Yellowstone Center for Resources
Yellowstone National Park
Mammoth Hot Springs, Wyoming

National Park Service
U.S. Department of the Interior

YELLOWSTONE NATIONAL PARK
Natural & Cultural Resources

VITAL SIGNS

2013

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National Park Service
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Yellowstone Center for Resources

Enabling Legislation (16 U.S.C. § 22): The Yellowstone National Park Act of 1872 "dedicated and set aside" land in portions of Idaho, Montana, and Wyoming "as a public park or pleasuring ground for the benefit and enjoyment of the people." Congress placed the land and resources of the park "under the exclusive control of the Secretary of the Interior" and directed the Secretary to set forth rules and regulations "to provide for the preservation ... of all timber, mineral deposits, natural curiosities, or wonders within said park, and their retention in their natural condition." Congress also declared that the Secretary "shall provide against the wanton destruction of the fish and game found within said park, and against their capture or destruction for the purposes of merchandise or profit." In addition, Congress (30 U.S.C. 1026) declared all of Yellowstone National Park a "significant thermal feature" and stated that "The secretary shall maintain a monitoring program for significant thermal features within the units of the National Park System."

Mission Statement: The Center for Resources will work to protect and manage the fundamental natural and cultural resources and values of Yellowstone National Park, including its unique geothermal systems and geologic wonders, one of the largest remaining intact ecosystems in the United States, and its extensive human history to provide for the education, enjoyment, and inspiration of people. The Center for Resources will share their expertise with other park operations to the benefit of the visiting public.

Foreword

Yellowstone continues to function as a dynamic and exciting system. Just as the status of resources changes, so too will this year's Vital Signs Report. Traditionally, we have reported on a suite of natural resource vital signs, all of which were integral to understanding the park's ecosystem. However, something had been missing: the status of Yellowstone National Park's incredible cultural resources. As the world's first national park, rich in America's history, we steward and continue to use an incredible collection of historic structures–over 800 in total–that help tell the story of transportation, lodging, and park management. The park also contains more than 1600 known archeological sites that demonstrate at least 10,000 years of evidence showing deep human connections with the ecosystem. Hundreds of thousands of historic documents, ethnographic artifacts, fossils, pieces of clothing, souvenirs, and works of art also reside in the park's museum collections, providing priceless data and precious stories on the park's rich history. Highlights from this year's report include:

Climate: Precipitation data suggest that we are still in a long-term drought. Recent data support a continued trend of warming with average low temperatures increasing by 4.6 degrees since 1989.

Bears: Grizzly bear numbers appear to be stable in the GYE this year; supporting recent discussion that bears have reached carrying capacity in the ecosystem.

Wolves and elk: Elk surveyed along the northern range of Yellowstone continued to decline as a result of multiple factors, but show signs of stabilizing at a new low. The number of wolves that spend most of their time in Yellowstone National Park declined slightly.

Bison: The conservation of Yellowstone bison continues to be successful with population numbers over 4000 bison.

Historic structure conditions and archeological sites: Historic structure assessments of the 880 buildings, roads, bridges and grave markers have been completed for 80 percent of the sites. About 77 percent of historic structures and 65 percent of known archeological sites are in "good" condition.

Native fish: There are signs that the number of Yellowstone cutthroat trout in Yellowstone Lake is increasing. Efforts to reduce the population of non-native lake trout have resulted in the removal of over 1 million lake trout from Yellowstone Lake. Artic grayling and westslope cutthroat trout restoration efforts began in 2013 as part of the native fish preservation effort.

Over the last two years, we have also spent time evaluating the feasibility of establishing management targets, versus reporting on reference conditions. That's been challenging; it's not easy to determine the target population of trumpeter swans or the percent of suitable wetland habitat occupied by boreal toads, especially in an ecosystem that is expected to be dynamic and is now faced with an unprecedented rate of change in climate and habitat conditions. Some would even say that it is not appropriate in a national park, where our goals are largely to put the pieces of the ecosystem into place and then allow natural processes to prevail. So, our discussions on this topic will continue as we build understanding of the Yellowstone system through the scientific process.

It is a great pleasure to introduce the 2013 Natural and Cultural Resources Vital Signs Report.

David E. Hallac
Chief, Yellowstone Center for Resources

Wolves, ravens, and a grizzly bear vie to feed upon a carcass.

Why We Monitor the Park's Vital Signs

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's other landscapes, waters, and wildlife was largely taken for granted. As development throughout the West increased, however, the park's 2.2 million acres of forests, meadows, river valleys, and lakes became an important sanctuary for the largest concentration of wildlife in the lower 48 states.

The abundance and distribution of these animal species depends on their interactions with each other and on the quality of their habitat, 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 in elevation and underlain by volcanic bedrock, a terrain that is covered with snow for much of the year and supports forests dominated by lodgepole pine and interspersed with alpine meadows. Sagebrush steppe and grasslands on the park's lower-elevation northern range provide essential winter range for elk, bison, and bighorn sheep.

One of the management goals for Yellowstone is to minimize human interference with its ecological processes. To determine whether changes that take place in the park are a result of its ecology or of human influences (within or outside the park) requires systematic monitoring. The survival of some animal species depends on seasonal migration or other use of habitat that extends beyond the park's boundaries. Within the park, plant and animal species that have been introduced deliberately or accidentally can reduce the presence of native species through competition, predation, or disease.

To monitor changes in the condition of the park's resources, we pay particular attention to certain vital signs that are considered key ecosystem indicators. Although the data that have been collected for some of these vital signs may be too short term to indicate significant trends, this report summarizes 26 vital signs for which information is available for use in decisions about managing the park.

Natural Resource Vital Signs

Yellowstone's vital signs are grouped into four categories for purposes of this report. They include:

- **Ecosystem drivers** (climate, fire, and geothermal activity) are primarily the result of natural processes that operate on a distinctly larger scale than the park.
- **Environmental quality**, as measured by air and water quality, can be affected by human activities both within and outside the park, as well as by fires and geothermal influences in the park.
- **Native species** selected as vital signs include plants and animals that
  - are or have been listed under the federal Endangered Species Act (bald eagle, gray wolf, and grizzly bear)
  - have experienced significant declines in the park (arctic grayling, trumpeter swan, western cutthroat trout, whitebark pine, Yellowstone cutthroat trout)
  - have relatively small populations in the park and are considered vulnerable to sudden declines (bighorn sheep, pronghorn)
  - have a significant impact on the ecosystem and park management based on such factors as their large number, size, and movement outside the park, or where they are harvested (bison and elk).

– are considered important indicators of ecosystem health because they are especially sensitive to environmental pollutants, habitat alteration, and climate change (amphibians)
- **Stressors** (nonnative plants and animals, wildlife disease, park visitation, land use) are like ecosystem drivers in that they are change agents, but their impact is typically smaller in scale and generally caused or largely influenced by human activity.

Some of the park's vital signs are the focus of major management plans to
- restore or significantly increase a population to historical levels (arctic grayling, westslope cutthroat trout, Yellowstone cutthroat trout);
- protect a restored species (wolves and grizzly bears) or
- control unwanted impacts (bison, fire, lake trout and other aquatic nuisance species, invasive plants, and winter air quality and soundscape).

The natural resource vital signs are monitored by park staff with help from other federal and state agencies, university scientists, and the Greater Yellowstone Inventory and Monitoring Network, which includes Grand Teton National Park and Bighorn Canyon National Recreation Area, and is one of 32 networks the National Park Service has established to facilitate collaboration among natural resource agencies. Data are collected from aerial and ground surveys and automated equipment. In cases where surveying an entire animal or plant population is not feasible, estimates are arrived at through sampling. For wide-ranging species such as wolves and grizzly bears, monitoring is coordinated within the Greater Yellowstone Ecosystem (GYE).

Cultural Resource Vital Signs

Although natural resources have been the focus of NPS inventory and monitoring programs, park staff are also responsible for preserving the knowledge and tangible assets that embody the human history of the park. Whereas natural resources are expected to change over time as part of a dynamic ecosystem—we monitor them to identify trends—cultural resources are ideally kept as intact as possible. Cultural resources must be inventoried so that we know what requires protection, and monitored to ensure that these artifacts and the information associated with them are passed along to future generations. Cultural traditions will continue to evolve and historic buildings may be put to new uses, but maintaining the park's cultural resources increases our understanding of how Yellowstone came to be the place it is today.

Comparison to Reference Conditions

The table on the following page summarizes the current status of 26 vital signs. In most cases, a reference condition is indicated that can be used for comparison purposes. Because conditions in the park may fluctuate widely over time in response to natural factors, the reference condition is not considered the "desired" condition unless it is one that has been specified by government regulation or a plan prepared under the National Environmental Policy Act or the Endangered Species Act. In other cases, the reference condition simply provides a measure for understanding the current condition, e.g., a historical range or scientific opinion as to the level needed to maintain biological viability.

Collecting fleas from a squirrel to test for pathogens.

This obsidian point was found in the southern part of the park in 2013. From the Paleoindian period, it is the oldest point yet found in the park.

Vital Signs Summary

✸ = Current Condition is not within Reference Condition. TBD = to be determined

Vital Sign	Indicators	Current Condition 2012 (or latest available)	Reference Condition
Ecosystem Drivers			
Climate	Average min., max. daily temp. (Mammoth) Annual precipitation (Mammoth) Drought index (Mammoth) Growing degree days (Mammoth) Peak snow water equivalent (Canyon) Peak streamflow (Corwin Springs)	31°F, 55°F 14.4” –0.2 3,212 13.0" 17,900 ft^3 per second	27°F, 52°F (1971–2000 average) 14.6” (1971–2000 average) -2.0 to +2.0 (1894–2012) 2,731 (1971–2000 average) 14.3” (1983–2012 average) 12,500 (1971–2000 median)
Fire	Acres burned per year	6,232 acres	1–28,849 (1990–2005 range)
Geothermal System	Annual discharge of chloride through major rivers	Discharge within natural variation (2010)	47.5 to 60.0 billion grams per year (range 1984–2010).
Subsurface Geology	Earthquakes per year Annual ground deformation in caldera	698 earthquakes up to 5 cm subsidence (2010 to 2012)	154–3,572 (range 1985–2012) TBD
Environmental Quality			
Air Quality	Visibility (deciviews) Ozone (W126) Nitrogen in precipitation (kg/ha/yr) Sulfur in precipitation (kg/ha/yr)	3.1 (2010) ✸ 10.5 ppm-hr (2010) ✸ 1.9 (2010) ✸ 0.8 (2010)	< 2 deciviews < 7 ppm-hr < 1.4 kg/ha/yr < 1 kg/ha/yr
Winter Air Quality	West Entrance CO, maximum 1-hour average Old Faithful $PM_{2.5}$, maximum 24-hour average	12.6 ppm (2013) 4.4 $PM_{2.5}$ $\mu g/m^3$ (2013)	28 ppm 28 ppm
Water Quality	Basic water quality parameters at 18 sites Reese Creek base flow, April 15–October 15 Soda Butte iron concentration	Unimpaired 2.3 ft^3/sec (average) 0.11 to 16.7 mg/L ✸	State water quality standards ≥ 1.3 ft^3/sec (minimum) ≤ 1.0 mg/L
Native Species			
Amphibians	% of potential sites suitable for breeding % of catchments occupied by boreal toads % of major drainages with 4 native species	75% 53% 60% ✸	TBD TBD 100%
Bald Eagles	Breeding pairs	22 pairs	22 pairs
Bighorn Sheep	Northern range count; lambs per 100 ewes	378 sheep, 39 lambs	300–500 sheep
Bison	Estimated summer population	4,230 bison	2,500–4,500 bison
Elk	Northern range winter count	3,915 (2013) ✸	4,000–15,000 elk
Gray Wolves	Wolves in Wyoming Breeding pairs in Wyoming	243 (83 in park) 19 pairs (6 in park)	≥ 150 wolves ≥ 15 pairs
Grizzly Bears	GYE population estimate Distribution of females with cubs Annual mortality: Adult female • Adult male • Dependent young (human-caused only)	610 (≈150 in park) 18 bear management units 13%, 6% (2011, 2012) 29%, 15%, 21% (2010–2012) 4%, 4%, 3% (2010–12)	≥ 500 grizzly bears ≥16 bear management units not > 9% for 2 consecutive years not >15% for 3 consecutive years not > 9% for 3 consecutive years
Pronghorn	Northern range spring count	351 pronghorn (2013)	300–600 pronghorn
Trumpeter Swans	Resident adults and subadults, fall count Nesting pairs	16 swans ✸ 2 pairs ✸	40 swans 10 pairs
Arctic Grayling	Occupied stream habitat	0 km ✸	≥ 200 stream km
Westslope Cutthroat	Occupied historical habitat	~10 stream km ✸	≥ 200 stream km
Yellowstone Cutthroat Trout (YCT)	Average no. per net in fall assessment Average no. observed in spawning streams Average no. caught per hour by anglers	10.7 YCT ✸ 2.76 YCT ✸ 0.55 YCT ✸	≥15 YCT ≥ 60 YCT ≥ 2 YCT
Whitebark Pine	Blister rust infection (% of trees in the GYE) Pine beetle infestation (in the park)	20%–30% of trees 6,362 acres (2011)	TBD 0–41,000 (range 1983–2011)

Vital Sign	Indicators	Current Condition 2012 (or latest available)	Reference Condition
Stressors			
Nonnative Plants and Animals			
• Aquatic Nuisance Species	TBD	TBD	TBD
• Invasive Plants	TBD	TBD	TBD
• Lake Trout	Annual reduction, Yell. Lake population	~0% (preventing increase) ✸	25% annual reduction
• Mountain Goats	Estimated population in and near the park	200–300 goats ✸	0
Wildlife Diseases			
• Brucellosis	Estimated seroprevalence in elk and bison	< 5% in elk, 40–60% in bison	0
• Chronic Wasting Disease	Presence in deer and elk	Not evident	0
• Chytrid Fungus	Prevalence in sampled amphibians	45%	0
• Parvovirus and Mange	Presence in wolves	Some mange present	0
• West Nile Virus	Presence in birds	Not evident	0
• White Nose Syndrome	Presence in bats	Not evident	0
Direct Human Impacts			
• Land Use	Road and home density	TBD	TBD
• Visitor Use	Annual visitation	3.4 million ✸	2.8–3.3 million (2000–2009 range)
• Winter Soundscape	% time OSVs are audible, 8 AM to 4 PM	66% (OF), 45% (Madison J)	TBD

Cultural Resources			
Archeological Sites	Percentage of park inventoried	< 3% of the park	TBD
	Percentage of documented sites in good condition	65%	TBD
Museum Collections	Percentage that has been catalogued	34%	100%
Historic Structures	Percentage assessed in good condition	77%	100%

Grand Prismatic Spring

Climate

Precipitation has been declining in many locations throughout the Greater Yellowstone Area in recent decades as temperatures have been increasing.

- Total annual precipitation at the Mammoth Hot Springs since 1976 has been generally below the long-term mean of 15.3 inches.
- At the Northeast Entrance, the 5-year running mean of the average annual daily minimum temperature has increased by 4.6˚F and the average annual daily maximum temperature by 3.5˚F since 1989.

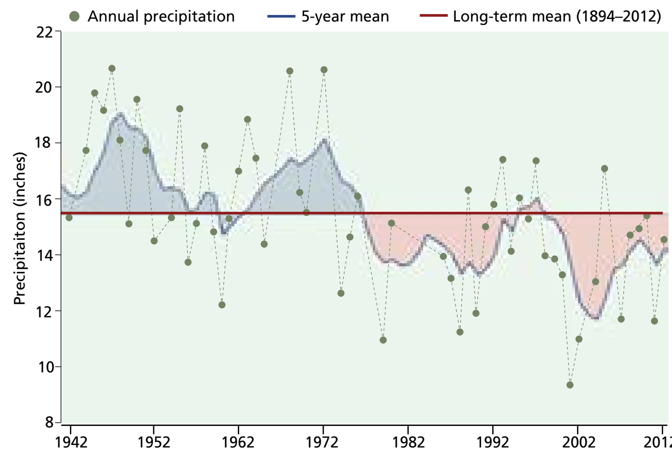
Warmer, drier conditions lead to less snowpack.

- The 5-year running mean of annual peak snowpack (expressed as snow water equivalent, SWE) at the Northeast Entrance has declined 22% since 1975 (from 14.5 inches to 11.3 inches).

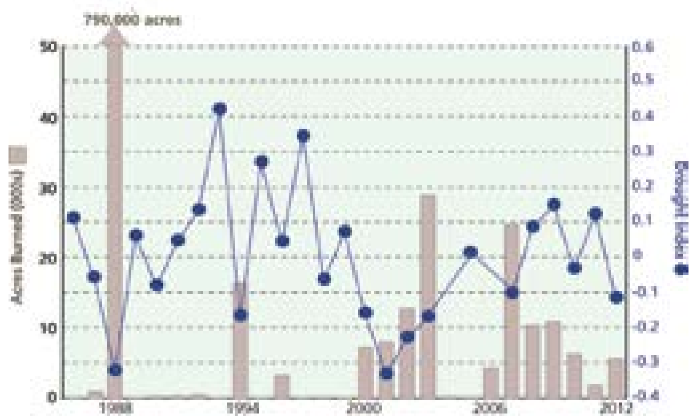
Snowy conditions have been prevailing for a shorter period during the year.

- The 10-year running mean of winter length (annual number of days with SWE > 0) has decreased from 208 in 1980 to 185 days in 2012.

Regional climate trends are monitored by Yellowstone Center for Resources and the Greater Yellowstone Inventory and Monitoring Network.



Annual precipitation at Mammoth Hot Springs 1942–2012, the 5-year running mean, and the long-term mean.



Acres burned in Yellowstone and the annual Reconnaisance Drought Index, which is based on cumulative precipitation and potential evapotranspiration, 1983–2012.

Fire

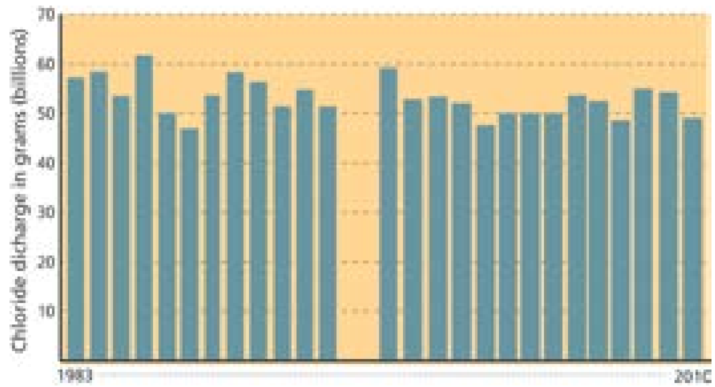
As monitored by Yellowstone's Wildland Fire Management Program, annual fire activity has fluctuated between less than one acre and nearly 29,000 acres since 1988. In 2012, a total of 5,612 acres burned as a result of 18 known wildland fire starts, of which 6 were considered the accidental result of human activity (campfire, vehicle, cigarette). Four of the fires went out quickly on their own, two were suppressed, and the others, including the largest (3,540 acres), were allowed to burn while monitoring for public safety. Park policy is to allow naturally ignited fires to burn, but suppress fires that are human caused or endanger people or property, taking weather conditions into consideration. Although the frequency and size of fires is affected by many factors, including wind conditions when a spark ignites, more acres are likely to burn during low-moisture summers.

Indian Pond, August 1994

Geothermal Systems

Energy and groundwater development outside the park, especially in the known geothermal areas of Island Park, Idaho, and Corwin Springs, Montana, could alter the function of hydrothermal systems in Yellowstone. The National Park Service is required by law to protect the park's world-unique, hydrothermal resource from the effects of such development. One method to monitor overall changes in the park's hydrothermal system is to measure the total amount of chloride leaving the park through its major rivers (Snake River, Madison River, Yellowstone River, and Fall River). Because chloride is postulated to be primarily sourced from the park's deeper hydrothermal reservoirs, variations in the total amount of chloride discharged per year may indicate changes in the hydrothermal system.

The graph shows the annual variation in chloride discharge from 1983 to 2010. Chemical analyses for 2011 and 2012 are pending. Although total chloride varied from 47.5 to 60.0 billion grams per year during this period, the data show no simple increasing or decreasing trend. The variation in total chloride shown in the graph is considered within the natural variation in Yellowstone's surface water, groundwater, and hydrothermal systems.



Total annual chloride discharge from Yellowstone's major rivers from 1983 to 2010. (No samples collected in 1995 and 1996.)

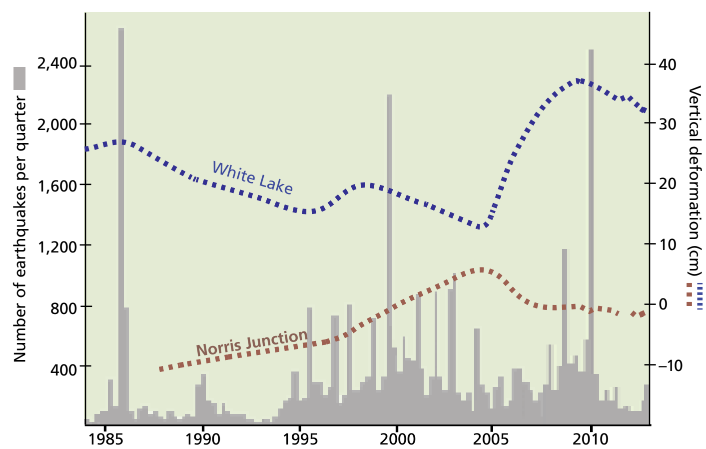
Subsurface Geology

Although a cataclysmic eruption of the Yellowstone volcano is unlikely in the foreseeable future, monitoring of seismic activity, ground deformation, and changes in geothermal water chemistry by the Yellowstone Volcano Observatory Consortium provides information to the public and government agencies.

- Approximately 698 earthquakes occurred in the general area of Yellowstone National Park in 2012.
- This compares to approximately 670 earthquakes in 2011 and 3,254 in 2010.

Beginning in 2004, GPS and InSAR measurements indicated that parts of the Yellowstone caldera were rising up to 7 cm per year as an area near the northern caldera boundary began to subside.

- From 2004 to 2010, the largest vertical movement was recorded at the White Lake GPS station, inside the caldera's eastern rim, where the total uplift was about 27 cm.
- From 2010 to 2012, the caldera has subsided about 5 cm at White Lake. Some episodes of uplift and subsidence have been correlated with the frequency of earthquakes in the park.



Number of earthquakes in the park each calendar quarter and vertical movement recorded at White Lake and Norris Junction.

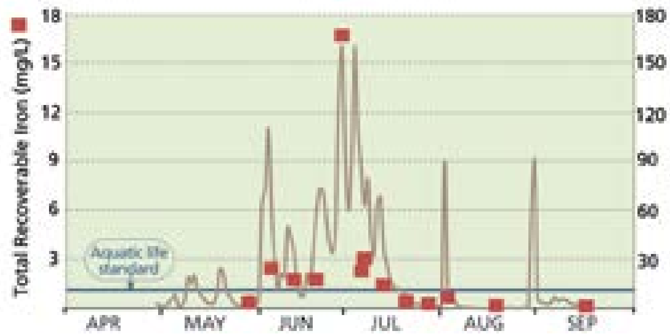

Thermal runnoff channel

Water Quality

All water bodies within Yellowstone National Park are classified as Outstanding Natural Resource Waters. Park staff monitor water temperature, dissolved oxygen, pH, specific conductance, turbidity, and total suspended solids at 11 stream and 7 lake sites in the park. Despite naturally high levels of arsenic associated with geothermal activity, nearly all monitored sites meet or exceed national and state water quality standards.

The state of Montana has found that a portion of Reese Creek on the park's northern boundary only partially supports cold water aquatic life. The suspected cause of the impairment to the creek, where Yellowstone cutthroat trout are present, is periodic dewatering associated with irrigation activities outside the park. In 2012, streamflow peaked in early June at 24.6 cubic feet per second, but because of a low snowpack the average summer base flow was only 2.3 cfs. No observations of dewatering occurred in 2012.

As a result of mining activity 8 km from the park, tailings remain in the Soda Butte Creek floodplain, impairing the segment that extends downstream to the park boundary. Because of its impaired status, park staff periodically measure the total and dissolved arsenic, copper, iron, and selenium in the water. Iron concentrations at the park boundary exceeded the Montana standard for aquatic life (1.0 mg/L total recoverable iron) during 7 of 13 site visits in 2011. The highest concentrations detected occurred during high stream flows.



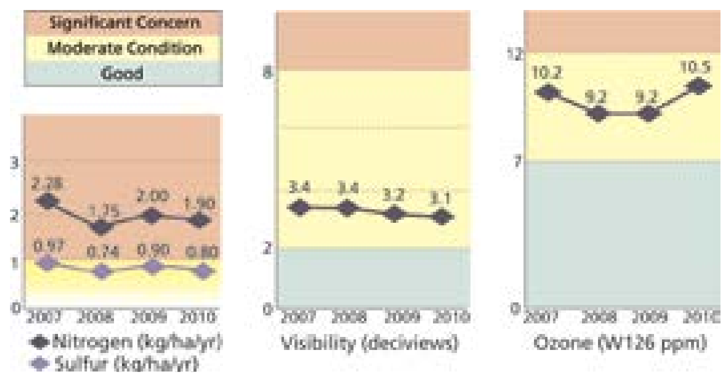
Iron concentrations and turbidity at Soda Butte Creek at the park boundary, 2011.

Air Quality

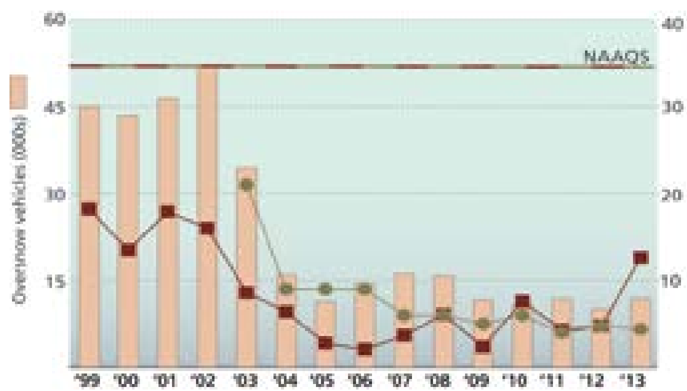
As a federally designated Class I airshed, Yellowstone is required to meet high standards for air quality. NPS Air Resources Division data indicate that the park is in compliance with federal standards for human health for ozone, sulfur dioxide, and particulate matter. However, air quality trends may be affecting other aspects of the ecosystem. For example, nitrogen in precipitation has increased at many Western sites as a result of ammonium ion concentrations associated with fertilizer use and feedlots. By stimulating plant growth, nitrogen can alter species abundance and distribution.

Ground-level ozone is produced by the reaction of ultraviolet radiation with nitrogen oxides and volatile organic compounds emitted by fossil fuel combustion, fire, and other sources that may be located far away. Ozone concentrations in Yellowstone peak in spring rather than summer, suggesting that human influences are less significant than changes in atmospheric circulation and lengthening daylight. However, ozone levels during the growing season (W126 exposure) may be high enough to cause biomass loss in sensitive species such as aspen.

Winter Air Quality. Carbon monoxide (CO) and particulate matter ($PM_{2.5}$) are monitored at West Yellowstone and Old Faithful, where oversnow vehicles (OSVs) are most concentrated. These pollutants have declined since 2002 as a result of fewer snowmobiles in the park and the "Best Available Technology" (BAT) requirement. Peak $PM_{2.5}$ levels during the day do not coincide with peak OSV use, indicating that other sources such as wood stoves contribute to them. Nitrogen deposition is emerging as an issue because although the BAT-required 4-stroke engines emit less CO than 2-stroke snowmobiles, they emit about 15 times more nitrogen dioxide.



Five-year averages as of 2007 to 2010 in Yellowstone relative to categories set by the NPS Air Resources Division. Total natural wet deposition in the West is estimated to be 0.13 kg/ha/yr.



For 1999 to 2013, OSVs entering the West Entrance and maximum one-hour average CO levels at the West Entrance and 24-hour $PM_{2.5}$ levels (98th percentile) at Old Faithful compared to national air quality standards (NAAQS). The spike in CO value for 2013 was 3 times higher than levels previously noted but still well below the NAAQS of 35. This reading may be a byproduct of the vagaries of meterology.

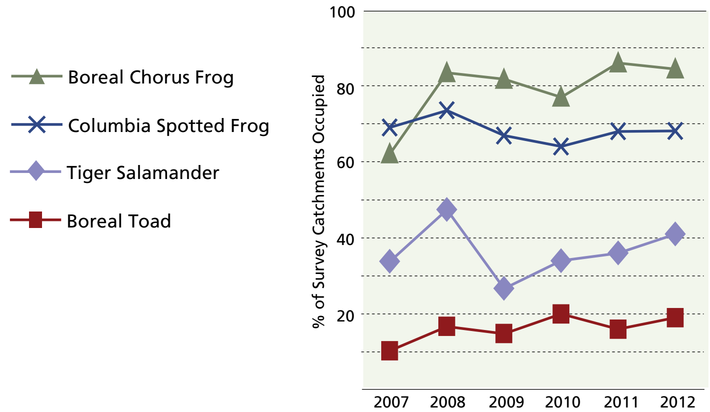
Amphibians

Annual surveys since 2002 have identified four species of native amphibians in Yellowstone and Grand Teton national parks: the barred tiger salamander, boreal toad, boreal chorus frog, and Columbia spotted frog. The boreal chorus frog may be the most widespread species in Yellowstone and Grand Teton; it was detected in 84% of surveyed catchments in 2012. Species occurrence in the catchments surveyed since 2007 shows some annual variation, but suggests that amphibian occupancy in these catchments has remained largely the same.

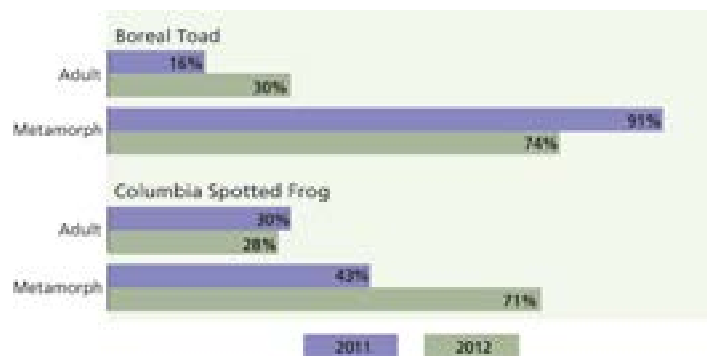
The hydrological fluctuations that result from annual meteorological variations alter the extent and mosaic of wetland breeding sites, which can affect amphibian reproduction. The percentage of visited wetland sites that supported surface water suitable for breeding was 86% in 2010, 96% in 2011, and dropped to 75% in 2012. All four native species require wetlands, but individual habitat needs differ and may leave some species more vulnerable to changes in wetland condition (e.g., cumulative loss of seasonal water bodies or shrinkage of year-round ponds).

Disease agents, such as ranavirus and a chytrid fungus, *Batrachochytrium dendrobatidis (Bd)*, could affect the survival and reproduction of amphibian populations in Yellowstone. Ranavirus typically affects larval amphibians, with the sudden onset of infection resulting in clusters of dead animals observed at the same location and time of year in subsequent years. Ranavirus has been isolated from tiger salamanders and Columbia spotted frogs collected from die-offs since 2008, with several specimens showing abnormalities typically associated with the infection.

In contrast, presence of the fungus *Bd* does not necessarily cause a fatal infection (the disease chytridiomycosis) and usually appears in Columbia spotted frogs and boreal toads following metamorphosis. Testing of 493 skin swabs collected from live Columbia spotted frogs and boreal toads at 26 survey sites in 2011 and 2012 identified *Bd* at 18 of the sites and in 45% of the samples. Evidence of infection was found shortly after the frogs and the toads completed metamorphosis, with the prevalence greater in adults. Impacts at the population level have not been determined.



Monitoring results for Yellowstone and Grand Teton national parks by the Greater Yellowstone Inventory and Monitoring Network.



Prevalence of *Batrachochytrium dendrobatidis* infection in 493 live boreal toads and Columbia spotted frogs sampled at 26 sites in Yellowstone National Park.

Several factors, including host susceptibility and environmental conditions, may determine whether an infection is lethal and results in population decline.

Boreal toad and Columbia spotted frog (photos by Jeff Arnold); boreal chorus frog and tiger salamander (photos by Jay Fleming).

Bison

Reduced by poaching to fewer than 50 bison by 1900, the Yellowstone population grew to more than 2,000 by the 1980s and expanded its use of lower elevation winter range outside the park. The National Park Service manages these bison like other migratory wildlife in Yellowstone. Park managers recognized that the bison population had been restored in the GYE, and began to collaborate with the state of Montana and the Gallatin National Forest on landscape-level management strategies. Interagency boundary control operations to resolve conflicts with neighboring jurisdictions are conducted near Gardiner and West Yellowstone, Montana, to minimize the risk of brucellosis transmission to cattle on nearby ranches. These interagency actions culled 4,100 bison from the population from 2000 to 2012, while maintaining an average summer population of 3,885.

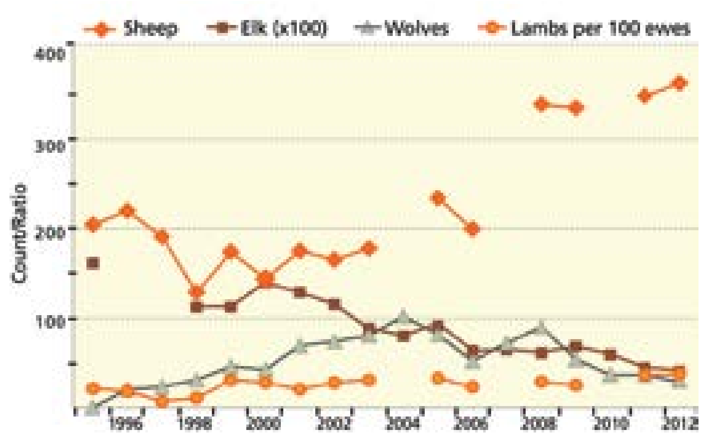
The conservation of Yellowstone bison has been relatively successful under the Interagency Bison Management Plan; since 2005 summer abundance has fluctuated between 2,432 and 5,015. The bison migrate in large herds and disperse across an extensive landscape where they are subject to competitive interactions with native ungulates, survival challenges from native predators, and other natural selection factors such as competition for mates and environmental variability. The population is reproductively prolific, growing at an average annual rate of 9%, and has recovered rapidly from decreases in abundance due to culling or natural mortality.

There are concerns that continued large-scale culls could affect the subpopulation structure, demographic rates, and genetic diversity. Yellowstone bison have a relatively high degree of genetic variation that could be maintained for centuries with a population averaging 3,000 to 3,500 bison. Also, adaptive management adjustments since 2005 have increased the spatial and temporal tolerance for bison on habitat in Montana. Disagreements among agency partners about the best management strategy to implement continue, but all agree that a systematic adaptive management process is the best way to achieve the collective goals of all partners, including the conservation of wild, migratory Yellowstone bison.

The number of bison killed each winter, including those taken by hunters; the number held at the park boundary and released later that winter or spring; and the estimated population the following summer, 1984–2012.

Bighorn Sheep

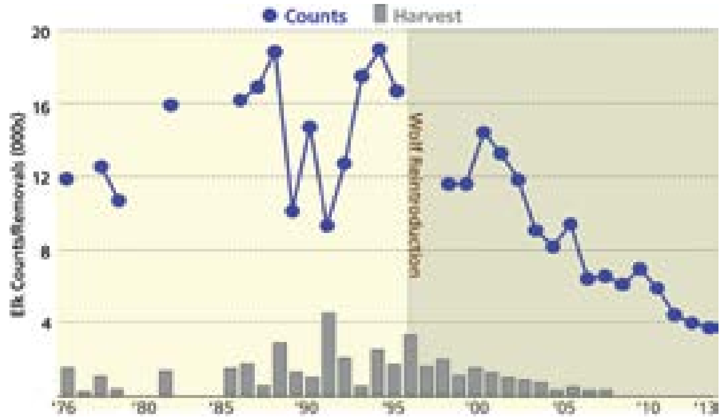
About 10 to 13 interbreeding bands of bighorn sheep occupy steep terrain in the upper Yellowstone River drainage, including habitat that extends more than 20 miles north of the park. From the 1890s to the mid-1960s, this bighorn sheep population size fluctuated between 100 and 400. The count reached a high of 487 in 1981, but a pinkeye epidemic reduced the population by 60% the following winter. After dropping to a low of 134 sheep following the severe winter of 1996–97, the overall trend has been upward. The 2012 count by the Northern Yellowstone Cooperative Wildlife Working Group (NYCWWG) was 378, with 39 lambs per 100 ewes, which is above average for this population. 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.



Northern range counts of bighorn sheep, lambs, elk, and wolves, 1995–2012.

Elk on the Northern Range

Yellowstone's largest elk herd winters in the area of the park's northern boundary. After decades of debate over whether this range was overgrazed by too many elk, there is now concern over the decreasing size fo the herd. The winter count by the NYC-WWG, 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 decreased from 94 in 2007 to 79 by the end of 2012. The elk count decreased to 4,174 in early 2012, the lowest since culling ended in the park in the 1960s. In addition to wolf predation, the recent elk population decline has been attributed to a growing bear population and possibly drought-related effects from 1998 to 2006. The state of Montana has reduced the hunting permits issued for this herd so that harvest now has little impact on population size.



Winter counts and hunting harvests of the northern elk herd in Yellowstone and adjacent areas of Montana, 1976–2012.

Pronghorn

Fluctuations in the northern range pronghorn population show the effects of management interventions, shifts in forage availability, and predation. Efforts to keep pronghorn in the park with fences and winter feeding actually reduced pronghorn abundance in the 1920s. During that time, the pronghorn also abandoned the use of their migration routes, remaining on the range in the park year- round. Between 1947 and 1967, about 1,200 pronghorn were removed to address perceived sagebrush habitat degradation. The population experienced another sudden decline in the 1990s. The reason for this decline are unclear, though there may be several contributing factors. Between 1985 and 2002, about 190 pronghorn were removed from private land because of crop depredation; fawn survival rates were low due to coyote predation; and the quantity and quality of winter range habitat decreased. The pronghorn winter range in the park is former agricultural land infested with nonnative vegetation that provides low-quality nutrition, and winter range north of the park has been reduced due to private land development. Recent evidence of migration and dispersal into Paradise Valley and mixing with pronghorn herds outside the park should improve the long-term viability of the Yellowstone population.

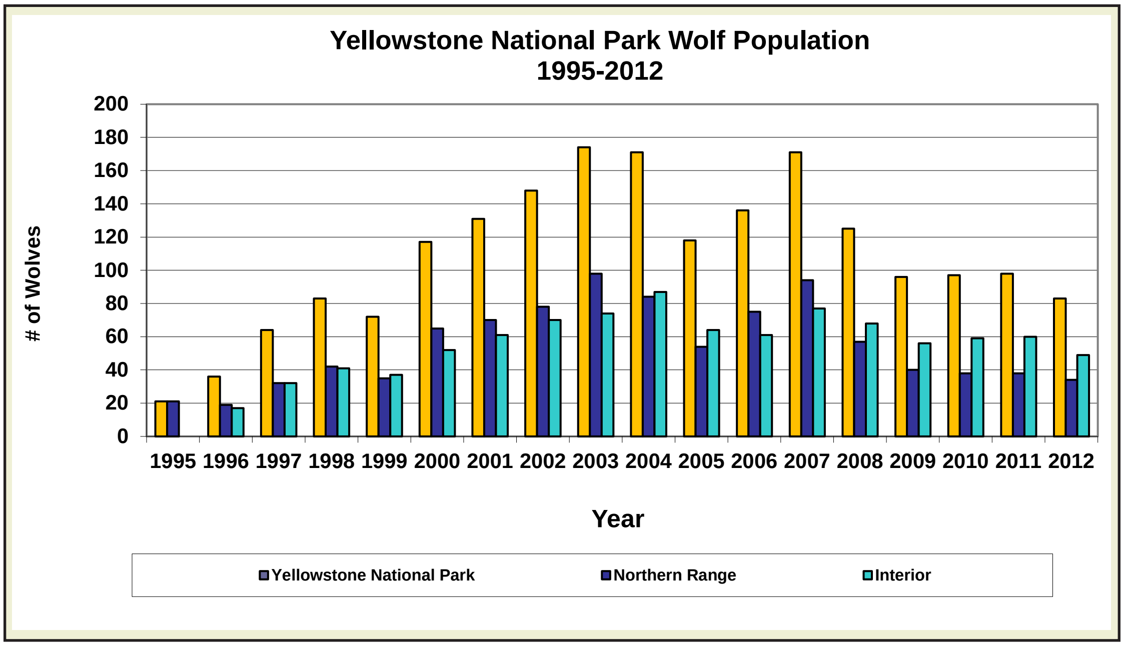
Pronghorn removals and spring counts in Yellowstone and adjacent areas of Montana, 1918–2013. The most recent count in April 2013 was 351, the highest since 1991.


Pronghorn doe near the north entrance of the park.

Gray Wolves

Predator eradication programs eliminated wolf packs from Yellowstone by 1926, and by 1978, all wolf subspecies were on the federal endangered species list for the lower 48 states except Minnesota. When restoration began in Yellowstone in 1995, the wolf population grew rapidly as the newly formed packs spread out to establish territories with sufficient prey, primarily elk. The wolf count in the Greater Yellowstone Recovery Area was more than 500 wolves at 2012 year end, including 83 wolves (10 packs and 6 breeding pairs) occupying territories located primarily in the park. The population has dropped substantially since 2007, when the count was 171. Most of the decrease has been in packs on the northern range, where there has also been a decrease in elk numbers. The gray wolf was removed from the endangered species list in Idaho and Montana in 2011, and in Wyoming in 2012.

Wolf counts for the Greater Yellowstone Recovery Area, Wyoming, and Yellowstone National Park. One of the recovery criteria is a population of at least 150 wolves in Wyoming. Licensed wolf hunting began outside the park in 2011 in Idaho and Montana, and in 2012 in Wyoming.



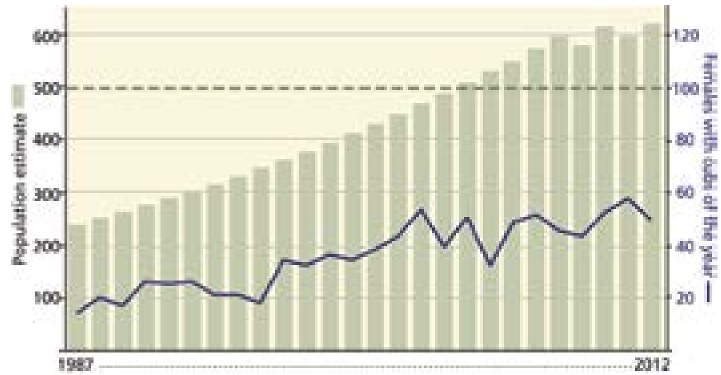
Wolf counts for Yellowstone National Park since recovery efforts began in 1995.

Grizzly Bears

Predator eradication programs had eliminated grizzly bears from most of the western U.S. by the 1950s. Due to its isolation, Yellowstone National Park became one of the last refuges for grizzly bears south of the Canadian border. Following establishment of the park, garbage became a significant food source for bears. To return bears to a diet of native foods, garbage dumps in the Greater Yellowstone Ecosystem (GYE) were closed in the 1960s and 1970s. Following the dump closures, human-caused mortality increased significantly and the population declined from an estimated 312 grizzly bears prior to the dump closures to 136 bears in 1975. That same year the grizzly bear was federally listed as a threatened species.

Intensive conservation efforts over the next 33 years allowed bears to make a remarkable recovery. As of December 2012, the GYE grizzly population was estimated at 610 bears. There are more grizzly bears today (610), occupying a larger area (19,305 mi^2), than there were in the late 1960s prior to the closure of the garbage dumps (312 bears occupying 7,813 mi^2). Grizzly bears have reoccupied areas from which they have been absent for decades. In the park, cub survival has significantly exceeded human-caused mortality in 24 of the last 25 years. Although park visitation increases almost every decade and now averages about 3.5 million visitors annually, bear attacks on people and incidents of bears damaging property remain low. Bear attacks on people average 1 per year, while incidents of bears damaging property average 5 per year. The high visibility of bears foraging native foods in roadside meadows has made the park one of the most popular bear viewing destinations in the world.

Whitebark pine, a preferred fall food for grizzly bears, has declined over the last decade due to an outbreak of mountain pine beetle, raising concerns for the bears' future. Although no one can predict for certain how declines in whitebark pine will affect grizzly bear population demographics, grizzly bears are well suited to adapt to changes in the abundance of individual foods. Since whitebark pine is a masting species that does not produce a seed crop every year, past poor seed production years provide an indication of what bears might rely on in the fall if whitebark pine becomes functionally extinct. GYE grizzly bears currently consume more ungulate meat and eat more roots and false truffles during years with poor whitebark pine seed production. Research is ongoing to determine how whitebark pine seed production influences grizzly bear reproduction and survival. The U.S. Fish and Wildlife Service will use the outcome of this research to determine if GYE grizzly bears warrant delisting from their federal status as a threatened species in the lower 48 states.

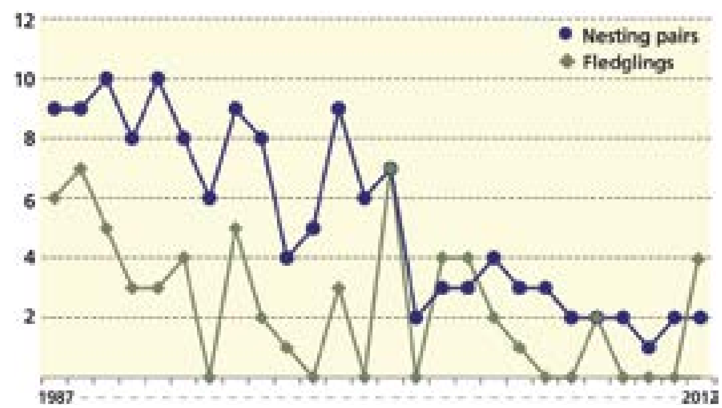


Counts of grizzly bear females with cubs of the year and total population estimate within the USFWS-designated Yellowstone Ecosystem Suitable Habitat, 1987–2012. One of the recovery criteria for this area is an estimated population of at least 500 grizzly bears.

Trumpeter Swans

Nearly all Rocky Mountain trumpeter swans, including several thousand that migrate from Canada, winter in ice-free waters in the greater Yellowstone area, but only a small portion remain in the area to build their nests. The park's resident trumpeter swan population increased after counts began in 1931 and peaked at 69 in 1961. The number dropped after cessation of the feeding program and draining of winter ponds at Red Rock Lakes National Wildlife Refuge in the early 1990s to only 16 in 2012.

The best available scientific evidence suggests that Yellowstone provides marginal conditions for trumpeter swan nesting and acts as a sink for swans dispersing from more productive areas (that is, the swan population in Yellowstone does not produce enough offspring to maintain iself without an influx from other populations). This effect has been compounded in recent decades by habitat changes (e.g., decreased wetlands due to long-term drought or warmer temperatures) and community dynamics (e.g., recovery of wolf, bear, and raptors that prey on swans). Trumpeter swan presence in the park may be primarily limited to occasional residents and wintering migrants from outside the park. However, a nesting platform constructed at Grebe Lake in 2011 was used by a pair the following spring, resulting in the first fledglings at that lake since 1952.

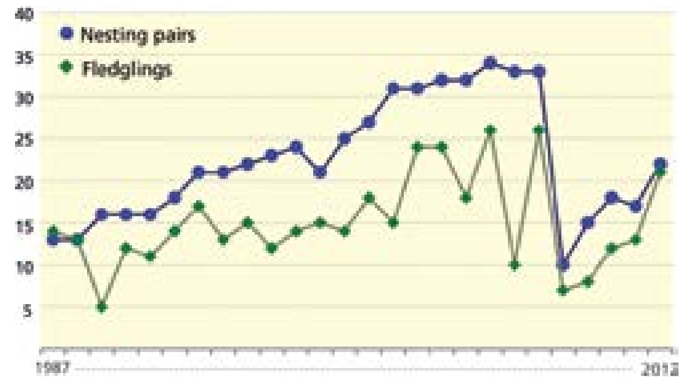


Counts of trumpeter swan nest attempts and fledglings in Yellowstone National Park, 1987–2012. Four of the seven cygnets produced in 2012 fledged and survived at least until the fall.

Bald Eagles

Bald eagles, which may reuse the same nest year after year, occupy territories near the park's major rivers and lakes. Juveniles may migrate to warmer habitat in the fall, but adults often stay in the park year-round. Winter numbers in the park are increased by the arrival of bald eagles that breed farther north. The number of eaglets that fledge each year depends partly on weather and can fluctuate widely. Of the 36 territories monitored during aerial surveys in 2010, 18 appeared to have bald eagle pairs engaged in nesting activity. Eaglets were observed in nine nests, and 12 fledglings were later counted.

The reproductive rates of bald eagles in the park is stable. More than half of the known bald eagle nests in the park are located near Yellowstone Lake where, the productivity and nesting success rates in recent years have generally been much lower than those of bald eagles elsewhere in the park. During 2012, however, nesting success for both areas was the same, about 64%.

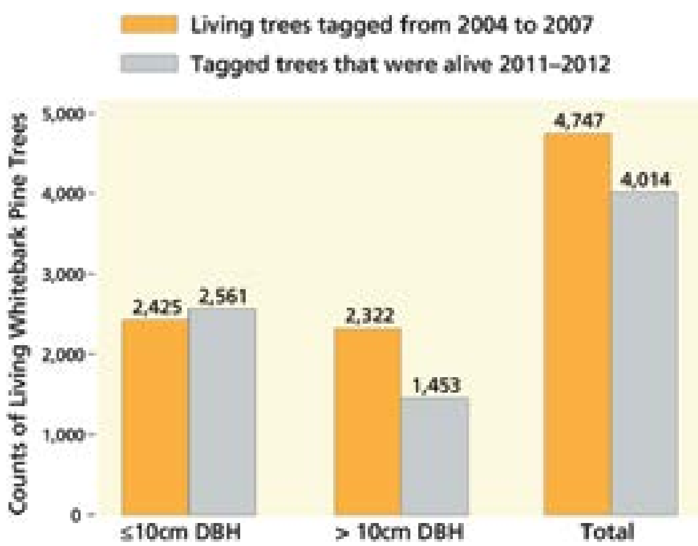


Counts of bald eagle nesting pairs and fledglings in Yellowstone National Park, 1987–2012.

Whitebark Pine

Whitebark pine, a high-elevation keystone species that promotes ecological community diversity and produces seeds that are an important food source for grizzly bears and other wildlife, has been experiencing significant mortality throughout its range in the Rocky Mountains. The primary causes of mortality are blister rust, (*Cronartium ribicola*, an introduced pathogen), infestations by an endemic pine beetle, and abiotic factors associated with wildland fire and climate change.

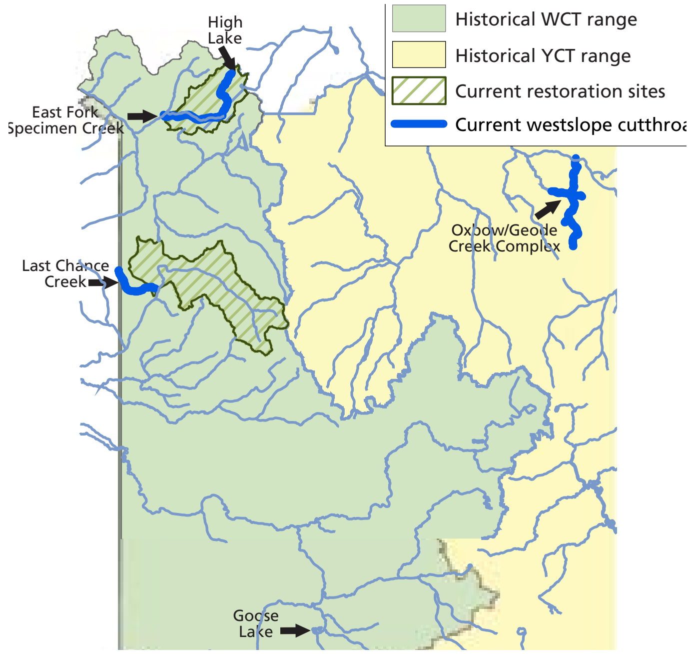
As part of an interagency long-term monitoring program in the Greater Yellowstone Ecosystem, living whitebark pine trees taller than 1.4 m were tagged in 176 belt transects from 2004 through 2007. Results through 2012 show a 5% increase in the number of monitored trees with a diameter at breast height less than 10 cm. The mortality in this size group (9.6%) was offset by the over 370 newly tagged trees that had grown taller than 1.4 m since the transects were established. The larger trees (> 10 cm diameter) had a higher rate of mortality (37.4%).



The monitoring program recorded observations of various indicators identified collectively and independently as factors in tree mortality, including mountain pine beetles, blister rust, fire, and windfall. Based on the surveys, it is estimated that 20-30% of whitebark pines in the Greater Yellowstone are infected with blister rust. Mountain pine beetle activity and whitebark pine mortality have been more evident in large trees, which the beetles appear to prefer for laying their eggs; the larvae feed on the inner phloem of the bark. The rate of new attacks in the park began increasing in about 2000, peaked from 2007 to 2009, and since then has declined.

Westslope Cutthroat Trout

The stocking of competing and interbreeding species of fish led to the near elimination of westslope cutthroat trout (WCT) from park streams by the 1930s. In most of its remaining habitat (64% of the approximately 641 stream miles it previously occupied in the park), it exists only in a hybridized form. Three of the four known pure wild populations that remain are in the park. They have persisted in Last Chance Creek, a tributary in the Madison River drainage, and in the Oxbow/Geode Creek complex, Yellowstone River tributaries where they are not within their native range and were likely introduced in the 1920s. The project to restore WCT to High Lake and East Fork Specimen Creek, began in 2006 and was completed in 2012 using fish from park populations and Upper Missouri River broodstock. In 2011, efforts began at Goose Lake to establish a self-sustaining broodstock in the park using Last Chance Creek and other upper Missouri River wild populations. The Goose Lake broodstock will be used in restoration projects like those that have begun in 2012 in Grayling Creek, which will restore WCT as well as Arctic grayling to an immense, remote stronghold over the next decade.

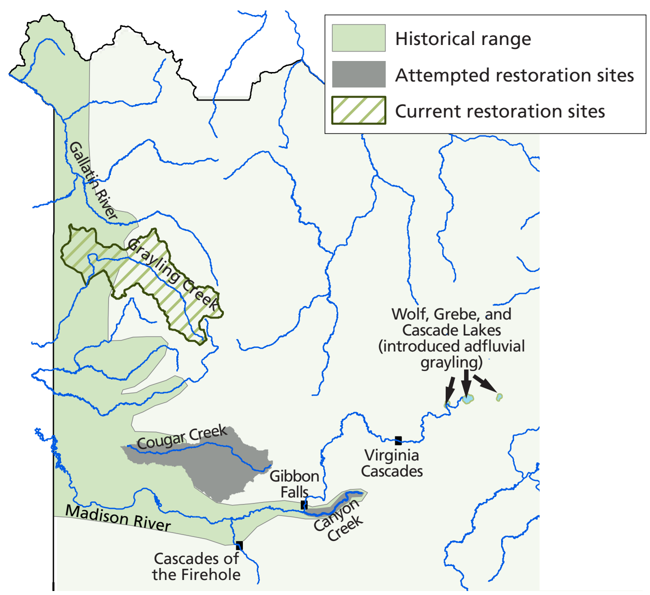


Westslope cutthroat trout have been restored to High Lake and East Fork Specimen Creek, and will be established as a broodstock in Goose Lake. Five percent of 5% of historic WCT historical habitat is currently occupied.

Arctic Grayling

Fluvial (entirely stream-dwelling) Arctic grayling were historically common in the Madison, Gibbon, Firehole, and Gallatin rivers. By the 1950s, competition from introduced fish had eliminated the species from park waters, and Hebgen Dam had submerged the lower reaches of Grayling Creek outside the park. The only known populations left in the park are adfluvial (lake-dwelling) descendants of fry that were stocked in Cascade and Grebe lakes and in Wolf Lake and the Gibbon River. Following unsuccessful efforts to restore fluvial grayling in Canyon Creek in 1975 and in Cougar Creek in 1993, a project has begun in the uppermost 20 miles of Grayling Creek in 2012. Removal of the nonnative fish in the creek (brown trout and hybridized cutthroats) will take several years beginning in 2013, followed by up to five years of native fish reintroduction. This project is one of the potential actions in the Native Fish Conservation Plan/Environmental Assessment and one of the most significant Arctic grayling recovery projects in the species' historical range.


JAY FLEMING



Former distribution of Arctic grayling within Yellowstone National Park, previously attempted restoration sites, and current restoration sites. None of the historical habitat is currently occupied.

NATIVE SPECIES

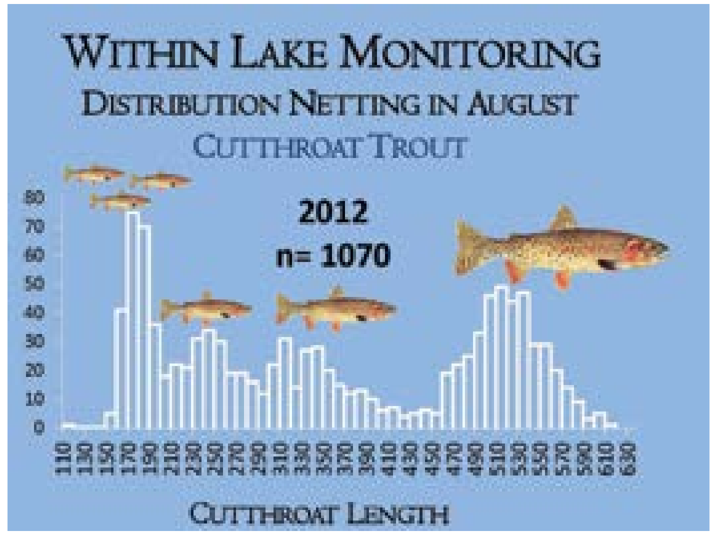
Yellowstone Cutthroat Trout

The Yellowstone cutthroat trout (YCT) population has declined substantially since the mid-1980s in the Yellowstone Lake ecosystem where it provides an important food source for an estimated 42 wildlife species, including bears, osprey, and bald eagles. The YCT spawning at Clear Creek, a Yellowstone Lake tributary where monitoring began in 1945, peaked at more than 70,000 in 1978 and fell to 538 by 2007.

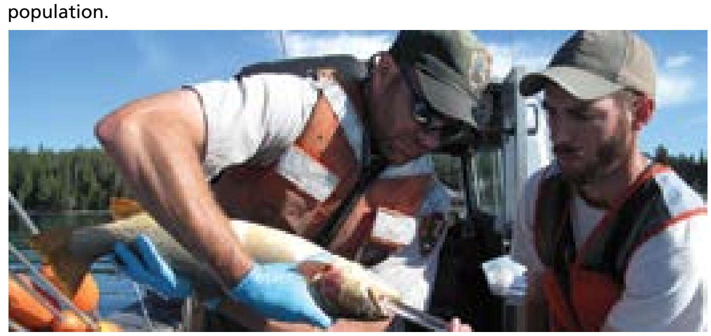
The decline is attributed to predation by nonnative lake trout, low water during drought years, and the exotic parasite that causes whirling disease. Two-thirds of the 3,000 km of park streams that were part of the species' native habitat outside the Yellowstone Lake watershed still contain genetically pure YCT; the other streams have YCT hybridized with introduced rainbow trout.

The objectives of Yellowstone's Native Fish Conservation Plan (2010) include maintaining access for spawning YCT in at least 45 of 59 Yellowstone Lake's historical spawning tributaries, recovery of YCT abundance in the lake to that documented in the late 1990s, and maintaining or restoring genetically pure YCT in the current extent of streams occupied by pure or hybrid YCT.

The average number of YCT caught per net at lake sites as part of an annual monitoring program reached 19.1 in 1984, dropped to a record low of 5.3 in 2010, and was 10.6 in 2012. Approximately 33% of the YCT in the catch were more than 330 mm in total length; 48% were from 200 mm to 330 mm; and 19% were smaller than 200 mm; a good sign that the population continues to include smaller fish that are surviving into adulthood.



Length-frequency distribution of cutthroat trout from the summer distribution netting on Yellowstone Lake in 2012. Note that small juvenile cutthroat trout (<325 mm length) now comprise a significant proportion of the lakewide population.

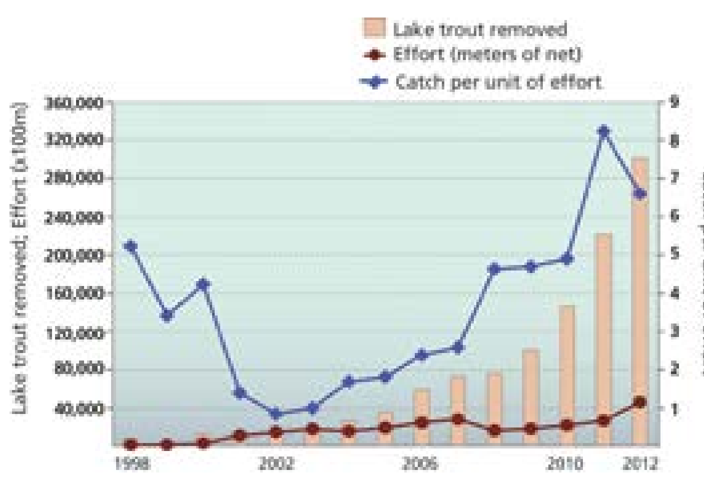


STRESSORS

Lake Trout in Yellowstone Lake

Lake trout are not native to the park and were illegally introduced. They have had a major impact on Yellowstone cutthroat trouty in Yellowstone Lake due to competition and predation. Since its presence in the lake was confirmed in 1994, more than 1.1 million lake trout have been removed. With the assistance of contracted fishermen using commercial-scale gear, the National Park Service was able to greatly increase the suppression effort to remove more than 300,000 lake trout in 2012. For the first time since 2002, the catch-per-unit effort (the number of lake trout caught in 100 meters of net fished in one night) decreased. The largest lake trout recorded from Yellowstone Lake (over 33 pounds) was netted in 2012.

One goal of the park's 2010 Native Fish Conservation Plan is to reduce the lake trout population by 25% each year until it collapses to an insignificant level. Although this goal has not yet been achieved, population modeling suggests it may be possible with continued and increased effort.



Number of lake trout removed, units of effort (meters of net in place during the season, counted daily), and catch per unit of effort, 1998–2012.

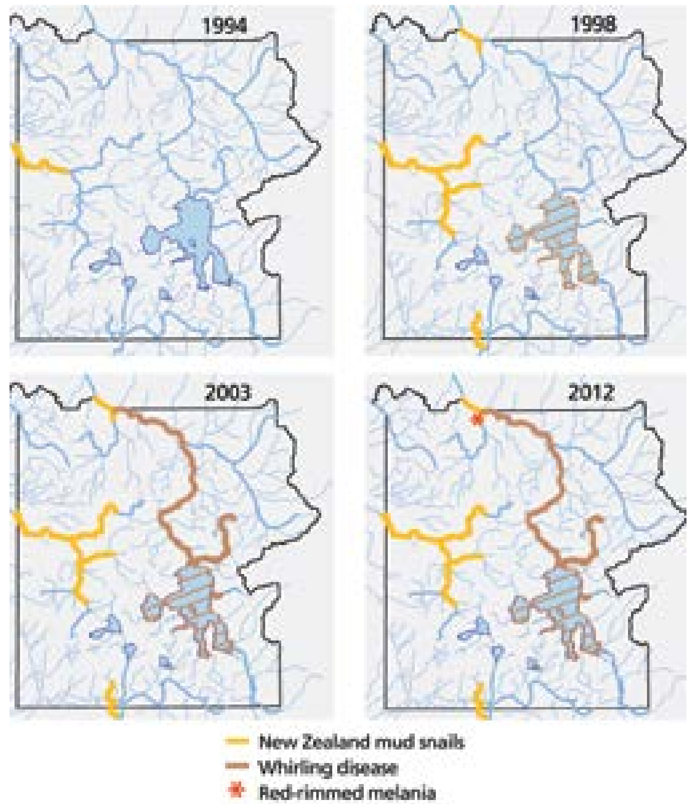
Aquatic Nuisance Species

In addition to the lake trout in Yellowstone Lake, two nonnative species are having a significant detrimental effect on the park's aquatic ecology.

First detected in the park in 1994, New Zealand mud snails are now in all of the major watersheds, where they form dense colonies and compete with native species. Confirmed in the park in 1998, the parasite that causes whirling disease in cutthroat trout and other species has been found in the Firehole River and the Yellowstone Lake watershed.

Another nonnative species, the red-rimmed melania, a small trumpet snail imported by the aquarium trade, was discovered in the warm swimming area at the confluence of the Boiling River with the Gardner River in 2009. Subsequent surveys of popular hot springs have found melania only in the Boiling River soaking area and downstream approximately 1 km. 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 appear in other thermal waters in the park.

From 2009 to 2012, park staff and volunteers spoke with more than 7,000 visitors bringing boats into the park, resulting in more than 3,000 inspections and the non-chemical decontamination of 120 potentially affected boats. Beginning in 2013, all watercraft entering the park's lakes must be inspected as part of the watercraft permitting process. This process of inspection and cleaning when necessary is usually sufficient to prevent the entry of aquatic invasive species; however, some life stages of certain organisms cannot be easily detected or decontaminated.

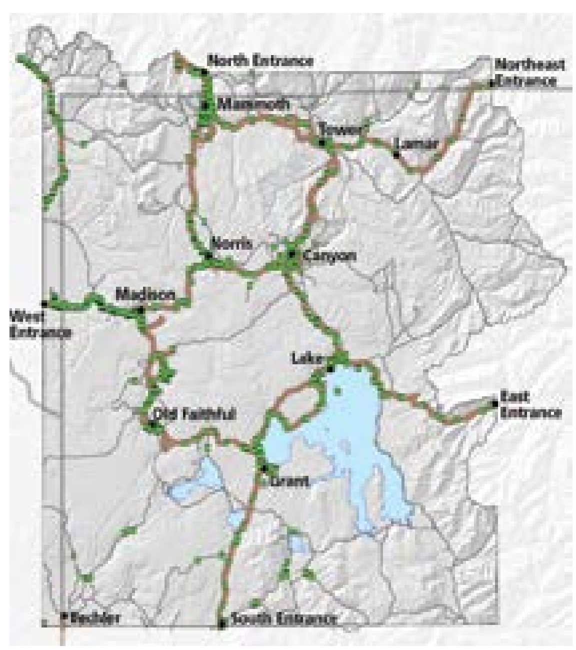


Locations in Yellowstone National Park where whirling disease, New Zealand mud snails, and red-rimmed melania have been documented.

Invasive Plants

In addition to about 1,300 native plant species, 219 nonnative plants have been documented in the park. During each of the last three summers, dozens of park staff and volunteers participated in surveys of more than 20,000 acres (about 1% of the park), mostly along roads where invasive plants are more likely to become established. They found that more than a quarter of this area was infested with weeds. Based on program priorities, 112 acres were selected for treatment in 2012. Plants were physically pulled on 41 acres; the rest were treated using herbicides.

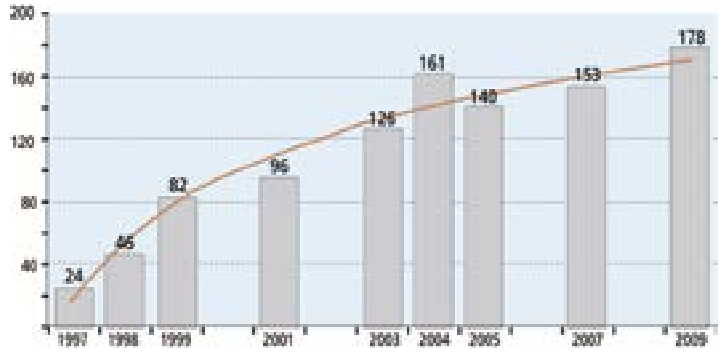
Nonnative plant species are prioritized according to the threat they pose to park resources and the prospects for successful treatment. Some infestations can be eradicated if the species is treated when the outbreak is still small; other species, such as spotted knapweed, are so common that stopping them from spreading is the primary goal. This strategy has helped prevent high-priority invasive species from moving into backcountry areas where control is more difficult. Most of the approximately 37 species targeted for treatment are listed by the states of Idaho, Montana, or Wyoming as "noxious weeds," which means that they are considered detrimental to agriculture, aquatic navigation, fish and wildlife, and/or public health.



Green patches indicate areas treated for invasive plants in 2012.

Mountain Goats

Descendants of mountain goats introduced in Montana during the 1940s and 1950s established a population in the park in the 1990s and have reached a relatively high abundance in the northeastern and northwestern portions. This colonization has raised concerns about adverse effects on alpine areas of the park. Surveys in 2002 and 2003 suggest that ridgetop vegetation cover is lower, and barren areas along alpine ridges are more prevalent in areas with relatively high goat use. An estimated 200 to 300 goats are using habitat in and adjacent to the park. In 2010, the NPS began a long-term research program with Montana State University and other federal and state agencies on mountain goat ecology and the potential for competition with bighorn sheep. Competition with high densities of mountain goats could negatively affect bighorn sheep, whose range overlaps with mountain goats.



Counts of mountain goats in Yellowstone National Park and adjacent areas of Montana and Wyoming by the Northern Yellowstone Cooperative Wildlife Working Group, 1997–2009.

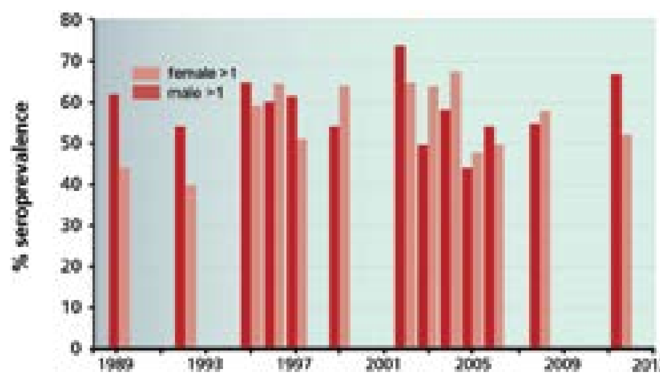
Wildlife Diseases

In national parks, where the goal is to minimize human intervention in ecological processes, disease may be an acceptable cause of wildlife mortality. However, diseases that are not indigenous to the area, but have spread into Yellowstone as a result of human activity and caused population declines, require management interventions.

Significant diseases present in Yellowstone wildlife include:

- **Brucellosis.** Many bison and elk in the GYE have been exposed to the bacterium that causes brucellosis, which originated in domestic livestock. It does not appear to have had substantial population-level impacts in wildlife, but infected females may abort their first calf, and the disease can be transmitted to livestock if they have contact with infected birth materials.
- **Canine diseases.** Parvovirus, distemper, mange, and hepatitis are believed to have been a major factor in wolf population declines in Yellowstone in 1999, 2005, and 2008; these diseases also appear to have affected coyotes, foxes, and possibly cougars and other smaller carnivores.
- **Amphibian diseases.** Ranavirus and chytrid fungus are of uncertain origin and often result in amphibian die-offs.

Diseases that could potentially appear in Yellowstone include chronic wasting disease (which affects deer, elk, and moose), West Nile virus (birds), and white-nose syndrome (bats), which is believed to be caused by a fungus adapted to the cold and humid conditions of the hibernacula used by wintering bats. Hantavirus, considered native in origin, has been found in some Yellowstone voles and deer mice, but transmission to humans in the park is not known to have occurred.



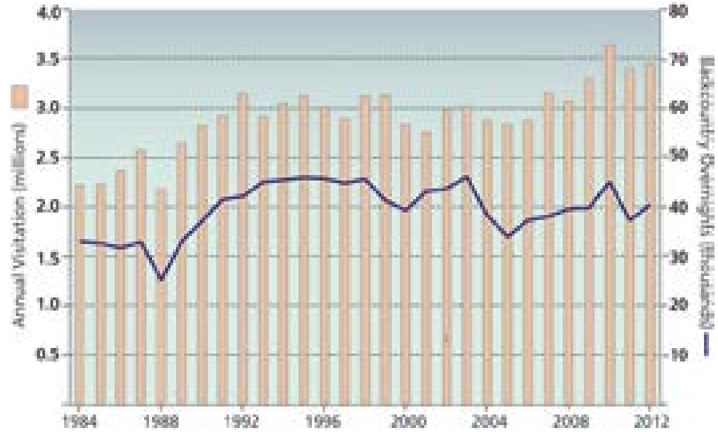
Brucellosis seroprevalence rates in adult bison from 1984 to present.

Visitor Use

Use of the park by visitors is both a primary reason for Yellowstone's establishment and a factor in the condition of some of the natural resources that the park is intended to protect. Visitor activities and associated infrastructure has affected many park resources, including:

- air and water quality
- natural soundscape
- wildlife habitat, distribution, and habituation
- the spread of nonnative plants, diseases, and aquatic organisms
- the functioning of geothermal features.

Annual visitation exceeded 3 million for the first time in 1992, and has been at least 3.3 million each year since 2009, reaching a record 3.6 million in 2010. About 68% of visitation occurs from June through August. AAlthough there are no day-use limits, lodging and campgrounds in the park can accommodate only about 14,300 visitors during the summer. Daily visitation during July 2012 averaged 28,656. Fall visitation has increased since the 1980s and now comprises about 21% of annual use; winter visitation has never been more than 6% of the annual total.

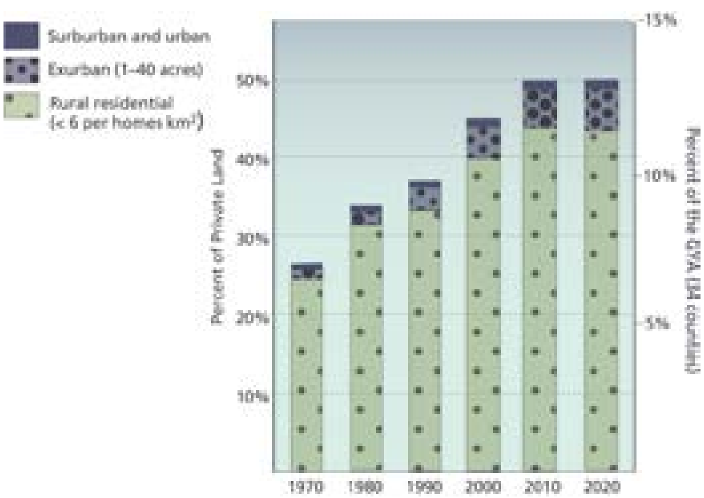


Annual Yellowstone visitation and backcountry overnight use, 1984–2012, from data collected by Yellowstone's Visitor Services.

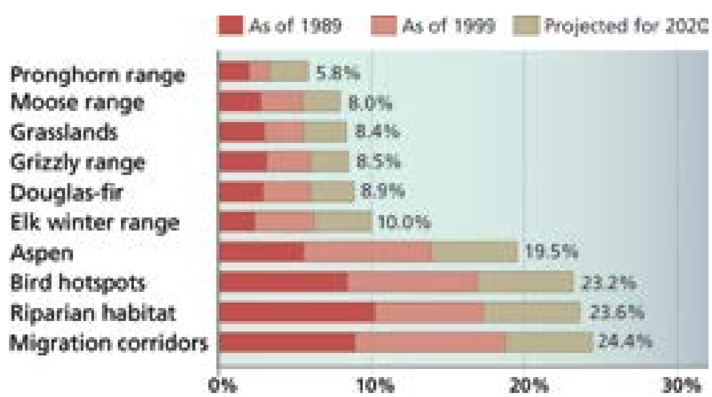
Similar to trends at other western parks, overnight backcountry use in Yellowstone peaked in the 1970s at more than 50,000 "people-use nights" (the total number of nights spent in the backcountry). Since the mid-1980s, the trend in backcountry use has roughly paralleled that of overall visitation; an increase since 2005 brought the total people-use nights to 45,045 in 2010.

Land Use

Changes in land use outside the park can affect the ecology within the park, including fire frequency, species distributions, habitat fragmentation, and the presence of nonnative plants, animals, and pathogens. In the 34 counties that comprise the Greater Yellowstone Ecosystem, about 27% of the land is privately owned. The distribution of population growth on that land in recent decades is having a larger impact on the ecosystem than the population increase itself. From 1970 to 2010, most of the development was in the least-densely populated category, referred to as "rural residential." 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 important for biodiversity, especially grizzly bear habitat, bird hotspots, and riparian zones. The percentage of the GYE used for agriculture remained relatively constant from 1920 to 1990, but has declined slightly since them to about 18%.



Housing density in the Greater Yellowstone Area (34 counties), 1970–2010 and projected for 2020. (Data from McIntyre, C.L., and C. Ellis. 2011. Landscape dynamics in the Greater Yellowstone Area. Natural Resource Technical Report. National Park Service, Fort Collins, Colorado.)



Habitat types impacted by rural development in the 20 counties in and closest to Yellowstone National Park. (Data from Gude, P.H., A.J. Hansen, and D.A. Jones. 2007. Biodiversity consequences of alternative future land use scenarios in Greater Yellowstone. *Ecological Applications* 17(4), 1004-1018).

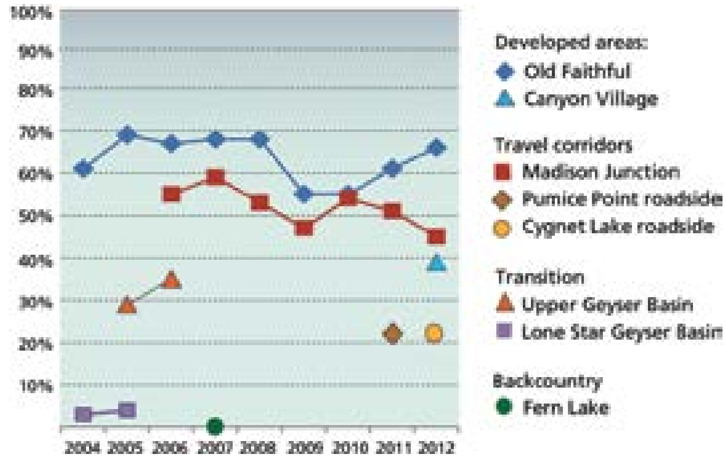
STRESSORS

Winter Soundscape

The natural soundscape, which is important for the biotic community and enjoyed by park visitors, predominates in most of Yellowstone. At some times of day in some areas, however, it is masked by human-caused sounds. Aircraft noise, which is the most widespread human-caused sound in the park, is heard on average for less than 10% of the day, but the potential for frequent and pervasive high-decibel noise from oversnow vehicles (OSVs) has made the winter soundscape an issue of particular concern in Yellowstone.

Fewer snowmobiles, lower speed limits, and "Best Available Technology" requirements have reduced sound levels and the percent of time that OSVs are audible in the park. Snowmobiles may not produce more than 73 dBA (the relative loudness of sounds in air as perceived by the human ear) at 50 feet. A 6 dB increase generally doubles the distance at which a sound can be heard. Maximum levels near travel corridors occasionally exceed 75 dBA during the day because of snowcoaches, which produce up to 80 dBA at 50 feet. Snowcoaches will be required to meet a 75 dBA limit by the 2014–2015 winter. (Except for OSVs and motorboats, the maximum sound level permitted for human-caused sounds in national parks is 60 dBA.)

The OSV percent time audible is affected by the time of day and proximity to roads and developed areas, topography, and the camouflaging effect of natural sounds such as wind, moving water, and geothermal activity. Acoustic data collected since 2003 show small annual fluctuations around the average percent time OSVs were audible from 8 am to 4 pm at Old Faithful (63%) and at Madison Junction (53%). At the Old Faithful monitoring station, the recent average is one-third lower than the time audible measured prior to 2004 (90%).



The percentage of time from 8 AM to 4 PM that OSVs were audible at eight locations in Yellowstone National Park, 2004–2012.

CULTURAL RESOURCES

Historic Structures

Yellowstone's infrastructure includes 880 buildings, roads, bridges, and grave markers that have been documented in the NPS List of Classified Structures (LCS) and listed in or determined eligible for the National Register of Historic Places. Six sites have been designated National Historic Landmarks: Fort Yellowstone and five examples of park "rustic" architecture—the Old Faithful Inn, the Northeast Entrance Station, and the Norris, Madison, and Fishing Bridge museums. LCS assessments, which are based on historical integrity not functionality, have found that 77% of the park's historic structures are in good condition, 21% fair, and 2% poor. About 80% of the structures have been assessed within the last five years.

Preserving a historic structure requires minimizing the rate at which historical material is lost. Many structures in the park require replacement of historical materials to avert structural failure and strengthening to withstand seismic events. Old interiors often have lead-based paint or deficient wiring that poses a fire risk.

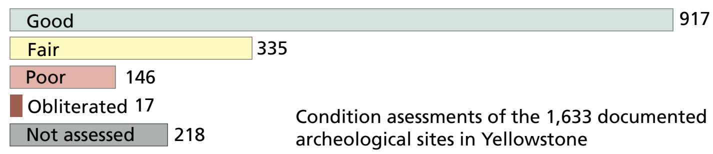
Condition of the 880 historic structures in Yellowstone

Archeological Sites

Although 1,633 sites in the park have been recorded in the NPS Archeological Sites Management Information System since Yellowstone's archeology program began in 1995, less than 3% of the park has been inventoried, leaving what are estimated to be tens of thousands of undocumented sites. The recorded sites show evidence of human use ranging from more than 9,500 years ago to the early 20th century. Most of these sites are in developed areas where archeological remains are more likely to be discovered inadvertently or as part of National Historic Preservation Act compliance for construction activities and hazard fuel reduction projects. One site, Obsidian Cliff, has been listed on the National Register of Historic Places. As of 2012, 290 additional sites had been determined eligible for listing, 252 had been determined ineligible, and 1,091 had not been evaluated for eligibility.

Assessments of 1,415 of the sites found 65% were in good condition, 24% fair, and 10% poor; 1% no longer existed because of natural factors or disturbance as a result of construction or other authorized activity. Nearly 80% of the sites have been assessed within the last 10 years.

Salvage efforts have been made at some sites where the remains are especially vulnerable to disturbance or loss through natural causes or illegal collecting. At a site on the shore of Yellowstone Lake that was excavated because it was at risk of erosion, evidence was found of a 9,350 year-old camp containing buried projectile points, scrapers and other tools, and concentrations of burned and butchered bone, including the first evidence found in the park of fishing and the consumption of fish.

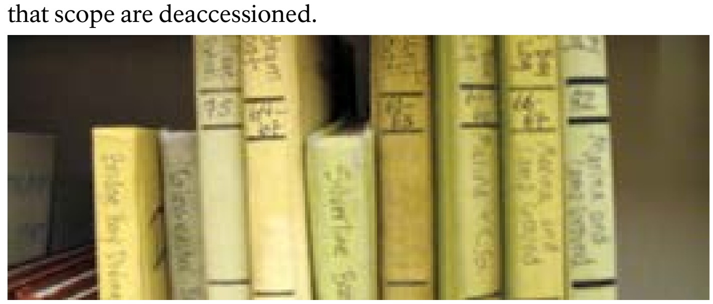


Condition asessments of the 1,633 documented archeological sites in Yellowstone

Museum Collections

Yellowstone's museum collections include archival documents, photographs, archeological and ethnographical artifacts, fossils, uniforms, vehicles, hotel furnishings, souvenirs, biological and geological specimens, and works of art. Some items are displayed in the park's visitor centers, museums, and the Yellowstone Heritage and Research Center, where most of the collection is stored in conformance with standards set by the National Park Service and the American Association of Museums. Other items are held in repositories maintained by other institutions outside the park, and objects are loaned out for exhibits.

Although 300,000 archival documents were cataloged during the last year, about two-thirds of the 4 million items in the collections have not been accessioned or cataloged. The Scope of Collections Statement defines what is to be included in the museum collection as the best representation and documentation of Yellowstone's natural and cultural history, taking into consideration the expense of curation and preservation. Items that fall outside of that scope are deaccessioned.



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Fire	2010 Fire Report, Yellowstone National Park. http://www.nps.gov/yell/parkmgmt/report10.htm
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Whitebark Pine	Gannon, A. and S. Sontag. 2011. Montana Forest Insect and Disease Conditions and Program Highlights, 2010 . Montana Department of Natural Resources and Conservation, Forestry Division, and USDA Forest Service, Northern Region, Forest Health Protection
Yellowstone Cutthroat	Native Fish Conservation Plan for Yellowstone National Park Environmental Assessment, 2010.
Lake Trout	Native Fish Conservation Plan for Yellowstone National Park Environmental Assessment, 2010.
Visitor Use	National Park Service Public Use Statistics Office. http://www.nature.nps.gov/stats/park.cfm.

As explained on page 5, reference conditions have not been established for all of the vital signs.

For an in-depth look at Yellowstone National Park's cultural and natural resources consider subscribing to our publication, *Yellowstone Science* magazine.

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