowstone National Park. National Park Service staff and partners will continue surveillance and, if necessary, take action to minimize both transmission of the disease and the effects of intervention on the elk population and other park resources.

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Staff Reviewer

Dan Stahler, Senior Wildlife Biologist

Moose

Yellowstone moose are the smallest of four subspecies of moose (*Alces alces shirasi*) in North America. Found in forested areas and willow flats from southeastern British Columbia to southern Colorado, they are better adapted to survival in deep snow than other ungulates in Greater Yellowstone. Except during the rut, moose are usually found alone or in small family groups. This behavior, and their use of habitat where they are often well concealed, impedes accurate estimates of population size and distribution.

Description

Moose are the largest members of the deer family in Yellowstone. Both sexes have long legs that enable them to wade into rivers and through deep snow, to swim, and to run fast. Moose, especially cows with calves, are unpredictable and have chased people in the park.

Moose are dark brown, often with tan legs and muzzle. Bulls have antlers for most of the year, or pedicles (flat bony protrusions on the skull) in the winter after antlers are cast. Females are distinguished from bulls without antlers by the white patch beneath their tail. Adults of both sexes have "bells"—a pendulous dewlap of skin and hair that dangles from the throat. Bulls urinate in wallows and lay down and splash in it spreading the scent all over them. The dewlap holds the scent that is then dispersed by the wind.

In summer, moose eat aquatic plants like water lilies, duckweed, and burweed. But the principle staples of the moose diet are the leaves and twigs of the willow, followed by other woody browse species such as gooseberry and buffaloberry. In winter when available, moose exhibit a high preference to subalpine fir. An adult moose consumes approximately 10–12 pounds of food per day in the winter and as much as 50 pounds of food per day in the summer.

Bull moose usually shed their antlers in the beginning of winter to help conserve energy and survive winter.

Some moose that summer in the park migrate in winter to lower elevations west and south of Yellowstone where willow remains exposed above the snow. But many moose move to higher elevations (as high as 8,500 feet) to winter in mature stands of subalpine fir and Douglas-fir.

During the rut, both bulls and cows are vocal. Cows emit a drawn out groan in search of a mate, and bulls challenge one another with low guttural and repetitive grunts before clashing with their antlers. The weaker bull usually gives up before any serious damage is done; on rare occasions the opponent's antlers inflict a mortal wound.

Bulls usually shed their antlers in late December to late January, although young bulls may retain their antlers as late as March. Shedding their heavy antlers helps moose conserve energy and promotes easier winter survival. In April or May, bulls begin to grow new antlers. Small bumps called pedicles on each side of the forehead start to swell, then enlarge until

Quick Facts

Number in Yellowstone

- Fewer than 200
- Population has declined in past 40 years due to loss of old-growth forests surrounding the park, hunting outside the park, burning of habitat, and predators.

Where to See

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

Behavior and Size

- Adult male (bull) weighs close to 1,000 pounds; female (cow) weighs up to 900 pounds; 5½ to 7½ feet at the shoulder. Young weigh 25–35 pounds at birth.
- Usually alone or in small family groups.
- Mating season peaks in late September and early October; one or two calves born in late May or June.
- Lives up to 20 years.

they are knobs covered with a black fuzz (called velvet) and fed by blood that flows through a network of veins. Finally, the knobs change into antlers and grow until August. The antlers are flat and palmate (shaped like a hand). Yearlings grow six- to eight-inch forked antlers; prime adult bulls usually grow the largest antlers—as wide as five feet from tip to tip. When the antlers reach their full size, the bull rubs his antlers on small trees and brush to remove the velvet and polish the antlers in preparation for the rut. Cows breed in early fall; gestation is approximately eight months. Cows most commonly give birth to a single calf in Yellowstone.

Population

Moose appear to have been scarce in Yellowstone until the latter half of the 1800s and in Jackson Hole until the early 1900s. The first documented report of a moose on the northern range was 1913. Predator-control programs, forest-fire suppression, and restrictions on moose hunting contributed to their subsequent range expansion and increased numbers.

Forest-fire suppression was probably the most important factor in moose population increase because moose in Greater Yellowstone depend on mature spruce/fir forests for winter survival, unlike other North American moose populations that prefer large willow flats or shrubland that has been created by events like fires or logging.

The Yellowstone moose population has declined from roughly 1,000 in the 1970s to about 200 in 1996 (the most recent data), with the northern range population down by at least 75% since the 1980s. The population declined steeply following the fires of 1988 that burned mature fir forests. Many old moose died during the winter of 1988–89, probably as a combined result of the loss of good moose winter forage and a harsh winter. Large populations of elk and bison, which also browse willow, likely reduce the amount of willow forage available for moose. 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.

Recent studies south of the park also suggest that fire on the summer ranges of migratory moose is partially responsible for the population decline. The population of moose that uses burned areas is declining more rapidly than the portion of the population that forages in unburned areas.

Predation of moose calves by bear and wolf populations may be limiting population growth, but the low pregnancy rates of greater Yellowstone moose suggest limits set by food availability. Long-term studies suggest that North American moose populations tend to erupt, crash, and then stabilize for a time.

Montana has noted a state-wide decline in moose populations. Moose hunting in the districts immediately north of Yellowstone has been limited to antlered bulls since 1996. Only two permits were issued in those districts in 2014. In 2012, Montana Fish, Wildlife and Parks began a study to assess and monitor the population across the state. A three-year northern Yellowstone National Park moose study was completed between the winters of 2013–2014 and 2015–2016 with the main objective to estimate population abundance and vital statistics of northern Yellowstone moose. Population modelling based on fecal DNA estimated between 150 and 186 moose occupied northern Yellowstone between 2013 and 2015 and that the annual population growth rate is 4%, (considered moderate growth). However, because mature conifer forest (important wintering habitat) were reduced by the 1988 fires and large populations of elk and bison compete with moose for willow browse, northern YNP moose will likely persist at a low density. Today, moose are most likely seen in the park's southwestern corner and in the Soda Butte Creek, Pelican Creek, Lewis River, and Gallatin River drainages.

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Staff Reviewer

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Deer

The Greater Yellowstone Ecosystem is home to both mule deer (*Odocoileus hemionus*) and white-tailed deer (*Odocoileus virginianus*). The mule deer, also called blacktail deer, is an exclusively western species commonly seen in open-brush country throughout the western states. Widely dispersed throughout Yellowstone National Park during the summer, mule deer migrate seasonally, and most of the population winters outside of the park. Although the white-tailed deer is the most common deer species throughout North America, it has never been abundant in Yellowstone. This may be due to habitat and elevation constraints on the northern range or competition from other ungulates that are better suited to park habitat. The two species are differentiated by their antler shape and tail size and appearance.

Behavior

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

Population

In 2018, aerial surveys detected 1,996 mule deer in the Gardiner Basin area and across the northern range of Yellowstone Park. This was the highest population count since 2009, and above the ten-year average of 1,901. Deer population numbers have increased each year since a low in 2012 following a severe winter. In 2018, recruitment was 29 fawns per 100 adults, lower than the long-term average of 41 fawns per 100 adults. This likely reflects fawn mortality from harsh winter conditions during 2017–18 on mule deer range in and outside Yellowstone National Park.

While the relative distribution of mule deer across their winter range has remained similar over the past two decades, the population appears to cyclically increase and decrease. Mule deer populations may decline during severe winters, when deep snow and extremely cold temperatures make foraging difficult, thereby increasing starvation and predation susceptibility.

Although researchers estimate that northern Yellowstone has a summer mule deer population

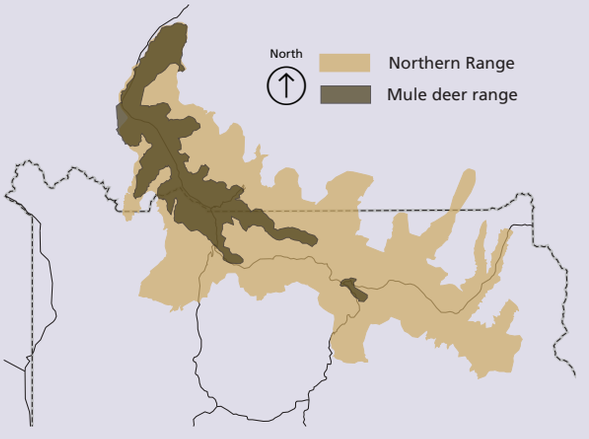
Mule Deer

Number in Yellowstone
Summer: 1,850–1,900; winter: fewer than 400

Where to See
Summer: throughout the park; Winter: North Entrance area.

Size and Behavior

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



Mule deer winter range lies primarily north of the park boundary.

of 1,850 to 1,900, fewer than several hundred stay in the park all winter. Unlike elk and bison, many of which remain in the park throughout the year, mule deer are preyed upon by wolves, coyotes, cougars, and bears in the park mostly in the summer. Because of the mule deer's seasonal distribution, the relative scarcity of white-tailed deer, and the abundance of elk, which are the main prey of wolves, wolf recovery in Yellowstone is believed to have had little effect on deer populations and recruitment.

Although the primary causes of deer mortality are winter kill and predation, mule deer and white-tailed deer outside the park are subject to state-regulated harvesting in the fall. Because of their scarcity, little is known about the white-tailed deer that inhabit the northern range, and the population within the park is not monitored.

In 2024, chronic wasting disease (CWD) was detected in a radio collared male (buck) mule deer from Wyoming that migrated into the southeast portion of Yellowstone. National Park Service staff and partners will continue surveillance and, if necessary, take action to minimize transmission of the this disease.

White-tailed Deer

Number in Yellowstone
Scarce, not monitored

Where to See
Along streams and rivers in the northern range.

Size and Behavior

- Adults 150–250 pounds; 3½ feet at the shoulder.
- Summer coat: red-brown; winter coat: gray-brown; throat and inside ears with whitish patches; belly, inner thighs, and underside of tail white.
- Waves tail like a white flag when fleeing.
- Males grow antlers from May until August; shed them in early to late spring.
- Mating season (rut) peaks in November; fawns born usually in late May or June.
- Eats shrubs, forbs, grasses; conifers in spring.
- Predators include wolves, coyotes, cougars, and bears.

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Staff Reviewer
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Pronghorn

The North American pronghorn (*Antilocapra americana*) is the surviving member of a group of animals that evolved in North America during the past 20 million years. It is not a true antelope, which is found in Africa and southeast Asia. The use of the term "antelope" seems to have originated when the first written description of the animal was made during the 1804–1806 Lewis and Clark Expedition.

Description

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

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

Pronghorn evolved in North America 20 million years ago. They can run sprints at 45–50 miles per hour, an adaptation to outrun an extinct cheetah.

Behavior

Females that bred the previous fall commonly deliver a set of twins in May or June. The newborn fawns are uniform grayish-brown and weigh six to nine pounds. They walk within 30 minutes of birth and are capable of outrunning a human in a couple of days. The young normally stay hidden in the vegetation while the mother grazes close by. After the fawns turn three weeks old, they begin to follow the females as they forage. Several females and their young join together in nursery herds, along with yearling females.

For increased protection against predators, pronghorn form groups. When one individual detects danger, it flares its white rump patch, signaling the others to flee. The pronghorn is adapted well for outrunning its enemies—its oversized windpipe and heart allow

Quick Facts

Number in Yellowstone
500–600 as of Spring 2024.

Where to See

- Summer: Lamar Valley; some may be near the North Entrance at Gardiner, Montana.
- Winter: between the North Entrance and Reese Creek.

Behavior and Size

- Male (buck) weighs 100–125 pounds; female (doe) weighs 90–110 pounds; adult length is 45–55 inches and height is 35–40 inches at shoulder.
- Average life span: 7–10 years.
- Young (fawns) born in late May–June.
- Live in grasslands.
- Can run for sustained sprints of 45–50 mph.
- Eat sagebrush and other shrubs, forbs, some grasses.
- Both sexes have horns; males' horns are pronged.

History

- Prior to European American settlement of the West, pronghorn population estimated to be 35 million.
- Early in the 1800s, pronghorn were abundant in river valleys radiating from Yellowstone; settlement and hunting reduced their range and numbers.
- Park management also culled pronghorn during the first half of the 1900s due to overgrazing concerns.

Management Concerns

- Pronghorn are a species of special concern in the park.
- This small population could face extirpation from random catastrophic events such as a severe winter or disease outbreak.

large amounts of oxygen and blood to be carried to and from its unusually large lungs. Pronghorn can sustain sprints of 45–50 mph. Such speed, together with keen vision, make the adults difficult prey for any natural predator. Fawns, however, can be caught by coyotes, bobcats, wolves, bears, and golden eagles.

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

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

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

Pronghorn fawns are very vulnerable to predation in their first half-hour of life. However, within two days of birth, fawns can outrun a human being, and they pick up speed as they grow.

Reduction of pronghorn winter range north of the park through development by private land owners, likely contributed to populations declines in the 1990s.

Population

During the early part of the 1800s, pronghorns ranked second only to bison in numbers, with an estimated 35 million throughout the West. The herds were soon decimated by conversion of rangeland to cropland, professional hunters who sold the meat, and ranchers who believed that pronghorns were competing with livestock for forage. Today, due to transplant programs and careful management, pronghorns roam the sagebrush prairies in herds totaling nearly 500,000 animals.

The pronghorn's population fluctuations on the northern range show the effects of management interventions as well as natural shifts in forage availability, competition with elk, and predation. Efforts to keep pronghorn in the park with fences and winter feeding reduced their abundance and use of migratory routes by the 1920s, and about 1,200 pronghorn were removed from 1947 to 1967 to address perceived sagebrush degradation. Complaints about crop depredation led to the removal of about 190 pronghorn on private land from 1985 to 2002. The reason for the sudden population decline in the early 1990s remains unclear, but fawn survival appears to have been low. This was probably due to coyote predation and reduction of winter range north of the park through development by private land owners. Pronghorn winter range inside the park is former agricultural land infested with nonnative vegetation of low nutritional quality.

Since the mid 2000s, the pronghorn population has seen a steady rebound in population, and since 2012, the population has recovered to the highest population estimates since the early 1990s. Removal of fences and better forage availability in areas adjacent to Yellowstone National Park appear to have reduced predation factors on pronghorn on the winter range, and those are some of the factors attributed to increases in pronghorn numbers. Outside Yellowstone National Park, a limited pronghorn hunt was re-established in response to population increases beginning in 2016. Since the early 2000s, evidence of migration and dispersal into Paradise Valley as well as mixing with pronghorn herds outside the park, indicate long-term viability of the Yellowstone population. Research continues to search for answers concerning the Yellowstone pronghorn herd. This small population continues to be susceptible to extirpation from random catastrophic events, such as a severe winter or disease outbreaks.

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Wolves

Although wolf packs once roamed from the Arctic tundra to Mexico, loss of habitat and extermination programs led to their demise throughout most of the United States by the early 1900s. In 1973, the US Fish and Wildlife Service (USFWS) listed the northern Rocky Mountain wolf (*Canis lupus*) as an endangered species and designated Greater Yellowstone Ecosystem (GYE) as one of three recovery areas. From 1995 to 1997, 41 wild wolves from Canada and northwest Montana were released in Yellowstone. As expected, wolves from the growing population dispersed to establish territories outside the park, where they are less protected from human-caused mortalities. The park helps ensure the species' long-term viability in GYE and has provided a place for research on how wolves may affect many aspects of the ecosystem. January 12, 2025, marked the 30th anniversary since wolves returned to Yellowstone.

Members of the Delta pack, November 2013.

Description

In the years following wolf restoration, the population grew rapidly as newly formed packs established territories with sufficient prey. Over time, the wolves expanded their range and are now found throughout the Greater Yellowstone Ecosystem (GYE). Since 2009, Yellowstone's wolf population has stabilized following a decline from the initial recolonization period. This decrease has been most pronounced in northern range packs, primarily due to declines in the elk population and limited available territory. Disease outbreaks have also contributed to the decline.

Wolves are highly adaptable predators with remarkable physical characteristics. Adult males in Yellowstone average 110 pounds (50 kg), while females weigh around 90 pounds (41 kg), with the heaviest known Yellowstone wolf weighing 148 pounds. Standing approximately 81 cm (males) and 77 cm (females) tall at the shoulder, wolves average 181 cm in length. Their eyes, blue at birth, change to shades of light yellow, gold, or brown in adulthood. Wolves have 319 bones in males and 318 in females, along with 42 teeth designed for a carnivorous diet. Their dental formula includes 3 incisors, 1 canine, 4 premolars, and 2–3 molars on each side.

Wolves have dense, typically gray or black pelage. As tetrapedal digitigrades, wolves are built for endurance and speed, traveling an average of 5 mph (8 kph) but capable of sprinting up to 35 mph (56 kph). Their physiology supports their active lifestyle, with a body temperature of 100–102.5°F (37.3–39.1°C), a resting respiration rate of 10–30 breaths per minute, and a

Quick Facts

Number

- In 2024, there were at least 108 wolves in the park. Nine packs were noted. Wolves in YNP sit at the core of a larger population connected throughout the Greater Yellowstone Ecosystem.
- In general, wolf numbers have fluctuated between 83 and 123 wolves since 2009.

Where to See

- They inhabit most of the park; peak activity is at dawn and dusk.
- The northern range of Yellowstone is one of the best places in the world to watch wolves.

Size and Behavior

- 26–36 inches tall at the shoulder, 4–6 feet long from nose to tail tip; males weigh 100–130 pounds, females weigh 80–110 pounds.
- Home range within the park is 185–310 square miles (300–500 km^2); varies with pack size, food availability, and season.
- Average lifespan in the park is four to five years, average outside is two to three years. The oldest known wolf here was 12.5 years old.
- Two main color variations exist in Yellowstone in approximately equal proportions: black and gray.
- Prey primarily on hoofed animals. In Yellowstone, 90% of winter diet is elk; summer prey consist of more deer and smaller mammals.
- Mate in February; give birth to average of five pups in April after a gestation period of 63 days; young emerge from den at 10–14 days; pack remains at the den for three to ten weeks unless disturbed.
- Leading cause of death for wolves within the park is death by other wolves; leading cause of death for wolves outside the park is human-caused.

Wolves (back) are larger than coyotes (middle) and red foxes (front).

Yellowstone wolves are predominantly colored gray or black (top photo). Coat color can also be influenced by age as shown by long-term dominant female of Canyon pack who turned from gray to almost white with age (lower left) and 10-yr old Canyon dominant male 712M who turned from dark black to light silver with age (lower right).

heart rate of 70–120 beats per minute. Equipped with a powerful bite pressure of 1,200 psi, wolves are well-suited to capture and consume large prey, showcasing their vital role in Yellowstone's ecosystem.

Genetics

Since their reintroduction, genetic studies have examined Yellowstone wolves' genetic health, pack kinship, connectivity with other Northern Rocky Mountain populations, and genes linked to physical and behavioral traits. One notable finding involves coat color: about half of Yellowstone wolves are black, while the other half are primarily gray. The black coat results from a single mutation in the K-locus gene (CBD103), which likely originated from hybridization with domestic dogs brought to North America via the Bering Land Bridge within the last 7,000 years.

In addition to influencing coat color, the K-locus gene is linked to immune function. Black wolves, for example, show higher survival rates during distemper outbreaks. Research also indicates behavioral and reproductive differences: gray wolves tend to be more aggressive in territorial conflicts and achieve higher reproductive success, while black and gray wolves preferentially mate with individuals of the opposite coat color. These findings suggest a fitness trade-off between coat colors, contributing to the persistence of black wolves in Yellowstone's population.

Diet

Wolves consume a wide range of prey, efficiently hunting large animals that many other predators cannot. In Yellowstone, elk make up 90% of their winter diet, while deer account for 10–15% of their summer prey. Wolves also kill bison, an increasingly important food source.

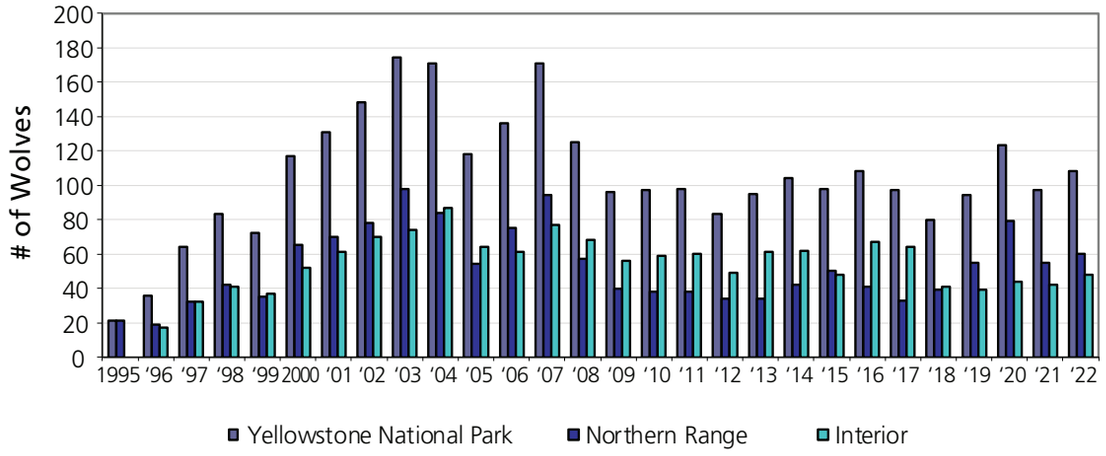
Wolf kills provide vital resources for many other animals. Ravens and magpies arrive almost immediately after a kill, followed by coyotes, which wait nearby until the wolves are finished. Bears often chase wolves off their kills and claim the remains. Eagles, invertebrates, and other scavengers also benefit.

From 1995 to 2000, elk calves made up 50% of early winter wolf prey, while bull elk comprised 25%. Between 2001 and 2007, this ratio reversed, reflecting shifts in prey vulnerability and availability. While predation on bison occurs across all age groups, wolves primarily scavenge bison that die during winter or

Interesting Wolf Behavior

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

In 2019, a subordinate female wolf of the Junction Butte pack killed the pups of the pack's alpha female; then the rest of the pack raised the subordinate female's pups.



Yellowstone National Park wolf population, 1995–2022.

from injuries sustained in the breeding season.

These findings underscore the importance of long-term monitoring to understand predator–prey dynamics. Wolf predation patterns are influenced by multiple factors, including competition with other predators, ungulate management outside the park, and weather conditions like drought and winter severity. Such factors affect forage quality and elk nutritional condition, ultimately shaping prey selection and kill rates over time.

Disease

Disease has periodically impacted the population, particularly pups and older adults. Canine distemper outbreaks occurred in 2005, 2008, and 2009, with the 2005 outbreak killing two-thirds of the park's pups. Other diseases, such as infectious canine hepatitis, canine parvovirus, and bordetella, have been confirmed, though their effects on mortality remain unclear.

In 2009, sarcoptic mange, caused by the mite *Sarcoptes scabiei*, reached epidemic levels among northern range wolves. Transmitted through direct contact, the mites burrow into the skin, triggering intense itching, hair loss, and secondary infections. By late 2011, the epidemic had largely subsided, but the infection persists at lower levels across the park.

History of Wolf Management

Wolves have been a vital part of North America's ecosystems for thousands of years, ranging from the Arctic tundra to forests, grasslands, and deserts. Once widespread across the continent, they played a key role as apex predators, maintaining the balance of prey populations and supporting biodiversity. However, due to habitat loss, hunting, and government eradication programs, wolves were nearly eliminated from most of their historical range by the mid-20th century. Conservation efforts, including reintroduction programs, have since helped restore wolf populations in select areas, highlighting their ecological and cultural significance.

Early Wolf Management

In the 1800s, westward expansion brought settlers and livestock into direct conflict with native predators like wolves. As agriculture expanded, much of the wolves' prey was wiped out, leading them to target livestock. In response, humans launched widespread eradication efforts, including poisoning, which eliminated wolves from most of their historical range. Even within Yellowstone, predator control measures in the late 1800s and early 1900s targeted wolves, bears, cougars, and coyotes to protect

Ranger Ted Ogsten and Chief Ranger Sam Woodring with coyote pelts, 1927.

Canadian and American wildlife biologists captured wolves in Canada and relocated and released them in both Yellowstone and central Idaho. Wolves were temporarily penned before their release.

livestock and "desirable" wildlife like deer and elk.

When Yellowstone was established in 1872, gray wolves were present. The fossil record also shows their presence in the region going back thousands of years. However, early park managers, lacking an understanding of ecosystems, viewed wolves as destructive predators. Between 1914 and 1926, at least 136 wolves were killed in the park, and by the 1940s, wolf packs were nearly extinct in the area. By the mid-20th century, wolves were virtually eliminated from the lower 48 states.

An intensive survey in the 1970s found no evidence of a wolf population in Yellowstone. Occasional sightings occurred, such as a wolf-like canid filmed in Hayden Valley in 1992, but no breeding pairs were confirmed. During the 1980s, wolves began to reestablish breeding packs in northwestern Montana, with 50–60 wolves reported by 1994.

In the 1960s, National Park Service (NPS) wildlife management policies shifted to let populations manage themselves, emphasizing the importance of predators like wolves. Growing national awareness of environmental issues led to laws like the 1973 Endangered Species Act (ESA), requiring the restoration of endangered species. By 1978, all wolf subspecies except those in Minnesota were federally listed as endangered, aligning with NPS policy to restore native species where feasible.

Restoration Efforts

In 1987, the USFWS Northern Rocky Mountain Wolf Recovery Plan proposed reintroducing an "experimental population" of wolves into Yellowstone. Under section 10(j) of the Endangered Species Act, experimental populations are nonessential, allowing greater management flexibility. Scientists predicted wolves would have minimal effects on mule deer, pronghorns, bighorn sheep, white-tailed deer, or bison, with minor impacts on grizzly bears and cougars. They expected wolves to reduce coyote numbers and increase red fox populations.

In 1991, Congress funded the USFWS to prepare an Environmental Impact Statement (EIS) on wolf restoration, in consultation with the NPS and US Forest Service. After extensive public input, the Secretary of the Interior signed the Record of Decision in June 1994, approving gray wolf reintroduction to Yellowstone and central Idaho.

Although a five-year reintroduction plan was anticipated, no transplants were needed after 1996 due to the program's early success. Some expressed concerns about wolves becoming habituated to humans while in pens, but confinement reinforced their natural avoidance of people, as it was a negative experience for them.

Relocation and Release

In late 1994, early 1995, and again in 1996, USFWS and Canadian wildlife biologists captured wolves in Canada and relocated them to Yellowstone and central Idaho. In January 1995, 14 wolves were temporarily penned in Yellowstone: eight arrived on January 12 and six more on January 19. Each social group was kept together in acclimation pens. A second group of 17 wolves arrived in January 1996, with 11 brought on January 23 and six more on January 27. The wolves, ranging in age from nine months to five years and weighing 72–130 pounds, included individuals known to hunt bison and included breeding adults and younger pack members.

Each wolf was fitted with a radio collar before relocation. While penned, wolves were fed twice weekly with elk, deer, moose, or bison carcasses and had minimal contact with humans. Law enforcement rangers guarded the pens, and the surrounding areas were closed to visitors to prevent unauthorized access. Biologists monitored the wolves' welfare twice weekly using telemetry or visual observation during feedings.

Although a five-year reintroduction plan was anticipated, no transplants were needed after 1996 due to the program's early success. Some expressed concerns about wolves becoming habituated to humans while in pens, but confinement reinforced their natural avoidance of people, as it was a negative experience for them.

Restoration Results

Preliminary studies indicated that wolf recovery was likely to enhance biodiversity in the Greater Yellowstone Ecosystem (GYE). Wolves primarily prey on elk, with their kills benefiting a variety of scavengers. They are also increasingly preying on bison in late winter, though most bison biomass consumed comes from scavenging carcasses of bison that died naturally. Grizzly bears frequently usurp wolf kills, providing bears with a crucial food source in low-food years—contrary to expectations based on other regions. Additionally, wolf aggression toward coyotes has reduced their numbers in wolf territories, likely benefiting smaller predators, rodents, and birds of prey.

Wolves have contributed to decreased survival rates of elk calves and older female adults while also influencing elk habitat use. These effects, while partly predictable, are more complex in Yellowstone's ecosystem, which features multiple large predators—grizzly bears, black bears, coyotes, and cougars—as well as human hunting outside the park. This complexity makes it challenging to project long-term elk population trends.

The impact of wolves on northern Yellowstone elk dynamics cannot be generalized across the GYE. Variations depend on factors like elk densities, predator abundance, alternative prey availability, winter severity, and human influences such as hunting and livestock interactions. A coalition of professionals and researchers is studying additional wolf-ungulate systems in the western GYE. Findings suggest that wolf predation's effects on elk range from significant to minimal, depending on the specific context.

Legal Challenges

Several lawsuits were filed to halt wolf restoration, citing various concerns. The cases were consolidated, and in December 1997, a judge ruled that the reintroduction program in Yellowstone and central Idaho violated section 10(j) of the Endangered Species Act. The ruling found insufficient geographic separation between fully protected wolves in Montana and the reintroduction areas, where special management rules applied. The judge, expressing "utmost reluctance," ordered the removal—but not the killing—of reintroduced wolves and their offspring. However, he stayed the order pending appeal. The Justice Department appealed, and in January 2000, the decision was reversed, allowing the wolf reintroduction program to continue.

Wolf Management Timeline

- Late 1800s–early 1900s: predators, including wolves, are routinely killed in Yellowstone.
- 1926: The last wolf pack in Yellowstone is killed, though single wolves are occasionally reported after.
- 1974: The gray wolf is listed as endangered; initiating recovery efforts under the Endangered Species Act.
- 1975: Efforts to restore wolves in Yellowstone begin.
- 1991: Congress allocates funding for an environmental impact study (EIS) on wolf recovery.
- 1994: EIS for wolf reintroduction completed with over 160,000 public comments, the largest at the time for any federal proposal.
- 1995 and 1996: 31 gray wolves from western Canada relocated to Yellowstone.
- 1997: 10 wolves from northwestern Montana relocated to Yellowstone National Park; a court orders their removal, but the decision is stayed pending appeal (reversed in 2000).
- 1995–2003: Wolves kill significantly fewer livestock than expected: 256 sheep and 41 cattle.
- 2005: Wolf management is transferred from the federal government to Idaho and Montana.
- 2008: Wolves in Montana, Idaho, and Wyoming are delisted, then relisted.
- 2009: U.S. Fish and Wildlife Service (USFWS) delists wolves in Montana and Idaho, but not Wyoming; a legal challenge relists the Northern Rocky Mountain wolf population.
- 2011: Wolves in Montana and Idaho are delisted by Congress, and USFWS proposes delisting in Wyoming.
- 2012: Wolves in Wyoming are delisted under a Congressional directive.
- 2014: Wolves are relisted in Wyoming.
- 2017: Wolves are delisted in Wyoming, and the Northern Rocky Mountain wolf population is no longer listed as endangered.
- April 26, 2017 (current status): Wolves are delisted in Montana, Idaho, and Wyoming.
- January 4, 2021: All gray wolves in the lower 48 states removed from the list of species protected under the ESA.

Legal Status

The biological requirements for delisting wolves from the Endangered Species Act (ESA) were met with at least 300 wolves and 30 breeding pairs sustained for three consecutive years across three recovery areas. In 2008, the USFWS delisted wolves in Idaho, Montana, and Yellowstone and Grand Teton national parks after approving management plans in Idaho and Montana. However, lawsuits from environmental groups successfully argued that Wyoming's wolf management plan was inadequate and that genetic connectivity between recovery areas was not established. As a result, wolves were relisted as endangered.

In 2009, wolves were delisted again in Montana and Idaho, though not in Wyoming. Legal challenges led to the Northern Rocky Mountain wolf population being relisted under the ESA. In 2011, Congress delisted wolves in Montana and Idaho, and in 2012 directed the USFWS to reissue its 2009 delisting rule, contingent on Wyoming developing an approved regulatory framework. On September 30, 2012, wolves in Wyoming were delisted and managed under the state's plan, but litigation led to their relisting on September 23, 2014. Following an appeal, wolves in Wyoming were delisted again on April 25, 2017, and are now managed under regulated hunting seasons in Montana, Wyoming, and Idaho.

The USFWS continues to monitor wolf populations in Montana and Idaho for at least five years post-delisting, with the option to relist or emergency relist if necessary. Wolves are now managed by state, Tribal nations, and federal agencies, with management in national parks and wildlife refuges guided by existing legislation and regulations.

The Future of Wolf Management

The future of wolves in the GYE will largely depend on the management of livestock depredation, wolf hunting outside the park, and the social acceptance of coexisting with wolves. Wolf populations will also be influenced by the availability of prey species such as elk, deer, and bison, which fluctuate due to hunting quotas, winter severity, and disease. The extent to which wolves have contributed to the decline of the northern Yellowstone elk population since the mid-1990s—and the potentially related resurgence of willow and aspen in some areas—remains an active area of research.

Wolf Management

Wolf management in Yellowstone involves strategies for both the short and long term. Over time, we keep track of the wolf population to learn how they live, interact with each other, and affect other wildlife. To do this, we use tools like radio collars, remote cameras, sound recordings, and direct observations. This research helps us make decisions about managing the park's natural resources, create educational programs, and work with other agencies and groups interested in wildlife management.

Our Goals

- **We study wolves to understand how they behave as individuals, how they interact within and between packs, and how they influence the ecosystem as apex predators.** Bringing wolves back to Yellowstone after nearly 70 years is a major conservation success. Our monitoring and research gives us valuable insights into their population health, social behavior, interactions with prey, relationships with other predators, and impact on the food web.
- **We work to ensure wolves stay wild.** In the park, we manage roadside carcasses, temporarily close areas near wolf dens, and ensure wolves don't access human food. Outside the park, we share information with wildlife agencies and others to help manage issues like state-managed wolf hunting near the park and conflicts between wolves, humans, or livestock.
- **We provide educational opportunities for the public to understand and appreciate wild wolves in their natural habitat.** Yellowstone is one of the best places in the world to see wild wolves. We teach visitors how to watch wolves safely to avoid disturbing them and to protect both wolves and people. Our research, monitoring, and education efforts help create a world-class experience for visitors to watch and learn about wolves.

Long-Term Monitoring & Research

Long-term monitoring and research are vital for managing wildlife because ecosystems and species relationships are always changing. Since wolves were reintroduced to Yellowstone in 1995, we've collected long-term data to gain valuable insights about them. We gather much of this information by tracking

wolves with radio collars. We also use noninvasive tools like sound recordings and remote cameras to better understand wolf behavior and their role in the ecosystem.

Wolf Capture

We track most wolf packs by fitting some individuals with radio collars during winter capture efforts, usually done using helicopters with darting or net-gunning techniques. These collars can be GPS (global positioning system) collars, which send daily location data via satellite, or VHF (very high frequency) collars, which are tracked from the ground or air. We aim to collar about 30% of each pack to account for losses due to wolf deaths, collar failures, or wolves leaving to join or form new packs inside or outside the park. We focus on collaring key wolves, like breeders and pups, and replacing older or failed collars. During captures, we collect blood samples, record weight and body measurements, and determine the wolf's sex and age. This radio-collared population, combined with monitoring data, supports long-term research, guides management actions in the park, and helps with decisions within and beyond Yellowstone's boundaries.

Genetics & Disease

Yellowstone collects DNA samples from all wolves we handle or find deceased to create genetic profiles. These profiles help us study how wolves evolve, maintain population health, and relate to one another. They also show how genetic traits influence their appearance, behavior, survival, and reproduction. Using this data, we estimate relationships within and between packs, including parentage and sibling ties. This helps us track reproduction and identify wolves moving in or out of the park—important for understanding population health and long-term survival. We also use hair and fecal samples to estimate population size and analyze blood and tissue to detect diseases and their effects on wolf health and behavior.

Population Size & Social Behavior

We conduct two population counts each year. The first, from mid-November to mid-December, shows the maximum population after pups have stabilized. The second, in March, reflects the population at the end of the biological year, just before denning season in late April.

During capture operations, biologists collect blood samples, record weight and body measurements, and determine the wolf's sex and age.

These observations help us track survival, mortality, and movements of individual wolves. Radio-tracking also reveals details about pack dynamics, such as pack size, the roles of breeders, territory use, den locations, and long-term pack stability. We also study interactions between packs, like territorial behavior, scent marking, and howling, to better understand their social structure.

Our latest research uses autonomous recording units (ARUs) to capture wolf howls throughout the park. This helps us study the patterns and purposes of howling and develop bioacoustic methods to estimate wolf numbers. These techniques are particularly useful in remote areas where direct observation is difficult. By combining data from radio collars with noninvasive tools like ARUs and remote cameras, we aim to enhance wolf population monitoring in Yellowstone and beyond.

Wolf–Prey Relationships

We study wolf–prey relationships by examining wolf diets and how often they hunt and scavenge. While we collect diet data year-round, we focus on specific seasons: early winter (mid-November to mid-December), late winter (March), and spring-summer (May–July).To better understand these interactions, we monitor the northern elk herd by fitting adult female elk with radio collars. This provides information to help us estimate the elk population, such as: survival, causes of death, habitat use, migration, and how likely elk are to be seen during aerial surveys. We also plan to revisit studies on elk calves, last conducted in 2003–2005, which showed bears as the main predators of newborn calves. By analyzing GPS data from

wolves and elk, we study how wolf presence, numbers, and kill locations affect elk movements. This research shows how wolves indirectly impact the ecosystem, including their role in food web dynamics and trophic cascades. A trophic cascade happens when changes at the top of the food chain, like wolf behavior, cause a ripple effect through other species and habitats, shaping the entire ecosystem.

Winter Predation Study

Our Winter Study, conducted every year since wolves were reintroduced to Yellowstone in 1995, takes place during early and late winter. Over these two 30-day periods, we study what wolves eat by identifying the type of prey (such as elk, bison, or deer), as well as the prey's sex and age, and how often wolves feed. We also examine feeding sites to see if prey were killed or scavenged, looking for clues like blood or the prey's nutritional condition.We detect feeding events through ground and aerial observations or by investigating clusters of wolf GPS locations. While we can't find every feeding event, combining these methods helps us estimate the ones we miss for each pack. During this time, we also observe wolf hunting behaviors to learn how factors like prey species, group size, or the age of wolves affect their hunting success.

Summer Predation Study

In the spring–summer period, we conduct our Summer Predation Study. During this time, wolves often forage in multiple groups and feed on smaller, newborn ungulates. Using GPS cluster searches, we systematically locate carcasses to understand what wolves eat and how frequently, focusing on seasonal variation in wolf diet.

Interactions with Other Species

Yellowstone biologists work with outside researchers to study how wolves, bears, and cougars interact in the Northern Range, using GPS collars to track their movements. For example, we've studied how bears affect wolf hunting and how bears or wolves influence cougar hunting. These studies help us understand the combined effects of carnivores on prey populations, coexistence, and competition.We also study how wolves indirectly provide food for scavengers. For instance, ravens benefit from wolf kills, and we plan to expand this research to other scavengers, like golden eagles. Using data such as GPS tracking, activity patterns, and remote camera footage, we explore how large carnivores and the carrion they leave behind affect scavenger behavior and decision-making.

Managing the Human–Wolf Interface

Wolves are very popular with visitors, and because they can often be seen, we sometimes need to manage interactions between wolves and people. This includes temporarily closing sensitive areas, managing traffic to protect both wolves and visitors, and occasionally hazing wolves to keep them from becoming too comfortable around people. These actions are based on years of experience and data from radio collars. This information also helps guide discussions with stakeholders and nearby wildlife management agencies about the shared Yellowstone wolf population.

Roadside Viewing of Wolves

Yellowstone is known as the best place in the world to see wild wolves, an attraction that brings over $80 million annually to local communities. However, this also means visitors often come close to wolves, requiring careful management to ensure safety, protect wildlife, and provide a world-class visitor experience. Park rules require people to stay at least 100 yards away from wolves, bears, and cougars and prohibit disturbing or approaching wildlife, but park staff often manage viewing opportunities at even greater distances to maintain safety. No-stopping zones might be created if wolves make a kill near a road. In some cases, carcasses are moved farther from roads to reduce risks while still allowing wildlife access. These decisions are made situationally, prioritizing visitor and wildlife safety first, followed by protecting resources and ensuring visitor enjoyment.

Wolf Homesites

To protect active wolf homesites during sensitive periods, the park may temporarily close certain areas. Homesites include dens, where pups are born and spend early summer, and rendezvous sites, where packs care for pups until they're old enough to travel. These closures, lasting from a few weeks to a few months, are decided case by case to minimize disturbances during this critical time.

Most wolf packs choose remote backcountry

homesites that require little management. However, when homesites are visible or discovered by visitors, intervention may be needed. Human activity near homesites can cause wolves to abandon the area and move their pups, increasing the risk of pup deaths. Frequent disturbances can also make wolves too comfortable around people, leading to unwanted behaviors.

While some homesites can be safely observed from a distance and enjoyed by thousands of visitors, closures aimed at reducing disturbances can also enhance visitor experiences by promoting responsible wildlife viewing and protecting the natural behavior of wolves.

Wolf watchers at Slough Creek, one of the best places in the world to observe wild wolves.

Wolf Habituation

Wolves rarely pose a threat to people, but if they become too comfortable around humans, safety concerns can arise. Preventing wolves from losing their natural wariness of humans is a key goal of Yellowstone's wolf management. This is why the park may temporarily stop traffic to let wolves cross a road or close areas near carcasses or dens to reduce disturbances.

Feeding wolves—or any wildlife—is strictly prohibited because it can quickly lead to habituation. Even behaviors like wolves traveling on snow-free or groomed roads can contribute to this problem. Managing these situations can be challenging, especially when wolves are drawn to roads for easier travel. Visitors play an important role by giving wolves plenty of space and allowing them to leave roads naturally.

If wolves start showing signs of being too comfortable around people, park staff may use techniques like hazing to discourage this behavior and reinforce their natural caution. These efforts help prevent habituation and ensure safer interactions between wolves and visitors.

Hazing Operations

Hazing is a step-by-step process that starts with mild actions and increases in intensity if the wolf doesn't respond. Low-level hazing methods include yelling, honking a car horn, or using a siren from a ranger's vehicle. Mid-level hazing uses biodegradable paintball rounds, which are safe for wolves and easy for park staff to handle and train with.

More intense hazing methods involve nonlethal tools like beanbag rounds or rubber bullets, which have more impact than paintballs. Another option is cracker shells, which are fired from a shotgun and create a loud explosion overhead to scare the wolf away.

Hazing is considered successful if the wolf stops showing habituated behavior within a year. If these methods fail and the wolf is seen as a potential danger to people, it may be removed from the population. Since wolves were reintroduced to Yellowstone in 1995, only two wolves have been removed due to habituation. In both cases, the wolves had likely been fed by humans, leading to irreversible food conditioning and behavior changes.

Working Across Boundaries

Most wolves in Yellowstone stay within the park, contributing to Wyoming's annual wolf population counts as required by US Fish and Wildlife Service guidelines for Endangered Species Act delisting. However, some packs have territories that extend beyond the park's boundaries, occasionally moving into neighboring states of Idaho, Montana, and Wyoming. These movements often happen during the fall elk migration, which overlaps with state-managed hunting seasons.

When wolves leave the park, they are subject to state wildlife regulations, including legal hunting during designated seasons. Yellowstone works with neighboring states by sharing data on wolf pack sizes, movements, and time spent outside the park to support state management decisions. The park also collaborates with state agencies to determine if wolves killed—legally or illegally—were part of packs that primarily live in Yellowstone.

Since wolves were delisted, some Yellowstone wolves are legally hunted each year under state-specific quotas, which vary by location and season. Ongoing research examines how hunting affects the park's wolf population, including its impacts on pack stability, pup survival, social behavior, and genetic health. This research helps us understand the broader effects of human-caused mortality on Yellowstone's wolves.

Education & Outreach

We are committed to educating both the public and the scientific community about wolves. In the field, our staff track wolves, collect data, and share their knowledge with visitors. When wolves are visible, we often set up spotting scopes and talk with visitors about Yellowstone's wolf population, their history of removal and recovery, and their role in the park's ecosystem. These interactions educate visitors while supporting the National Park Service's mission to provide a world-class experience focused on protecting and preserving resources.

Each year, we reach tens of thousands of visitors through these roadside discussions. Beyond the field, we deliver hundreds of presentations to schools and universities, create video content, participate in media interviews, lead ranger programs, and share insights through podcasts. Our annual report keeps the public informed about wolf populations, prey interactions, and other ecological factors. Our nonprofit partner, Yellowstone Forever, also provides valuable educational content about wolves.

For the scientific community, we present our findings at conferences and work with university and agency scientists to publish peer-reviewed research. These publications contribute to better wolf management practices in Yellowstone and other areas where wolves are present.

Lean more about wolf management at **www.nps.gov/yell/learn/management/wolf.htm**

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Staff Reviewers

Daniel Stahler, Senior Wildlife Biologist
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Coyotes

Coyotes (*Canis latrans*) are intelligent and adaptable. They can be found throughout North and Central America, thriving in major urban areas as well as in remote wilderness. This adaptability helped coyotes resist widespread efforts early in the 1900s to exterminate them in the West, including in Yellowstone National Park, where other mid-size and large carnivores such as cougars and wolves were eradicated. The coyote is a common predator in Greater Yellowstone, often seen traveling through open meadows and valleys.

Description

Often mistaken for a wolf, the coyote is about one-third the wolf's size with a slighter build. Its coat colors range from tan to buff, sometimes gray, and with some orange on its tail and ears. Males are slightly larger than females.

During the 1900s, coyotes partially filled the niche left vacant after wolves were exterminated from the park. In Yellowstone, they lived in packs or family groups of up to seven animals. This social organization is characteristic of coyotes living in areas free from human hunting. With the reintroduction of wolves, Yellowstone coyotes have returned to a more typical social organization—pairs with pups.

Coyotes, also known as "song dogs," communicate with each other by a variety of long-range vocalizations. You may hear groups or lone animals howling, especially during dawn and dusk periods. Coyotes also mark with their scent (urine and feces) to communicate their location, breeding status, and territorial boundaries.

Coyotes are abundant throughout the park, and pup survival has increased. Coyotes may be killed by disease and vehicle-collisions as well as by other carnivores like wolves and cougars.

Quick Facts

Number in Yellowstone
Abundant

Where to See
Meadows, fields, other grasslands, and foraging for small mammals along roadways.

Size and Behavior

- Weigh 25–35 pounds, stand 16–20 inches high at the shoulder.
- Average life span six years; up to 13 years in the park.
- Home range: three to fifteen square miles.
- Primarily eat voles, mice, rabbits, other small animals, and carrion—and very young elk calves in the spring.
- Four to eight pups are born in April in dens; emerge in May.

History

- Like other predators, coyotes were often destroyed in the early part of the 1900s because they sometimes preyed on livestock.
- Coyotes continued to thrive because their adaptability enabled them to compensate for the destruction efforts.
- Elimination of wolves probably resulted in high coyote population densities; wolves' absence opened a niche that coyotes could partially occupy in Yellowstone.

Population

Until 1995, coyotes faced few predators in Yellowstone other than cougars, who will kill coyotes feeding on cougar kills. After wolves were restored, however, dozens of coyote pups and adults were killed by wolves—primarily when feeding on other animals killed by wolves. After wolves were restored on the northern range, the coyote population decreased by as much as 50% as a result of competition for food, attacks by wolves, and loss of territory to wolves. More recent trends in the Lamar Valley, however, indicate that the coyote population has increased.

Comparisons of coyote population and behavioral data from before and after wolf restoration provide evidence of how the presence of wolves is changing ecological relationships on the northern range. A reduced coyote population could mean that smaller predators, such as the native red fox, whose numbers were previously kept low by coyotes, will have less competition for small prey and their populations may increase. While this relationship is yet to be evaluated critically, recent data from remote camera studies in

the park show that coyotes and red foxes have opposite peaks and lulls in their daily activity patterns in winter months. This suggests some level of temporal avoidance is occurring, despite their ubiquitous occupancy of similar habitats. Furthermore, data suggests movement patterns and habitat use overlaps with top predators like wolves and cougars in a way that balances the risks and rewards of scavenging from predator kills given that these smaller canids are sometimes killed by the larger carnivores.

Coyotes and Humans

Coyotes also face threats from humans. They quickly learn habits like roadside feeding. This may lead to aggressive behavior toward humans and can increase the risk of the coyote being hit by a vehicle. Several instances of coyote aggression toward humans, including a few attacks, have occurred in Yellowstone.

Park staff scare coyotes away from visitor-use areas and prevent them from becoming habituated to humans by hazing with cracker-shell rounds, bear pepper spray, or other negative stimuli. Animals that continue to pose a threat to human safety or property are killed.

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Coyotes (middle) are larger than red foxes (front) and smaller than wolves (back).

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Staff Reviewer

Daniel Stahler, Senior Wildlife Biologist

Red Foxes

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

Three native subspecies exist at high elevations in the United States: the Sierra (*V. v. necatar*), Cascade (*V. v. cascadensis*), and Rocky (*V. v. macroura*) mountains and are collectively called mountain foxes. Little is known about any of these subspecies. Most foxes in the lower 48 states, particularly in the eastern and plains states, are a subspecies of fox from Europe introduced in the 1700s and 1800s for fox hunts and fur farms. The foxes that survived the hunt or escaped the fur farms proliferated and headed westward.

Population

Red foxes are more abundant than were previously thought in Yellowstone. The many miles of forest edge and extensive semi-open and canyon areas of the park seem to offer suitable habitat and food for foxes. They are widespread throughout the northern part of the park with somewhat patchy distribution elsewhere in the park. During the past century, especially within the past few decades, the number of fox sightings has significantly increased. This could be related to better documentation beginning in 1986. Wolves and coyotes are more closely related both genetically and physically than wolves and foxes.

During winter, red foxes may increase their activity around dawn and dusk, and even sometimes in broad daylight.

Wolves successfully competed with coyotes, causing a decline in the coyote population when they were reintroduced. This may have caused an increase in the number of fox sightings in core wolf areas such as the Lamar Valley.

A research project conducted between 1994–1998 determined at least two subpopulations of foxes live in the Greater Yellowstone Ecosystem. At about 7,000 feet in elevation, there seemed to be a dividing line with no geographical barriers separating these foxes. The genetic difference between these subpopulations was similar to the differences between mainland and island populations of foxes in Australia. Habitat use across the two groups was different as well. In addition, their actual dimensions, such as ear length and hind-foot length, were adapted to some degree for colder environments with deep snow and long winters. A yellowish or cream color most often occurs above 7,000 feet in areas such as Cooke City and the Beartooth Plateau, and this variation is being studied by researchers.

Quick Facts

Number in Yellowstone
Unknown, but not nearly as numerous as coyotes.

Where to See
- Hayden and Pelican valleys, Canyon Village area.
- Typical habitat: edges of sagebrush/grassland and within forests.

Size and Behavior
- Adult males weigh 11–12 pounds; females weigh average 10 pounds.
- Average 43 inches long.
- Average life span: three to seven years; up to 11 years in Yellowstone.
- In northern range, home range averages 3.75 square miles, with males having slightly larger range than females.
- Several color phases; usually red fur with white-tipped tail, dark legs; slender, long snout.
- Barks; rarely howls or sings.
- Distinguished from coyote by size, color, and bushier tail.
- Solitary, in mated pairs, or with female from previous litter.
- Prey: voles, mice, rabbits, birds, amphibians, other small animals.
- Other food: carrion and some plants.
- Killed by coyotes, wolves, mountain lions.

Red foxes (front) are smaller than coyotes (middle) and wolves (back).

Behavior

Foxes are not often seen because they are nocturnal, usually forage alone, and travel along edges of meadows and forests. During winter however, foxes may increase their activity around dawn and dusk, and even sometimes in broad daylight. In late April and May, when females are nursing kits at their dens, they are sometimes more visible during daylight hours, foraging busily to get enough food for their growing offspring.

Recent research shows that red foxes are more nocturnal than coyotes, and strongly prefer forested habitats, while coyotes tend to use sagebrush and open-meadow areas. In this way, potential competition between foxes and coyotes is minimized. Foxes do not seem to actively avoid coyotes during an average day, they just stick with forested habitat, sleep when coyotes are most active, and then forage opportunistically. Foxes will visit carcasses (e.g., wolf and cougar kills) for the occasional big meal, especially during winter, but this is much rarer than the scavenging coyotes that park visitors can expect to see regularly.

Data from remote camera studies in the park also show that coyotes and red foxes have opposite peaks and lulls in their daily activity patterns in winter months. This suggests some level of temporal avoidance is occurring, despite their ubiquitous occupancy of similar habitats. Furthermore, data suggests movement patterns and habitat use overlaps with top predators like wolves and cougars in a way that balances the risks and rewards of scavenging from predator kills given that these smaller canids are sometimes killed by the larger carnivores.

Foxes can become habituated to humans, usually due to being fed. In 1997, one fox was trapped and relocated three times from the Tower Fall parking area because visitors fed it human food. The fox was relocated between 10 and 60 miles away from Tower, but it returned twice. Finally, the fox came to Mammoth where it was fed again and as a result was killed by managers. While this story gives us interesting information about the homing instinct of the fox, it also shows the importance of obeying rules to avoid inadvertently causing the death of one of Yellowstone's animals.

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Staff Reviewer

Daniel Stahler, Senior Wildlife Biologist

Cougars

The cougar (*Puma concolor*), also known as mountain lion, is the one of the largest cats in North America and a top predator native to Greater Yellowstone. (The jaguar, which occurs in New Mexico and Arizona, is larger.) As part of predator-removal campaigns in the early 1900s, cougars and wolves were killed throughout the lower 48 states, including in national parks. Wolves (*Canis lupus*) were eradicated, and, although cougars were largely eliminated from Yellowstone, the species survived in the West because of its cryptic nature and preference for rocky, rugged territory where the cats are difficult to track. Eventually, the survivors re-established themselves in Yellowstone in the early 1980s, possibly making their way from wilderness areas in central Idaho.

This male cougar was photographed by a remote camera during the 2014 research study.

Population

Prior to wolf reintroduction (1987–1993), Yellowstone National Park's northern range was occupied year-round by an estimated 15 to 22 cougars, including adults, subadults, and kittens. There were 26–42 cougars estimated after wolf establishment (1998–2005). In 2014, a new study began which seeks to estimate population abundance in the same region using noninvasive genetic-survey methods. Biologists estimated between 29–45 individuals resided across the northern portion of Yellowstone (all age and sex classes combined) between 2014 and 2017 (Anton 2020). Currently, population estimation is underway using a remote camera survey grid methodology with preliminary results indicating a stable population since 2017. Since 2016, Global Positioning Collars (GPS) are used to study movements, predation, and population monitoring on 4–7 individuals a year..

While disease and starvation are occasional causes of cougar deaths, competition with other cougars or predators, and human hunting (during legal seasons outside protected areas), are the main causes of cougar mortality. Habitat fragmentation and loss are the main long-term threats to cougar populations across the western United States.

Behavior

Cougars live throughout the park in summer, but few people ever see them. The northern range of Yellowstone is prime habitat for cougars because snowfall is light and prey always available. Cougars follow their main prey as they move to higher elevations in summer and lower elevations in the winter.

Adult male cougars are territorial and may kill other adult males in their home range. Male

Quick Facts

Number in Yellowstone
Estimated 29–45 (across all age classes) on the northern range; others in park seasonally.

Where to See
Seldom seen

Size and Behavior

- Litters range from three to four kittens; 50% survive first year.
- Adult males weigh 145–170 pounds; females weigh 85–120 pounds; length, including tail, 6.5–7.5 feet.
- Average life span: males, eight–10 years; females, 12–14 years. Cougars living in areas where they are hunted have much shorter average life spans.
- Preferred terrain: rocky breaks and forested areas that provide cover for hunting prey and for escape from competitors such as wolves and bears.
- Prey primarily on elk and mule deer, plus smaller mammals, especially marmots.
- Bears and wolves frequently displace cougars from their kills.
- Male cougars may kill other male cougars within their territory.
- Adult cougars and kittens have been killed by wolves.

Interaction with Humans
Very few documented confrontations between cougars and humans have occurred in Yellowstone.

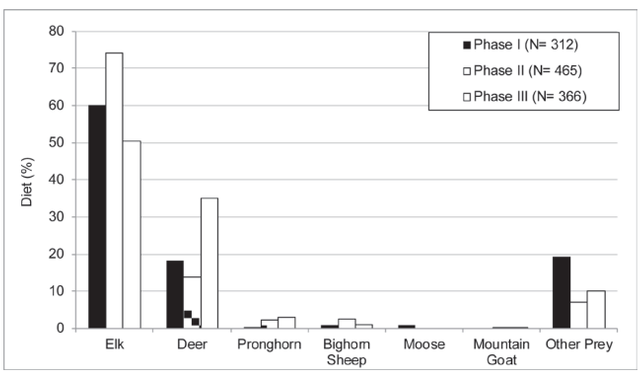
If a big cat is close by, stay in a group; carry small children; make noise. Do not run, do not bend down to pick up sticks. Act dominant—stare into the cat's eyes and show your teeth while making noise.

territories may overlap with several females. In non-hunted populations, such as in Yellowstone, the resident adult males living in an area the longest are the dominant males. These males sire most of the litters within a population; males not established in the same area have little opportunity for breeding.

Although cougars may breed and have kittens at any time of year, most populations have a peak breeding and birthing season. In Yellowstone, males and females breed primarily from February through May. Males and females without kittens search for one another by moving throughout their home ranges and communicating through visual and scent markers called scrapes. A female's scrape conveys her reproductive status. A male's scrape advertises his presence to females and warns other males that an area is occupied. After breeding, the males leave the female.

In Yellowstone, most kittens are born between June and September. Female cougars den in a secure area with ample rock and/or vegetative cover. Kittens are about one pound at birth and gain about one pound per week for the first 8–10 weeks. During this time, they remain at the den while the mother makes short hunting trips and then returns to nurse her kittens. When the kittens are about 10 weeks old, the female begins to hunt over a larger area. After making a kill, she moves the kittens to the kill. Before hunting again, she stashes the kittens. Kittens are rarely involved in killing until after their first year.

Most kittens leave their area of birth at 14 to 18 months of age. Approximately 99% of young males disperse 50 to 400 miles; about 70–80% of young



Species composition of cougar-killed prey, including primary ungulate prey species and other prey (e.g., marmots, grouse, foxes, coyotes, porcupines), across three research phases (phase I: 1987–1993; phase II: 1998–2004; and phase III: 2014–present; sample sizes of kills detected are indicated in parentheses).

This male cougar kitten was briefly examined and genetically sampled in summer of 2016.

females disperse 20 to 150 miles. The remaining proportion of males and females establishes living areas near where they were born. Therefore, most resident adult males in Yellowstone are immigrants from other areas, thus maintaining genetic variability across a wide geographic area. In Yellowstone, cougars prey upon elk (mostly calves) and deer. They stalk the animal then attack, aiming for the animal's back and killing it with a bite to the base of the skull or the throat area.

A cougar eats until full, then caches the carcass for later meals. Cougars spend an average of three to four days consuming an elk or deer and four to five days hunting for the next meal. Cougars catch other animals—including red squirrels, porcupines, marmots, grouse, and moose—if the opportunity arises.

Cougars are solitary hunters who face competition for their kills from other large mammals. Even though a cached carcass is harder to detect, scavengers and competitors such as bears and wolves sometimes find it. In Yellowstone, black and grizzly bears will take over a cougar's kill. Coyotes will try, but can be killed by the cougar while doing so. Wolves displace cougars from approximately 6% of their elk carcasses.

Although cougars and wolves once co-existed across much of their historical range, ecological research on each species has often had to be conducted in the absence of the other. By assessing pre- and post-wolf reintroduction data, biologists can learn about the ecological relationships between the

two species. As social animals, wolves use different hunting techniques from the solitary cougar, but the two species prey on similar animals. While prey is abundant this competition is of little concern, but, a decrease in prey abundance could lead to an increase in competition between these carnivores.

History

In the early 1900s, cougars were killed as part of predator control in the park and largely eradicated, along with wolves, in the 1930s. While there may have been some individuals that persisted in the Greater Yellowstone Ecosystem, there is no evidence of an ecologically viable population present after the 1930s. However, cougars naturally recolonized by the early 1980s.

From 1987 to 1996, the first cougar-ecology study was conducted in Yellowstone National Park. The research documented population dynamics of cougars in the northern Yellowstone ecosystem inside and outside the park boundary, determined home ranges and habitat requirements, and assessed the role of cougars-as-predator. Of the 88 cougars captured, 80 were radio-collared.

From 1998 to 2006, the second phase of that research was conducted. Researchers monitored 83 radio-collared cougars, including 50 kittens in 24 litters. Between 1998 and 2005, researchers documented 473 known or probable cougar kills. Elk comprised 74%: 52% calves, 36% cows, 9% bulls, 3% unknown sex or age. Cougars killed about one elk or deer every 9.4 days and spent almost four days at each kill. The study also documented that wolves interfered with or scavenged more than 22% of the cougar-killed ungulates.

In 2014, the park began new research to evaluate population abundance, predation patterns, and competition with other carnivores. Currently, the park is home to a healthy, stable year-round population of cougars on the northern range where prey is available all year. Cougars also occupy many areas in the park's interior during the summer but vacate during winter due to lack of prey..

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

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Staff Reviewer

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Canada Lynx

Historical information suggests lynx (*Lynx canadensis*) were present, but uncommon, in Yellowstone National Park during 1880 to 1980. The presence and distribution of lynx in the park was documented from 2001 to 2004, when several individuals were detected in the vicinity of Yellowstone Lake and the on the Central Plateau. A lynx was photographed in 2007 along the Gibbon River, and another lynx was observed near Indian Creek Campground in the northwestern portion of Yellowstone during 2010. Tracks of an individual were verified near the Northeast Entrance in 2014. Reliable detections of lynx continue to occur in surrounding National Forest System lands. Evidence suggests lynx successfully reproduce in the greater Yellowstone ecosystem (GYE), though production is limited.

In 2000, the US Fish and Wildlife Service listed the lynx as threatened in the lower 48 states. Portions of the park and surrounding area are considered much of the critical habitat for the species in the GYE.

Habitat

Lynx habitat in the Greater Yellowstone Ecosystem is often naturally patchy due to natural fire frequency and is generally limited to conifer forests above 7,700 feet where the distribution of its primary prey, the

Quick Facts

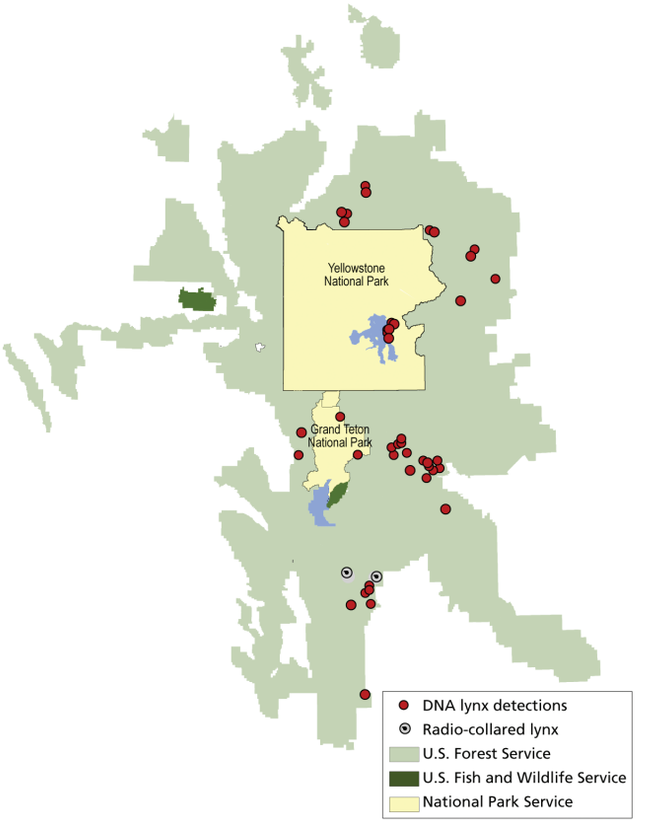
Number in Yellowstone
Few; 112 known observations

Where to See
- Very rarely seen.
- Typical habitat: cold conifer forests.

Size and Behavior
- Adult: 16–35 pounds, 26–33 inches long.
- Gray-brown fur with white, buff, or brown on throat and ruff; tufted ears; short tail; hind legs longer than front legs.
- Distinguish from bobcat: black rings on tail are complete; tail tip solid black; longer ear tufts; larger track.
- Wide paws with fur in and around pads; allows lynx to run across snow.
- Track: four to five inches.
- Solitary; diurnal and nocturnal.
- Eats primarily snowshoe hares, particularly in winter; also rodents, rabbits, birds, red squirrels, and other small mammals, particularly in summer.

COURTESY FRED PAULSEN

In December 2007, Fred Paulsen, a Xanterra Parks and Resorts employee in Yellowstone, photographed this lynx along the Gibbon River. In 2010, visitors also saw a lynx, which was wearing a radio collar—indicating it may have come from Colorado where the population is collared.



DNA-based detections of lynx documented in the Greater Yellowstone Ecosystem, 1996 to 2008. Numerous locations of radio-collared lynx from Colorado that were obtained using satellite-based telemetry are unavailable. Data provided by Endeavor Wildlife Research, Wild Things Unlimited, the US Forest Service, and the National Park Service.

snowshoe hare, is often insufficient to support lynx residency and reproduction. The lower-quality habitat means home ranges in this ecosystem are larger than those farther north, with lynx traveling long distances between foraging sites.

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Staff Reviewer

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Bobcats

Lynx rufus

Number in Yellowstone

Unknown, but generally widespread.

Where to See

- Rarely seen; most reports from rocky areas and near rivers.
- Typical habitat: rocky areas, conifer forests.

Size and Behavior

- Adult: 15–30 pounds; 31–34 inches long.
- Color ranges from red-brown fur with indistinct markings to light buff with dark spotting; short tail; ear tufts.
- Distinguished from lynx: has several black rings that do not fully circle the tail; no black tip on tail; shorter ear tufts; smaller track (two inches).
- Solitary; active between sunset and sunrise.
- Eats rabbits, hares, voles, mice, red squirrels, wrens, sparrows, grouse; may take deer and adult pronghorn.

Bats

Bats are the only mammals capable of sustained, flapping flight, which has given rise to a great diversity of species throughout the world. All bat species documented in Yellowstone National Park are insectivores (insect-eaters). To support the energy demands for flight, insectivorous bats must eat many insects. Nursing females can consume their own body weight in food each night during the summer. In temperate environments, bats mate in late summer or autumn, just before entering hibernation for the winter. During spring and summer, bats tend to be highly localized near sources of food, water, and roosting structures. They roost in natural habitats, including thermally heated caves, as well as in bridges, buildings, and other human structures. Bats are considered indicator species because their distribution and population trends provide valuable information about habitat quality and the overall health of an ecosystem.

Population

Bat-monitoring efforts using acoustic surveys at 36 point stations and mist-net captures have identified the following thirteen bat species in Yellowstone National Park:

- Little brown bat (*Myotis lucifugus*)
- Big brown bat (*Eptesicus fuscus*)
- Long-eared myotis (*Myotis evotis*)
- Long-legged myotis (*Myotis volans*)
- Townsend's big-eared bat (*Corynorhinus townsendii*)
- Fringe-tailed bat (*Myotis thysanodes*)
- Hoary bat (*Lasiurus cinereus*)
- Silver-haired bat (*Lasionycteris noctivagans*)
- Spotted bat (*Euderma maculatum*)
- Pallid bat (*Antrozous pallidus*)
- California Myotis (*Myotis californicus*)
- Western-Small-footed Myotis (*Myotis ciliolabrum*)
- Yuma myotis (*Myotis yumanensis*)

The goal of bat monitoring in Yellowstone is to establish baseline data on the distribution, activity, and habitat use by bat species and identify impacts to bat populations from the disease white-nose syndrome (WNS). The fungal pathogen *Pseudogymnoascus destructans* (Pd), which causes WNS, has been responsible for declines as high as 99% in wintering bat populations, leading to the extirpation of several species in eastern North America. Bats cannot recover quickly, if at all, from these substantial population declines because most species that are vulnerable to WNS rear only a single pup per female each year. As of 2024, WNS has been confirmed in 9 Canadian provinces and 40 states, including Montana and Wyoming. However, monitoring efforts in Yellowstone have not yet detected Pd in the park. The Yellowstone wildlife health program tested 99 samples for Pd from bat skin swabs and guano samples in 2024 with consistent Pd negative results.

Physical adaptations to their environments have given bats their looks. The large ears of this Townsend's big-eared bat (*Corynorhinus townsendii*), held by a researcher, help it locate its prey.

It is important to identify the location of maternity roosts and hibernacula, locations that are used for

Quick Facts

Species in Yellowstone
13

Where to See
Dawn and dusk in areas with insects.

Behavior

- Develop and reproduce slowly, which is unusual given their small body size.
- Typically mate in the fall. In bats that hibernate, fertilization is delayed until the female emerges from hibernation. For most greater Yellowstone bats, hibernation ends around mid-April and the females give birth in mid-June.
- Most give birth to one pup a year, although four species in the greater Yellowstone area have two or more pups at a time. These species typically begin flying in two to six weeks, are weaned around five to ten weeks, and become mature in one to two years.
- Few predators specialize on bats. Predators are generally opportunistic and include owls, falcons, hawks, snakes, and raccoons.
- Of bats that survive their first year, 40–80% survive seven to eight years; many bats live 10–30 years.

reproduction and over-winter survival, respectively. Female bats captured with mist-nets and fitted with radio transmitters have helped to identify buildings that serve as maternity roosts (where females raise young) for little brown bats. Research suggests that access to building attics within Yellowstone National Park is critical for their reproductive success and long-term conservation.

Habitat

Roosts provide bats with protection from weather and predators and bats in Greater Yellowstone use both natural habitats and man-made structures including bridges and abandoned mines. Research suggests that that the thermal conditions in maternity roosts are important for the reproductive success of little brown bats. Roosts allow young bats to maximize their growth rate, wean, and begin to fly and forage earlier because they use less energy to stay warm. Bats are long-lived (10–30 years) and show fidelity to maternal roost sites where they have successfully raised young. For this reason, bats will continually return to attics of park buildings, which can lead to conflicts with human use and historical preservation plans.

The presence of other bats in Yellowstone is probably restricted by the limited location of suitable roosts and/or the distribution of insect prey. Most western bat species migrate short distances from their summer roosts to their winter hibernating locations. However, bat activity has been documented within Yellowstone during every month of the year, which suggests multiple bat species remain within Yellowstone over winter. Some species migrate long distances to areas where temperature and insect populations support continued activity. These species may not hibernate. In Greater Yellowstone, the hoary bat likely migrates south for the winter.

Physical Adaptations

Bats with long, narrow wings (e.g., the hoary bat) are fast but less maneuverable fliers that typically forage in open areas. Bats with short, broad wings (e.g., Townsend's big-eared bat) are slower but more agile fliers and typically forage in or near forested areas. A few Yellowstone bats, such as long-eared myotis, pallid bat, and Townsend's big-eared bat, can glean insects off the surface of vegetation, and have wing shapes that enable them to hover and carry larger prey.

Bats use echolocation to navigate and forage in the dark. Many species produce pulses of high-frequency, ultrasonic sound and listen for the returning echoes. The echoes provide bats with a sonic picture of the environment, which includes the movement of prey. High-frequency calls are less likely to alert predators and are effective for locating prey, although some moths have developed the capability of detecting such calls. Bats also use lower-frequency calls (often audible to humans) to communicate with each other.

Bats make efficient use of the energy obtained through foraging by regulating their body temperature (thermoregulation). To conserve energy, bats can enter a state of torpor, which allows them to lower their metabolic rate and body temperature. Most bat species in Greater Yellowstone use torpor during winter months and periods in spring and summer with cold nightly temperatures and reduced food availability

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Staff Reviewers

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Beavers

The beaver (*Castor canadensis*) is a keystone species that affects habitat structure and dynamics through the damming and diverting of streams and the felling of trees and other woody vegetation. The resulting ponds and flooding help create an environment favorable to willow and aspen, the beavers' preferred winter foods and lodge-building material. The territoriality of beavers probably deters two colonies from locating within 165 feet (50 m) of each other, and most streams in the park lack either suitable vegetation or a sufficiently low gradient to provide beavers with habitat, but information about the distribution and number of beaver colonies in the park over time adds to our understanding of the long-term effects of changes in vegetation and climate.

The beaver is a keystone species that affects habitat structure and dynamics through the damming and diverting of streams, and the felling of trees and other woody vegetation.

Habitat

Beavers live throughout Yellowstone National Park but are concentrated in the southeast (Yellowstone River delta area), southwest (Bechler area), and northwest portions (Madison and Gallatin rivers) of the park. These areas are likely important habitat because of their waterways, meadows, and the presence of preferred foods such as willow, aspen, and cottonwood.

However, beavers are not restricted to areas that have their preferred foods. Essentially no aspen exist in most areas where beavers' sign is most abundant, such as the Bechler River, or in other areas where beavers periodically live, such as Heart Lake, the lower Lamar River and Slough Creek area, Slide Lake, and the lower Gardner River. In these areas, beavers use willows for construction and for food. Where their preferred plants are few or absent, beavers may cut conifer trees and feed on submerged vegetation such as pond lilies.

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

When hunched over their food, beavers can resemble round rocks. Beavers are most active in the

Quick Facts

Number in Yellowstone
121 colonies estimated in 2024

Where to See

- Willow Park (between Mammoth and Norris) and the Gallatin River along US 191.
- In the backcountry: upper Yellowstone River (Thorofare region), Bechler River, Slough Creek, Cougar and Gneiss Creeks. Occasionally seen in the Lamar, Gardner, and Madison rivers
- Wait in areas near known beaver activity. You may see them swimming or clambering onto the bank to gnaw at trees and willows. Listen for the sound of the beaver slapping its tail on the water before it submerges to seek safety.

Size and Behavior

- Crepuscular: active in evening and morning.
- If living on rivers, may build bank dens instead of lodges.
- One colony may support two to 14 beavers that are usually related. Six is considered average.
- 35–40 inches long, including tail.
- Weighs 30–60 pounds.
- Average life span: five years.
- Male and female beavers look alike—thick brown fur, paddle-shaped tail.
- Like wolves, beavers live in family groups, which are called colonies. Fewer than 5% of mammals live organized like this.

Other Information

- Beavers are native to Yellowstone.
- Yellowstone's beavers escaped most of the trapping that occurred in the 1800s due to the region's inaccessibility.

early morning and late evening, which seems to allow them to use areas near human use. Beavers do not appear to avoid areas of moderate to high levels of human use. Several occupied lodges in Yellowstone are close to popular backcountry trails and campsites.

Population

The first survey of beavers in the park, conducted in 1921, reported 25 colonies, most of them cutting aspen trees. Although the survey was limited to parts of the northern range, comparing the locations of those beaver colonies with subsequent survey results demonstrates how beavers respond and contribute to changes in their habitat. A 1953 survey found eight colonies on the northern range, but none at the sites reported in 1921, and a lack of regrowth in cut aspen. Willow were also in decline during this period.

To help restore the population of beavers on Gallatin National Forest, 129 beavers were released into drainages north of the park from 1986 to 1999. Parkwide aerial surveys began in 1996, with a count of 49 colonies, followed by an increase to 127 by 2007. While the long-term increase is partly attributable to the improved capability of aerial observers to locate colonies, the park's population of beavers probably has grown in the past 20 years. Since 2011, surveys have documented anywhere from 51 colonies (2017) to 121 (2024) parkwide. This variation is likely due to natural fluctuations in beaver population dynamics and influenced by colony sightability challenges typical of aerial surveys. The historic flood of 2022 also altered beaver habitat and disrupted colonies along some northern range watersheds. Some of the increase likely came from beavers dispersing from the national forest, but they would not have survived without suitable habitat. The increase has occurred throughout the park and is likely related to the resurgence in willow since the late 1990s, at least on the northern range, and possibly in the park interior. Nearly all of the colonies documented in recent years were located in or near willow stands, none near aspen.

Willow, which is more common in the park than aspen, is a hardier shrub that quickly regenerates after being clipped by beavers. The reason for the prolonged decline and relatively sudden release of willow on the northern range, and whether aspen have begun a sustained surge in recruitment, are topics of intense debate. Possible factors include the relationship of these plant species to changes in the abundance of beavers and elk, fire suppression, the recovery of large carnivores, and climate change.

The preferred foods of beaver are willow, aspen, and cottonwood. Where their preferred plants are few or absent, beavers may cut conifer trees and feed on submerged vegetation such as pond lilies.

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Staff Reviewers

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Pikas

The pika (*Ochotona princeps*) is considered an indicator species for detecting ecological effects of climate change. While abundant in the Greater Yellowstone Ecosystem, pika numbers are declining in some areas of lower elevations in response to increased warming, which reduces their suitable habitat. The US Fish and Wildlife Service review of the pika found no current need to list the species as threatened or endangered; however, pikas will likely disappear from some lower-elevation or warmer sites.

Behavior

Pikas are territorial. They inhabit rocky alpine and sub-alpine zones, feeding on the vegetation that fringes their preferred talus slopes. Because pikas do not hibernate, this relative of the rabbit must gather enough plant materials during the short growing season to survive the winter. Piles of drying vegetation, called haystacks, and a distinctive high-pitched call are the most recognizable indicators of active pika habitat. Prolific breeders, pikas usually have two litters of young each summer. The mortality rate is high for the youngsters, and the first litter has a greater rate of survival. These small mammals are sensitive to temperatures above 77.9°F (25.5°C); therefore, they are most active during cooler parts of the day.

Outlook

The National Park Service's five-year project, Pikas in Peril, assessed the vulnerability of the pika to climate change by studying populations in eight western national parks. The study located many small, isolated territories in Yellowstone. Initial analysis at the end of 2015 predicted that pika habitat would decline 80% by 2026 and that pika would eventually be extirpated from the park. Further analysis found that habitat sites did not decline; but population modeling showed that resident turnover can be high (50% between some years). Turnover is exacerbated by winter cold stress, summer heat stress, and variation in site-habitat quality. High genetic diversity among the Yellowstone pika population may increase their resistance to these stressors. www.nps.gov/orgs/1778/pikas-in-peril.htm.

A pika, blending in with its surroundings, carries greenery to its haystack. Yellowstone provides classic talus habitat for pikas.

Reviewer
Tom Rodhouse, Natural Resources Stewardship and Science Directorate

Quick Facts

Number in Yellowstone
Abundant

Where to See
Tower and Mammoth areas.

Identification and Behavior

- 7–8.4 inches long, 5.3–6.2 ounces (about the size of a guinea pig).
- Active year-round; agilely darts around on rocks; travels through tunnels under snow.
- Breeds in spring; two litters per year.
- Often heard but not seen; makes a distinct shrill whistle-call or a short "mew."
- Grey to brown with round ears; no tail; blends in with rocks.
- Scent-marks by frequently rubbing cheeks on rocks.
- In late summer, it gathers mouthfuls of vegetation to build "haystacks" for winter food; defends haystacks vigorously.
- Haystacks often built in same place year after year; have been known to become three feet in diameter.
- Like rabbits and hares, pika eat their own feces, which allows additional digestion of food.

Habitat

- Found on talus slopes and rock falls at nearly all elevations in the park.
- Eats grasses, sedges, aspen, lichen, and conifer twigs.
- Predators include coyotes, martens, and hawks.

Management Concerns
Pikas are vulnerable to loss of habitat related to climate change.

White-tailed Jackrabbits

Considered an agricultural or garden pest in many parts of the country, the white-tailed jackrabbit (*Lepus townsendii*) found a niche in Yellowstone. Most of the park is too forested or accumulates too much snow to provide suitable habitat, but in lower-elevation areas of the northern range this animal can feed on sagebrush, rabbitbrush, and other shrubs during the winter. The jackrabbit is preyed upon by bobcats, coyotes, wolves, eagles, hawks, and owls in the park, but perhaps because of its limited distribution, it does not appear to provide a significant source of food for these species.

The coat of white-tailed jackrabbits turns white during winter in Yellowstone and other areas with snow.

Description

Despite its common name, the jackrabbit is more closely related to other hares than to rabbits (*Sylvilagus spp.*). Like the much smaller snowshoe hare (*L. americanus*), which resides in Yellowstone's coniferous forests, the jackrabbit has a grayish-brown summer coat that turns nearly white to provide winter camouflage in areas with persistent snow cover. The slightly smaller black-tailed jackrabbit (*L. californicus*), which is found in lower elevation areas, has not been documented in the park and is generally less common in greater Yellowstone.

Population

Nearly all of the 501 jackrabbit observations recorded in 2008, and the spottier records kept prior to that year were made in sagebrush-grassland habitat at elevations below 6,500 feet (2,000 m) where the average annual precipitation is fewer than 16 inches (40 cm). Less than 1% of the park (about 18,700 acres) is located in these areas. In Yellowstone National Park, jackrabbits currently occupy the area from the Gardiner Basin south to Mammoth Hot Springs and east to the Blacktail Plateau. Review of the historical record indicates that jackrabbits used to also occupy the slopes of Mount Washburn and the lower elevations of the Lamar Valley. However, there have been no known observations of jackrabbits east of the Blacktail Plateau since the early 1950s.

Quick Facts

Number in Yellowstone
Common in suitable low elevation habitats in the park.

Where to See
Elevations below 6,500 feet from the Blacktail Plateau to Mammoth to the Gardiner Basin area.

Identification

- Easily distinguished from true rabbits by their large ears, large feet, and generally large body size.
- Use their ears to listen for danger and to radiate body heat. Large ears allow them to release excess body heat and tolerate high body temperatures.
- Summer coat is grayish brown, with a lighter underside. In Yellowstone and other places where there is persistent and widespread snow cover, the coat changes to nearly white in winter. Ears are rimmed with black.

Habitat

- Found in prairie-grassland and grass-shrub steppe habitat types in western high plains and mountains. They generally prefer grass-dominated habitats and have also been found to flourish above treeline in the alpine zone and avoid forested areas.

Behavior

- Have one to four litters per year with up to 15 offspring.
- Gestation is 36–43 days.
- In most areas, the breeding season of white-tailed jackrabbits averages 148 days and may run late February to mid July. Breeding in the northern Yellowstone ecosystem is not well documented.
- Feed on grasses, forbs, and shrubs at night and are less active during the day.
- Can run from 35 to 50 mph (56 to 80 kph) and cover six to ten feet (2–3 m) with each bound. Will also swim when being pursued by predators.

Jackrabbits are found as high as 14,600 feet (4,200 m) in Colorado, but a limiting factor in Yellowstone appears to be snow, which begins to accumulate earlier in the winter, attains greater depths, and lasts later into spring with increasing elevation.

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Staff Reviewer
Kerry Gunther, Bear Management Biologist

Snowshoe Hares
Lepus americanus

Number in Yellowstone
Common in some places.

Where to See
Norris Geyser Basin area.

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

Habitat
- Found particularly in coniferous forests with dense understory of shrubs, riparian areas with many willows, or low areas in spruce-fir cover.
- Rarely venture from forest cover except to feed in forest openings.
- Eat plants; use lodgepole pine in winter.
- Preyed upon by lynx, bobcats, coyotes, foxes, weasels, some hawks, and great horned owls.

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

Wolverines

A mid-size carnivore in the weasel family, the wolverine (*Gulo gulo*) is active throughout the year in cold, snowy environments to which it is well adapted. Its circumpolar distribution extends south to mountainous areas of the western United States, including the greater Yellowstone area where they use high-elevation islands of boreal (forest) and alpine (tundra) habitat. Wolverines have low reproductive rates, and their ability to disperse among these islands is critical to the population's viability. Climate-change models predict that by 2050, the spring snowpack needed for wolverine denning and hunting will be limited to portions of the southern Rocky Mountains, the Sierra Nevada range, and greater Yellowstone, of which only the latter currently has a population. Wolverines are so rarely seen and inhabit such remote terrain at low densities that assessing population trends is difficult and sudden declines could go unnoticed for years.

US FOREST SERVICE/GARDINER RANGER DISTRICT

Remote cameras, like the one that took this photo, were used to record wolverine activity at live traps during a collaborative study in the greater Yellowstone area from 2006 to 2009. Here, wolverine F3 revisits a live trap, which did not capture her, in 2008. Each trap was baited with a skinned beaver carcass obtained from Montana fur trappers and had a transmitter that signaled up to 18 miles when the trap was triggered.

Population

Commercial trapping and predator-control efforts substantially reduced wolverine distribution in the lower 48 states by the 1930s. Some population recovery has occurred, but the species has not been documented recently in major portions of its historic range. In the greater Yellowstone area, wolverines have been studied using live traps, telemetry, and aerial surveys. A group sponsored by the Wildlife Conservation Society has documented ranges that extend into Yellowstone National Park along the northwest and southwest boundary. A second group, which included researchers from the National Park Service, the US Forest Service, and the Northern Rockies Conservation Cooperative, which surveyed the eastern part of the park and adjoining national forest from 2006 to 2009, documented seven wolverines. The average annual range for the two monitored females was 172 square miles (447 km^2); for three males, it was 350 square miles (908 km^2). The other two males, both originally captured by the Wildlife Conservation Society, dispersed from west and south of the park: M557 established a home range north of the park in 2009; M556 became the first confirmed wolverine in Colorado in 90 years.

On March 5, 2022, a wolverine was photographed by a park visitor along the Northeast Entrance Road corridor. In recent years, NPS staff have documented individual wolverines annually through tracks and

Quick Facts

Number

2006–2009: seven documented in eastern Yellowstone and adjoining national forests (two females, five males). Since 2009, documentation of sightings by park staff constributes to a larger interagency monitoring effort.

Size and Behavior

- 38–47 inches long, 13–31 pounds.
- Opportunistic eaters. Eat burrowing rodents, birds, eggs, beavers, squirrels, marmots, mice, and vegetation (including whitebark pine nuts); chiefly a scavenger in winter, but has also been known to take large prey such as deer, elk, and moose.
- Active year-round, intermittently throughout the day.
- Breed April to October; one litter of two to four young each year. Females give birth in dens excavated in snow, under log jams and uprooted trees in avalanche chutes.
- Mostly solitary except when breeding.

Management Concerns

- Since 2013, the wolverine has fluctuated between being listed as threatened under the Endangered Species Act (ESA) to having no federal protections. A series of court cases over the last decade have resulted in restoration of ESA threatened status in 2023. Climate change and habitat fragmentation are chief threats to this species.

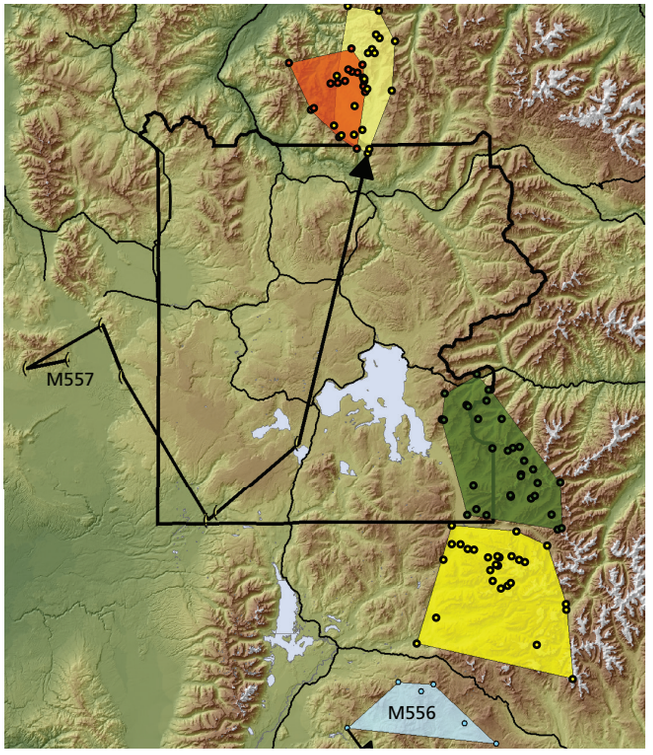
remote camera footage obtained from other wildlife monitoring programs.

Conservation Status

Wolverine populations in the US Rockies are likely to be genetically interdependent. Even at full capacity, wolverine habitat in the Yellowstone area would support too few females to maintain viability without genetic exchange with peripheral populations. The rugged terrain that comprises a single wolverine home range often overlaps several land-management jurisdictions. Collaborative conservation strategies developed across multiple states and jurisdictions are therefore necessary for the persistence of wolverines in the continental United States.

In 2013, USFWS proposed the wolverine be listed as "threatened" under the Endangered Species Act, only to reverse course the following year. Conservation groups challenged that reversal, and a judge found that the federal government failed to follow the best available science in its decision to not list the animals as threatened. In 2020, USFWS determined that federal protections were not warranted. ESA threatened status was officially restored in 2023.

Climate change impacts on wolverine habitat, specifically the likelihood of declining habitat in high elevation snowpack for denning females, had been identified as a chief threat to this species. Until recent years, wolverines could still be trapped in Montana which is home to the largest populations of wolverines in the lower 48 States. In 2019, however, the state closed trapping for this species.



Home ranges of five wolverines documented in 2009.

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Staff Reviewer
Dan Stahler, Senior Wildlife Biologist

Other Small Mammals

Badger (*Taxidea taxus*)

Identification

- 20–34 inches long, up to 26 pounds.
- Short and stout; long, curved claws.
- Grayish grizzled fur with dark legs and feet. Broad head forms a wedge. Sides of face are white with black patches, prominent white stripe extends down center of the nose .

Habitat/Diet

- Prefers open areas like grasslands and shrub-steppe. Most likely to be seen in Lamar Valley.
- Adapted to eat ground squirrels, pocket gophers, and other small burrowing rodents; will also eat birds, rabbits, mice, insects, and fish.
- Dig burrows in pursuit of prey, chasing prey into dead-end tunnels within burrows

Behavior

- Mostly solitary except in mating season (summer and early fall). Have delayed implantation; active gestation starts around February. May live up to 14 years.
- Excavated dens are used for daytime resting sites, food storage, and giving birth.
- May be inactive in their dens for up to 70 days in winter, but they are not true hibernators.
- Adults preyed on by mountain lions, bears, and wolves. Coyotes and eagles will prey on young.
- Known to hunt cooperatively with coyotes.

Golden-mantled Ground Squirrel (*Spermophilus lateralis*)

Identification

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

Habitat/Diet

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

Behavior

- Diurnal; hibernate October thru March to April (depending on elevation).
- Breeding occurs shortly after both males and females emerge from hibernation.
- Predators include coyotes, weasels, badgers, hawks, and grizzly bears.

Conservation Status

Unless otherwise noted, the conservation status of small mammals covered in this section is:

- Not listed federally. Not generally considered a species of conservation concern by Idaho, Montana, or Wyoming

Red Squirrel (*Tamiasciurus hudsonicus*)

Identification

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

Habitat/Diet

- Spruce, fir, and pine forests; young squirrels found in marginal aspen habitat.
- Eat conifer seeds, terminal buds of conifer trees, fungi, some insects; sometimes steal young birds from nests.

Behavior

- Breed February through May, typically in March and April; one litter of three to five young.
- Diurnal; do not hibernate; thus, territorialism ensures winter food supply.
- In fall, cuts cones from trees and caches them in middens, which are used for years and can be 15 by 30 feet; grizzlies search out these middens as food source of whitebark pine seeds.
- Preyed on by coyotes, grizzly bears, and hawks

Uinta Ground Squirrel (*Spermophilus armatus*)

Identification

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

Habitat/Diet

- Found in disturbed or heavily grazed grasslands, sagebrush meadows, and mountain meadows up to 11,000 feet.
- Eat grasses, forbs, mushrooms, insects, and carrion (including road-killed members of its own species).

Behavior

- Hibernate as early as mid-July through March.
- Breed in early spring; one litter of six to eight young per year.
- Preyed on by long-tailed weasels, hawks, coyotes, badgers, and grizzly bears.
- During cool spring weather, Uinta ground squirrels are active at all times of day; as the weather warms, activity is more limited to morning, late afternoon, and evening.
- During winter, Uinta ground squirrels are sometimes active near the Albright Visitor Center and Mammoth Hot Springs Hotel.

Conservation Status

- Not listed federally. Not generally considered a species of conservation concern by Idaho or Wyoming. Montana has listed them as a Potential Species of Concern.

Least Chipmunk (*Tamius minimus*)

Identification

- 7.5–8.5 inches long, 1–1.9 ounces.
- Smallest member of the squirrel family; one of three chipmunk species in the park.
- Can be identified by quick, darting movements; seems to carry its tail vertically when moving.
- Often mistaken for golden-mantled ground squirrel; distinguished by smaller size, longer tail, and lateral stripes that extend onto the sides of the head

Habitat/Diet

- Prefer sagebrush valleys, shrub communities, and forest openings.
- Eat primarily plant material, particularly seeds and other fruits, but will also eat insects and fungi.

Behavior

- In Yellowstone, this species hibernates but also stores some food and may be somewhat active below ground during winter.
- Breeding begins as snowmelt occurs, usually late March until mid-May; one litter of five to six young per year.
- Preyed on by various hawks, weasels, foxes, and coyotes.

Short-tailed Weasel (Ermine) (*Mustela erminea*)

Identification

- 8–13 inches long, 2.1–7 ounces.
- Typical weasel shape: very long body, short legs, pointed face, long tail.
- Males about 40% larger than females.
- Fur is light brown above and cream below in summer; all white in winter except for tail, which is black-tipped all year.
- Compare to long-tailed weasel and marten.

Habitat/Diet

- Found in grassy and forested areas with abundant voles and mice, and in talus fields above treeline.
- Eat voles, shrews, deer mice, rabbits, rats, chipmunks, grasshoppers, and frogs.

Behavior

- Breed in early to mid-summer; one litter of six to seven young per year.
- Will often move through and hunt in rodent burrows.
- Competition with long-tailed weasels is believed to influence distribution and habitat use.

Long-tailed Weasel (*Mustela frenata*)

Identification

- 13–18 inches long, 4.8–11 ounces.
- Typical weasel shape: a very long body, short legs, pointed face, long tail.
- Fur is light brown above and buff to rusty orange below in summer; all white in winter, except for tail, which is black-tipped all year.
- Males 40% larger than females.
- Compare to marten and short-tailed weasel.

Habitat/Diet

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

Behavior

- Breed in early July and August; one litter of six to nine young per year.
- Solitary animals except during breeding and rearing of young.

Marten (*Martes americana*)

Identification

- 18–26 inches long, 1–3 pounds.
- Weasel family; short limbs and long, bushy tail; fur varies from light to dark brown or black; irregular, cream throat patch.
- Compare to long-tailed weasel and short-tailed weasel.

Habitat/Diet

- Found in conifer forests with understory of fallen logs and stumps; will use riparian areas, meadows, forest edges and rocky alpine areas.
- Eat primarily small mammals such as voles and red squirrels; also to a lesser extent birds, eggs, insects, fruit, berries, and carrion.

Behavior

- Solitary and territorial except in breeding season (July and August); have delayed implantation; young born in mid-March to late April.
- Active throughout the year; hunts mostly on the ground.
- Rest or den in hollow trees or stumps, in ground burrows or rock piles, in excavations under tree.
- Snow tracking shows that they occasionally "skydive"; when descending a tree, they will leap out from the tree from a height of several meters.

Montane Vole (*Microtus montanus*)

Identification

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

Habitat/Diet

- Found at all elevations in moist mountain meadows with abundant grass and in grassy sagebrush communities; also common in riparian areas.
- Grass and forbs are their primary food.

Behavior

- Active year-round, maintain tunnels in winter; also dig shallow burrows.
- Typically breed from mid-February to November; up to four litters of two to ten young per year.
- Preyed on by coyotes, raptors, grizzly bears, other animals.

Pocket Gopher (*Thomomys talpoides*)

Identification

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

Habitat/Diet

- Found all over Yellowstone; only range restriction seems to be topsoil depth, which limits burrowing.
- Burrow systems are elaborate and often bi-level; can be 400–500 feet long.
- Snakes, lizards, ground squirrels, deer mice, and other animals use their burrows.
- Forage for forbs, some grasses and underground stems, bulbs, and tubers.

Behavior

- Transport food in cheek pouches to underground cache.
- Do not hibernate; instead burrow into the snow; often fill tunnels with soil, forming worm-like cores that remain in the spring after snow melts.
- Very territorial; only one per burrow.
- Preyed upon by owls, badgers, grizzly bears, coyotes, weasels, and other predators.

More Information, Other Small Mammals

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Staff Reviewers

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River Otter (*Lontra canadensis*)

Identification

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

Habitat/Diet

- Most aquatic member of weasel family; generally found in riparian habitat near water.
- Eat crayfish, fish, frogs, turtles, small mammals, aquatic birds, and insects.

Behavior

- Active year-round. Mostly crepuscular but have been seen at all times of the day.
- Young born in March-April; mating occurs just after; have delayed implantation. Females and offspring remain together until next litter; may temporarily join other family groups.
- Can swim underwater up to 6 miles per hour and for 2–3 minutes at a time.
- Not agile or fast on land unless on snow or ice, then can move rapidly by alternating hops and slides; can reach speeds of 15 miles per hour.
- Can often be seen sliding on mud and snow and playing with sticks and rocks in the water.

Conservation Status

- Not listed federally. Not generally considered a species of conservation concern by Idaho or Montana. Wyoming has listed them as a Species of Greatest Conservation Need, categorizing their population status as Vulnerable.

Yellow-bellied Marmot (*Marmota flaviventris*)

Identification

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

Habitat/Diet

- Found from lowest valleys to alpine tundra, usually in open grassy communities and almost always near rocks.
- Feed mostly on grasses, forbs, and seeds.

Behavior

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

Nearly 300 bird species have been sighted in Yellowstone, including raptors, songbirds, shorebirds, and waterfowl. About 150 species, like this Ruby-crowned kinglet, build nests and fledge their young in the park.

Birds

Records of bird sightings have been kept in Yellowstone since its establishment in 1872. These records document more than 300 species of birds to date, including raptors, songbirds, shorebirds, and waterfowl. Approximately 150 species nest in the park. The variation in elevation, terrains, and vegetative communities support habitats for a relatively high diversity of birds. Many of the birds are migratory species with approximately 50 species residing in the park year-round. There are currently no federally listed bird species known to breed in Yellowstone National Park.

The Yellowstone National Park bird program monitors a small portion of its breeding bird species to gather information on reproduction, abundance, and habitat use. Data are collected on multiple species from a wide variety of taxonomic groups and have been maintained for 40 or more years for several species. Long-term monitoring efforts help inform park staff of potential shifts in ecosystem function, e.g., climate change effects, for Yellowstone's bird community and may guide future conservation of the park's birds and their habitats.

Quick Facts

Number in Yellowstone
Approx. 330 documented species; approximately 150 species nest in the park.

Species of Concern
- Trumpeter swan
- Golden eagle
- Common loon

Current Management
The Yellowstone National Park bird program monitors the park's bird species, including species of concern. The program's core activities are monitoring raptors (bald eagles, ospreys, peregrine falcons, and golden eagles), wetland birds, and passerine/near passerine birds (songbirds and woodpeckers).

Climate Change

The timing of available food sources for birds may change with rising temperatures and changing weather patterns. Birds are sensitive to shifts in seasonal weather patterns and show a relatively rapid response to these fluctuations. For example, climate change has been shown to influence migration patterns, population size and distribution, the timing of reproduction, and nesting success for birds. Through monitoring, birds can be used as environmental health indicators to help managers detect changes in ecosystem function and, if necessary, take appropriate management action.

The Yellowstone bird program monitors the spring arrival of species to the park, as well as the timing of nest initiation and fledging for several raptor species, which may be useful in observing the effects of climate change in Yellowstone.

More Information

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FREQUENTLY ASKED QUESTION:

Where are good birding locations?

That depends on what kind of birds you want to see, the time of day you are looking, and your location in the park. In general, riparian areas and wetlands, especially those with shrubby willows, aspen, and cottonwoods, attract the greatest diversity and abundance of songbirds.

Hayden Valley is one of the best places to view water birds and birds of prey. Shorebirds feed in the mud flats at Alum Creek. Sandhill cranes often nest in the valley. Ducks, geese, and American white pelicans cruise the river. Bald eagles and osprey hunt for fish along the river; northern harriers fly low looking for rodents in the grasses. Great gray owls are sometimes seen searching the meadows for food (these birds are sensitive to human disturbance). Blacktail Ponds and Floating Island Lake, between Mammoth and Tower Junction, and the Madison River west of Madison Junction are also good places to look for birds.

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

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

Watch for birds in the early morning 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. As with all park wildlife, visitors should keep at least 25 yards away from birds and their nests.

Most birds migrate to lower elevations and more southern latitudes beginning in August. At the same time, other birds pass through Yellowstone. Hawk-watching can be especially rewarding in Hayden Valley late August through early October. In early November, look for tundra swans on the water.

Birds that can be viewed in Yellowstone year-round include the common raven, Canada goose, trumpeter swan, dusky grouse (formerly blue grouse), Canada jay, black-billed magpie, red-breasted nuthatch, American dipper, and mountain chickadee. A few species, such as common goldeneyes, bohemian waxwings, and rough-legged hawks, migrate here for the winter.

Visitors may report sightings with a bird observation form, available at www.nps.gov/yell/learn/nature/wildlife-sightings.htm and at visitor centers.

Please note: The use of audio bird calls is illegal in the park.

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Staff Reviewers

David Haines, Wildlife Biologist

Great horned owls are one of more than a dozen raptor (birds of prey) species in Yellowstone.

Raptors

The park supports 19 breeding raptor species, with additional species during migrations and seasonal movements. The park monitors bald eagles, golden eagles, ospreys, and peregrine falcons. Bald eagles and peregrine falcons were previously listed as endangered and threatened species, and the park has continued monitoring since their delisting. The osprey is monitored because of the decline of one of their primary food sources, the cutthroat trout in Yellowstone Lake. The park monitors golden eagles because they are affected by expanding energy development and increasing human activity across the United States. Other species that occur in the park, such as American kestrels and Swainson's hawks, are of growing conservation concern throughout their ranges in the United States.

Yellowstone Raptor Initiative

The Yellowstone Raptor Initiative was a five-year (2011–2015) program designed to provide baseline information for species not previously monitored, including golden eagles (*Aquila chrysaetos*), red-tailed hawks (*Buteo jamaicensis*), Swainson's hawks (*Buteo swainsoni*), American kestrels (*Falco sparverius*), prairie falcons (*Falco mexicanus*), and owls.

Surveys located 29 pairs of golden eagles, and it is likely that more breed within the park. Observed breeding success was low on average and is the subject of current research.

Researchers documented at least 60 red-tailed hawk territories across the northern range, with particularly high local density on the Blacktail Deer Plateau. Red-tailed hawks also exhibited variable breeding success that was, on average, much lower than the level thought necessary to maintain a stable population. Efforts to continue monitoring this species using citizen science are ongoing.

Swainson's hawks proved a difficult species to survey in Yellowstone. Most studies have focused on their association with agricultural land, and the park is a vestige of their native environment.

At least 17 species of raptor use Hayden Valley as a migration corridor, comparable to other migration sites in the Intermountain Flyway. The Initiative provided the first look at owl distribution and occurrence in the park. Ongoing surveys, will improve our knowledge and understanding of this under-studied group of raptors. Finally, while not monitored during this study, accipiters are of growing conservation concern, particularly American goshawks, and should be considered in future raptor studies.

Owls

Owl surveys continued after the completion of the Raptor Initiative in 2015, enabled by dedicated volunteers. Surveys provide an index of sites that attract advertising males of several northern forest owl species. Surveys in 2024 observed the highest abundance of northern saw-whet owls since surveys were initiated in 2013. Additionally, annual monitoring has revealed high year-to-year variation in abundance and diversity of species across the study area.

More Information

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Bald Eagles

The bald eagle (*Haliaeetus leucocephalus*) was named the national symbol of the US by Congress in 1782. Found near open water from Mexico to Alaska, bald eagles may range over great distances but typically return to nest in the vicinity where they fledged. In greater Yellowstone, they feed primarily on fish, but also on waterfowl and carrion. Numbers declined dramatically during most of the 1900s due to habitat loss, shooting, and pesticide contamination. In 1967, the US Fish and Wildlife Service listed the bald eagle as an endangered species in 43 states, including Idaho, Montana, and Wyoming. Habitat protection, restrictions on killing, and restrictions on pesticide use led to population growth and delisting of the species in 2007. Bald eagles nesting in northwestern Wyoming are part of the Rocky Mountain breeding population that extends into Idaho and Montana.

Bald eagles are a recovered endangered species.

Population

Bald eagles, which may reuse the same nest year after year, occupy territories near the park's major rivers and lakes. The number of eaglets that fledge each year depends partly on weather and can fluctuate widely. Juveniles may migrate west in the fall, but adults often stay in the park year-round. Historically, about half of the park's known bald eagle nests have been in the Yellowstone Lake area, where the productivity and success rates are generally much lower than in the rest of the park. In 2023, four occupied nests were detected on Yellowstone Lake. Parkwide, 31 territories were monitored, and occupied nests were detected at 13. Occupancy could not be determined at 13 of the 31 territories monitored. Five of the 13 occupied nests fledged a total of eight young, while six were unsuccessful and the outcome for the remaining two could not be determined.

Outlook

Research has shown that human presence can disturb eagle nesting and foraging; therefore, nest areas in national parks may be closed to visitors. Yellowstone manages nest sites on a case-by-case basis.

Bald Eagle Quick Facts

Number in Yellowstone

- In 2023, park staff monitored 31 bald eagle territories. Of 11 occupied nests where season outcome could be determined, five (45%) successfully fledged young.
- Eight young were produced. Productivity for occupied nests in 2023 (0.73 young per nesting female) was just above the long-term average (0.72).

Identification

- Large, dark bird; adult (four or five years old) has completely white head and tail.
- Females larger than males, as is true with most predatory birds.
- Immature bald eagles show varying amounts of white; they can be mistaken for golden eagles.

Habitat

- Bald eagles are usually found near water where they feed on fish and waterfowl. They also generally nest in large trees close to water.

Behavior

- In severe winters, eagles may move to lower elevations such as Paradise Valley, north of the park, where food is more available. On these wintering areas, resident eagles may be joined by migrant bald eagles and golden eagles.
- Feed primarily on fish and waterfowl, except in winter when fish stay deeper in water and lakes and rivers may be frozen. Then they eat more waterfowl. Eagles will also eat carrion in winter if it is available.
- Form long-term pair bonds.
- Some adults stay in the park year-round, while others return to their nesting sites by late winter.
- Lays one to three eggs (usually two) from February to mid-April.
- Both adults incubate the eggs, which hatch in 34 to 36 days.
- At birth, young (eaglets) are immobile, downy, have their eyes open, and are completely dependent upon their parents for food.
- Can fly from the nest at 10–14 weeks old.
- Some young migrate in fall to western Oregon, California, and Washington.

Golden Eagles

Golden eagles (*Aquila chrysaetos*) are large, long-lived raptors that feed on grouse, small mammals (e.g., rabbits, marmots, and ground squirrels), and carrion. Across the western US, and in Wyoming in particular, there are growing concerns about the status of golden eagle populations due to broad-scale energy development (wind, gas) and increasing human activity. To better understand the current population status and the drivers of population trends across the ecosystem, park biologists began focused study of golden eagles in Yellowstone in 2011.

Surveys have located 30 golden eagles territories inside the park. Twenty-two of the 30 territories are located in Yellowstone's Northern Range, the resulting density (one territory per 45.5 km2) is relatively high. Likewise, territory occupancy rates from 2011 to 2023 have been consistently high (100%). In contrast, low average productivity at these nests (0.32 young/occupied territory) is driven by both infrequent nesting attempts and low nest success. For example, in 2023, researchers monitored 23 occupied territories through the end of the breeding season; 12 occupied nests were detected and six were successful in fledging seven young. With such low productivity, the Yellowstone golden eagle population may be dependent on outside immigration, although much about the status of the park's golden eagle population remains unknown.

In other studies, reproductive failure of eagles and other raptors has been correlated with weather (e.g., high failure in high precipitation years), often interacting with food availability. Research in northern Yellowstone has found that prolonged precipitation, high snow pack, and severe weather events during winter and early spring have a negative effect on successfully fledging young.

Outlook

In response to broad concerns about golden eagle populations, Wyoming has initiated a golden eagle working group, and the US Fish and Wildlife Service has instituted a western US study modeling eagle habitat suitability, human development risks, lead exposure, and large-scale movements. Better understanding of the ecology of YNP eagles requires study of their food habits, toxicology, survival, and movement both within and outside the park. In recent years, extensive data relating to these key topics have been collected in two study areas flanking the park to the north and east, and complementary research within the park is ongoing.

Golden eagles are named for the yellow feathers at the base of the neck.

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Staff Reviewers

David Haines, Wildlife Biologist

Osprey

Like many other birds of prey, osprey (*Pandion haliaeetus*) populations declined due to pesticide use in the mid-1900s and rebounded in the latter part of the century, after the banning of pesticides such as DDT. The first study of osprey in Yellowstone National Park was conducted by M. P. Skinner, the park's first naturalist, in 1917. It was not until 1987 that the Yellowstone National Park bird program began monitoring breeding osprey annually, although an extensive survey on reproduction, diet, and habitat was conducted during the 1970s.

Ospreys are surveyed via fixed-wing aircraft and by ground-based surveys from May through August. During the survey flights, the majority of nests are monitored for occupancy and breeding activity. In addition, many suitable lakes and rivers are surveyed for potential new territories and nest sites.

Since monitoring began, Yellowstone's population of osprey has declined, particularly on and around Yellowstone Lake where currently no occupied territories are known. Nest success has remained relatively stable, with about 50% of nests producing one to two young per year.

Ospreys are monitored by park staff. In 2017, 27 active nests were monitored in Yellowstone.

Research

A recently completed study conducted by park biologists found a significant relationship between the declines in cutthroat trout and osprey reproduction at Yellowstone Lake. Recent increases in the number of young cutthroat trout caught by the Yellowstone fisheries program during the fall netting assessment are encouraging. An increase in cutthroat trout production may lead to an increase in nesting pairs of osprey and improved nesting success at Yellowstone Lake.

More Information

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Staff Reviewers

David Haines, Wildlife Biologist

Quick Facts

Number in Yellowstone

- In 2023, 27 active nests were monitored, of which 76% were successful, above the 37-year average (54%).
- Productivity for active nests in 2023 (1.36 young per nesting female) was also above the 37-year average (0.92).
- No osprey were detected nesting on Yellowstone Lake in 2023.

Identification

- Slightly smaller than the bald eagle.
- Mostly white belly, white head with dark streak through eye.
- Narrow wings, dark patch at bend.
- Fledglings have light edges to each dark feather on their backs and upper wing surfaces, which gives them a speckled appearance.

Habitat

- Dependent on fish for food, osprey are usually found near lakes (such as Yellowstone Lake), river valleys (such as Hayden, Madison, Firehole, and Lamar valleys), and in river canyons (such as the Gardner Canyon and the Grand Canyon of the Yellowstone River).

Behavior

- Generally returns to Yellowstone in April and leaves in September.
- Builds nest of sticks in large trees or on pinnacles close to water.
- Lays two to three eggs in May to June.
- Eggs hatch in four to five weeks.

Peregrine Falcons

The peregrine falcon is among the fastest birds, flying at up to 55 mph and diving at more than 200 mph when striking avian prey in mid-air. Peregrine populations began to decline in the 1940s because of pesticide contamination. One of three North American subspecies, the peregrine in Greater Yellowstone (*Falco peregrinus anatum*) was considered extirpated by the 1970s. As part of a national reintroduction program, captive-bred peregrines were released in Yellowstone and Grand Teton national parks during the 1980s. They typically reside in Greater Yellowstone from March through October, when their favored prey—songbirds and waterfowl—are most abundant. During winter, they may migrate as far south as Mexico or Central America.

TOM STANTON

Peregrine falcons are a recovered endangered species in Yellowstone.

History

In 1962, Rachel Carson sounded an alarm about the irresponsible use of pesticides with her landmark book, *Silent Spring*. Among the dangers she described were the adverse effects of chemicals—particularly DDT—on the reproductive capacity of some birds, especially predatory species such as the bald eagle and peregrine falcon. Her book raised public awareness of this issue, and was one of the catalysts leading to the United States banning some of the most damaging pesticides.

The peregrine falcon was among the birds most affected by the toxins. It was listed as Endangered in 1970. Yellowstone National Park was a site for peregrine reintroductions in the 1980s, which were discontinued when the peregrine population began increasing following restrictions on organochlorine pesticides in Canada and the United States, habitat protection, and the reintroduction program. The falcon made a comeback in much of its former range, and was delisted in 1999.

In Yellowstone, the most nesting pairs recorded was 32 in 2007, and they produced 47 fledglings. Although nesting pairs may reuse the same eyrie for many years, their remote locations on cliff ledges makes it impractical to locate and monitor activity at all eyries in a single year.

Yellowstone National Park's protected conditions and long-term monitoring of peregrines provide baseline information to compare against other populations in the United States. Continued monitoring is essential, not only for comparisons with other populations, but also because peregrine falcons and other raptors are reliable indicators of contaminants such as polybrominated diphenyl ether (PBDE), disease, and climate change. For example, to assess the levels

Quick Facts

Number in Yellowstone

- In 2023, park staff monitored 23 of the 42 known peregrine breeding territories. Twenty territories were occupied and occupancy could not be determined at the remaining three.
- Seven of 11 occupied nests fledged at least 12 young in 2023. Nest success was 41%, slightly lower than the 40-year average (75%).
- In 2023, average productivity was 0.71 young per occupied territory, lower than the 38-year average (1.7).

Identification

- Slightly smaller than a crow.
- Black "helmet" and a black wedge below the eye.
- Uniformly gray under its wings. (The prairie falcon, which also summers in Yellowstone, has black "armpits.")
- Long tail, pointed wings.

Habitat

- Near water, meadows, cliffs.
- Nests on large cliffs over rivers or valleys where prey is abundant.

Behavior

- Resident in the park March through October, when its prey—songbirds and waterfowl—are abundant.
- Lays three to four eggs in late April to mid-May.
- Young fledge in July or early August.
- Dives at high speeds (can exceed 200 mph/320 kph) to strike prey in mid-air.

of PBDE and other contaminants, scientists collect eggshell remains after peregrines have left their nests for the season.

Recovery in Yellowstone

While the organochlorines found in peregrine eggshell fragments and feather samples have declined significantly, several studies indicate that certain flame-retardant chemicals developed in the 1970s for use in electronic equipment, textiles, paints, and many other products leach into the environment and have been found in birds of prey at levels that impair their reproductive biology. In 2010, 2011, 2013, and 2014 eggshell fragments, feathers, and prey remains were collected from nest sites in Yellowstone after fledging occurred. Comparative data on eggshell thickness, which is an indicator of environmental contaminants, is within the range considered normal for the Rocky Mountain Region.

The major cause of peregrine endangerment is no longer a threat and Yellowstone's peregrine population appears stable. Productivity and nesting success in 2023 was well below the 40-year average of 1.7 and 74% respectively. Relatively low nesting success and productivity over the past decade warrants continued close monitoring of this species and may require further study to determine the cause(s).

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Staff Reviewers

David Haines, Wildlife Biologist

American white pelicans, sometimes mistaken for trumpeter swans at a distance, and other colonial nesting birds nest primarily on the Molly Islands in the southeast arm of Yellowstone Lake.

Wetland Birds

Approximately 30% of the bird species that breed in Yellowstone depend on wetlands. Scientists are concerned about these species because wetlands are expected to diminish as global and local temperatures increase. Yellowstone has years of data about the rate and success of nesting for some wetland species, but little information about changes in the timing of nesting activity—an indicator of climate change.

Colony Nesting Birds

Colonial nesting birds nest primarily on the Molly Islands in the southeast arm of Yellowstone Lake. These two small islands are cumulatively just 0.7–3.0 acres in size, depending on lake water levels, yet hundreds of birds have nested there in a single year.

Prior to the late 1970s, the Molly Islands were surveyed only intermittently. Some data go back to 1890 when nesting American white pelicans (*Pelecanus erythrorhynchos*) and California gulls (*Larus californicus*) were first noted in the area. Caspian terns (*Hydroprogne caspia*) are suspected of nesting on the Molly Islands as early as 1917, although information on breeding status was not collected until 1933. Double-crested cormorant (*Phalacrocorax auritus*) nests were confirmed by 1928.

Currently, American white pelicans, California gulls, and double-crested cormorants nest with varying rates of success. Photographic interpretation from three aerial surveys conducted June through August 2023, showed approximately 823 pelican nests that fledged an estimated 440 young. Thirteen nesting double-crested cormorants were successful in fledging 15 young. No California gulls or Caspian terns were observed on the islands.

Habitat

Birds nesting on the Molly Islands are subject to extreme environmental conditions ranging from flooding to frosts that can occur at any time of year to high winds. As a result, birds nesting there experience large year-to-year fluctuations in the number of nests initiated and fledglings produced. Populations of California gulls and double-crested cormorants have declined over the past 20 years. Caspian terns have not nested on the islands since 2005.

The reasons for the decline in colonial nesting birds are not well understood, but a previous study indicates that high levels of water in Yellowstone Lake are associated with low reproduction for nesting pelicans. Notably, quick spring melt-off events can cause a significant rise in the water level on Yellowstone Lake and flood the Molly Islands. Additionally, the introduction of lake trout to Yellowstone Lake has changed prey availability for species like the California gull and Caspian tern.

The decline in cutthroat trout, a known food source for the Molly Island colonial nesting birds, may also influence nesting success. Bald eagles on Yellowstone Lake that formerly depended on cutthroat trout may have switched prey to target the flightless and vulnerable young of these colonial nesting species. Observations of bald eagles perched on the islands during the nestling period is common.

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Staff Reviewers

David Haines, Wildlife Biologist

Common Loons

The majority of the Greater Yellowstone Ecosystem's (GYE) breeding common loon (*Gavia immer*) population occurs in Yellowstone and is one of the most southerly breeding populations in North America. The common loon is listed as a Species of Special Concern in Wyoming because of its limited range, small population, sensitivity to human disturbance, and loss of breeding habitat outside of Yellowstone. The GYE's breeding loon population is isolated from populations to the north by more than 200 miles, limiting immigration from other populations. The Yellowstone Loon population appears stable; however, detailed data from a study initiated in 2012 indicate that the number of loons present in the park can vary from year to year. Continuing research will try to analyze any trends in productivity, nesting success, and number of breeding pairs to attempt to determine why some years are more productive than others.

The common loon is a species of concern in Yellowstone.

Population

In 2023, cooperating biologists and park staff identified 23 occupied territories throughout the GYE, 18 of which were located within YNP. In total, the park housed 38 adult loons. Twelve pairs attempted to nest, and four of those failed. The eight successful pairs produced 10 loonlets during 2023.

Quick Facts

Number in Yellowstone

- In 2023, 38 loons in total. 12 territorial pairs. Eight successful nests produced 10 young.

Identification

- Breeding adults (March–October) have black and white checkering on back, a black bill, red eyes, and iridescent green head and neck. The neck has a black and white chinstrap and distinctive collar.
- Loon chicks hatch with a blackish-brown down and a white belly and retain this plumage for two weeks. Body feathers emerge at 4½ weeks on the chick's upper back. By six weeks, brown down remains only on the neck and flanks.
- Gray juvenile plumage is present at seven weeks.
- Juveniles and winter adults have dark upperparts and white underparts.

Habitat

- Summer on ponds or lakes: large lakes, such as Yellowstone, Lewis, and Heart lakes; and smaller ones such as Grebe and Riddle lakes.
- Winter on open water.
- May be found foraging or resting on larger, slow-moving rivers.
- Nest sites are usually on islands, hummocks in wetlands, or floating bog mats.
- Pairs nesting on lakes smaller than 60 acres usually require more than one lake in their territory. Lakes smaller than 15 acres are rarely used.

Behavior

- Primarily eat fish (4–8 inches).
- Unable to walk on land.
- Migrate in loose groups or on own, not in organized flocks. Arrive at summer lakes and ponds at or soon after ice-off.
- Four common calls: wail—for long-distance communication; yodel—used as a territorial signal by males only; tremolo—a staccato call, usually by an agitated adult; and hoot—a contact call, often between adults or adults and their young.
- Females generally lay two eggs, typically in June.
- Males and females share incubation duties equally. Chicks hatch after 27–30 days. Both adults also care for their young.
- Chicks are able to fend for themselves and attain flight at 11–12 weeks.
- In late summer, adults form social groups, especially on larger lakes, before leaving in October.

Management Concerns

- The breeding population in Wyoming is isolated; populations to the north are more than 200 miles away.
- Loons can be bioindicators of the aquatic integrity of lakes, responding to lead and mercury levels.
- Not all factors affecting loon reproduction in Yellowstone are known, but human disturbance of shoreline nests has a negative impact.

Distribution

In the western United States, common loons breed in Idaho, Montana, Washington, and Wyoming. The total western US breeding population is estimated at 90 territorial pairs. In 2023, Yellowstone National Park hosted 60% of the GYE's total loon population and 57% of the breeding pairs. Furthermore, YNP loons produced 63% of the ecosystem's fledged chicks, highlighting the park's important role in regional loon population stability and persistence. Western populations of breeding common loons are known to overwinter from Washington south to California. Spring and fall migrants in Wyoming represent breeding populations from Saskatchewan that overwinter around Mexico's Baja California peninsula.

Outlook

There are several threats to Wyoming's loon populations. Direct human disturbance to shoreline nests and chicks lowers survival rates and adversely affects numerous loon territories in YNP each year. Increased outreach to the public to minimize shoreline disturbance could help improve the long-term outlook for loons within the park. Throughout YNP and Wyoming, the loss of breeding habitats and water level fluctuations (e.g., erratic spring flooding) also impact loon nest success and productivity.

Contaminants like lead (from sinkers) and mercury, in combination with hazards on wintering grounds (e.g., marine oil spills and fishing nets) challenge loon reproduction and survival even further. Visitors to Yellowstone's lakes can help minimize disturbance of loon nests by staying on trails during the breeding season, avoiding shorelines, and, as with all wildlife species, giving adult and fledgling loons plenty of space.

On average, one loon is killed per year on Yellowstone Lake by gill nets as bycatch in the park's effort to remove invasive lake trout. Ongoing research will better assess patterns in gillnetting mortalities to improve coordination with fisheries crews, thereby reducing the threat to local loons while allowing for continued lake trout removal.

Fish are the primary prey of loons. As part of a multi-park study on mercury concentration in fish, fish from various lakes where loons nest were screened for mercury. Fish were sampled from Beula, Grebe, Yellowstone, and Lewis lakes. Fish from Beula, Grebe, and Yellowstone lakes exceeded the threshold at which fish-eating birds may be affected by mercury toxicity. Fish from Lewis did not exceed that threshold, although they still contained mercury.

Loons can live up to 30 years, have relatively low chick production, and are poor colonizers to new breeding areas. Given the very small size and isolation of Wyoming's breeding loon population, it is at a particularly high risk of local extinction.

More Information

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Staff Reviewers

David Haines, Wildlife Biologist

Trumpeter Swans

The trumpeter swan (*Cygnus buccinator*), named for its resonant call, is North America's largest wild waterfowl, with a wingspan of up to eight feet. These swans require open water, feed mainly on aquatic plants, and nest in wetlands. Although they once nested from Alaska to northern Missouri, trumpeter swans were nearly extirpated in the lower 48 states by 1930 due to habitat loss and hunting. A small population of approximately 70 birds survived in the Greater Yellowstone Ecosystem. With intensive management, this population provided the basis for widespread swan recovery later in the century.

As a result of conservation measures, populations across the continental United States began increasing. As of 2015, there are approximately 63,000 trumpeter swans in North America belonging to three distinct subpopulations: the Pacific, the Rocky Mountain, and the Interior. Swan numbers in the Greater Yellowstone Ecosystem, belonging to the Rocky Mountain subpopulation, grew steadily through the early 1960s, after which cygnet production in Yellowstone and subsequent recruitment of adults into the breeding population began declining.

Population

The park's resident trumpeter swan population increased after counts began in 1931 and peaked at 72 in 1961. The number began declining shortly after and dropped further after the Red Rock Lakes National Wildlife Refuge feeding program ended and winter ponds were drained in the early 1990s. Other factors contributing to the decline may include predation, climate change, and human disturbance. In 2023, park biologists observed 29 trumpeter swans in Yellowstone, including 26 adults and 3 cygnets. Five pairs attempted to nest in the park, and four of the five pairs hatched 12 cygnets. However, only one territory was successful in fledging three cygnets. Other apparent pairs were observed throughout the park but no other nesting was detected.

A pair of trumpeter swans successfully fledged four cygnets (young) on Grebe Lake in 2012.

Eight young trumpeter swans were released in Yellowstone in 2023 in Hayden Valley on the Yellowstone River, near the confluence with Alum Creek. Staff hope that these released swans will become bonded to their release location and return the following spring. In total, the park has released 64 cygnets over a 11-year period. At least two territories have one or more individuals that were released in previous years.

Swans typically take at least four years to reach sexual maturity, so biologists are hopeful more of these young birds may breed in coming years. The release program is part of an ongoing effort to augment

Quick Facts

Number in Yellowstone
29 resident swans in 2023, including five breeding pairs.

Trumpeter swans are increasing in the Rocky Mountains, stable in the Greater Yellowstone Ecosystem, but have declined in Yellowstone National Park since the early 1960s.

Identification
- White feathers, black bill with a pink streak at the base of the upper mandible.
- During migration, can be confused with the tundra swan. Trumpeters are larger and have narrower heads, a pink mandible stripe, and lack a yellow spot in front of the eye.

Habitat
- Slow-moving rivers or quiet lakes.
- Nest is a large, floating mass of vegetation.

Behavior
- Feed on submerged vegetation and aquatic invertebrates.
- Low reproduction rates.
- Can fail to hatch eggs if disturbed by humans.
- Lay four to six eggs in June; young (cygnets) fledge in late September or early October.
- Usually in pairs with young in summer; larger groups in winter.

Management Concerns
- Limiting factors in Yellowstone appear to be flooding of nests, predation, possibly effects of drought caused by climate change, and less immigration into the park from outside locations.
- Because swans are sensitive to human disturbance during nesting, nest areas are closed to public entry.

Yellowstone's swan populations and increase the number of breeding pairs that nest inside the park.

Nearly all Rocky Mountain trumpeter swans—including several thousand that migrate from Canada—over-winter in ice-free waters in the Greater Yellowstone Ecosystem, but only a portion of them remain here to breed.

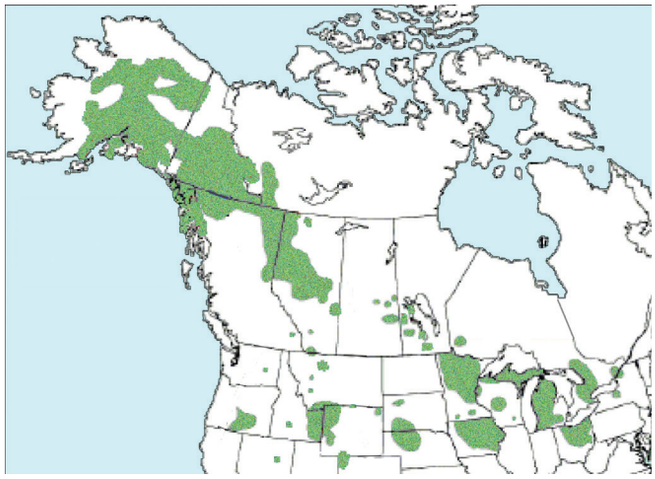
The best available scientific evidence suggests that Yellowstone provides marginal conditions for nesting and acts as a sink for swans dispersing from more productive areas. This effect has been compounded in recent decades by reduced wetland areas (due to long-term drought or warmer temperatures) and community dynamics (e.g., changes in bald eagle diets due to the limited availability of cutthroat trout in Yellowstone Lake). Trumpeter swan presence in the park is currently limited to a small local population of residents and wintering migrants from outside the park. Concern about the Greater Yellowstone Ecosystem population has resulted in cooperative efforts between state and federal agencies to monitor swan distribution and productivity.

Across the region, federal agencies currently survey swans in September to estimate the resident swan population and annual number of cygnets produced.

Outlook

Trumpeter swans are particularly sensitive to human disturbance. Because of this, park managers restrict human activity in known swan territories and nesting areas. With a low count of four adult birds in 2009 to 26 adults and five breeding pairs in 2023, these restrictions on human activity during nesting and the release of cygnets into this local population are now beginning to show a positive response. The total number of birds observed in Yellowstone today mirrors numbers that have not been seen since the mid-1990's. Further, efforts to protect and increase the resident swans in the park along with a better understanding of habitat quality will help to determine the future of this iconic Yellowstone species.

Trumpeter swans are a species of concern in Yellowstone.



Current nesting range of trumpeter swans.

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Songbirds, such as this mountain chickadee, and woodpeckers comprise the majority of bird species in Yellowstone National Park.

Songbirds and Woodpeckers

Songbirds and woodpeckers, or passerine and near passerine species, comprise the majority of bird species in Yellowstone National Park. They are monitored through counts in willow stands, recently burned forests, mature forests, and grasslands/sagebrush steppe; the North American Breeding Bird Survey; fall migration surveys; and a summer and early fall banding station.

Willows

Willow stands are one of a few deciduous wetland habitats in the Greater Yellowstone Ecosystem. Bird diversity is considerably higher in wetland habitats than in grasslands, shrublands, and upland coniferous forests. Several Yellowstone bird species, including Wilson's warbler (*Cardellina pusilla*), willow flycatcher (*Empidonax traillii*), and gray catbird (*Dumetella carolinensis*), only breed in willow communities.

From the early 1900s, growth of willows and other woody vegetation on Yellowstone's northern range was stunted (suppressed) by elk browsing, reduced beaver populations, consumption by fire, and/or climate change. Correlated with the recovery of several large predator species in the park, some willow stands in the northern range have grown taller and thicker since the mid-1990s, creating a range of growth conditions in current willow stands.

Monitoring of willow–songbird communities in Yellowstone began in 2005. Scientists compare the presence and abundance of breeding songbirds across different willow stand conditions. In 2023, park staff recorded 37 songbird species in willows. Species richness (diversity) and average songbird abundance was higher in taller than in suppressed willows. Recovered willow stands provide shrubby cover for ground- and low-nesting species such as song sparrows. Suppressed willows appear to provide habitat for generalist and grassland/sagebrush species. Willow stands are slowly changing and biologists plan to regularly reassess the vegetation characteristics as bird communities continue to be monitored.

Mature Forests

While the importance of mature and old growth forests to songbirds is poorly understood, mature forests notably provide nesting habitat and foraging opportunities for many species that young stands do not. Climate warming may cause more frequent and severe fires in Yellowstone National Park, which could disproportionately impact mature forest stands that, by definition, take longer to regenerate post-burn.

Due to the potential loss of this habitat type as the climate changes, park biologists initiated songbird surveys in three mature forest types in 2017 to document the bird communities that currently use them. No surveyed forests had a major disturbance (i.e., wildfire) in at least 100 years, although forest structure and tree species composition varied. In 2022, observers recorded 19 species and the most abundant species were pine siskin (*Spinus pinus*), mountain chickadee (*Poecile gambeli*), American robin (*Turdus migratorius*), ruby-crowned kinglet (*Regulus calendula*), yellow-rumped warbler (*Setophaga coronata*), and dark-eyed junco (*Junco hyemalis*). Species richness increased with forest complexity from 10 species in lodgepole-dominated and mixed lodgepole-spruce forests to 15 species in Douglas fir and spruce.

Burned Landscapes

Birds are among the first returning vertebrates to forests affected by fire. Birds that nest in cavities of trees depend on forest fires to provide their habitat—and different species depend on different effects of forest fires. For example, black-backed (*Picoides*

Three-toed woodpeckers nest in trees that burned in low to moderately severe fires, and hunt for the beetles in the bark.

arcticus), American three-toed (*P. dorsalis*), and hairy (*P. villosus*) woodpeckers use trees that burned in low to moderately severe fires, two to four years after the fire. Northern flickers (*Colaptes auratus)* move into severely burned areas three years after a fire. Standing dead trees left behind after a fire attract bark and wood-boring beetles—primary prey for woodpeckers. Nest cavities created by woodpeckers are later used by chickadees, nuthatches, bluebirds, owls, and some species of duck.

Because fire size, frequency, and intensity are expected to increase with climate change, scientists are studying how the different bird species use different types of post-burn forests and they are developing monitoring methods for the future.

Grasslands/Sagebrush Steppe

Grasslands are a threatened habitat type across the continent and grassland songbirds are the most imperiled songbird guild in North America. In Yellowstone, grasslands and sagebrush steppe are impacted by invasive plants, changing intensities of ungulate grazing, and climate change. In 2022, bird program staff and volunteers conducted songbird surveys in sagebrush steppe and grasslands across the northern range, in areas that vary in bison grazing intensity as well as native and invasive plant species composition.

Staff observed 15 species of songbird in grasslands and sagebrush steppe in 2022. In areas with high grazing intensity and abundant non-natives, the most abundant species were horned lark (*Eremophila alpestris*), vesper sparrow (*Pooecetes gramineus*), and Brewer's blackbird (*Euphagus cyanocephalus*). At other sites, species diversity varied significantly, although Brewer's sparrow (*Spizella breweri*), vesper sparrow (*Pooecetes gramineus*), and savannah sparrow (*Passerculus sandwichensis*) were all common.

Breeding Bird Surveys

North American Breeding Bird Surveys (BBS) are a continent-wide monitoring effort coordinated by the US Geological Survey, the Canadian Wildlife Service's Research Center, and Mexico's National Commission for the Knowledge and Use of Biodiversity (CONABIO). Since the 1980s, Yellowstone National Park has participated in these long-term surveys conducted throughout North America. The surveys are road-based with the registered observer recording all birds seen and heard within a quarter mile radius; survey points occur every half mile. Surveys are conducted in June, during the height of the songbird breeding season, and occur on three routes: Mammoth (Indian Creek to Tower Junction), Northeast Entrance (Tower Junction to Round Prairie), and the Yellowstone route (Dunraven Pass to Mary Bay).

In 2022, surveyors detected 3,464 individuals of species. The greatest overall bird abundance was observed along the Yellowstone route through the interior. Large flocks of Canada geese along the Yellowstone River accounted for 79% of all observations along the interior route. Canada goose numbers were relatively stable from 1987 to 2010, after which they increased substantially.

Fall Migration

Fall migration represents an important and vulnerable part of the annual cycle for many songbirds. As they make the long journey south to winter range, migrating songbirds must find appropriate places to rest and refuel. During this season, the songbird community within Yellowstone National Park changes, accommodating species and individuals who do not breed here but are just passing through. In addition to breeding-season efforts, bird program staff monitor autumn songbirds in willow stands, mature forest, and grassland/sagebrush steppe to better document patterns in habitat use by fall resident and migrating passerines.

Songbirds, particularly migrants, were most abundant and diverse in willows in the fall, consistent with

patterns seen during the breeding season. In sagebrush steppe, migrants were more frequent and more diverse than resident songbirds, while mature forest largely provided fall habitat for resident species. Dark-eyed juncos were the most common fall songbird species in willows as well as in mature forest. In grasslands and sagebrush steppe, Brewer's blackbirds were the most commonly observed species. These fall surveys help highlight the year-round importance of Yellowstone to the resident and migrant avian community.

Banding Station

While songbird counts can provide good estimates for songbird diversity and abundance, they do not provide any information about measures of demography, i.e., reproduction and survival. To improve our understanding of songbird demography in the park, the bird program began annual operations of a mist-netting and songbird banding station in 2018, located in a willow-lined riparian corridor on the northern range. During the breeding season, researchers participated in the international MAPS (Monitoring Avian Productivity and Survivorship) program, operated by the Institute for Bird Populations. To help assess use of riparian habitats by juvenile and migrating songbirds, staff continued banding operations into the fall, through late September.

In 2023, staff captured 232 new birds belonging to 30 different species during the breeding season. One hundred ten individual birds banded between 2018 and 2023 have been recaptured at least one time since banding was initiated. The most commonly captured species during the breeding season are yellow warbler (*Setophaga petechia*) and warbling vireo (*Vireo gilvus*).

Biological technicians take vital statistics and measurements from a Yellow warbler while fitting the bird with a band.

Continued netting and banding efforts in future years will provide additional demographic information that will help researchers better understand songbird population dynamics within the park.

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American avocets are one of the nearly 300 bird species found in Yellowstone National Park. These shorebirds sweep their upturned bills back and forth through shallow water to collect aquatic invertebrates.

Other Notable Birds

American Dippers

The dark-gray American dipper *(Cinclus mexicanus)* bobs beside streams and rivers. Also called the water ouzel, the dipper dives into the water and swims in search of aquatic insects. Thick, downy feathers made waterproof with oil from a preen gland enable this bird to thrive in cold waters.

Ravens

Several members of the Corvid family (jays, crows, and ravens) live in Yellowstone, including the common raven (*Corvus corax*). Common ravens are smart birds, able to put together cause and effect. Ravens are attracted to wolf kills and may follow wolves while they hunt elk. Wolves also provide better access to carrion, as ravens are not able to rip open thick skin on their own. Ravens are willing to eat almost anything and are frequently seen near parking lots searching for food. Do not feed them.

Recent surveys indicate 200–300 ravens are present in the northern range of Yellowstone and 53% of those are in wolf habitat, away from human areas. Before wolf reintroduction, nearly 74% of ravens likely used human areas. Researchers are further investigating seasonal and spatial patterns in raven habitat use, and ravens' relationships with humans and wolves by monitoring raven movements using satellite transmitters.

Clark's Nutcrackers

Clark's nutcracker (*Nucifraga columbiana*) is common throughout Yellowstone. Nutcrackers are important seed dispersers for many western conifers and are the primary disperser for whitebark pine (*Pinus albicaulis*). Whitebark pine seeds are the preferred food resource for nutcrackers and the two species are heavily dependent on one another. Whitebark pine prevalence is threatened throughout the west, including the park due to infestations of mountain pine beetle, white pine blister rust, and a changing climate and fire regime. To track nutcrackers' response to projected declines in whitebark pine, researchers are monitoring nutcracker populations, habitat and food selection.

Sandhill Cranes

Sandhill cranes (*Grus canadensis*) nest in Yellowstone each summer. Because their gray feathers blend in well with the grassland habitat, their guttural calls announce their presence long before most people see them. The tallest birds in Yellowstone, they stand about four feet (1.2 m) high. They have a wingspan of approximately 6.5 feet (2 m) and are often mistaken for standing humans or other animals at a distance.

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JAY FLEMING

Yellowstone cutthroat trout are found in Yellowstone National Park and are a keystone species. They provide an important source of energy for many species of birds and mammals.

Native Fish Species

Yellowstone has 11 fish species native to its lakes and streams. Native sport fish include two species of cutthroat trout, Arctic grayling, and mountain whitefish. Yellowstone's native fish underpin natural food webs, have great local economic significance, and provide world-class visitor experiences.

Yellowstone Cutthroat Trout

Yellowstone cutthroat trout (*Oncorhynchus virginialis bouvieri*, YCT) are the most widespread native trout in the park and the dominant fish species. They provide an important source of food for an estimated 16 species of birds and mammals including bald eagles, grizzly bears, and river otters.

Some populations live and spawn within a single stream or river (fluvial), some live in a stream and move into a tributary to spawn (fluvial-adfluvial), some live in a lake and spawn in a tributary (lacustrine-adfluvial), and still others live in a lake and spawn in an outlet stream (allacustrine). Life history diversity within an ecosystem helps protect a population from being lost in a single extreme natural event.

Genetically unaltered YCT populations have declined throughout their natural range in the Intermountain West due to competition with and predation by nonnative fish species, a loss of genetic integrity through hybridization, habitat degradation, and angling harvest. Many of the remaining genetically unaltered YCT are found within the park. State and federal wildlife agencies classify YCT as a sensitive species. However, the US Fish and Wildlife Service concluded that YCT does not warrant listing as a threatened species under the Endangered Species Act.

The YCT population in the Yellowstone Lake ecosystem was abundant in the 1980s. Nonnative lake trout caused a dramatic decline in YCT in the early 2000s. Strong suppression efforts have reduced lake trout numbers allowing YCT numbers to increase. Although YCT numbers are still below target, the fish are making a comeback and currently are much greater in size than when population numbers were much higher. An adult YCT now weighs twice what one did in the 1970s, probably because of reduced competition with other YCT. As the population continues to increase in numbers, and competition increases, this will likely change.

Two-thirds of the streams that were part of the species' native habitat outside the Yellowstone Lake watershed still contain genetically unaltered YCT, but in many others, they have hybridized with rainbow trout, or are in competition with brook or brown trout..

Description

- Red slash along jaw.
- Body mostly yellow-brown with darker olive or gray hues on the back, lighter yellow on sides.
- Highly variable black spotting pattern, but few to no spots on the head.

Behavior

- Spawn in rivers or streams from late April until mid-July.
- Most important foods are aquatic insects—mayflies, stoneflies, caddisflies, etc.—and other small aquatic animals, plus terrestrial insects that fall into the water. Leeches, amphipods, worms, and small aquatic invertebrates such as water fleas and copepods are important foods in Yellowstone Lake.

- Also eat smaller fish, fish eggs, small rodents, frogs, algae and other plants, and plankton.

Distribution

- Native to the Yellowstone River, Snake River, and Falls River drainages.
- Require cold, clean water in streams or lakes.

Westslope Cutthroat Trout

Westslope cutthroat trout (*Onchorhynchus lewisi*, WCT) are the most widely distributed species of cutthroat trout in the U.S. but have undergone range-wide declines. Genetically pure WCT were thought to have been extirpated from their native range in Yellowstone National Park in the Gallatin and Madison river drainages due to hybridization with nonnative rainbow trout and YCT stocked outside of its historic range, and competition with nonnative brook trout and brown trout. However, two populations of genetically pure WCT were discovered in the early 2000s in Last Chance Creek, an indigenous WCT population, and in Oxbow/Geode Creek complex, containing WCT descendants from "cutthroat trout" stocking events in the Yellowstone River drainage before different cutthroat trout species were widely recognized. Conservation actions by the National Park Service and its partners have restored and expanded WCT to nearly 70 stream miles and 280 lake acres, including, Goose, High, Grebe, and Wolf lakes.

Description

- Red slash along jaw and dark spots.
- Greenish gray in color.
- Larger, irregular spots more numerous around tail, forming an arched pattern above lateral line toward gills and head.
- Crimson streak above the belly.
- Some have white leading edges on pelvic and pectoral fins (unlike genetically pure YCT).
- Sometimes mistaken for rainbow trout.

Behavior

- Fluvial and lacustrine life histories.
- Spawn in rivers or streams in late May through mid-July.
- Most important foods are aquatic insects such as mayflies, stoneflies, caddisflies, dragonflies, damselflies, and terrestrial insects that fall into the water. Leeches, amphipods, worms, and small aquatic invertebrates such as copepods and zooplankton are important foods in lakes.

Westslope cutthroat trout

Distribution

- Last Chance Creek, Oxbow/Geode Creek complex
- Goose, High, Grebe, and Wolf lakes.
- East Fork Specimen Creek, Grayling Creek, Gibbon River upstream of Virginia Cascades
- Hybridized populations exist throughout the Gallatin and Madison river drainages.

Arctic Grayling

Arctic grayling (*Thymallus arcticus*, grayling) historically existed in the contiguous U.S. in two disjunct groups in Michigan and Montana/Wyoming. The Michigan group was extirpated in the 1930s and the Montana/Wyoming group has undergone drastic declines. In Yellowstone National Park, grayling historically occupied fluvial habitat in the Gallatin and Madison river drainages, including the lower Gibbon and Firehole rivers, and Grayling Creek. However, fluvial grayling were extirpated from streams and rivers in the park by the mid-1900s, presumably resulting from nonnative fish introductions and habitat degradation with the construction of Hebgen Reservoir in 1915.

The only known grayling populations left in the park were descendants of grayling with the lacustrine life history that is nonindigenous to Yellowstone National Park that were stocked in Cascade and Grebe lakes and did not establish in riverine habitats. From 2017–2021, the National Park Service implemented a grayling and WCT conservation project in the upper Gibbon River drainage. Biologists removed nonnative rainbow trout and the lacustrine-sourced grayling, and stocked more than 100,000 WCT embryos and fish, and 170,000 fluvial-sourced grayling

Arctic grayling

©ZAC SEXTON

Mountain whitefish

fry. An additional 7,000 grayling fry were stocked in Grebe Lake in 2023.

From 2015–2017, the National Park Service also reintroduced nearly 60,000 WCT embryos and fish, and 110,000 fluvial-sourced grayling embryos and fry to upper Grayling Creek in the Madison River drainage.

Description

- Large sail-like dorsal fin.
- Large scales, silver in color.
- Dark spots on the front half of body.
- Black throat slash.
- Sometimes confused with mountain whitefish.

Behavior

- Fluvial ancestry. A fluvial grayling source was used in conservation projects to increase the likelihood that grayling will populate riverine habitat. Grayling with fluvial ancestry stocked in lakes have exhibited lacustrine life-history behaviors.
- Spawn in rivers and streams from mid-May to late-June.
- Similar to trout, they eat true flies, caddisflies, macroinvertebrates, and small crustaceans. Younger, smaller fish feed on zooplankton.

Distribution

- Cascade, Ice, Grebe, and Wolf lakes.
- Gibbon River upstream of Virginia Cascades.
- Occasionally reported in Grayling Creek and, lower Gibbon, Madison and Firehole rivers.
- Require clear, clean, and cold water.

Mountain Whitefish

The mountain whitefish (*Prosopium williamsoni*) is a slender silver fish, sometimes confused with Arctic grayling. It lives in Yellowstone's rivers and streams and requires deep pools and clear, clean water. This species is very sensitive to pollution. The mountain whitefish has persisted in its native waters, unlike the Arctic grayling. Mountain whitefish are commonly caught by anglers in most of the park's large rivers. They are less common in smaller streams.

Description

- Silver or olive green to dark gray. No spots.
- Body nearly round on cross-section.
- Small mouth with no teeth.

Behavior

- Spawns in fall.
- Generally, feeds along the bottom, eating aquatic insect larvae, and competes with trout for the same food.

Distribution

- Heart Lake and its tributaries.
- The Yellowstone River below the Lower Falls, Gardiner, Gibbon, Madison, Snake, and Lewis rivers and Middle Creek.

Rocky Mountain Sculpin (*formerly Mottled Sculpin, pending confirmation*)

The Rocky Mountain sculpin (*Cottus bondi*) lives primarily in shallow, cold water throughout Yellowstone, including the Yellowstone River downstream of the Lower Falls. It has modified pectoral and pelvic fins to help it move and grip the bottom of the stream. It lacks scales and a swim bladder. It eats small insects, fish, and fish eggs, and is consumed by trout.

Description

- Coloration is a combination of bars, spots, and speckles randomly distributed.
- Large banded pectoral fins
- Dorsal fin contains soft spines, and just barely joins with the second dorsal.
- Maximum length is 6 inches.

Behavior

- Feeds primarily on aquatic insect larvae. Also eats crustaceans, small fish, fish eggs, and some plant material.
- Preyed upon by other fish, notably trout.
- Favored habitat is well-oxygenated and clear water, such as over gravel riffles in mountain streams, springs, and along rocky lake shore.
- Spawns during early winter and late spring.

Distribution

- Widely distributed in drainages throughout the park.

Utah Chub

The Utah chub (*Gila atraria*) is the largest of the minnows (12 inches) and has a robust round body. It is native to the Snake River drainage and abundant in Heart Lake and the Heart River. They have a high reproductivity capacity with a 12-inch female carrying up to 90,000 eggs. Utah chub prefer slow, warm waters with abundant aquatic vegetation.

Redside Shiner

The Redside shiner (*Richardsonius balteatus*) is a species of minnow most often found in lakes along the shallow margins. It is native to the Snake River drainage but has been introduced to Yellowstone Lake where it is now common.

Longnose Dace

The longnose dace (*Rhinichthys cataractae*) has an elongated, rounded body that tapers towards the head and tail. It grows to about 6 inches and is often found behind rocks and in eddies of cold, clear waters of the Yellowstone, Snake, and Madison river drainages. It can also be found in Yellowstone Lake. Longnose dace will feed on aquatic insects, aquatic vegetation, or algae.

Longnose sucker

Speckled Dace

The speckled dace (*Rhinichthys osculus*) is found in the Snake River drainage. It is similar in body form and size to the Longnose dace but has a much smaller distribution. Interestingly, the Speckled dace and Redside shiner have naturally hybridized in several locations in southern Yellowstone.

Mountain Sucker

The Mountain sucker (*Catostomus platyrhynchus*) is found in cold, fast, rocky streams and some lakes. It is widely distributed throughout YNP. It can be misidentified with the Longnose dace as they can have similar body forms and size. The back and head are typically dark brown or greenish brown, underside is white, and both males and females have a red/orange strip along the side. Typically grow to a maximum of 6 inches.

Longnose Sucker

The Longnose sucker (*Catostomus catostomus*) is native to the Yellowstone River drainage below the Grand Canyon and was introduced to Yellowstone Lake and its surrounding waters. It is equally at home in warm and cold waters, streams and lakes, and clear and turbid waters. These large, round fish can grow to 22 inches or more and weigh in at over five pounds. They are typically silvery to blueish/gray and develop a reddish band along their side during the spawning season. Concurrent with the decline in cutthroat trout is a steady, long-term decline in the introduced Longnose sucker population within Yellowstone Lake. The mechanism causing this decline is unclear. Longnose suckers are found primarily in shallow water and spawn in tributaries during

the spring. Predation by lake trout during the summer is not significant but it is possible that consumption of suckers by lake trout is higher during winter when water temperatures are extremely cold, allowing lake trout to exploit shallow water habitats where the suckers reside.

Utah Sucker

The Utah sucker (*Catostomus ardens*) is native to the Snake River drainage and can grow to similar size as the Longnose sucker. This species is abundant in Heart River and Heart Lake. Utah suckers have been aged at over 20 years.

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Nonnative Fish Species

Nonnative fish species that were introduced to the park in the late 1800s and early 1900s include Rainbow trout, Brown trout, Brook trout, Lake trout, and Lake chub. Fish species native to Yellowstone have also been transported outside of their native waters. Although nonnative trout are also important to the angler experience in Yellowstone, they have contributed to a decline in the park's native fish species. Nonnative fish distributions and their influence on native fish are not static. While Rainbow trout have not been intentionally stocked since the 1930s, the hybridization of cutthroat trout resulting from Rainbow trout range expansion continues to be the greatest threat to the park's remaining stream dwelling cutthroat trout populations. Additionally, Lake trout were introduced to Yellowstone Lake by unknown means in the mid-1980s and first appeared in angler catches in 1994. The Lake trout population expanded and, over the following decade, caused a rapid decline in the YCT population in Yellowstone Lake. Through the most intense fish control program in the NPS, the YCT numbers are steadily improving in Yellowstone Lake.

Many nonnative fish were introduced to Yellowstone waters to increase angling opportunities for visitors.

Lake Trout

Lake trout (*Salvelinus namaycush*) are native to Canada, Alaska, the Great Lakes, New England, and parts of Montana. Lake trout were intentionally stocked in Lewis and Shoshone lakes in 1890 by the US Fish Commission (a predecessor of today's US Fish & Wildlife Service). Although lake trout need energy-rich prey to continue to grow, they can persist for years with minimal food resources.

The species was first documented in Yellowstone Lake in 1994. Evidence from chemical patterns in lake trout ear bones (otolith) sampled in the late 1990s indicate that the initial stock originated from nearby Lewis Lake sometime in the 1980s. Despite major efforts to remove them by gillnetting, lake trout have had a significant ecological impact on native YCT, which are an important food source for other native animals. Lake trout differ from cutthroat trout as potential prey because they can grow larger, occupy deeper areas of the lake, and spawn in the lake instead of in shallow tributaries. Lake trout also consume foods that have historically fed cutthroat trout in Yellowstone Lake, thereby making cutthroat trout recovery impossible until the lake trout population is suppressed.

Lake trout, Lewis Lake

Description

- Dark gray body with white spots. Numerous spots on head.
- Deeply forked tail.
- Often white on the edge of fins.

Behavior

- Lake trout are voracious and efficient predators.
- Frequently live >25 years and can grow very large. The Wyoming state record weighed 50pounds (23 kg).
- Fall spawners (September/October). A 12-pound female could produce up to 9,000 eggs annually.
- About 30% of a mature lake trout's diet is cutthroat trout. They can consume cutthroat trout up to 55% their own size.

Distribution

- Heart, Lewis, Shoshone, and Yellowstone lakes

Rainbow trout

Rainbow Trout

Rainbow trout (*Oncorhynchus mykiss*) are native to North America in waters that drain to the Pacific Ocean from northern Mexico to Alaska. Of the nonnative fish in Yellowstone, Rainbow trout have the closest geographic origin. As the most adaptable member of the salmonid family, they have been successfully introduced throughout the world. Unfortunately, they readily hybridize with cutthroat trout and produce fertile offspring.

Description

- Silvery body, red lateral band, often white on the edge of lateral fins.
- Numerous black spots on head and back, none on belly.

Behavior

- Mainly spawn between March and July. Select populations (Firehole drainage) spawn in fall.
- Eats aquatic and terrestrial insects, crustaceans, mollusks and earthworms.

Distribution

- Widely distributed due to historic stocking efforts.
- Not present in Yellowstone Lake.
- Not present in the Yellowstone River above the Upper Falls or the Snake River.

Eastern brook trout

Eastern Brook Trout

Eastern brook trout was the first nonnative species introduced in Yellowstone. They were stocked in the (then fishless) Firehole River in 1889. Brook trout are native to the eastern United States from Hudson Bay down to the Carolinas and through the Great Lakes.

Description

- Sides spotted with red, pink, or yellow dots, haloed with blue.
- Light spots on dark skin.
- Back, dorsal, adipose, and tail fins have a marbled (vermiculated) appearance.
- Lower fins have a vivid white stripe on the tip

Behavior

- Spawn in fall between September and December. Have a strong tendency to return to natal streams.
- Food selection similar to other trout, but tend to feed on a wider variety of foods.

Distribution

- Not present in the Gallatin River, Yellowstone Lake, or the Yellowstone River above the Upper Falls.

Cutthroat x Rainbow Trout Hybrids

In waters where rainbow trout have been introduced, there has been a serious degradation of the cutthroat trout population through interbreeding.Presently, hybridized cutthroat trout exist throughout the Bechler, Falls, Gallatin, Gardner, Lamar, and Madison river drainages, and the Yellowstone River below the Upper Falls. Hybrids will have characteristics consistent with both species.

Brown trout

Lake chub

Brown Trout

The Brown trout (*Salmo trutta*) is the only nonnative fish species in Yellowstone that is not native to North America. This European species was introduced to Yellowstone in the later part of the 19th century and was recorded as two different species—the Von Behr and the Loch Leven brown trout. These are now thought to be varieties of the same species, and most of the populations in Yellowstone are indistinguishable. They can be aggressive predators and can grow to large sizes. Brown trout have a higher thermal tolerance then Yellowstone's native salmonids and thrive in the Firehole River. Anglers report that they are notoriously finicky when it comes to striking a fly or lure.

Description

- Dark in color, olive, brown, or yellow.
- Pale halos around black spots.
- Vibrant red or orange spots.

Behavior

- Spawn in fall, migrating to small tributaries of large rivers, upstream in small rivers, or to lake inlets.
- Eat mostly insects, crustaceans, and mollusks but have a reputation for eating larger prey: other fish, crayfish, birds, mice, and frogs.

Distribution

- Widely distributed in Gallatin, Gibbon, Firehole, Madison, Lewis, Snake, Gardner, and Yellowstone rivers.
- Not present upstream of Knowles Falls on the Yellowstone River, Yellowstone Lake or the Bechler or Falls rivers.

Lake Chub

The Lake chub (*Couesius plumbeus*) is native to the Missouri and Yellowstone River drainages in Montana and Wyoming, but not to Yellowstone National Park waters. It was most likely introduced by bait fishermen into Yellowstone Lake, McBride Lake, and Abundance Lake in the Slough Creek drainage.

Description

- Dull gray or bluish-gray.
- Rarely more than 6 inches long.

Behavior

- Inhabits cooler lakes and streams, prefers small creeks to large rivers.
- Spring spawner.
- Competes with small trout for food, but likely provides fodder for trout over 16 inches.

Distribution

- Established but uncommon in Yellowstone Lake. Removed from Lake Abundance in 1969.
- Well-established in the Slough Creek drainage.

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History of Fish Management

About 8,000–10,000 years ago, twelve species of native fish, including Arctic grayling, mountain whitefish, and cutthroat trout, dispersed to this region following glacier melt. These native fish species provided food for both wildlife and human inhabitants. The distribution of native fish species was originally constrained by natural waterfalls and watershed divides. These landscape features provided a natural variation of species distributed across the landscape and vast areas of fishless water. At the time Yellowstone National Park was established in 1872, approximately 40% of its waters were barren of fish—including Lewis Lake, Shoshone Lake, and the Firehole River above Firehole Falls.

Early Fish Management

Created in 1872, Yellowstone National Park was, for several years, the only wildland under active federal management. Early visitors fished and hunted for subsistence, as there were almost no visitor services. At the time, fishes of the park were viewed as resources to be used by sport anglers and provide park visitors with fresh meals. Fish-eating wildlife, such as bears, ospreys, otters, and pelicans, were regarded as a nuisance, and many were destroyed as a result.

To supplement fishing and to counteract "destructive" consumption by wildlife, a fish "planting" program was established in Yellowstone. Early park superintendents noted the vast fishless waters of the park and asked the US Fish Commission to "see that all waters are stocked so that the pleasure seeker can enjoy fine fishing within a few rods of any hotel or camp" (Boutelle 1889). The first fishes from outside the park were planted in 1889–1890 and included brook trout (*Salvelinus fontinalis*) in the upper Firehole River, rainbow trout (*Oncorhynchus mykiss*) in the upper Gibbon River, and brown trout (*Salmo trutta*) and lake trout (*Salvelinus namaycush*) in Lewis and Shoshone lakes. The harvest-oriented fish management program accounted for the planting of more than 310 million native and nonnative fish in Yellowstone between 1881 and 1955. In addition, from 1889 to 1956, some 818 million eggs were stripped from Yellowstone trout and shipped to locations throughout the United States.

Many rows of wooden boxes used to raise trout
Trout-rearing ponds in Mammoth. May 1929
Largely due to these activities and the popularity of Yellowstone's fisheries, recreational angling became

Early Run of blackspotted spawners. May 1936, Pelican Creek, Lanoue.

The newly constructed Yellowstone Lake Fish Hatchery, 1928.

a long-term, accepted activity in national parks throughout the country. In Yellowstone, fisheries management, as the term is understood today, began with the US Army, and was assumed by the National Park Service in 1916. Fish stocking, data gathering, and other monitoring activities began with the US Fish Commission in 1889, were continued by the US Fish and Wildlife Service until 1996, and have been the responsibility of the National Park Service since then.

The stocking of nonnative fishes by park managers has had profound ecological consequences. The more serious of these include displacement of intolerant natives such as westslope cutthroat trout (*O. clarki lewisi*) and Arctic grayling (*Thymallus arcticus*); hybridization of Yellowstone (*O. c. bouvieri*) and westslope cutthroat trout with each other and with nonnative rainbow trout; and, most recently, predation of Yellowstone cutthroat trout by nonnative lake trout. Over the years, management policies of the National Park Service have drastically changed to reflect new ecological insights. Subsistence use and harvest orientation once guided fisheries management. Now, maintenance of natural biotic associations or, where possible, restoration to pre-Euro-American conditions have emerged as primary goals. Eighteen fish species or subspecies are currently known to exist in Yellowstone National Park; 12 of these are considered native (they were known to exist in park waters prior to Euro-American settlement), and five are introduced (nonnative). Today, about 40 lakes have fish; others were either not stocked or have reverted to their original fishless condition.

Yellowstone Lake Fish Hatchery

Hatchery operations at Yellowstone Lake became part of this undertaking when fish hatched from Yellowstone's trout were used to stock waters in the park and elsewhere, sportfishing was promoted to encourage park visitation, and satisfying a recreational interest took precedence over protection of the park's natural ecology. Built in 1930 by the National Park Service, the hatchery's log-framed design is also an example of the period of rustic architectural design in national parks.

The hatchery was thought to be among the most modern in the West. The main room was outfitted with tanks and raceways for eggs, fingerlings, and brood fish taken from 11 streams that flowed into the lake. Small fry were fed in three rectangular rearing ponds in a nearby creek until they were ready for planting. Superintendent Horace Albright explained that the hatchery had also been designed with visitor education in mind, by making it possible "to take large crowds through the building under the guidance of a ranger naturalist without in any way impairing the operations of the Bureau of Fisheries."

Yellowstone was the largest supplier of wild cutthroat trout eggs in the United States, and its waters received native and nonnative fish. A rift developed, however, between the federal fish agencies and the National Park Service, which began moving away from policies that allowed manipulation of Yellowstone's natural conditions. In 1936 Yellowstone managers prohibited the distribution of nonnative fish in waters that did not yet have them and opposed further hatchery constructions in the park's lakes and streams. After research showed that it impaired fish reproduction, egg collection was curtailed in 1953. Four years later, the fish hatchery ceased operations and the US Fish and Wildlife Service transferred ownership of the building to the National Park Service. Official stocking of park waters ended by 1959.

Today, vegetation and stream flow have largely reclaimed the rearing ponds on Hatchery Creek, but their outlines can still be detected, and the most serious results of fish planting are irreversible. Nonnative fish can alter aquatic ecology through interbreeding or competition with native species. Although its condition has deteriorated, the hatchery building has changed relatively little. Nearly all of the exterior and interior materials are original to the building or have been repaired in kind. Now used as a storage facility, it is the primary structure of the nine buildings in the Lake Fish Hatchery Historic District, which was listed on the National Register in 1985.

Rotenone drip station.

Native Fish Restoration Efforts

Yellowstone Cutthroat Trout

While the Yellowstone cutthroat trout is historically a Pacific drainage species, it has naturally traveled across the Continental Divide into the Atlantic drainage. One possible such passage in the Yellowstone area is Two Ocean Pass, south of the park in the Teton Wilderness. Habitat remains pristine within Yellowstone National Park, but nonnative fish species pose a serious threat to native fish. In Yellowstone Lake, lake trout are a major predator of cutthroat trout. In other waters, brown, brook, and rainbow trout all compete with cutthroat trout for food and habitat. Rainbow trout pose the additional threat of hybridizing with cutthroat trout.

Lamar River

Because no barriers to upstream fish migration exist in the mainstem Lamar River, descendants of rainbow trout stocked in the 1930s have spread to many locations across the watershed and hybridized with cutthroat trout. Genetic analysis indicates that cutthroat trout in the headwater reaches of the Lamar River remain genetically unaltered.

To protect the remaining Yellowstone cutthroat trout, the NPS has implemented a selective removal approach. A mandatory kill fishing regulation on all rainbow trout caught upstream of the Lamar River bridge was instituted in 2014. Currently regulations state that all nonnative fish and identifiable cutthroat x rainbow trout hybrids upstream of Knowles Falls must be killed. Selective removal by electrofishing has been conducted annually through the Lamar Valley since 2013. In 2019, 7% of fish sampled during electrofishing surveys upstream of the Lamar River Canyon were classified as rainbow or hybrid trout. This low percentage is a stark contrast to work conducted downstream of the Canyon.

In 2015, 136 fish were sampled downstream of the Lamar River bridge. Based on field identification, 48% were Yellowstone cutthroat trout, 19% were rainbow trout, and 31% were hybrids. The majority of these fish were tagged with radio transmitters or passive integrated transponder (PIT) tags as part of an ongoing research project to determine if Yellowstone cutthroat, rainbow, and hybrid trout are using the same areas to spawn and spawn timing and to inform management actions.

Slough Creek

In Slough Creek, rainbow-cutthroat trout hybrids have been found with increasing frequency over the past decade. Unlike the Lamar River, Slough Creek is smaller, and a barrier to upstream fish movement has been constructed. With a barrier in place and rainbow trout no longer allowed passage into the system, existing rainbow and hybrid trout can be effectively managed with angling and electrofishing removal.

Soda Butte Creek

Brook trout became established in Soda Butte Creek outside of the park boundary and spread downstream into park waters in the early 2000s. Initially, brook trout were isolated in headwater reaches by a chemical barrier created by mine contamination upstream of Cooke City, Montana. When the mine tailings were capped and water quality improved, brook trout passed downstream and began to negatively impact the cutthroat trout.

For nearly two decades, interagency electrofishing surveys were enough to keep brook trout populations

low but did not prevent range expansion. Over time, brook trout spread downstream and became a threat to the Lamar River. In addition, rainbow trout hybridization continued to be identified in cutthroat trout upstream of Ice Box Canyon.

In 2013, Ice Box Falls was modified to be a complete barrier to upstream fish movement, preventing further rainbow trout introgression. Rotenone, a fish toxin, was then used to remove all nonnative fish from the system. Nearly 450 brook trout were removed during the chemical treatment in 2015. Only two brook trout were collected from Soda Butte Creek during a second treatment in 2016. From 2017 through 2021, eDNA sampling as well as electrofishing surveys found no evidence of brook trout in the system. This is a good indication that a complete kill was achieved in the drainage. However, in 2022, following historic flooding in the system, brook trout were discovered.

In 2023, NPS, USFS, and MTFWP fisheries biologists worked to determine the spatial extent of the invasion, develop an action plan, and ultimately chemically treat Soda Butte Creek from the Yellowstone National Park boundary downstream to Ice Box Falls. Prior to chemical treatment, crews electrofished the stream and collected over 1,000 Yellowstone cutthroat trout and moved them to a holding location outside of the treatment area. Chemical treatment took place on August 16, and the stream was clear of chemical on August 17. The salvaged YCT were released back into the waters of Soda Butte Creek. The treatment appears to have been a success as all sentinel fish held in cages through the treated waters died within a few hours of receiving chemical. Continued monitoring of the system via electrofishing and eDNA sampling will take place over the next several years to confirm that all brook trout have been eliminated from Soda Butte Creek.

Elk Creek Complex

There is a natural cascade barrier in Elk Creek just upstream from its confluence with the Yellowstone River. The cascade prevented fish from naturally populating the system, so the Elk, Lost, and Yancey creeks complex of streams (Elk Creek Complex) was fishless when first stocked with cutthroat trout in the early 1920s. In 1942, the streams were stocked with brook trout, eventually resulting in the complete loss of cutthroat trout.

To restore YCT to the system, the Elk Creek Complex was treated with rotenone annually from 2012 to 2014 to remove the brook trout population. Once clear of brook trout, reintroduction of native Yellowstone cutthroat trout began. Antelope and Pebble creeks provided fish for restocking in October 2015. Additional stocking took place in 2016 and 2017. Natural reproduction was also documented in 2017 during electrofishing surveys. Semi-annual surveys of the Elk Creek Complex show that YCT are well established in the system and continue to naturally reproduce. No brook trout have been detected since the 2014 rotenone treatment

Arctic Grayling

One of the goals of the park's 2010 Native Fish Conservation Plan is to restore fluvial grayling to approximately 20% of their historical distribution. The upper reaches of Grayling Creek are considered the best site for immediate fluvial grayling restoration. Near the park boundary, a small waterfall exists in the creek (which flowed directly into the Madison River prior to the construction of Hebgen Dam in 1914).

The Grayling Creek restoration project aims to establish Arctic grayling and westslope cutthroat trout to 95 kilometers (59 miles) of connected stream habitat in one of the most remote drainages in the species historic range within Yellowstone.

During summer 2013, the waterfall was modified to prevent upstream movement of fish into the system. During August 2013, a crew of 27 biologists from Yellowstone National Park, Montana Fish, Wildlife and Parks, Gallatin National Forest, Turner Enterprises, and US Fish and Wildlife Service treated the stream segment with piscicide to remove all fish. A second treatment took place in 2014. Restocking the Grayling Creek watershed with native fluvial Arctic grayling and WCT began in 2015 and continued through 2017. The effort included moving approximately 950 juvenile and adult WCT to the lower reaches of Grayling Creek, above the project barrier. In addition, 54,200 WCT eggs and 210,000 fluvial grayling eggs were placed in remote-site incubators throughout the upper watershed. In 2018, park biologists and Montana State University researchers began to evaluate the success of reintroduction efforts on upper Grayling Creek. Preliminary results suggest that WCT are slowly repopulating the system, but grayling are struggling to establish a self-sustaining population.

From 2017–2021, park managers worked on a native fish restoration project in the upper Gibbon River drainage including Grebe, Wolf, and Ice lakes, and the Gibbon River upstream of Virginia Cascades. After removing nonnative species, biologists stocked more than 100,000 westslope cutthroat trout embryos and fish, and 170,000 Arctic grayling fry. An additional 7,000 grayling fry were stocked in Grebe Lake in 2023.

Angling has been highly successful for both species post-stocking, and natural reproduction was first documented for westslope cutthroat trout in 2022 and for Arctic grayling in 2023. Downstream dispersal of both species indicates the upper Gibbon River may serve as a fish source for the lower Gibbon and Madison rivers. Sites were established in 2023 to monitor native fish recovery and fish captured by electrofishing and angling were equipped with orange Floy tags to estimate abundance, survival, and movement patterns. Anglers who recapture tagged fish in Yellowstone are encouraged to report tag numbers and locations to assist with monitoring efforts.

Westslope Cutthroat Trout

Native species restoration depends on secure brood sources. A brood should be accessible, safe from contamination, self-sustaining, genetically diverse, abundant, of traceable origin, and pose no risk to existing wild populations.

In the park, genetically pure WCT only persisted in one tributary in the Madison River drainage (now called Last Chance Creek) and in the Oxbow/Geode Creek complex where they were introduced in the 1920s. In 2006, Yellowstone began efforts to restore WCT in East Fork Specimen Creek and introduce them into High Lake by constructing a fish barrier, removing nonnative fish, and stocking genetically pure WCT. In 2016 and 2018, surveys conducted throughout East Fork Specimen Creek indicated a naturally reproducing population of WCT, with all fish appearing healthy. Unfortunately research in 2019 revealed that hybridized fish have moved upstream of the constructed barrier, threatening the restored portion of the creek. The long-term goal for this watershed is to integrate East Fork Specimen Creek into a larger WCT restoration project that includes the North Fork to improve the resilience of this isolated population to natural threats. In 2021, the lower reaches of the East Fork Specimen Creek were chemically treated to remove all hybridized fish from this section of stream.

A range expansion project was conducted in Goose Lake and two other small, historically fishless lakes in the Firehole drainage. Nonnative fish removal was conducted in 2011 and staff stocked fry from 2013 to 2015. The long-term project goal is to one day use this pure WCT population as a brood source, providing offspring for restoration projects elsewhere within the upper Missouri River system. While WCT have been found in Goose Lake in low numbers, stocking efforts in the other two lakes have proven unsuccessful.

Another range expansion project is the upper Gibbon River. In 2017, native fish restoration began on the upper portion of Gibbon River, above Virginia Cascades. This project encompasses more than 21 stream miles and 232 lake acres (Wolf, Grebe, and Ice lakes). Since fall of 2017, park biologists have introduced approximately 75,000 WCT and 170,000 Arctic grayling to Wolf, Grebe, and Ice lakes and surrounding tributaries. Fish removal continued on the upper Gibbon River from 2018 through 2020 between Virginia Cascades and Wolf Lake. Removal of nonnative fish in this section was completed in 2020. Future restoration projects for WCT and Arctic grayling are proposed for North Fork Specimen and Cougar creeks. Once completed, native fish will be restored to an additional 61 km of stream waters.

Gillnetting Lake Trout

In 1995, after confirming lake trout were successfully reproducing in Yellowstone Lake, the NPS convened a panel of expert scientists to determine the likely extent of the problem, recommend actions, and identify research needs. The panel recommended that the

Since 2009, the park has contracted a commercial fishing company to increase the catch of lake trout.

park suppress lake trout to protect and restore native cutthroat trout. The panel also indicated that direct removal efforts such as gillnetting or trapnetting would be most effective but would require a long-term, possibly perpetual, commitment.

As initial gillnetting efforts expanded, the number of lake trout removed from the population also increased. This suggested the lake trout population was continuing to grow. In 2008 and 2011, scientific panels were convened to re-evaluate the program and goals. The panel concluded netting is still the most viable option for suppressing lake trout. Both reviews also indicated a considerable increase in suppression effort would be needed over many years to collapse the lake trout population.

Starting in 2009, the park contracted a commercial fishing company, to increase the take of lake trout through gillnetting. From 2011 to 2013, they also used large, live-entrapment nets that allow removal of large lake trout from shallow water while returning cutthroat trout to the lake with little mortality.

Discovery of New Species in Yellowstone Lake

On August 22, 2019, a gill net set in 158 feet of water northeast of Stevenson Island captured one fish of a new species not previously known to exist in Yellowstone Lake. This was a 3-year-old immature female cisco (*Coregonus artedi*). Based on otolith microchemistry, it likely hatched in Yellowstone Lake. Undoubtedly this species was illegally introduced to Yellowstone Lake, as the nearest source populations are in northern Montana and Minnesota. There are no existing waterways between Yellowstone Lake and any known cisco populations. In its native range, cisco are a preferred prey item for lake trout where the two species overlap. They prey mostly on aquatic invertebrates and tend to reside at mid-water depths. Fortunately, despite miles of gill nets, some specifically targeting cisco habitat, surface tows for larvae, eDNA sampling at 24 sites around the lake, and examination of thousands of lake trout stomachs, no other cisco have been found in Yellowstone Lake.

Fish Management Research

In 2010, Yellowstone developed the Native Fish Conservation Plan. This adaptive management plan guides efforts to recover native fish and restore natural ecosystem functions based on scientific assessment.

In 2011, the National Park Service and the US Geological Survey launched a movement study to target lake trout embryos in spawning beds and identify general and seasonal movement patterns. The results helped gillnet operators to target lake trout more efficiently.

In 2013, NPS and Montana State University conducted a mark-recapture study of lake trout in Yellowstone Lake. To estimate population size, 2,400 lake trout were tagged and released back into the lake. More than 5% of tagged fish were recaptured within the same fishing season. Results produced an estimate of the number of lake trout present in the lake: 367,650 fish greater than 210 millimeters (8.3 in.) long.

The mark-recapture study also helped estimate rates of capture for four size classes. This effort removed 72% of lake trout 210–451 millimeters (8.3–17.8 in.) in length, 56% for fish 451–541 millimeters (17.8–21.3 in.) long, 48% for fish 541–610 millimeters (21.3–24.0 in.) long, and 45% for fish more than 610 millimeters (>24.0 in.) long. These results supported previous estimates and highlighted the difficultly in catching older, mature lake trout, which eat the most native cutthroat trout and have the highest reproductive success. In 2022, we caught three lake trout which had originally been tagged in 2013 as part of this study.

More Information

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Hammerhead crew member holds a large lake trout from Yellowstone Lake.

Fish Management

As early as 1889, soon after the park was established in 1872, park managers started planting native fish in fishless waters and bringing nonnative species into the park. In the mid-1930s, the park stocking policy changed to exclude the stocking of nonnative fish species and selected waters were left "barren of fish." In the 1950s, the large-scale stocking of native species for recreational purposes was stopped in favor of wild fish management and native species conservation. However, by then over 300 million fish had been stocked in park waters and, nonnative species were firmly established in many lakes, rivers, and streams. To this day, nonnative fish are the biggest threat to the persistence of native fish in Yellowstone National Park and its surrounding waters.

An example of the significant negative consequences nonnative fish can have on an ecosystem is highlighted by the take-over of non-native lake trout in Yellowstone Lake. In 1994, lake trout were discovered in Yellowstone Lake. Soon after, park biologists confirmed that lake trout, a voracious predatory fish, were reproducing and proliferating at a rapid rate in Yellowstone Lake. It was also confirmed that larger lake trout were feeding heavily on native Yellowstone cutthroat trout, decimating the population of this native species in the lake. An expert panel suggested gillnetting would be the most effective method to remove lake trout to protect native Yellowstone cutthroat trout, although it would a require a long-term, possibly perpetual, commitment. The National Park Service agreed, and the lake trout control program was started.

Our Goals

- **We reduce the long-term extinction risk for Arctic grayling, westslope cutthroat trout, and Yellowstone cutthroat trout.** Nonnative brown, brook, and rainbow trout all compete with native species for food and habitat. Rainbow trout pose the additional threat of hybridizing with cutthroat trout. Lake trout are a primary predator of young fish, including Yellowstone cutthroat trout, in Yellowstone Lake.
- **We restore and maintain the important ecological role of native fishes.** Bald eagles, ospreys, pelicans, otters, grizzly bears, and other wildlife eat native fishes. Nonnative lake trout live and spawn in waters too deep for most of Yellowstone's predators.
- **We create sustainable native fish angling and viewing opportunities, delivering a world-class visitor experience.** Yellowstone Lake and the Yellowstone River together are home to the world's largest inland population of Yellowstone cutthroat trout. They're the most prized and highly regarded by visiting anglers.

Native Fish Conservation Plan

To reverse the decline in native fish populations in Yellowstone and restore ecosystem integrity, the National Park Service is implementing targeted actions to promote native fish recovery. The actions aim to conserve native fish species from threats of nonnative species, disease, and the impacts of climate change. Guided by scientific peer review and informed by an environmental assessment completed in 2010, the Native Fish Conservation Plan uses the best available methods to address threats to Yellowstone's native fisheries. The plan focuses on direct intervention and welcomes the assistance of visiting anglers.

Efforts in Yellowstone Lake Ecosystem

Since 1994, over 4.5 million lake trout have been removed from Yellowstone Lake. Gillnet operations provide important data about lake trout population, age, maturity, and potential spawning areas, which help control them more effectively. Accidental catching of native trout is minimized by fishing in deeper waters not typically used by Yellowstone cutthroat trout.

In partnership with Montana Fish, Wildlife & Parks, Yellowstone resumed the Soda Butte Creek Native Fish Restoration Project to remove newly discovered, nonnative brook trout.

The Future of Lake Trout Control

Although complete elimination of lake trout in Yellowstone Lake is not possible with today's tools, ongoing efforts can significantly decrease their numbers. Continued strong suppression efforts will reduce lake trout to a level where they have only minor impacts on Yellowstone cutthroat trout. Since lake trout can reproduce rapidly, their numbers are likely to rebound quickly without sustained suppression efforts.

Currently, gillnetting is the main method used to decrease lake trout numbers. Alongside partners at the US Geological Survey (USGS) Montana Cooperative Fishery Research Unit and Montana State University, methods to destroy lake trout eggs at their spawning sites are being explored. Several techniques have been tested, with spreading plant-based pellets over spawning sites to suffocate the eggs being the most promising. Early research suggests these pellets are easier to manage than other substances and effectively kill the embryos. While this method alone may not reduce overall lake trout numbers, it could be crucial for keeping their population down once control targets are reached and gillnetting can be reduced.

Efforts in Other Park Streams, Rivers, and Lakes

Competition, predation, and hybridization are the primary challenges posed by nonnative fish in other park streams, rivers, and lakes. Other concerns include habitat changes, diseases, and the impacts of climate change. Work involves isolating the project area, removing nonnative fish, and reintroducing genetically pure native species.

Using this method over 200,000 westslope cutthroat trout and 400,000 Arctic grayling have been introduced to 67.2 stream miles and 281 lake acres in the Gallatin and Madison watersheds since 2007.

Isolating a Project Area

Headwater refuges are important for native inland fish survival because in many instances, they offer isolation from nonnative fish. To create refuges where they don't exist, natural waterfalls are enhanced or artificial barriers are constructed to block fish from moving upstream.

Removing Nonnative Fish

Fish toxins (piscicides), like rotenone, are often used to control nonnative fish. Rotenone is toxic to gill-breathing organisms but relatively safe for humans and wildlife. To minimize the impacts to other aquatic life, park biologists conduct surveys to ensure the lowest effective concentration is used, time chemical use after amphibian metamorphosis, and neutralize the chemical at the end of the desired treatment area. Native fish are also temporarily removed using electrofishing and reintroduced once the water is safe.

Reintroducing Native Fish

Remote site incubators and live fish stocking are the two methods used for native fish reintroduction, each with advantages and limitations. To ensure long-term sustainability, park biologists monitor progress at project sites through population surveys. Different age classes of fish are collected to evaluate population health and confirm natural reproduction in years following stocking.

Remote Site Incubators

Gametes are obtained from native fish populations within and outside of the park. After fertilization, eggs are raised in hatcheries outside the park. Once reaching the eyed (near hatching) stage, the embryos are moved to remote site incubators (RSIs) in the park, where they will hatch and swim into the stream system. RSIs allow the fish to imprint to these streams, encouraging them to return as spawning adults. RSIs also make it possible to stock large numbers of fish with minimal effort.

Stocking

Stocking live fish involves transporting young fish (fry), juveniles, or adults from a hatchery or wild population to the project area. This method is low maintenance, swiftly restores recreational fishing, and is less susceptible to disturbances. However, it can be expensive in remote areas when helicopters are needed to transport fish. Additionally, stocked fish

Many people come to Yellowstone to fish.

may have lower survival and reproductive levels since they weren't imprinted within the project area waters.

Sport Fishing

Yellowstone supports some of the world's most famous fisheries and has been a destination for generations of anglers for over 150 years. Fishing regulations are designed to maintain native fish abundance and genetic integrity, the park's overall ecological integrity, and a recreational fishery for park visitors.

Examples of recent regulation changes include a "must kill" for lake trout and other nonnatives when caught in areas where they are harming native fish, "drought fishing" closures during periods of heat stress, and a ban on felt-soled wading boots to prevent introduction of harmful aquatic invasive species.

The Yellowstone Fly Fishing Volunteer Program

There are an estimated 2,650 miles of streams and 150 lakes with surface waters covering 5% of Yellowstone's 2.2 million total acres. The Yellowstone Fly Fishing Volunteer Program engages in "fly fishing for science" to aid fisheries biologists in their efforts to identify, maintain, enhance, and restore native fish populations throughout the park. Established in 2002, this approach allows Yellowstone's biologists to acquire data without having to travel to distant locations with electrofishing or other sophisticated gear.

FRENQUENTLY ASKED QUESTIONS

How many Lake trout were removed from Yellowstone Lake in 2024?

In 2024, the National Park Service and commercial crews removed a total of 260,650 lake trout. Catch rates were down in the small sized meshes but increased again for the large meshes, giving 2024 the highest catch rates we've seen in large meshes since 2015. Efforts will continue to focus on all sizes of lake trout while concentratingon these larger fish, aiming to reduce their numbers before they spawn.

How much support has Yellowstone Forever Provided to the Native Fish Conservation Program?

Since 2018, Yellowstone Forever—Yellowstone's official nonprofit partner—has provided a total of $4.3 million to the program.

Why don't Yellowstone predators eat lake trout?

Lake trout differ from cutthroat trout as potential prey because they are generally not available: they can grow larger, occupy deeper areas of the lake, and spawn in the lake instead of in shallow tributaries.

How did lake trout get into Yellowstone Lake?

Lake trout were introduced to Yellowstone Lake by unknown means in the mid-1980s and first appeared in angler catches in 1994. Otolith microchemistry and genetics research suggest they came from Lewis Lake.

How do you locate lake trout spawning sites in Yellowstone Lake?

We use a combination of likely habitat, relocations of lake trout equipped with acoustic transmitters, and gillnetting results.

How many miles of gillnet are deployed each year?

In recent years, miles of gillnet ranged from 5,000 to 6,000 miles per year.

What is a Judas fish?

A "Judas" fish is one who betrays his friends by leading others to them. In our case, it's a lake trout equipped with an acoustic transmitter who can help us find where concentrations of lake trout may be spawning.

How many people volunteered or the Fly Fishing Program in 2024?

In 2024, 65 volunteers spent 1,796 hours capturing, tagging, and recording Yellowstone cutthroat trout, rainbow and hybrid trout, in Slough Creek and Lamar River. Nonnative rainbow and hybrid trout were removed to support native fish recovery and assess angling as a method for long-term population monitoring. Volunteers also gathered data on the grayling population in Ice Lake and the upper Gibbon River watershed.

The lake trout, introduced to Yellowstone Lake, is one of several aquatic nonnative species having a significant detrimental effect on the park's aquatic ecology.

Aquatic Invasive Species

During the late 1880s when the Army administered Yellowstone, the US Fish Commission (a predecessor of today's US Fish and Wildlife Service) stocked nonnative fish in some park waters. These stockings are the first known, deliberate introductions of nonnative fish to Yellowstone.

Other aquatic invasive species (AIS), such as the New Zealand mud snail and the parasite causing whirling disease have arrived since. We may never know exactly how those species were introduced to the park, but it's likely they were carried here from other parts of the country by unwitting anglers.

New Zealand Mud Snails

The New Zealand mud snail (*Potamopyrgus antipodarum*) is an invasive species that was first found in the western United States in the 1980s. Their habitat includes flowing water and some geothermal streams. The snails can form dense colonies on aquatic vegetation and streambed rocks. This crowds out invertebrates that are a primary food for immature trout and other native species. New Zealand mud snails consume large amounts of algae, which is a primary food for native aquatic invertebrates. Its impact on algae is likely to affect entire stream food webs. With its protective shell, the mud snail provides little if any nutrition to its predators. It may pass through a fish alive. Scarcely a quarter-inch long, mud snails may cling to boats, trailers, waders, and other fishing gear. This gear can inadvertently transfer the snails to another waterbody. Because the species can reproduce asexually, a single mud snail is all that is required to establish a new colony.

Population

First detected in the park in 1994, New Zealand mud snails are now in all major watersheds. Although they are abundant in several streams, they are absent or uncommon in others. This suggests that the mud snail's upstream density and distribution is limited by spring runoff. Spring runoff can cause colder temperatures, low productivity, and unstable streambeds.

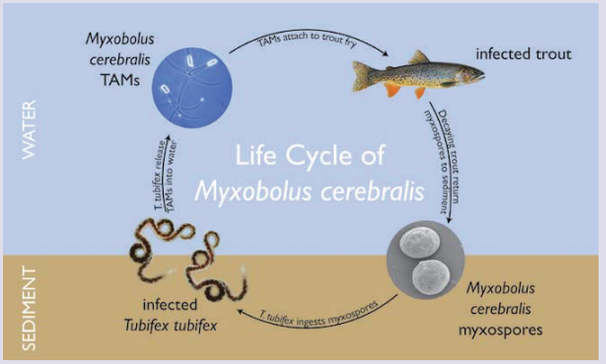
New Zealand mud snails shells resting on a dime.

Impacts of Mud Snails

Once mud snail colonies become established in a stream, removing them without disrupting native invertebrates is not possible. Mud snail research aims to determine the species' impacts on the aquatic ecosystem. A study of the Gibbon and Madison rivers found that 25–50% of the macroinvertebrates were mud snails. The areas they occupied had fewer native mayflies, stoneflies, and caddisflies. These insects are important in the diet of native fish and several bird species.

Whirling Disease

Whirling disease is caused by a microscopic parasite from Europe (*Myxobolus cerebralis*) that can infect some trout and salmon. It does not infect humans. Twenty-five states have detected whirling disease. During the parasite's life cycle, it takes on two different forms. Each form needs its own host. The triactinomyxon (TAM) form, develops in common aquatic worms (*Tubifex tubifex*) and is released into the water column. Once released they float with the current and can come into contact and attach to trout. Cutthroat trout are susceptible, especially during the



Whirling Disease

Description

- Caused by a microscopic parasite.
- Infected fish may have skeletal deformities and a blackened tail.
- Infected fish may have a whirling swimming behavior.

Habitat

- Early stage of the parasite's life cycle requires a widespread aquatic worm as a host.
- The second stage of life infects cutthroat trout.
- Young cutthroat trout are especially vulnerable.

Distribution

- Has been found in the Firehole, Madison, Gibbon, Lamar rivers and the Yellowstone Lake drainage.

first months of life. The parasite feeds on the trout's cartilage and develops into the myxospore form of the parasite. This can cause skeletal deformities, a blackened tail, and whirling swimming behavior. Because infected trout can't feed normally, and are more vulnerable to predation, whirling disease can be fatal. No practical treatment exists for trout infected with this disease or for the waters containing infected trout or tubificid worms.

Presence and Impact in Yellowstone

Whirling disease was first detected in Yellowstone in 1998 in cutthroat trout from Yellowstone Lake. The disease was described in Europe more than 100 years ago. It was detected in the United States in the mid-1950s before making its way to Yellowstone. It most likely came to the US in frozen fish products. In Yellowstone it has been found in the Firehole, Madison, Gibbon, Gallatin, and Lamar rivers and the Yellowstone Lake watershed. In the lake, the infection has spread to about 20% of cutthroat trout. The parasite is most prevalent in Pelican Creek and the Yellowstone River downstream of the lake. Infection has been most severe in Pelican Creek. This stream once supported nearly 30,000 upstream-migrating cutthroat trout. Whirling disease and nonnative lake trout that eat cutthroat trout in Yellowstone Lake are likely causes of this decline. Some adult cutthroat trout in Yellowstone Lake have survived their initial infection. This suggests some resilience to whirling disease among cutthroat trout.

Studying the Disease

Yellowstone's cutthroat trout spawning streams vary widely in thermal, hydrological, and geological characteristics. This provides an exceptional opportunity to study whirling disease in native trout. Park staff have been working with Montana State University's Department of Ecology to measure how the infection rate might vary in different stream conditions. Recent laboratory tests suggest cutthroat trout are highly susceptible to whirling disease. Lake trout and grayling appear immune to the disease. Brown trout are resistant to whirling disease but can carry the parasite to other species. Certain fish-eating birds have also been shown to disperse the parasite. Research has found that the parasite can pass alive through the digestive tract of some birds, such as great blue herons. Recent surveys showed that whirling disease risk was still very high in Pelican Creek. But it does not appear that whirling disease has spread widely throughout spawning tributaries to Yellowstone Lake. Also, prevalence of infection in young and adult cutthroat within the lake remains low. Despite this, there are still many unknowns about how the parasite functions in Yellowstone's unique environment.Park staff focus on prevention through education. Visitors who fish, boat, or swim are asked to take steps to help stop the spread of the disease. Thoroughly cleaning mud and aquatic vegetation from all equipment and footwear before moving to another drainage is the best prevention. Anglers should not transport fish or water between drainages. Fish should be cleaned in the body of water where they were caught.

Red-rimmed Melania

Red-rimmed melania (*Melanoides tuberculatus*), a small snail imported by the aquarium trade starting in the 1930s, were discovered in 2009 at the confluence of the Boiling River, a thermal spring, and the

Gardner River. Live snails were found downstream for approximately one kilometer. The following year, a survey of 18 similar thermal areas in the park found no additional melania. The species has a narrow temperature tolerance (18–32°C) and is unlikely to survive downstream of the Boiling River during the winter, but it could become established in other thermal water in the park.

The red-rimmed melania is a small snail imported by the aquarium trade beginning in the 1930s.

Aquatic Invasive Species of Concern

Many AIS species of concern are not yet present in Yellowstone, but they pose a grave and growing threat to the park and the Greater Yellowstone Ecosystem as they continue to spread into the surrounding states.

Further invasion of park waters by AIS could mean devastating effects on the Yellowstone's thriving and diverse aquatic ecosystem and detrimental impacts to recreational opportunities, waterways, and communities downstream. Yellowstone straddles the Continental Divide and headwaters that flow from the park drain to the Pacific and Atlantic oceans.

Zebra mussels removed during an inspection from a boat that was attempting to launch in Yellowstone waters.

Dreissenid Mussels

Both zebra mussels (*Dreissena polymorpha*) and closely related quagga mussels (*Dreissena bugensis*), are collectively called dreissenids. They are of particular concern because they can be spread easily and cause great harm. The mussels can attach to watercraft and survive many days out of water. Boaters must follow Clean, Drain, Dry to avoid unknowingly spreading them (more at **www.nps.gov/yell/learn/management/ais.htm**).

Zebra mussels are native to Eastern Europe and western Asia. They were first discovered in North America in 1988 in Lake St. Clair, one of the water bodies connecting the Great Lakes. It is believed they were introduced through ballast water discharges from international shipping.

Following their invasion, zebra mussels spread quickly across most of the eastern United States and Canada. Traveling boaters inadvertently spread the mussels from one body of water to another.

Zebra mussels drastically alter the ecology of infested water bodies. The effect on the ecosystem can be severe. These efficient filter-feeders consume significant amounts of phytoplankton. This depletes the foundation of the aquatic food web. Zebra mussels can attach to most hard surfaces, forming mats that may be up to 18 inches thick. Mussels can impact recreational activities and associated economies. They cover docks, boats, and beaches. Zebra mussels can also completely block water intake pipes. Blockages can severely damage power plants, water treatment plants, irrigation systems, and industrial facilities. Birds and fish that prey upon zebra mussels in Europe are not found in North America.

Smallmouth Bass

Smallmouth bass are an evolutionarily-advanced, prolific, and highly predatory fish species. They have caused severe losses of native fish populations in other North American locations where they have been introduced. Smallmouth bass will also prey upon many other native species, including macroinvertebrates, amphibians, reptiles, small mammals, and young waterbirds.

Warming river temperatures may have made the upstream movement of smallmouth bass easier in recent years. This could contribute to the species now being present at Yellowstone National Park's northern boundary. Climate-caused changes to river flows and temperatures may continue making it easier for smallmouth bass to move and live upriver. Of

USFWS

Zebra mussel colony.

particular concern is the ability of smallmouth bass to pass over natural cascades or waterfalls that often stop other fish species. If smallmouth bass move over the Knowles Falls of the Yellowstone River, they will eventually invade the Yellowstone River near Canyon Village. This would also allow them to enter the Lamar River watershed. Both are important habitats for native Yellowstone cutthroat trout. They are also some of the largest remaining strongholds for native Yellowstone cutthroat trout throughout their entire historical range in Montana, Idaho, and Wyoming.

Management may take actions to reduce further upstream invasion of smallmouth bass in Yellowstone National Park. Possible actions include education of park staff, outfitters, and anglers; incorporation of this new invasive species in the park angling regulations booklet; and/or population suppression by NPS biologists using electrofishing or other capture techniques. Any smallmouth bass caught by an angler in Yellowstone must be killed and reported.

Asian Carp

The bighead carp (*Hypophthalmichthys nobilis*), black carp (*Mylopharyngodon piceus*), and silver carp (*Hypophthalmichthys molitrix*) occur in at least 24 states. All three are types of Asian carp. They outcompete native fish, reduce forage for other fish, and can transmit disease. Silver carp can also jump great distances out of the water when boats travel near them. This can injure boaters.

Silver carp are native to Southeast Asia and east Russia. They were intentionally introduced into the United States in 1973 as an attempt to improve water quality, increase fish production in culture ponds, as biological control, and as a food fish. Silver carp now occur in at least 24 states and reproduce naturally. Both the silver and the bighead carp compete for food (zooplankton) with native fish.

Black carp are native to Asia and eastern Russia. These fish were unintentionally introduced as a stowaway with intentionally introduced grass carp. Black carp now occur in at least nine states. Black carp may reduce populations of native mussels and snails through predation. Fewer native mussels and snails harms the aquatic ecosystem. None of these species are currently found in Wyoming, or Montana.

These invasive species may continue to be spread intentionally or by accident. Accidental introductions happen through improperly using or disposing of live fish or fish eggs used as bait. Asian carp can also move to new areas through connected waterways.

Asian Clam

Asian clam (*Corbicula fluminea*) was introduced to the United States in 1938. It has spread into many of the major waterways of 46 states. The species have not been completely distinguished, but most varieties are small and yellow-green to light brown in color.

The native ranges are in temperate to tropical southern Asia west to the eastern Mediterranean; Africa, except in the Sahara Desert; and southeast Asian islands south into central and eastern Australia. The Asian clam is a filter feeder that removes particles from the water column. It is found at the sediment surface or slightly buried. The Asian clam can reproduce rapidly and has a low tolerance of cold temperatures (36–86°F/2-30°C). This can cause wild swings in population from year to year in northern water bodies.

Eurasian Watermilfoil

Eurasian watermilfoil (*Myriophyllum spicatum*) has spread to all the United States except Hawaii and Wyoming. In 2007, it was found in Montana.

This nonnative aquatic plant lives in calm waters such as lakes, ponds, and slow-moving parts of streams. It grows well in water with disturbances, sewage spills or abundant motorboat use, like Bridge Bay.

Eurasian watermilfoil is spread by stem fragments moved from one waterbody to another. Boats, gear, and trailers can all carry the stem fragments. Cleaning, rinsing, and inspecting these items before they enter Yellowstone can stop this spread.

Phytoplankton

Three nonnative plankton species that could harm Yellowstone may be on their way. These species can displace native zooplankton that are important food for cutthroat trout. The three nonnative zooplankton have long spines. The spines make them difficult for young fish to eat.

AIS Management

Aquatic invasive species (AIS) pose a grave and growing threat to the Greater Yellowstone Ecosystem. An AIS is a freshwater or marine organism that has spread or been introduced beyond its native range and is either causing harm or has the potential to cause harm. AIS can quickly and drastically transform habitats and food chains, causing permanent declines in fish and food resources for native wildlife. At least eight AIS already exist in Yellowstone's waters: New Zealand mud snail, red-rimmed melania, five nonnative fish, and whirling disease.

Our Goals

- **We promote aquatic invasive species awareness and communicate how to stop them.** Using Clean, Drain, Dry procedures is an effective way to stop the spread of AIS. Some invasive species, such as mussels, can survive as long as 30 days out of water (more at **www.nps.gov/yell/learn/management/ais.htm)**.
- **We work with partners to inspect incoming watercraft for aquatic invasive species.** Yellowstone National Park, Grand Teton National Park, and surrounding states aim to inspect all boats entering the region before launch to maximize protection of park and surrounding waters and minimize inconvenience to visitors.
- **We monitor Yellowstone waters for aquatic invasive species.** Early detection of AIS, including the use of environmental DNA surveys, can prevent the accidental spread to other areas.

Preventing Aquatic Invasive Species

Prevention is the best tool in AIS management. Once an AIS is established in an area, it's usually impossible to eradicate, or the eradication methods come with serious environmental consequences. Also, controlling an established population is difficult and expensive. Yellowstone works to prevent new AIS from entering the park through public education and awareness, a permit and inspection process, and aquatic resource monitoring.

To prevent the introduction of more aquatic nuisance species, park staff inspect all watercraft prior to launching in the water.

Education & Awareness

The Stop Aquatic Hitchhikers! national education campaign was launched by the Aquatic Nuisance Species Task Force in 2002. The goals of the campaign are to raise awareness, change behaviors, and build community capacity to stop the spread of aquatic invasive species across the United States and beyond. Currently, there is a network of over 1,400 campaign partners across the country.

As a proud campaign partner, Yellowstone empowers recreational users of aquatic resources to "Clean, Drain and Dry all watercraft, trailer, motors, and gear every time, everywhere."

Permits & Inspections

Yellowstone employs a team dedicated to inspecting all watercraft before launch. In combination with the efforts of responsible visitors who clean, drain, and dry their watercraft before arriving in Yellowstone, these inspectors provide a vital line of defense against aquatic invasive species. All watercraft, including angler float tubes and paddle boards, must pass a Yellowstone AIS inspection to receive a permit prior to launching.

Monitoring & Early Detection

Yellowstone biologists monitor the distribution of known AIS populations and screen for new populations or introductions. Monitoring efforts are

Incoming Threats

The greatest threat to Yellowstone's aquatic resources is from zebra and quagga mussels. Yellowstone, Wyoming, and Montana are currently mussel-free. To reduce the risk of spreading AIS, Wyoming and Montana have increased staff and inspection stations. Biologists from Yellowstone, Wyoming, and Montana will continueto monitor aquatic resources and may implement additional preventative measures.

If nonnative mussels are detected in the Greater Yellowstone Ecosystem or surrounding area, park managers will consider a temporary closure of all park waters to all watercraft.

If nonnative mussel larvae or adults are found in Yellowstone, all park waters would close to all watercraft (except authorized boats) to prevent the spread to other waterways. The park is currently developing an AIS rapid response plan.

Recent AIS Developments

- In 2024 zebra mussels were detected for the first time in the upper Colorado River system in the state of Colorado.
- In 2024 highly invasive golden mussels were discovered in California, the first detection of the species in North America. They tend to have similar impacts as quagga/zebra mussels where they establish outside of their native range.
- In 2023, invasive quagga mussels were found in the Snake River near Twin Falls, Idaho. In response, the state of Wyoming designated the entire reach of the Snake River from American Falls Reservoir downstream to CJ Strike Reservoir as a high-risk waterbody. As a result, a motor flush is now required for any motorized watercraft launched within this stretch of water in the last 30 days (a protocol that Yellowstone also adheres to).
- In 2023 a treatment was made of the mid Snake River in ID to eradicate quagga mussel populations. It was not successful. Another treatment was carried out in fall 2024, but it will not be known if it was successful until late 2025.
- In 2022 and 2023, adult zebra mussels were confirmed in new areas in South Dakota. One area was Pactola Reservoir in the Black Hills. The reservoir provides water for Rapid City, South Dakota, 13 miles to the east. This rules out draining the reservoir to control the mussels. The mussels are now just 27 miles from the Wyoming border. This prompted the state of Wyoming to close two nearby waterbodies to boating. Both Pactola Reservoir in South Dakota and the Snake River at Twin Falls, Idaho, are within a day's drive of Yellowstone.

focused on quagga and zebra mussels in waters open to boating or with high recreational use. Early detection of AIS is key to limiting the spread and preventing introduction into additional waterways. Park researchers utilize several techniques to monitor for AIS, including environmental DNA sampling, plankton sampling for veligers (the microscopic juvenile stage of mussels), and visual surveys for invasive plants and invertebrates.

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Staff Reviewers

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Amphibians are valuable indicators of environmental stressors such as disease or climate change. Researchers monitor amphibian populations in the park.

Amphibians

Amphibians are an important part of Yellowstone's aquatic and terrestrial ecosystems. Many of Yellowstone's reptiles, birds, mammals, and fish prey on larval and adult amphibians, and amphibians, in turn, eat a variety of vertebrate and invertebrate species. Amphibians are also sensitive to disease, pollution, drought, variations in annual snowpack, and the arrival of nonnative species; these documented sensitivities make them valuable indicators of environmental change. Amphibians often congregate in large numbers for breeding or overwintering. As a result, they can be adversely affected by localized disturbance or the loss of individual breeding or overwintering sites. Amphibian populations that are affected by one or more of these stresses may exhibit changes in their distribution or abundance. These changes can, in turn, have cascading effects on other aspects of the ecosystem.

Declines in amphibian populations are occurring globally in areas where habitat destruction is pervasive, but also in protected areas. About one-third of all amphibian species are believed to be threatened with extinction. Yellowstone includes some of the most climatologically and topographically complex landscapes in the lower 48 states and therefore provides a valuable study area to examine how climate may influence amphibian distribution and trends. Information about the status and trends of amphibians here may shed light on declines documented in other high-elevation locations or other protected areas around the West.

Population

Annual surveys since the early 2000s have documented four amphibian species as widely distributed in Yellowstone: boreal chorus frogs, Columbia spotted frogs, western tiger salamanders, and western toads occur in wetlands and ponds throughout Yellowstone. In 2014, the plains spadefoot (*Spea bombifrons*) was confirmed in Yellowstone through genetic analyses. Spadefoots are rarely seen because

Quick Facts

Number in Yellowstone
5 species: Western tiger salamander, boreal chorus frog, Western toad, Columbia spotted frog, and plains spadefoot.

Identification
Toads are not taxonomically different from frogs. The species called "toads" are associated with drier skin and more terrestrial habitats.

Status
- Columbia spotted and boreal chorus frogs are widely distributed with many breeding sites in the park.
- Western tiger salamanders are common and abundant on the northern range and in Hayden Valley.
- Western toads are abundant in some areas.
- None of the park's amphibians are federally listed as threatened or endangered.
- Scientists are concerned about the Western toad, which has declined sharply in other parts of the West.

Research
- 2000: Researchers begin inventorying amphibians.
- 2006: Long-term amphibian monitoring begins in Yellowstone.
- 2014: A breeding populaton of plains spadefoot (*Spea bombifrons*) was confirmed near Fountain Flat Drive.

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

they spend most daylight hours (and most of the year for that matter) underground. Currently, a single breeding population is known to exist within Yellowstone. However, monitoring efforts are under way to locate additional breeding sites because plains spadefoots typically do not disperse far from their natal pond.

In Yellowstone, amphibians depend on limited suitable habitat with shallow, quiet waters needed for egg laying and larval development. Annual differences in snowpack and precipitation change the extent and location of wetland sites, resulting in considerable year-to-year variation in amphibian reproduction. Breeding data collected across the park and since 2006 show that year-to-year variations in breeding are common. Multi-year monitoring data indicate that amphibian populations using small, shallow, isolated wetlands are most susceptible to drought or changes in precipitation. In contrast, amphibian populations occupying deeper wetlands and ponds appear to be more stable through time.

Since the 1950s, air temperatures have increased across this region and changes in the flooding patterns, or even the complete drying of wetlands, have been documented. Since 2006, annual visits to approximately 250 wetlands across Yellowstone have further documented annual variation in the availability of wetlands. These data suggest that in hot, dry years (e.g., 2007) upwards of 40% of the park's wetlands dry up. In cool, wet years (e.g., 2011), most wetlands across the park are flooded and available to support amphibian breeding. Further warming is anticipated for this region and could contribute to the drying of wetlands as well as influence the distribution and abundance of amphibians and other wetland-dependent species.

Disease agents, such as ranavirus and chytrid fungus (*Batrachochytrium dentrobatidis*), could also affect the survival and reproduction of amphibian populations in Yellowstone. Ranavirus has been found in tiger salamanders and Columbia spotted frogs collected from die-offs since 2008 and has also been involved with die-offs of all four widely distributed species in the region. Chytrid fungus usually appears in Columbia spotted frogs and western toads following metamorphosis and does not necessarily cause a fatal infection. The DNA of the chytrid fungus has been identified in skin swabs collected from both species in Yellowstone, though the impacts at the population level have not been determined. Since 2015, 44% of tissue samples (tail clips) collected from larval amphibians (frog and toad tadpoles) have tested positive for ranavirus. These findings highlight that several factors, including host susceptibility and environmental conditions, may determine whether an infection is lethal and results in a die-off or a decline in population abundance.

Amphibian or Reptile?

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

Studying Amphibians in Yellowstone

The Greater Yellowstone Network (GRYN) has led a collaborative monitoring of wetlands and amphibians in Yellowstone since 2006. Long-term monitoring of amphibian populations provides an opportunity to observe trends that may not be apparent at local scales or in areas with more direct human influences on habitat quality.

Amphibians are monitored at catchments (or watersheds) that average approximately 500 acres in size. On average, 31 catchments are revisited during annual monitoring visits (up to 24 in Yellowstone, and seven in neighboring Grand Teton National Park). All wetlands within the selected catchment are visited each summer, when two independent observers search for amphibians' breeding evidence (i.e., eggs, larvae, or recently metamorphosed individuals) and document important habitat characteristics and the presence or absence of surface water.

The objectives of GRYN's annual monitoring are to estimate the proportion of monitored catchments and wetlands used for breeding by each native amphibian species annually, to consider whether the rate and direction of use may be changing through time, and to document the number of wetlands within catchments that are potentially suitable for amphibian breeding.

This annual monitoring is then combined with local climate data to carefully examine the links among climate, wetlands, and amphibians. Taken

together, amphibian and wetland monitoring data from the past decade, coupled with local climate information, will help support predictions of amphibian occurrence under different climate scenarios.

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Western Tiger Salamander (*Ambystoma mavortium*)

Identification

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

Habitat

- Breeds in deeper ponds and fishless lakes.
- Widespread in Yellowstone in a great variety of habitats, with sizable populations on the northern range.

Behavior

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

Boreal Chorus Frog (*Pseudacris maculata*)

Identification

- Adults reach one to 1.5 inches in length, and females are usually larger than males; newly metamorphosed juveniles are less than one inch long.
- Brown, olive, tan, or green (sometimes bicolored) with a prominent black stripe on each side from the nostril through the eye and down the sides to the groin; three dark stripes down the back, often incomplete or broken into blotches.

Habitat

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

Behavior

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

Western Toad (*Anaxyrus boreas*)

Identification

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

Habitat

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

Behavior

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

Columbia Spotted Frog (*Rana luteiventris*)

Identification

- Common in deeper wetlands and beaver ponds.
- Maximum length is about 3.5 inches, newly metamorphosed juveniles less than one inch long.
- Upper surface of the adult is gray-brown to dark-olive to green, with irregular black spots; skin is bumpy; underside is cream-colored and may be splashed with brilliant orange on the thighs and arms.
- Tadpoles have long tails and may grow to three inches long.

Habitat

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

Behavior

- Breeds from April to early June, depending on temperatures and elevation.
- Tadpoles metamorphose between July and September.
- Tadpoles eat aquatic plants; adults eat mostly insects but, like many other adult amphibians, are highly opportunistic in their food habits.

Plains Spadefoot Toad (*Spea bombifrons*)

Identification

- A single breeding population has been identified in the Lower Geyser Basin east of Fairy Creek.
- Protruding eyes with vertical pupils, a prominent bony boss (raised bump) between the eyes.
- Has a single, dark tubercle, or "spade," on each of the hind feet.

Habitat

- Uses its spade to dig shallow summer burrows or deeper winter burrows. Newly metamorphosed animal may burrow in mud near its natal pond or hide in cracks in the hard earth.
- Typically occurs in warmer climates in the western United States. Scientists speculate that spadefoots are found in geothermally influenced habitat in Yellowstone because the warmer ambient conditions facilitate overwinter survival.

Behavior

- Breeds in ephemeral pools following significant rainfall.
- Tadpoles develop from eggs in two to six days.
- Produces cannibalistic and noncannibalistic tadpole body types.
- Tadpoles develop for three to six weeks before metamorphosis.

Reptiles are not well studied in Yellowstone National Park. The bullsnake (shown here) is one of six, and the largest, reptile species found in the park.

Reptiles

Yellowstone provides a valuable area for the study of reptiles. Information about the status and trends of reptiles here may shed light on declines documented in other high-elevation protected areas of the western United States. Many reptiles congregate to breed or overwinter, and they can be adversely affected by disturbance or loss of key sites.

Quick Facts

Number in Yellowstone

Reptiles are less studied than amphibians in Yellowstone. There are 6 confirmed species:

- bullsnake
- prairie rattlesnake
- rubber boa
- sagebrush lizard
- common garter snake
- terrestrial garter snake.

Status

- None of the park's reptiles are federally listed as threatened or endangered.
- Researchers began inventorying reptiles and amphibians in 2000.

Bullsnake (*Pituophis catenifer sayi*)

Identification

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

Habitat

- In Yellowstone, found at lower elevations; in drier, warmer climates; and in open areas , e.g., near Mammoth.

Behavior

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

Prairie Rattlesnake (*Crotalus viridis*)

Identification

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

Habitat and Behavior

- Only dangerously venomous snake in the park.
- Lives in the lower Yellowstone River areas of the park, including Reese Creek, Stephens Creek, and Rattlesnake Butte, where the habitat is drier and warmer than elsewhere in the park.
- Usually defensive rather than aggressive.
- Only two snake bites are known during the history of the park.

Rubber Boa (*Charina bottae*)

Identification

- Infrequently encountered in Yellowstone, perhaps due to its nocturnal and burrowing habits.
- One of two species of snakes in the United States related to tropical boa constrictors and pythons.
- Maximum length of 28 inches.
- Back is brown or greenish-brown, belly is lemon-yellow; scales are small and smooth, making it almost velvety to the touch.

Habitat and Behavior

- Eats small prey including mammals, amphibians, lizards, other snakes, and even small birds.
- May spend great deal of time partially buried under leaves and soil, and in rodent burrows.
- Usually found in rocky areas near streams or rivers with shrubs or trees nearby.
- Recent sightings have occurred in the Bechler region, Gibbon Meadows, and Old Faithful.

Similar species:

The racer (*Coluber constrictor)* can be found from southern British Columbia, east to Maine, and south across the United States to southern Florida and southern California. Racers, as their name implies, are fast and sleek snakes, unlike the slow-moving rubber boa.

Racers also have larger eyes than rubber boas and round pupils. Any sightings of this species should be reported to resource managers.

Sagebrush Lizard (*Sceloporus graciosus*)

Identification

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

Habitat

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

Behavior

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

Valley Gartersnake (*Thamnophis sirtalis fitchi*)

Identification

- Medium-sized snake up to 34 inches long.
- Nearly black or dark green base color with three bright yellow stripes running the length of the body; underside is pale yellow or bluish-gray.
- Most distinguishing characteristics of this species in this region are the irregular red spots along the sides.

Habitat

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

Behavior

- Generally active during the day.
- In the Yellowstone area, it eats mostly toads, chorus frogs, fish remains, and earthworms; can eat relatively poisonous species. Reliance on amphibian prey may contribute to reports of decline of this species in the greater Yellowstone area.
- Predators include fish, birds, and carnivorous mammals.

Wandering Gartersnake (*Thamnophis elegans vagrans*)

JEFF ARNOLD

Identification

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

Habitat

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

Behavior

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

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Carabid beetle

Insects

There are approximately 1.5 million described insect species in the world--three times the number of all other known species combined. Insects provide many critical ecosystem services, including pollinating native plant communities; providing a food source for hundreds of bird, amphibian, reptile, and mammal species; acting as primary and secondary decomposers; recycling nutrients to create organic soil; acting as predators and parasites to keep pest species in check; and providing economic benefits through crop pollination, honey, wax, silk, and other products. Despite these crucial functions, until recently insects in Yellowstone National Park were studied only opportunistically through external research projects.

Over the last several decades, insect studies have been conducted to document easily recognizable groups. The majority of groups, even at the order-level, remain understudied. Yellowstone has genus or species level records for the following orders:

- Coleoptera (beetles)—487
- Hymenoptera (bees, wasps, ants, and sawflies)—67 (365)
- Orthoptera (grasshoppers and cicadas)—51
- Diptera (true flies)—403
- Ephemeroptera (mayflies)—72
- Hemiptera (true bugs)—38
- Lepidoptera (moths and butterflies)—237
- Odonata (dragonflies)—47
- Plecoptera (stoneflies)—92
- Trichoptera (cad flies)—141
- Megaloptera (alderflies)—2

Quick Facts

- Insect diversity, abundance, trends, and baseline species list remain largely unknown.
- Until recently insects in Yellowstone were studied only opportunistically through external research projects.
- In 2018, The National Environmental Observatory Network (NEON) began to monitor ground beetle diversity, mosquitoes, and tick-borne disease in the park.
- YNP staff are replicating the NEON beetle monitoring protocols at seven Northern Range sites.
- There are approximately 1.5 million described insect species in the world--three times the number of all other known species combined.
- Insects provide many critical ecosystem services, including pollination, providing a food source, acting as decomposers, recycling nutrients, and acting as predators and parasites.

Recent analysis of a 27-year study in Germany, which is illustrative of global trends possibly found in Yellowstone National Park, documented an 82% mid-summer decline in flying insect biomass regardless of habitat type and unexplained by changes in weather, land use, or habitat characteristics. Except for a few groups like butterflies, bees and beetles, Yellowstone National Park insect diversity, abundance, trends, or baseline species lists remain largely unknown. Studies in the park have included the following: investigation of the respiratory physiology and thermal preference of water scavenger beetles in thermal features (2011–2013); benthic macroinvertebrate surveys to detect aquatic invasive species; annual butterfly counts (2003–ongoing); a thermal area tiger beetle project to investigate heavy metal metabolization (2017–ongoing); analysis of dragonfly larvae to detect methylmercury levels (2013–ongoing); a Bioblitz that documented 391 species (2009); a project that studied bee diversity and documented

350 species (2010–2012); and several insect studies that examined the effects of the 1988 fires and more recent beetle-kill forest die-offs. Recently, the western bumblebee (*Bombus occidentalis*), has become a candidate for listing under the Endangered Species Act, so a survey to document its occurrence in the park was conducted in 2017. Two high-elevation stoneflies, *Lednia tumana* and *Zapada glacier* are also candidate species for "Threatened" status.

In 2018 The National Environmental Observatory Network (NEON) initiated a 30-year project to monitor ground beetle diversity, mosquitoes, and tick-borne disease occurrence in the park. Yellowstone staff are replicating the NEON beetle monitoring protocols at seven Northern Range climate monitoring sites across an elevation gradient from 5,300 feet to 9,500 feet. This effort will examine a sentinel taxa (*Carabidae*) to infer population trends across other insect groups. Park staff are also collaborating with the Department of Agriculture to monitor grasshoppers, a potentially significant herbivore. It is currently unknown how the combination of climate change and the spread of invasive plant species will affect insects and native plant pollination, which are key to ecosystem functions supporting ungulate and bird habitat. Monitoring representative insect groups to detect changes over time is important. These studies will inform management actions to mitigate potential species loss.

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U.S. Department of the Interior
National Park Service

Yellowstone National Park

AURORA BOREALIS ABOVE CANARY SPRING
NPS Photo / Jacob W. Frank

YELLOWSTONE FOREVER

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