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U.S. Department of the Interior
Yellowstone National Park

Yellowstone National Park
Natural Resource Vital Signs, 2011

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

November 2011
YCR-2011-07

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Foreword

In 2008, Yellowstone National Park released its first report on the status of important natural resource vital signs. The selection of these indicators and development of a method to communicate their status and trends to scientists and managers represented a true advance in the synthesis of monitoring data for ecosystem management. The Park is grateful to Tom Olliff, Chief of the Yellowstone Center for Resources from 2006 to 2009, for his commitment to and vision for developing the 2008 report and framework for communicating science to managers. This report, Natural Resource Vital Signs, 2011, presents recent data that are available to help managers gauge the health of the Greater Yellowstone Ecosystem. A number of noteworthy highlights have emerged from this year's report, including:

Earthquakes: The University of Utah's seismic stations detected 3,274 earthquakes in the park during 2010, the largest number since 1985. Most were too small to be felt by people, but they included a swarm of about 2,400 quakes from mid-January to mid-February northwest of Old Faithful. It was the largest swarm since 1985.

Grizzly bears: The estimated Greater Yellowstone Ecosystem grizzly bear population reached 602 in 2010, the largest number since the recovery program began in 1975. About 150 bears occupy ranges partly or entirely within the park. For a short time from 2007 to 2009, the grizzly bear was removed from the endangered species list; however, it was re-listed as threatened in consideration of the potential threats caused by climate change and loss of whitebark pine.

Wolves and elk: The decline in Yellowstone's wolf population to 97 in 2010, the lowest since 1999, is attributed in part to a drop in the northern range elk population by more than two-thirds since the mid-1990s, which is attributed in part to predation by wolves, the growing bear population, hunting, and possibly drought-related effects on elk pregnancy and survival. However, the wolf population in Wyoming and the greater Yellowstone area overall has continued to increase. The gray wolf was removed from the endangered species list in Idaho and Montana in May 2011, but it remains on the list for Wyoming.

Bison: The state of Montana has expanded the area outside the park's north boundary where bison are allowed to use winter range. This increased tolerance for bison prevented the need to send to slaughter hundreds of bison that crossed the boundary when last winter brought an above-average snowpack. The estimated summer population is 3,700, down slightly from 2010.

Native fish: The Yellowstone cutthroat trout population in Yellowstone Lake has declined substantially since the 1980s as a result of low water flows during drought years, predation by nonnative lake trout, and whirling disease. Nearly 550,000 lake trout have been removed from the lake since 1994, including about 146,000 in 2010. The number of lake trout caught per 100 meters of net has been rising since 2002, suggesting that the lake trout population has been increasing faster than the fish are being removed.

Over the next year, the Yellowstone Center for Resources, along with our partners, will reexamine this suite of vital signs with special emphasis on developing desired conditions for many of the indicators. This will enhance the value of these indicators by helping to establish management targets.

David E. Hallac
Chief, Yellowstone Center for Resources

NPS/Stahler

Why Yellowstone's Vital Signs are Monitored

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 depend 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. However, 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 careful monitoring. For example, the survival of some animal species depends on the use of habitat that extends beyond the park's boundaries or seasonal migration to unprotected habitat. 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 natural 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 25 vital signs for which information is available for use in decisions about managing the park.

Types of Vital Signs

Yellowstone's vital signs are grouped here into four categories:

- **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 because of their large number, size, and movement outside the park, 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.

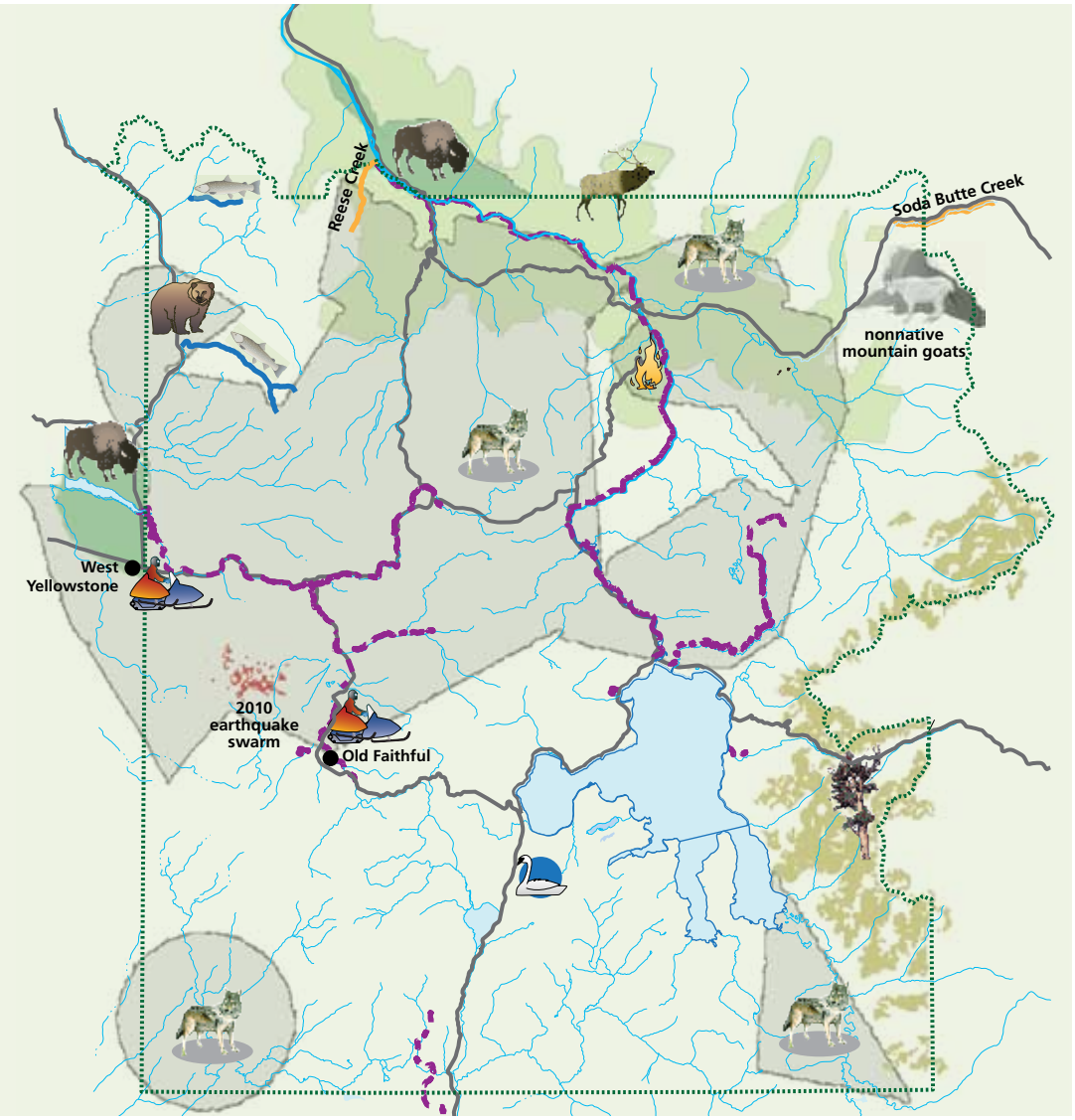
In addition to being monitored, some vital signs are the focus of major management plans to

- 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).

How Vital Signs are Monitored

The park's vital signs are monitored by park staff with help from the Greater Yellowstone Inventory and Monitoring Network (GRYN), other federal and state agencies, and university scientists. GRYN, which also includes Grand Teton National Park and Bighorn Canyon National Recreation Area, is one of 32 networks established by the National Park Service to conduct inventory and monitoring, and 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).

The table on the following page summarizes the current status of these 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 Protection Act or 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.



The map shows some of the locations associated with vital signs included in this report.

Vital Signs Summary

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

Vital Sign	Indicators	Current Condition (2010 or latest available)	Reference Condition
Ecosystem Drivers			
Climate	Average min., max. daily temp. (Mammoth) Annual precipitation (Mammoth) Drought (Standardized Precipitation Index) Annual growing season (Northeast Entrance) Snowpack (Canyon, April 1 SWE) Annual streamflow (Corwin Springs)	28°F, 50°F 14.7″ 0 118 days ✸ 8.0" 2,974 ft^3 per second	27–30°F, 50–56°F (1971–2000 range) 10.2–21.0″ (1971–2000 range) -1 to +1 (historical median) 77–98 days (1985–1996 range) 6.4–23.6"(1971–2000 range) 1,973–5,158 (1971–2000 range)
Fire	Acres burned per year	6,232 acres	1–28,849 (1990–2005 range)
Subsurface Geology	Earthquakes per year Annual subsidence or uplift Geothermal activity	3,274 earthquakes 3 cm subsidence since 2009 TBD	154–3,572 (range 1985–2000) TBD TBD
Environmental Quality			
Air Quality	Visibility (deciviews) Ozone (W126) Nitrogen in precipitation (kg/ha/yr) Sulfur in precipitation (kg/ha/yr)	3.2 (2005–09 av.)✸ 10.4 ppm-hr (5 yr. av.)✸ 2.0 (5 yr. av.)✸ 0.9 (5 yr. av.)	<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	4.3 ppm (2011) 4 $PM_{2.5}$ ug/m^3 (2011)	TBD TBD
Water Quality	Basic water quality parameters at 18 sites Reese Creek stream flow, April 15–October 15 Soda Butte iron concentration	Unimpaired 1.78 –12.45 ft^3/sec up to 9.6 mg/L ✱	State water quality standards ≥1.3 ft^3/sec ≤1.0 mg/L
Native Species			
Amphibians	% of potential sites suitable for breeding % of catchments occupied by boreal toads	82% 15%	TBD TBD
Arctic Grayling	Occupied stream habitat	0 km ✸	≥200 stream km
Bald Eagles	Breeding pairs	24 pairs (2011)	22 pairs
Bighorn Sheep	Northern range count; lambs per 100 ewes	363 sheep, 38 lambs (2011)	300–500 sheep, 22 lambs
Bison	Estimated summer population	3,700 bison (2011)	2,500–4,500 bison
Elk	Northern range winter count	4,635 elk (2011)	4,000–15,000 elk
Gray Wolves	Wolves in Wyoming Breeding pairs in Wyoming	343 (97 in park) 27 pairs (8 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)	602 (≈150 in park) 18 bear management units 8% (2009–10) 26%,12%, 29% (2008–10) 4% (2008–10)	≥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	297 pronghorn ✸	300–600 pronghorn
Trumpeter Swans	Resident adults and subadults, fall count Nesting pairs	10 swans ✸ 2 pairs ✸	40 swans 10 pairs
Westslope Cutthroat	Occupied historical habitat	~10 stream km ✸	≥200 stream km
Whitebark Pine	Blister rust infection (% of trees in the GYE) Pine beetle infestation (in the park)	20% of trees 19,722 acres	TBD 0–41,000 (range 1983–2009)
Yellowstone Cutthroat	Yellowstone Lake tributaries with spawners Spawner count at Clear Creek	TBD 538 spawners (2007) ✸	45 tributaries ≥12,800 spawners
Stressors			
Aquatic Nuisance spp.	TBD	TBD	TBD
Invasive Plants	TBD	TBD	TBD
Lake Trout	Annual reduction, Yell. Lake population size	~0% (preventing increase)✸	25% annual reduction
Land Use	Road and home density	TBD	TBD
Mountain Goats	Estimated population in and near the park	200–300 goats	0
Visitor Use	Annual visitation	3.6 million ✸	2.8–3.3 million (2000–2009 range)
Winter Soundscape	% time OSVs are audible, 8 AM to 4 PM	55% (OF), 54% (Madison J)	TBD
Wildlife Diseases	TBD	TBD	TBD

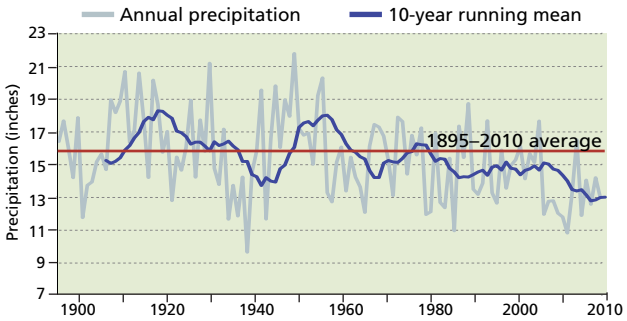
Sources for the Reference Conditions

Vital Sign	Source
Climate	Tercek, M.T., and S.T. Gray. 2010. Greater Yellowstone Inventory and Monitoring Network: Climate of 2009. Natural Resource Report NPS/GRYN/NRR—2010/262. National Park Service, Fort Collins, Colorado. USDA Natural Resources Conservation Service, Snowcourse Data, http://www.wcc.nrcs.usda.gov. USGS Surface-Water Annual Statistics, http://waterdata.usgs.gov. Western Regional Climate Data Center, Historical Climate Information, http://www.wrcc.dri.edu.
Fire	2010 Fire Report, Yellowstone National Park. http://www.nps.gov/yell/parkmgmt/report10.htm
Subsurface Geology	Yellowstone Volcano Observatory website, http://volcanoes.usgs.gov/yvo.
Air Quality	Thresholds set by the NPS Air Resources Division, i.e., "Assessment of Current Air Quality Conditions (http://www.nature.nps.gov/air/maps/AirAtlas/docs/2009_Assessment_of_Current_Air_Quality_Conditions.pdf). See also Inferring Critical Nitrogen Deposition Loads to Alpine Lakes of Western National Parks with Diatom Fossil Records. 2009. Saros, J. Final Report for the NPS Air Resources Division.
Water Quality	Montana Department of Environmental Quality. 2008. Circular DEQ-7: Montana Numeric Water Quality Standards. Montana Department of Environmental Quality. February 2008. Wyoming Department of Environmental Quality (WYDEQ). 2007. Water Quality Rules and Regulations, Chapter 1, Wyoming Surface Water Quality Standards.
Arctic Grayling	Native Fish Conservation Plan for Yellowstone National Park Environmental Assessment, 2010.
Bald Eagles	Greater Yellowstone Bald Eagle Working Group. 1996. Greater Yellowstone Bald Eagle Management Plan: 1995 update. Wyoming Game and Fish Dept., Lander Wyoming
Bighorn Sheep	White, P. J., T. O. Lemke, D. B. Tyers, and J. A. Fuller. 2007. Bighorn sheep demography following wolf restoration. *Wildlife Biology* 14:138–146.
Bison	Plumb, G.E., P.J. White. M.B. Coughenour, R.L. Wallen. 2009. Carrying capacity and migration of Yellowstone bison: implications for conservation. Biological Conservation 142:2377-2387. See also White, P.J., R.L. Wallen, C. Geremia, J. Treanor, and D.W. Blanton. 2010. Management of Yellowstone bison and brucellosis transmission risk—Implications for conservation and restoration. Biological Conservation 144:1322–1334.
Elk	Barber-Meyer, S.M., L.D. Mech, and P.J. White. 2008. Survival and cause-specific elk calf mortality following wolf restoration to Yellowstone National Park. Wildlife Monographs 169.
Gray Wolves	Federal Register 73(2008):10520. Final Rule Designating the Northern Rocky Mountain Population of Gray Wolf as a Distinct Population Segment.
Grizzly Bears	U.S. Fish and Wildlife Service. 2007. Grizzly Bear Recover Plan Supplement: Revised Demographic Criteria for the Yellowstone Ecosystem. 72 FR 11377.
Pronghorn	White, P. J., J. E. Bruggeman, and R. A. Garrott. 2007. Irruptive population dynamics in Yellowstone pronghorn. *Ecological Applications* 17:1598–1606.
Trumpeter Swans	Subcommittee on Rocky Mountain Trumpeter Swans. 2008. Pacific Flyway Management Plan for the Rocky Mountain Population of Trumpeter Swans. c/o USFWS, Portland, OR. Unpublished report.
Westslope Cutthroat	Native Fish Conservation Plan for Yellowstone National Park Environmental Assessment, 2010.
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.

Climate

Regional climate trends are monitored by the Greater Yellowstone Inventory and Monitoring Network, streamflow by the U.S. Geological Survey.

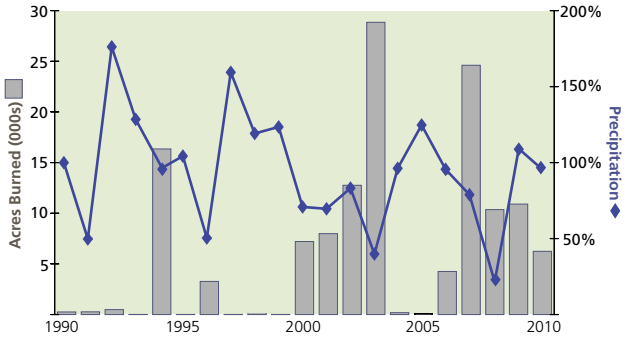
- Temperatures, precipitation, snowpack, and streamflow in Yellowstone during 2010 were all within 1971 to 2000 ranges.
- The April 1, 2010, snow water equivalent at Canyon (8 inches) was only 58% of the average for that period; the April 1, 2011, snow water equivalent (17.5 inches) was 126% of average.
- Data collected at the northeast entrance indicate that the growing season (number of days from May through October with lowest temperature above freezing) has been starting earlier and lengthened from an average of 88 days (1985–1996) to 117 days (2000–2010). It was 130 days in 2009 and 118 days in 2010.



Upper Yellowstone River Basin precipitation, 1985–2010 (data from the Western Regional Climate Center).

Fire

Naturally ignited fires in the park are allowed to burn if they meet specific criteria regarding weather conditions and fire danger. As monitored by Yellowstone's Wildland Fire Management Program, fire activity has fluctuated between less than one acre and nearly 29,000 acres since 1988. In 2010, a total of 6,232 acres burned from 11 known wildland fire starts, of which two were considered human-caused, including one downed power line. Four of the fires quickly went out on their own, five of the fires were suppressed, and two, including the largest (5,510 acres), were allowed to burn while monitoring for public safety. Although the frequency and size of fires is affected by many factors, more acres are likely to burn during summers when precipitation is below average.

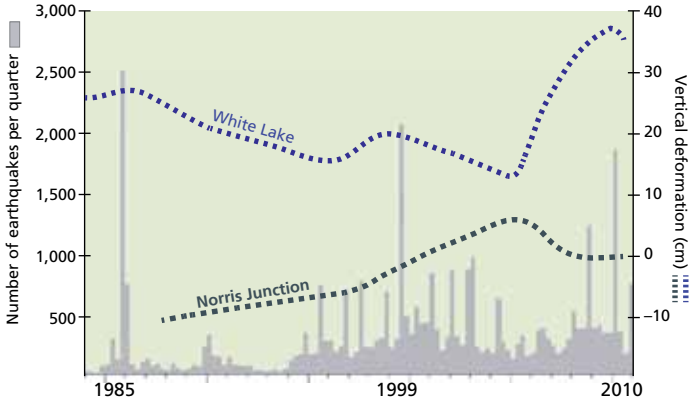


Acres burned in Yellowstone and summer precipitation as a percentage of the 1970–2000 average.

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 helps ensure public safety. The University of Utah's seismograph stations detected more than 3,200 earthquakes in the park in 2010, the largest count since 1985. From mid-January to mid-February, a swarm of about 2,300 quakes occurred about 10 miles northwest of Old Faithful. The two largest earthquakes, magnitude 3.7 and 3.8, were felt throughout the park and in surrounding communities, but both occurred after 11 PM and had little effect on park visitors.

Beginning in 2004, GPS and InSAR measurements indicated that parts of the Yellowstone caldera were rising up to 7 cm per year, 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 2009 was about 25 cm. The caldera began to subside during the first half of 2010, about 3 cm so far. Episodes of uplift and subsidence have been correlated with earthquake occurrence in the park.



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

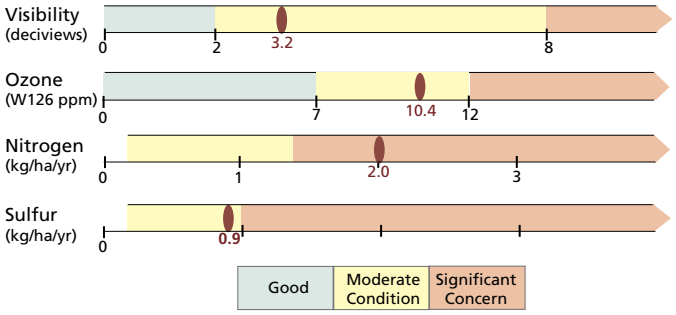
Energy and groundwater development outside the park, especially in known geothermal areas in Island Park, Idaho, and Corwin Springs, Montana, could alter the functioning of geothermal systems in the park.

Air Quality

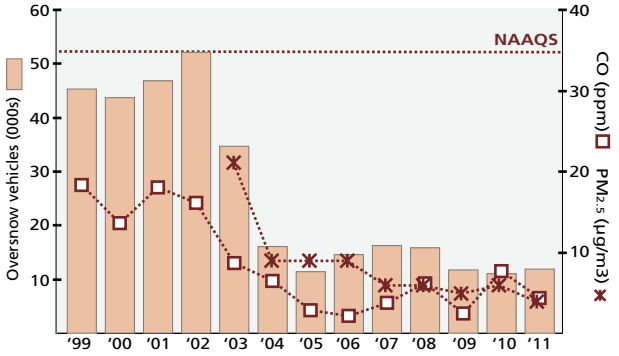
As a federally designated Class I airshed, Yellowstone is required to meet high standards for air quality. Data monitored by the NPS Air Resources Division indicate that the park is in compliance with federal standards for human health for ozone, sulfur dioxide, and particulate matter. However, air quality 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 ultra-violet 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. At the West Entrance, the daily maximum 1-hour concentration was 82 ppb in winter 2011, below the national standard of 100 ppb, but much higher than in the previous summer.



Five-year average values in Yellowstone relative to categories set by the NPS Air Resources Division. No national park in the lower 48 states meets the criteria for "good" visibility. A threshold for "good" condition has not been determined for nitrogen and sulfur wet deposition in Yellowstone. Natural wet deposition in the West has been estimated at 0.13 kg/ha/yr.



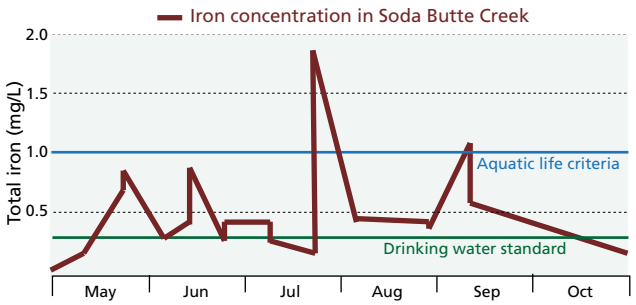
Maximum one-hour CO levels at the West Entrance and 24-hour $PM_{2.5}$ levels (98th percentile) at Old Faithful compared to national air quality standards.

Water Quality

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. Three sites did not meet EPA or state standards for pH values during 2010 because of local geology and contributions from nearby thermal sources.

Based on water quality standards for aquatic life, the state of Montana considers a portion of Reese Creek on the park's northern boundary impaired. Streamflow in 2009 and 2010 remained above the minimum threshold stipulated by adjudicated water rights, but irrigation by adjacent landowners often leaves too little water to sustain healthy invertebrate and fish populations.

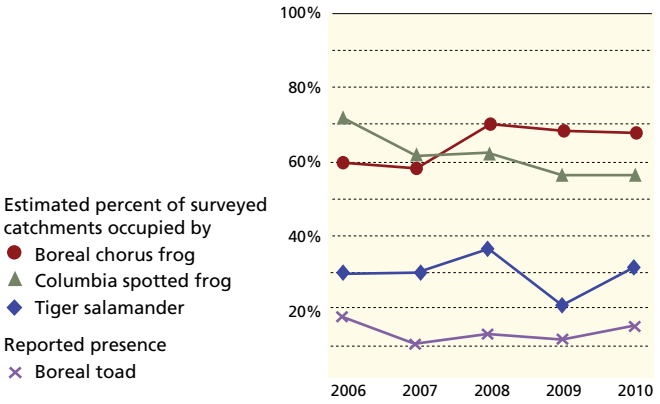
As a result of mining activity 8 km from the park, tailings remain in the Soda Butte Creek floodplain, impairing the segment of the creek that extends downstream to the park boundary. Park staff periodically measure arsenic, copper, iron, and selenium in the water and sediment at the boundary. The iron concentrations exceeded EPA and Montana standards for aquatic life in two out of 36 visits in 2009 and three out of 24 visits in 2010. However, aquatic invertebrate sampling indicated that the site scored high in supporting aquatic life. State and federal agencies are working on a plan to remove the tailings from the streambed.



Iron concentrations in Soda Butte Creek at the park boundary from May to October2009 compared to aquatic life and drinking water standards.

Amphibians

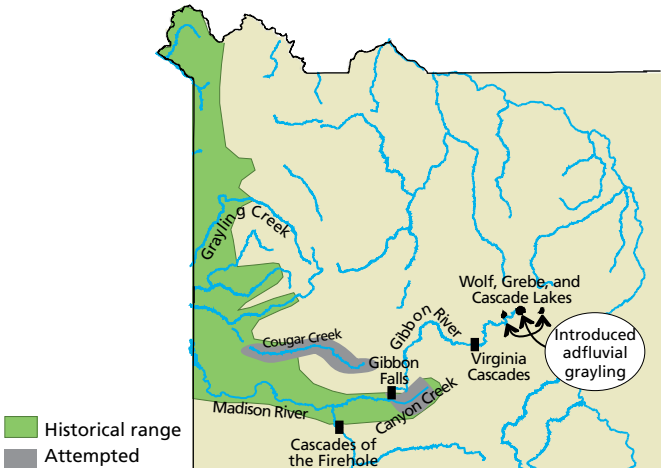
Annual surveys since 2002 have found the same four native amphibian species in Yellowstone: the Columbia spotted frog, boreal chorus frog, tiger salamander, and boreal toad. After five years of below-normal precipitation, the percentage of visited wetland sites that were suitable for amphibian breeding increased from 58% in 2007 to 92% in 2009. In 2010, 82% were suitable for amphibian breeding. Hydrological fluctuations change the extent and location of wetland sites, resulting in considerable year-to-year variation in amphibian reproduction, so longer-term data are needed to identify any significant trends. However, population data collected since 1992 appear to be within the range of natural variability and suggest that these species are resilient to at least short periods of drought. Reports from the 1950s suggest that the boreal toad was more widespread and common then, but it continues to be found at most of the major breeding sites that have been identified since the early 1990s, although at low numbers.



Monitoring results for Yellowstone and Grand Teton national parks by the Greater Yellowstone Inventory and Monitoring Network. A protocol for estimating the boreal toad occupancy rate has not been developed.

Arctic Grayling

Although fluvial (entirely stream-dwelling) Arctic grayling were historically common within 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 are also present now in Wolf Lake and the Gibbon River. Efforts to restore fluvial grayling in Canyon Creek in 1975 and in Cougar Creek in 1993 ultimately failed. The uppermost reaches of Grayling Creek, considered a potential site for fluvial grayling restoration, are occupied by brown trout and hybridized cutthroats. The restoration project on Grayling Creek was included as a potential action in the Native Fish Conservation Plan Environmental Assessment begun in 2010.

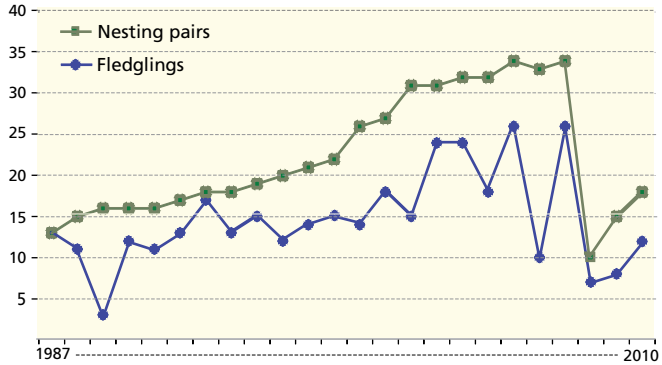


Former distribution of Arctic grayling within Yellowstone National Park and attempted restoration sites.

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.

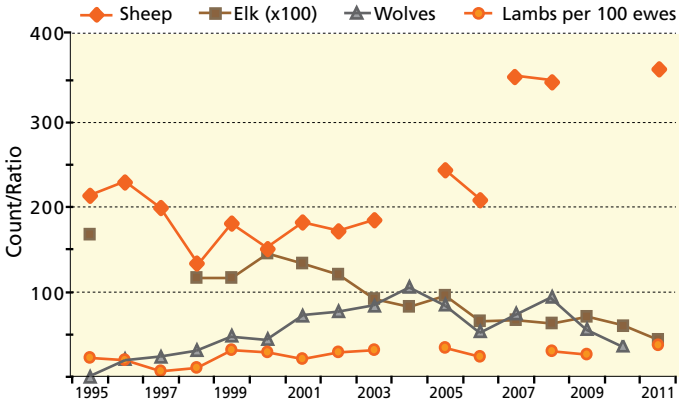
More than half of the park's known bald eagle nests have been in the Yellowstone Lake area, where the percentage of nests that produce fledglings has declined from 50% (1984–2000) to 30% (2001–2010). Possible causes include the reduction in cutthroat trout abundance, human disturbance, and climate change. Nest success outside the lake area from 2001 to 2010 was 68%.



Counts of bald eagle nesting pairs and fledglings in Yellowstone National Park, 1987–2010.

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 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 2011 count by the Northern Yellowstone Cooperative Wildlife Working Group (NYCWWG) was 363, with 38 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.

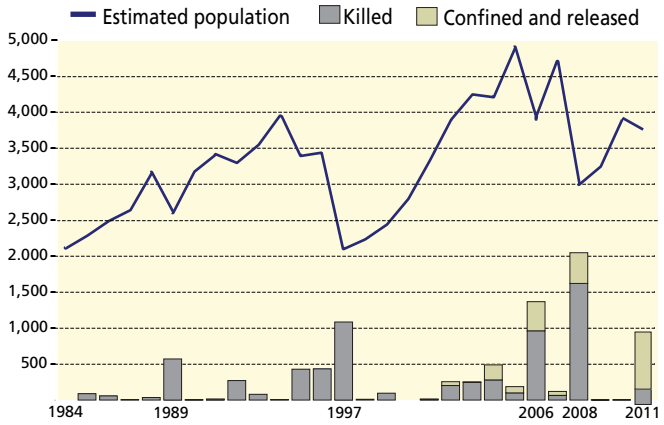


Northern range counts of bighorn sheep, lambs, elk, and wolves, 1995–2011.

Bison

Reduced by poaching to fewer than 50 by 1900, the Yellowstone bison population grew to more than 2,000 by the 1980s and expanded its use of lower elevation winter range outside the park. Boundary control operations with other federal and state agencies are conducted near Gardiner and West Yellowstone, Montana, to minimize the risk of brucellosis transmission to cattle on ranches. These interagency actions culled 3,207 bison from 2000 to 2010.

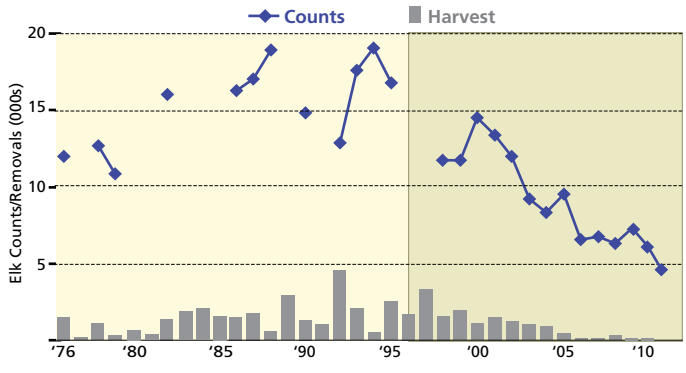
Bison movements are influenced by winter conditions and population size. During the unusually high snowpack of the 2010-11 winter, half of the population approached the boundary. To avoid sending bison to slaughter, nearly 800 were herded into fenced pastures and hundreds of others were allowed to remain on public and private land outside the park until greenup when they were hazed into the park. Of the confined bison, 53 were transferred to a research project and the others were released into the park in May after 150 had been vaccinated against brucellosis. Since bison hunting was authorized outside the park in 2006, a total of 481 have been harvested, including 211 in the winter of 2010–11.



Estimated summer population and the number of bison killed the preceding winter, including those harvested by hunters, 1984–2011.

Elk on the Northern Range

Yellowstone's largest elk herd winters along and north of the park's northern boundary. 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 by the NYCWWG, 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 38 in 2010. The elk count dropped to 4,635 in early 2011, 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 2004. The state of Montana has reduced the permits issued for this herd so that hunting now has little impact on population size.

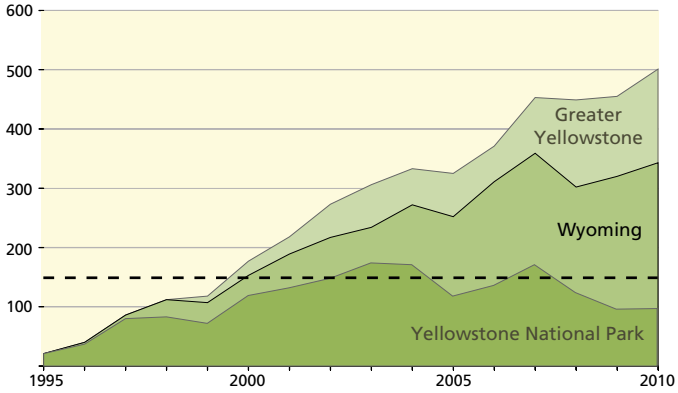


Winter counts and hunting harvests of the northern elk herd in Yellowstone National Park and adjacent areas of Montana, 1976–2011.

Gray Wolves

Predator eradication programs eliminated wolf packs from Yellowstone by 1926, and by 1978, all wolf subspecies were on the federal list of endangered species for the lower 48 states except Minnesota. In the first years after 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 501 at 2010 year end, including at least 97 wolves (11 packs and 6 loners) occupying territories located primarily in the park. However, the park's wolf population has dropped substantially since 2007, when the count was 171. Most of the decrease has been in packs on the northern range, where it has been attributed primarily to the decline in the elk population there.

In May 2011, the gray wolf was removed from the endangered species list in Idaho and Montana. It will be delisted in Wyoming when revisions agreed upon with the U.S .Fish and Wildlife Service have been made to the state's plan for managing wolves (outside of Yellowstone) after delisting.



Wolf counts for the Greater Yellowstone Recovery Area, Wyoming, and Yellowstone National Park. One of the recovery criteria for Wyoming is a population of at least 150 wolves in the state.

Grizzly Bears

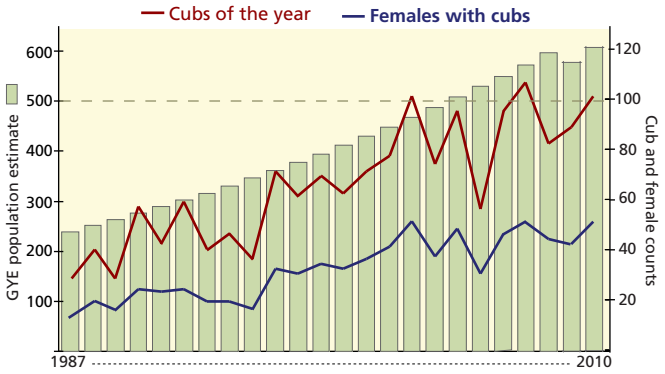
Grizzly bears were federally listed as a threatened species in 1975 due to unsustainable levels of human-caused mortality, habitat loss, and significant habitat alteration. As monitored by the Interagency Grizzly Bear Study Team, the criteria used to determine whether the population within the Greater Yellowstone Ecosystem (GYE) has recovered include estimated population size, distribution of females with cubs, and mortality rates. The population estimate increased from 136 in 1975 to 602 in 2010, and the bears have gradually expanded their occupied habitat by more than 50%. An estimated 150 grizzly bears occupy ranges that lie partly or entirely within Yellowstone. The number of females producing cubs in the park has remained relatively stable since 1996, suggesting that the park may be at or near ecological carrying capacity for grizzly bears.

The estimated adult grizzly bear male mortality rate was 13% in 2009 and 29% (26 bears) in 2010. If the rate exceeds 15% for three consecutive years, this failure to meet one of the recovery criteria will trigger a biology and monitoring review by the IGBST to identify the cause of the problem and potential corrective action.

Of the 41 grizzly mortalities known to have occurred in the GYE in 2010 (6 in Yellowstone), 3 were confirmed to be of natural cause, 3 were of undetermined cause, and the other 35 were human-caused. In addition to hunting-related deaths and road accidents, management actions resulted in the live removal of 6 bears (1 from Yellowstone) and the death of 15 bears, including 7 bears that had killed livestock and 2 that had killed humans. The two human fatalities, which occurred in separate incidents on national forest, were the first in the GYE since 1986.

Two conflicts with grizzly bears occurred in the park in 2010 compared to an average of seven a year during 1994–2009. Both involved human food and neither resulted in human injury. However, two human fatalities occurred in the park's backcountry during the summer of 2011. In one case a man was killed by a sow with cubs and no action was taken against the sow; in the other, no one witnessed the attack and investigation to determine the bear's identity through trapping and DNA analysis continues.

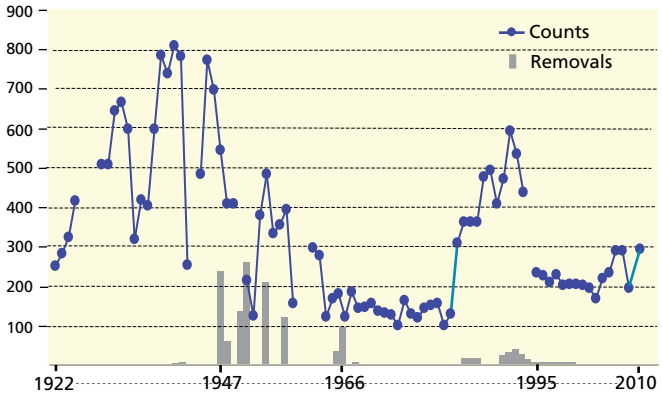
The demographic recovery goals for removing the GYE population segment from the endangered species list were achieved in 1998, but delisting was challenged and overturned in federal court. The U.S. Fish and Wildlife Service has filed an appeal, and a decision by the Ninth Circuit Court is expected during 2011.



Counts of grizzly bear females with cubs of the year, and estimated total GYE population, 1987–2010. One of the recovery criteria for the GYE is an estimated population of at least 500 grizzly bears.

Pronghorn

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. Although hunting has not been allowed north of the park since the 1970s, 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 is low due to coyote predation, and development of private land north of the park has reduced available winter range. The pronghorn winter range in the park is former agricultural land infested with nonnative vegetation of low nutritional quality.

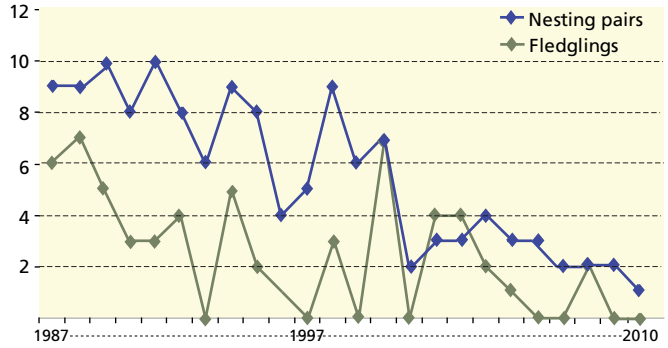


Pronghorn removals and spring counts in Yellowstone and adjacent areas of Montana, 1918–2010.

Trumpeter Swan

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, and had declined to 10 by 2010.

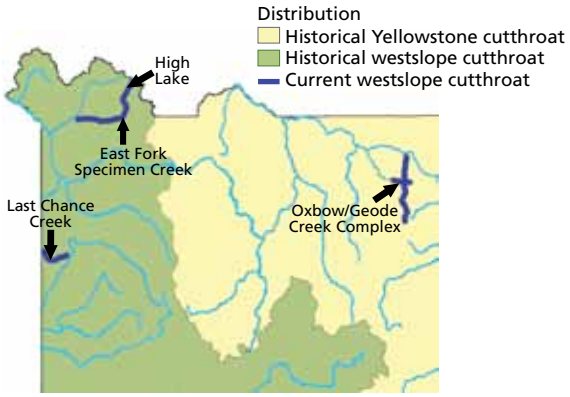
Nearly all Rocky Mountain trumpeter swans, including several thousand that migrate from Canada, winter in ice-free waters in the greater Yellowstone area, but only a small portion of them remain here to build their nests. The best available scientific evidence suggests that Yellowstone provides marginal conditions for nesting and acts as a sink for swans dispersing from more productive areas. This effect has been compounded in recent decades by habitat changes (e.g., decreased wetlands due to long-term drought or warmer temperatures) and community dynamics (e.g., recovery of wolf, bear, and raptor populations). Trumpeter swan presence in the park may therefore be primarily limited to occasional residents and wintering migrants from outside the park.



Counts of trumpeter swan nest attempts and fledglings in Yellowstone National Park, 1987–2010. Only one pair nested in the park in 2010, and they produced no cygnets.

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 (an estimated 64% of the approximately 641 stream miles it once 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 between 1922 and 1924. To help restore WCT, High Lake has been stocked annually since 2007 from the park populations and Upper Missouri River brood stock. In 2010, reproduction of the WCT in High Lake was first documented and restocking of East Fork Specimen Creek began.



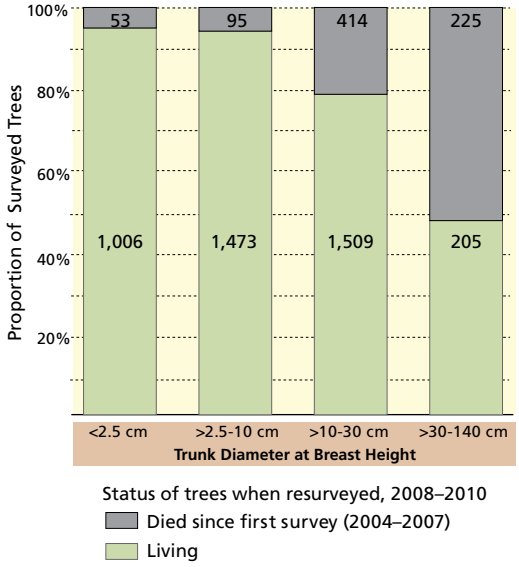
Westslope cutthroat trout are being restored in High Lake and East Fork Specimen Creek.

Whitebark Pine

Whitebark pine, which retains snow and reduces erosion at high elevations while producing seeds that are an important food source for grizzly bears and other wildlife, is experiencing unprecedented mortality throughout its range. A primary cause is blister rust (*Cronartium ribicola*), an introduced pathogen that increases the trees' vulnerability to infestation by endemic pine beetles.

Approximately 20% of nearly 4,800 live trees were infected by whitebark blister rust when first surveyed by the Greater Yellowstone Inventory and Monitoring Network from 2004 to 2007. When they were resurveyed from 2008 to 2010, 16% (787) had died, including more than half of the trees >30 cm in diameter, and only 238 new trees in the transects were tall enough to be tagged. The mountain pine beetle prefers larger trees for laying their eggs; the larvae feed on the inner phloem of the bark. The percent of trees with blister rust has increased in some transects but decreased in others, which could be an artifact of infected trees that have been killed by fire or beetles.

Aerial surveys, which measure the spatial extent of mortality rather than the percentage of individual dead trees counted on the ground, have generally arrived at higher whitebark pine mortality estimates in the GYE. 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. Aerial surveys by the U.S. Forest Service and the state of Montana indicate that approximately 7% of the 281, 700 acres of whitebark pine stands in Yellowstone National Park were infested with beetles in 2010, down from 15% in 2009.



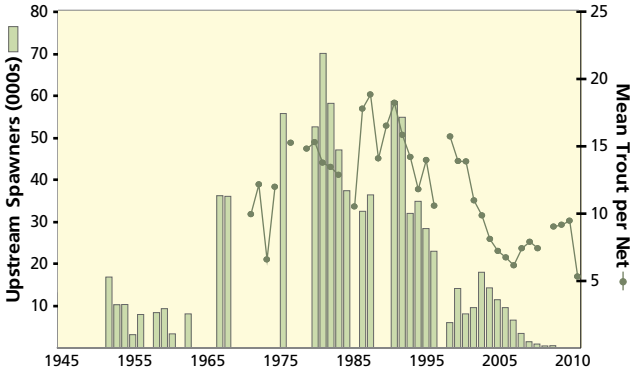
Proportion and number of tagged trees that had died or were still alive when resurveyed in 2008, 2009, or 2010.

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 number of YCT caught per net at lake-wide sampling sites during an annual monitoring program that began in 1969 reached 19.1 in 1984 and dropped to an all-time low of 5.3 in 2010. The number of 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 number of upstream-migrating cutthroat trout counted at Clear Creek (1945–2007) and the number of cutthroat trout caught per net during the fall netting assessment on Yellowstone Lake (1969–2010).

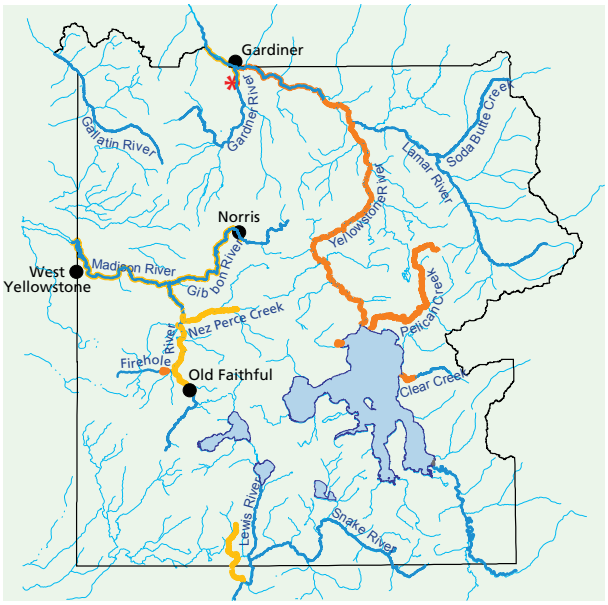
Aquatic Nuisance Species

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.

A third non-native species, the red-rimmed melania (*Melanoides tuberculatus*), a small snail imported by the aquarium trade starting in the 1930s, was discovered in the warm swimming area at the confluence of the Boiling River with the Gardner River in 2009. The following year, a survey of 18 of the park's most popular hot springs 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 become established in other thermal water in the park.

Each summer a small team of park technicians and volunteers is employed throughout the park to contact park visitors before they put their boats or angling gear in the water, and they inspect and clean the equipment if necessary. Such decontamination is usually adequate to prevent the entry of most aquatic nuisance species; however, some life stages of certain mussels and other organisms cannot be easily detected or decontaminated.

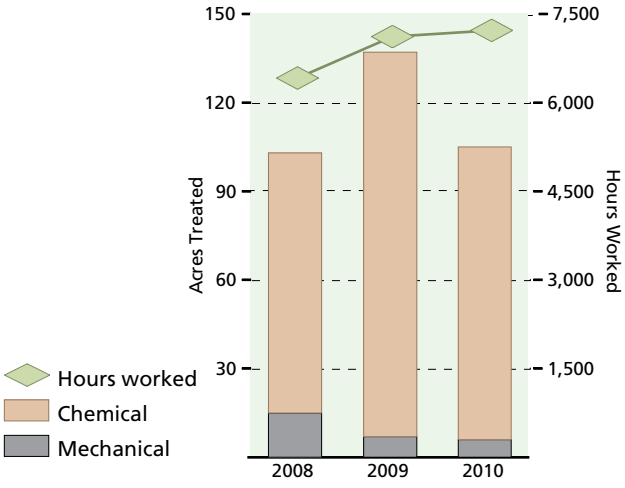


Locations in Yellowstone National Park where whirling disease, New Zealand mud snails, or red-rimmed melania have been documented.

Invasive Plants

In addition to about 1,300 native plant species, 218 nonnative species have been documented in the park through ongoing survey efforts over the years. 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.

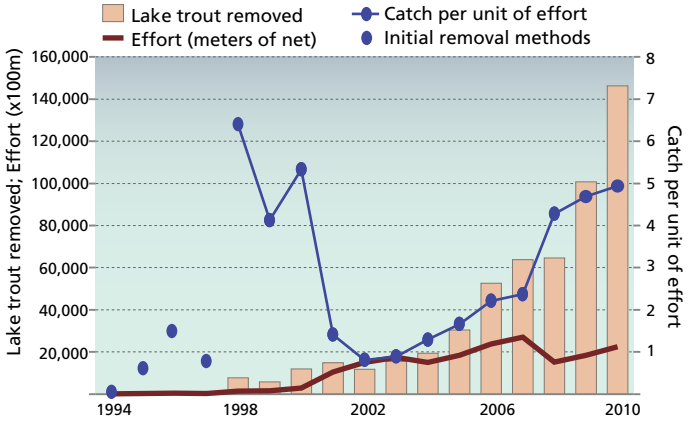
Of the 20,291 acres surveyed on foot in 2010, about 4,600 acres were affected by nonnative vegetation. Based on treatment priorities, 96 acres were selected for treatment, of which 9 acres were treated twice. Plants were physically pulled on six acres; the rest were treated using herbicides. Most of the 44 species targeted for treatment are listed by the states of Idaho, Montana, and/or Wyoming as "noxious weeds," which means that they are considered detrimental to agriculture, aquatic navigation, fish and wildlife, or public health. Roadways and developed areas comprised 75% of the treatment acres and the remaining 25% occurred along the park's trails and in the backcountry.



Acres of infested area receiving chemical and mechanical treatment, and hours spent on plant surveys and treatment by NPS staff, interns, and volunteers.

Lake Trout in Yellowstone Lake

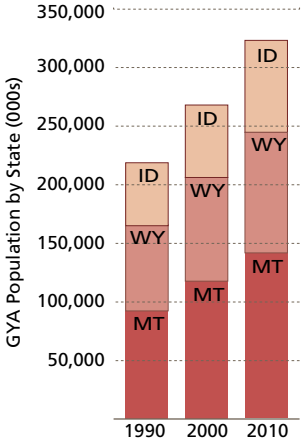
Lake trout, which are not native to the park, have had a significant impact by consuming and competing for food with the native Yellowstone cutthroat trout in Yellowstone Lake, where it was illegally introduced. More than 550,000 lake trout have been removed since the lake trout's presence was confirmed in the lake in 1994, including about 31,600 caught in gillnets by a contractor during a 10-week period in 2010. The largest lake trout to be caught in Yellowstone (26.25 pounds) was netted in 2009. The number of caught per 100 meters of net in one night (catch per unit of effort) has been rising since 2002, suggesting that the population has been increasing faster than the fish are being removed. One goal of Yellowstone's Native Fish Conservation Plan (2010) is to reduce the population by 25% each year until it collapses to an insignificant level. Population modeling suggests this may be possible with an increase in effort.



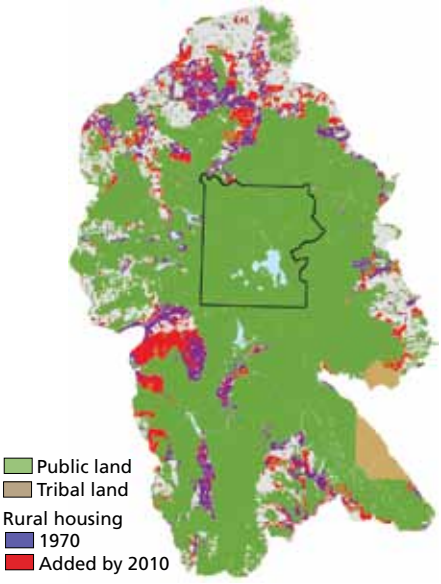
Number of lake trout removed, units of effort (meters of net in place during the season, counted daily), and catch per unit of effort, 1994–2010.

Land Use

How land is used outside the park can disrupt ecological processes within the park. Still sparse at the turn of the 20th century, the population in the greater Yellowstone area has grown steadily since 1970. Data compiled by the Greater Yellowstone Inventory and Monitoring Network show that from 1990 to 2010, the population of census block groups in and near the GYA increased nearly 50% (approximately 220,000 to 323,000). Much of the growth occurred in rural residential areas with one home per 0.4 to 16.2 hectares. Development density is expected to increase, but with rural residential development continuing to dominate. Agriculture is still a significant use of the land. In 2007, the percentage of land in the counties in and near the GYA on which crops were grown ranged from less than 5% to more than 50%.

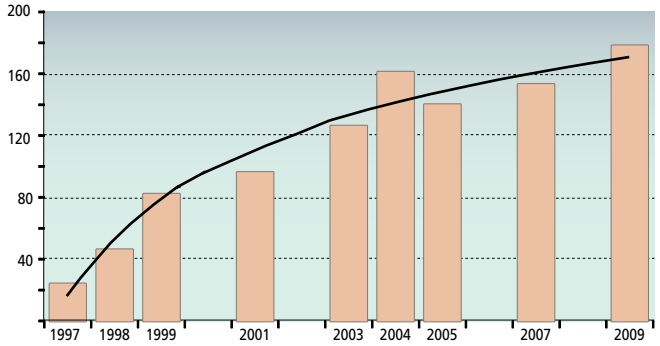


Population growth in the Idaho, Wyoming, and Montana portions of the GYA.



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 habitats. 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. Competition with high densities of mountain goats could negatively affect bighorn sheep, whose range overlaps with mountain goats. 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.



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.

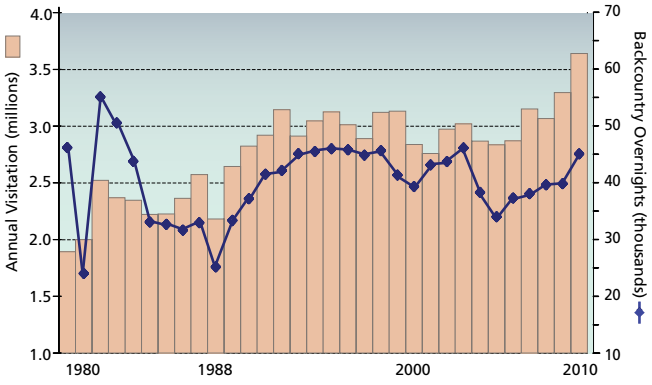
Visitor Use

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, and the natural soundscape
- wildlife habitat, distribution, and habituation;
- the spread of non-native plants, diseases, and aquatic organisms
- the functioning of geothermal features

After exceeding 3 million for the first time in 1992, annual visitation at Yellowstone fluctuated between 2.8 and 3.1 million until new records were set in 2009 (3.3 million) and 2010 (3.6 million). About 70% of the visitation occurs from June through August. Although there are no day use quotas, lodging and campgrounds in the park can accommodate only about 14,300 visitors during the summer, while daily visitation during July 2010 averaged 30,900. 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.

Similar to trends at other western parks, overnight backcountry use in Yellowstone peaked in 1977 at more than 55,000 "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.



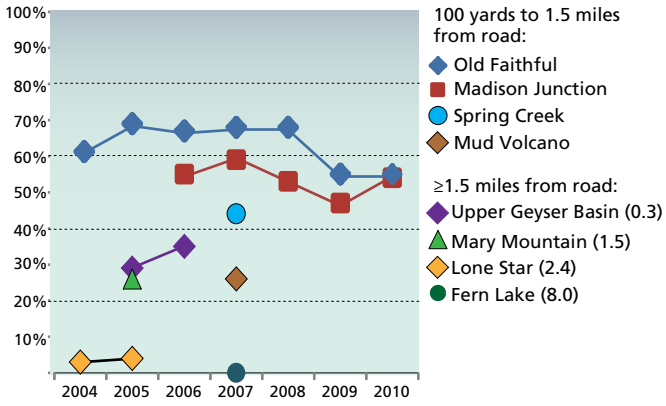
Annual number of Yellowstone visitors and number of backcountry overnights, 1979–2010, from data collected by Yellowstone's Visitor Services.

Winter Soundscape

Human-caused sounds that mask the natural soundscape used by wildlife and enjoyed by 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 (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 must produce no more than 73 dBA (a measure of sound pressure) at 50 feet. A 6-dB increase generally doubles the distance at which a sound can be heard. Maximum levels in the park 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 the 73 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 by a site's proximity to roads and developed areas, topography, and the camouflaging effect of other sounds such as wind and geyser activity. The increase in percent time audible at Madison Junction from 2009 to 2010 was at least partly due to a decrease in the time that wind was audible. At the Old Faithful monitoring station, the average percent time OSVs were audible from 8 AM to 4 PM has dropped from more than 90% prior to 2003 to about 55%.



The percentage of time from 8 AM to 4 PM that OSVs were audible at eight locations in Yellowstone National Park, 2004–2010.

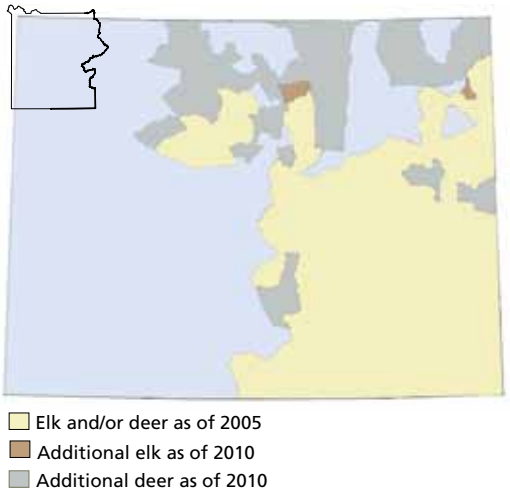
Wildlife Diseases

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 and have spread into Yellowstone as a result of human activity have caused population declines (e.g., wolves and trout) and required management interventions (e.g., bison and elk). Significant diseases present in Yellowstone wildlife:

- **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 (*Batrachochytrium dendrobatidis*), which are of uncertain origin and commonly cause amphibian die-offs, have been identified in the park. During 2010, twelve sites were found containing clusters of dead amphibians, including a die-off of more than 20 tiger salamanders (*Ambystoma tigrinum*).

Diseases that could potentially appear in Yellowstone include chronic wasting disease (deer, elk, and moose), West Nile virus (birds), and white-nose syndrome (bats), which is believed caused by a fungus adapted to the cold and humid conditions of the hibernacula used by wintering bats.

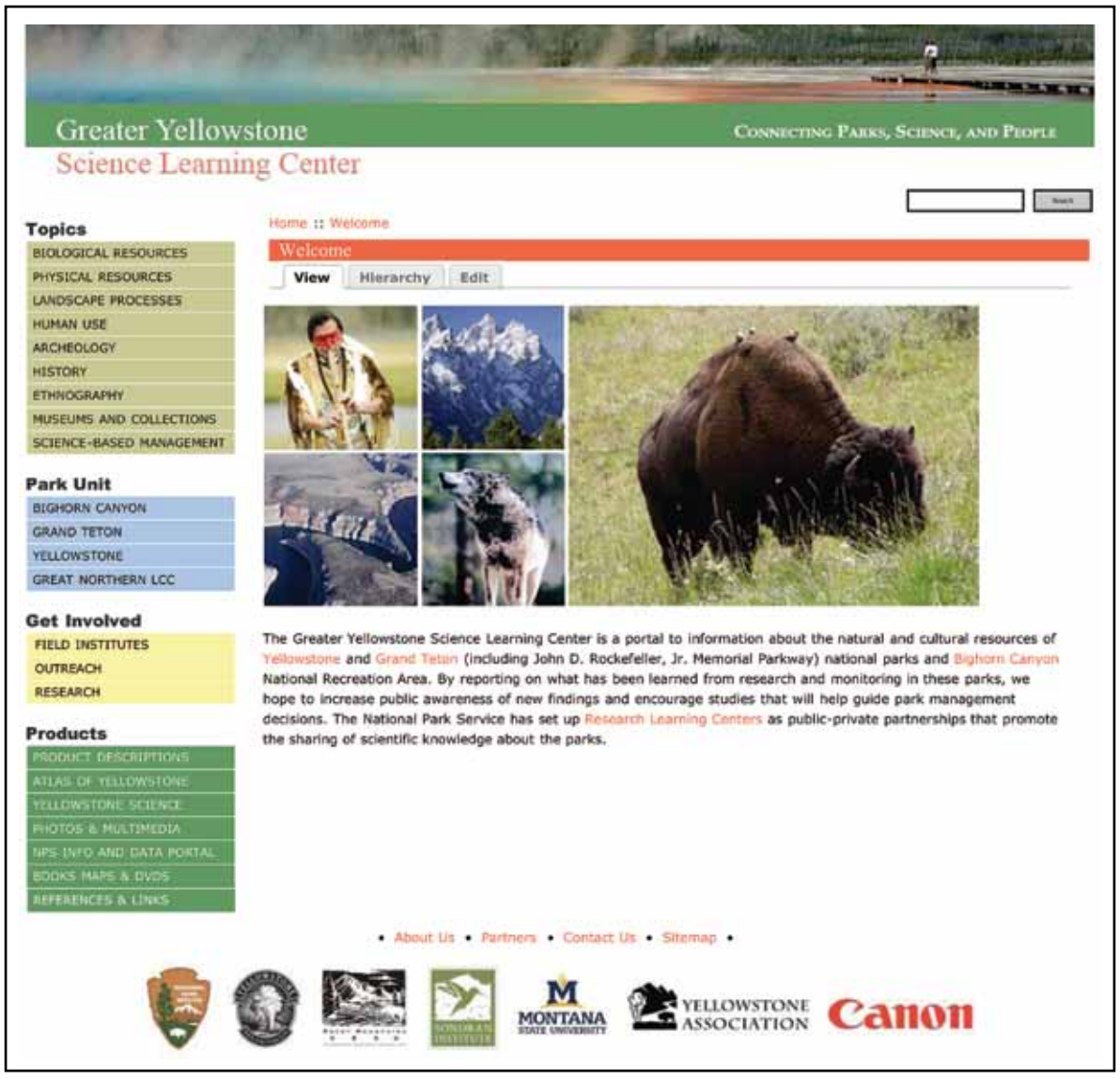
Hantavirus, considered native in origin, has been found in some Yellowstone voles and deer mice, but transmission to humans in the park is not known to have occurred.



Hunt areas in which the Wyoming Game and Fish Department has identified deer and elk with chronic wasting disease.

NPS/Peaco

For more information on any of the vital signs in this report,
please visit the Greater Yellowstone Science Learning Center website.



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