Science and Resource Management
Grand Teton National Park
& John D. Rockefeller, Jr. Memorial Parkway

National Park Service
U.S. Department of the Interior

GRAND TETON NATIONAL PARK
& John D. Rockefeller, Jr. Memorial Parkway

Natural and Cultural Resources

VITAL SIGNS 2022

This report is made possible through generous support from
Grand Teton Association.
It shares natural and cultural resource data collected
during the calendar year 2022 and compiled in 2023.

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Where not otherwise indicated, photos in this report are courtesy of the National Park Service.

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M. Gocke/WGF

Grand Teton resources include migratory bison herds.

Why We Monitor the Park's Resources

The National Park Service was established in 1916 with the mission of protecting the resources of the parks and providing for the public enjoyment of those same resources in such manner that the resources will remain unimpaired for future generations to enjoy. While Grand Teton National Park was not created until 1929 (and expanded in 1950), the mission remains the same. To protect and manage the wide variety of natural and cultural resources held within the park, resource management staff monitor and study individual resources and ecological processes—vital signs—to better inform decisions made in the park. Systematic monitoring is complicated by the fact that air resources, water resources, and many of the animals' seasonal migrations cross the boundaries of the park where other factors influence their condition. Inside the park, plant and animal species that may change or affect native species have been introduced both accidentally and intentionally. Pressure from humans, both within Grand Teton National Park and outside, may also affect conditions in the park. Data collected on some resources may be too limited to predict significant trends, but hopefully will provide a baseline for future study. Resources summarized in this report are monitored because of their significance to or influence on this ecosystem.

Vital Signs Summaries

Grand Teton's vital signs summaries are grouped into five categories for purposes of this report. They include:

- **Climate and Environment** (air quality, climate, fire, glaciers, rivers, and water quality) are primarily the result of natural processes that operate on distinctly larger scales than the park but can be affected by human activities both within and outside the park.
- **Natural Resources:** selected plants and animals that
  - are or have been listed under the federal Endangered Species Act (bald eagle, gray wolf, grizzly bear, peregrine falcon and whitebark pine).
  - have experienced declines in the park and surrounding areas or are of special concern (golden eagle, great blue heron, great gray owl, greater sage-grouse, moose, and trumpeter swan).
  - have relatively small populations in the park and are considered vulnerable (bighorn sheep, Columbia sharp-tailed grouse, common loon, harlequin ducks, and 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, elk, and mule deer).
  - are considered important indicators of ecosystem health because they are especially sensitive to environmental pollutants, habitat alteration, climate change and other human-caused factors (amphibians, cutthroat trout, osprey, red fox, and sagebrush steppe).
- **Cultural Resources** (archeological sites, historic structures, and museum collections) are significant representations of the human evidence in the park and are inventoried, protected, and monitored to ensure that these resources and the information associated with them are passed along to future generations.
- **Challenges** (nonnative plants and animals, park visitation and use, plant and habitat restoration, wildlife collisions, and the human-bear interface) are generally caused or largely influenced by human activity and are monitored to inform park management.

Comparison to Reference Conditions

The table on the following page summarizes the current status of selected resources. In most cases, a reference condition is indicated that can be used for comparison purposes. Because conditions 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. 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.

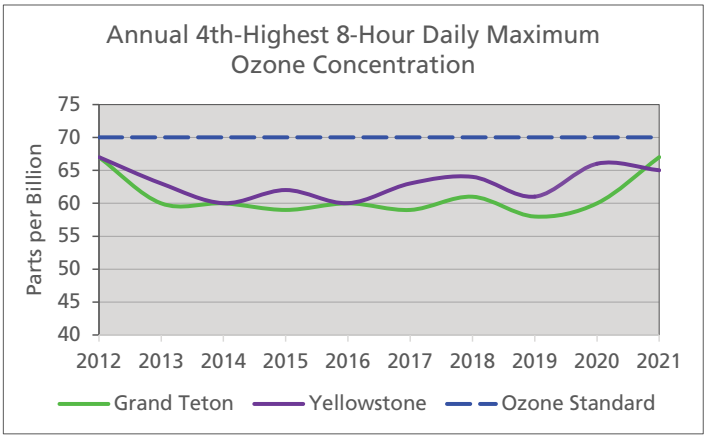
Vital Signs Summary

TBD = to be determined

Resource	Indicators	Current Condition 2021 (or latest available)	Reference Condition
Climate and Environment			
Air Quality	Basic air quality parameters at 1 site	Class I Airshed	Clean Air Act
Climate	Average min., max. daily temp. (Moose) Annual precipitation (Moose)	22°F, 54°F 17.81"	22°F, 53°F (1959–2022 average) 21.83" (1959–2022 average)
Fire	Acres burned per year by wildfire	1 acre	1–19,211 (2003–2022 range)
Glaciers	Extent of 10 named glaciers	0.8 km²	Long-term decline
Water Quality	Basic water quality parameters- 2 river sites	Iron within state standards	State water quality standards
Natural Resources			
Amphibians	% of potential sites suitable for breeding	83%	TBD
Bald Eagle	Breeding pairs	12 pairs	11.6 pairs (2013–2022 average)
Bighorn Sheep	Teton Range herd estimate	≈140 sheep	≥150–200 sheep
Bison	Jackson herd winter count (includes areas outside park)	466 bison	500 bison
Common Loon	Breeding pairs	0 pairs	TBD
Elk	Jackson herd winter count (includes areas outside park) Summer count (portion of park herd)	11,057 elk ≥1091 elk	11,000 elk ≤1600
Gray Wolves	Wolves in Wyoming (outside of Yellowstone) Breeding pairs in WY (outside of Yellowstone)	212 wolves (40 in park) 14 pairs (3 in park)	≥100 wolves ≥10 pairs
Great Blue Heron	Active nests	38 nests	27.7 nests (2013–2022 average)
Greater Sage-grouse	Active lek	5 leks (5 in park)	8 occupied leks (7 in park)
Grizzly Bears	GYE population estimate Distribution of females with cubs	965 18 bear management units	≥500 grizzly bears ≥16 bear management units of 18
Moose	Jackson herd winter count	≥326 (89 in park)	TBD
Osprey	Breeding pairs	8 pairs	10.9 pairs (2013–2022 average)
Peregrine Falcon	Breeding pairs	5 pairs	3.8 pairs (2013–2022 average)
Pronghorn	Jackson Hole/Gros Ventre herd estimate	708 pronghorn	350–900 (modeled range)
Trumpeter Swans	Occupying breeding territories (includes areas outside park) Pairs producing young	6 pairs (6 in park) 1 pair (3 cygnets hatched)	14 historic territories (10 in park) TBD
Whitebark Pine	Blister rust infection (% of trees in park)	60% of trees	TBD
Cultural Resources			
Archaeological Sites	Percentage of park inventoried	5% of the park	75–100%
Historic Structures	Percentage assessed in good condition	54%	100%
Museum Collections	Percentage that has been cataloged	86%	100%
Challenges			
Aquatic Invasive Species	Presence of nonnative species	13	0 (limit spread & effects on native sp.)
Fish	Species present	12 native 9 nonnative	12 native Limit spread & effects on native sp.
Human-Bear Conflicts	Injuries, human food obtained, or property damaged	6 in park	8.1 (2013–2022 average)
Invasive Plants	Species present	30 invasive species	Limit spread & effects on native sp.
Mountain Goats	Estimated number in park	10–20 goats	0 (limit spread & effects on native sp)
Plant Restoration	Restoring native plant communities in former agricultural fields (Kelly hayfields)	1411 acres under restoration treatment	100% of 4500 acres in the former Kelly hayfields area

Reference condition specified by government regulation or management plan.

Air Quality



Comparison of the maximum ozone levels annually on the fourth-highest day in Grand Teton and Yellowstone National Parks. The fourth-highest day of the year is identified to minimize the impact of short-term variations in weather conditions in any given year. (2022 statistics not available at publishing.)

Grand Teton National Park generally experiences good air quality; however, both distant and local sources of air pollution can affect the park. As a federally designated Class I airshed, Grand Teton is required to meet high standards for air quality. The park conducts monitoring to evaluate the potential for air pollution to affect park resources, like ecology, public health, and night sky visibility.

Air pollutants that affect ecology include sulfur and nitrogen compounds deposited by precipitation and settling out of the atmosphere. These compounds can harm surface waters, soils, and vegetation. High-elevation lakes are especially sensitive to acidification from sulfur and nitrogen deposition and excess nitrogen enrichment. Acidification may cause loss of sensitive macroinvertebrates and fish, while nutrient enrichment may alter lake diversity. Research suggests that deposition of nitrogen above 1.4 kilograms per hectare per year affected the diversity of diatoms (single-celled algae) found in high-elevation lakes in the Greater Yellowstone Ecosystem, an area that includes Grand Teton National Park. Additionally, alpine plant communities are also vulnerable to nitrogen enrichment, which may favor some species at the expense of others.

The park operates an air quality monitoring station, established in 2011, to track the deposition of these compounds in precipitation. This station is part of the National Atmospheric Deposition Program, which measures precipitation chemistry at over 200 locations across the country. The link for this station, including a webcam is https://www.nps.gov/subjects/air/webcams.htm?site=grte. The five-year averages (2016–2020) measured at the Grand Teton station indicate poor conditions for ecosystem health due to the estimated annual wet deposition of nitrogen (1.5–6.0 kg per hectare per year) and the estimated annual wet sulfur deposition (0.4–1.5 kg per hectare per year). Total wet sulfur concentrations in rain and snow, while still rated as poor, have improved over the past ten years.

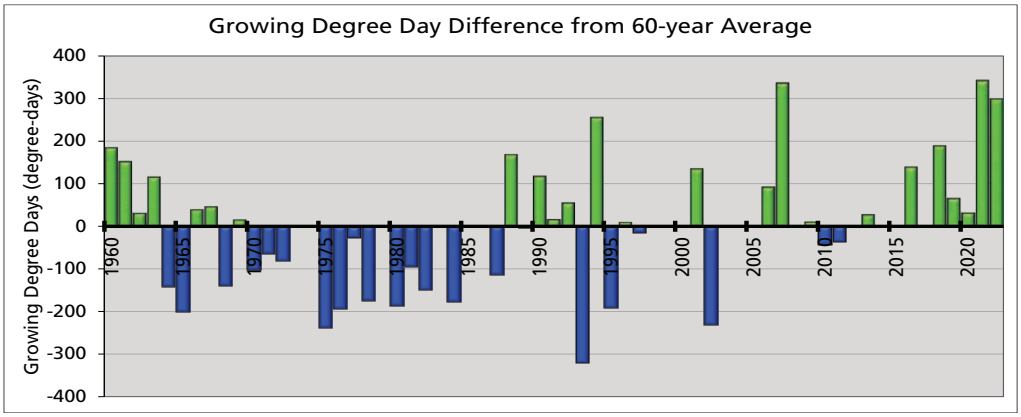
Park staff also measure ozone (O_3) concentrations and the air quality index. Ozone is harmful to human health as well as vegetation and is regulated under the Clean Air Act. The Environmental Protection Agency established a standard for ozone based upon the three-year average of the fourth-highest daily maximum eight-hour concentration. For good human health, the standard is 54 parts per billion (ppb); however, the estimated ozone concentration five-year average (2016-2020) in Grand Teton is 61.8 ppb, rated as fair human health conditions. The air quality index (AQI) indicates how much particulates and pollutants affect air quality. In 2022, the park installed 3 PurpleAir devices to measure AQI and provide online real-time updates. The link for the PurpleAir devices is https://map.purpleair.com/1/i/mAQI/a10/p604800/cC0#9.21/43.7973/-110.645.

Park staff maintain the air quality station replacing parts like the particulate filter on the ozone measuring instrument.

Visitors come to Grand Teton to enjoy spectacular views of the Teton Range and the Jackson Hole valley. Sometimes the park's scenic vistas are obscured by haze caused by fine particles in the air. Many of the same pollutants that ultimately fall out as nitrogen and sulfur deposition contribute to this haze and visibility impairment. Additionally, organic compounds, soot, and dust reduce visibility. To address regional haze and visibility impairment, the National Park Service is working with the Wyoming Department of Environmental Quality- Air Quality Division to update the state's air quality protection plan.

The clarity of Grand Teton's night sky has emerged as an important issue for nocturnal wildlife as well as visitor experiences. Wild animals, like birds and bats, are sensitive to excess light at night. Visitors come to national parks to stargaze. Night sky visibility can be impacted by light pollution from man-made sources. To develop a baseline of night-time skies visibility, park staff worked with Wyoming Stargazing to install a TESS-W photometer. The photometer is designed to continuously measure night sky brightness for light pollution and cloudiness. The link for real-time photometer information is https://tess.dashboards.stars4all.eu/d/tess_raw/s4a-photometer-network-raw?viewPanel=2&orgId=1&orgId=1&var-Tess=stars725&refresh=1m.

Climate



Annual cumulative growing degree day difference from average at Moose, WY 1960–2022. Green bars indicate years when growing season cumulative heat was higher than the 60-year average and blue bars indicate below average condition, while years without bars had more than 15 days of missing data. Data from Climateanalyzer.org.

In most aspects, weather recorded in 2022 at the Moose, WY station was uneventful providing a nice contrast to the record-breaking heat of 2021. The 2022 average temperature was much cooler than 2021, but 2022 was still 0.72°C above the 60-year average. While that may not seem like much, the accumulation of heat during the growing season, known as growing degree days, was in the 97th percentile and third highest recorded since 1960. A long-term increase in the number of growing degree days is a clear indicator of climate change. Despite the unusually warm growing season in 2022, drought stress was only slightly above normal (+10 mm) because precipitation was also above normal (+38.5 mm).

In May 2022 precipitation (112 mm) was in the 96th percentile which maintained soil moisture and vegetation growth through an unusually dry July (10 mm precipitation, < 1st percentile) which was followed by normal precipitation in late summer. The combination of late season heat and sustained soil moisture helps explain the beautiful fall weather and colorful foliage of 2022.

Fire

Wildfire has shaped the Greater Yellowstone Ecosystem (GYE) landscape over the past 10,000 yrs. Tree ring and paleo (lake sediment cores) studies indicate that subalpine forests experienced naturally ignited, infrequent, stand replacing fires every 100–300 years. Fire occurrence was climate-driven and primarily happened during occasional hot, dry summers. For example, many of the forests in Grand Teton National Park were established after historic stand-replacing fires that swept the valley during the notably warm years of 1856 and 1879.

Ecologists evaluating recent fires in subalpine forests throughout the GYE found that these forests are well adapted to historical cycles of fire and recovery. Fires result in a mosaic of burned patches varying in size. Native understory plants resprout following the fire. At lower elevations, where fire return intervals are 135–185 years, lodgepole pines have adapted to regenerate prolifically following the release of seeds from serotinous cones. Serotinous cones are naturally coated with a resin that must be melted before the cone opens and releases the seeds. When fire moves through the forest, it melts the resin allowing those cones to open and distribute seeds by winds and gravity after a fire. At higher elevations, where fire return intervals are 280–310 years, spruce, fir, and pines slowly fill the burned patches close to unburned seed sources. These landscapes provide habitat for a diversity of flora and fauna during the transition from a carpet of ashes to dense forests with mature cone-bearing trees.

The west has experienced a rapid increase in fire season length and activity caused by climate change. *The Greater Yellowstone climate assessment: past, present, and future climate change in greater Yellowstone watersheds (2021)* reported that, in the GYE alone, temperatures increased by an average of 2.3°F between 1950 and 2018. The precipitation amount has not changed significantly. However, more precipitation occurs in the spring (11–17% increase April–May) and fall (40% increase in October), and less during the summer (11–17% decrease June–July), and snowfall has decreased by 25%. By the end of the century, temperature is projected to increase by 5.3°F with further seasonal shifts in precipitation—increasing in the spring and fall but declining in winter and summer. Present and imminent changes in climate pose a multitude of threats that are destined to test the resiliency of GYE's fire-adapted forests.

The park's fire effects crew revisits specific locations annually after a fire to gather information on the types and densities of plants that are regrowing or moving into the area.

Fires in this region often burn in a classic mosaic pattern leaving islands of unburned forest within the fire perimeter. These unburned areas act as a seed bank supplying seeds to nearby areas; although, some plants that were burned will resprout from the roots, like aspen and willow..

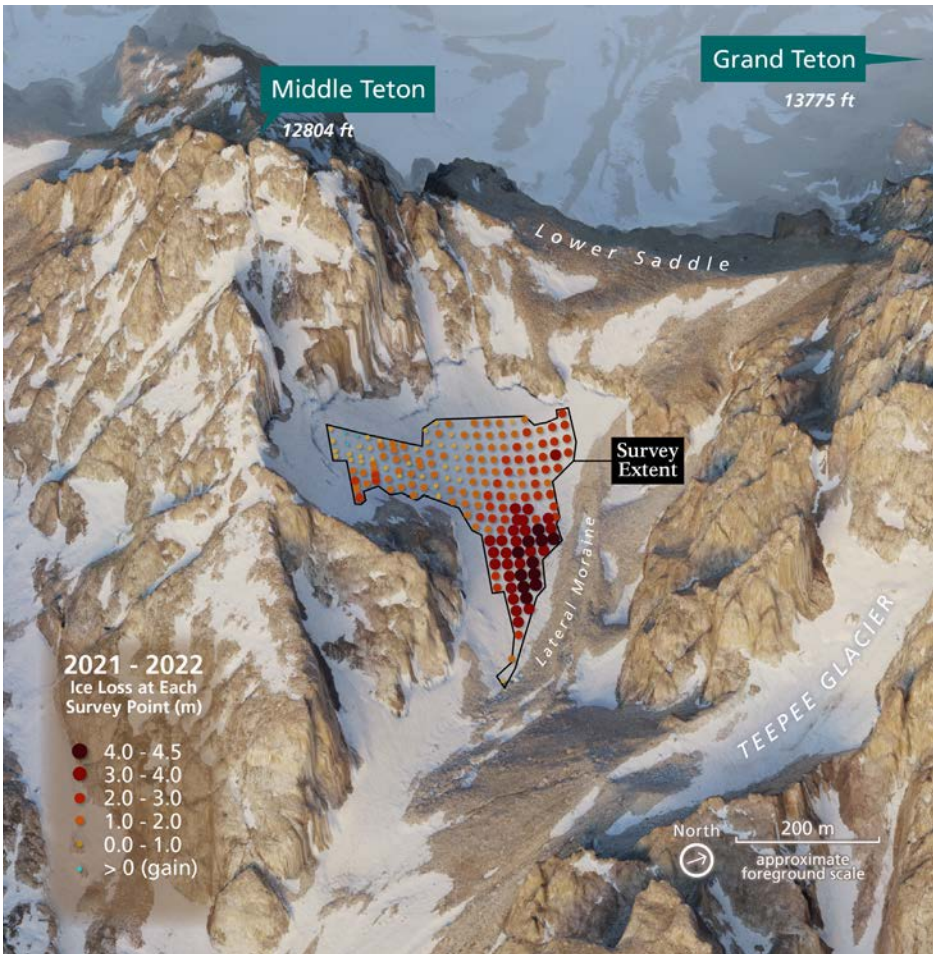
Hotter, drier summers result in more frequent large fires, likely reducing the fire return intervals to less than 100 years. Lodgepole pine stands produce cones once they are at least 15 years of age, but cones of young trees are generally not serotinous. Thus, fires that burn in young lodgepole pine stands experience very low tree regeneration. The Berry Fire that burned in Grand Teton National Park in 2016 provides a natural experiment to evaluate what is expected in the future because it reburned parts of the Glade (2000) and Huck Fires (1988). Researchers from the University of Wisconsin - Madison found higher burn severity in the dense, roughly 15-year-old regenerated stands and vastly reduced lodgepole pine regeneration. In addition to reduced fire return intervals, warming temperatures and drier summer will likely increase the size and severity of fires that occur. In larger burned patches that are surrounded by immature forests, tree seeds may have difficulty making their way from unburned forests to re-establish in burned areas. Hot, dry soils will pose additional challenges for tree seedlings to survive.

Anticipated increases in the frequency of large fires may exceed the historical range of variability in the GYE and challenge the ability of forests to recover. Once dense forests could fail to regenerate following fire and instead transition to open landscapes dominated by herbaceous plants and shrubs. Managers are now tasked with balancing their traditional understanding that forests in the GYE are generally resilient to fire with the prospect that unprecedented change and increased fire in will require managing forest refugia, isolated islands of the once wide-spread forests. Research is uncovering new outcomes as we continue to monitor the effects of a rapidly changing climate.

Glaciers

Grand Teton National Park has 11 known glaciers, previously thought to have formed during a short cold neoglaciation period called the Little Ice Age (1400–1850); however, recent research suggests that Teton Glacier may have been active since the last major glaciation approximately 10,000 years ago. Some of these glaciers are active, while others are considered remnant because they have lost so much volume they have stopped flowing. The Teton glaciers are iconic features of the park landscape, prompting efforts to monitor their fluctuations under current and future climate regimes.

Park staff monitor glacier movement, area and volume changes, as well as glacial influence on stream flow quantity and quality. Glaciers store water that provides critical input to land and aquatic ecosystems during the summer months. This is particularly evident in years of below-average precipitation. Researchers outside the park found summer stream temperatures can be 2–3 ºC cooler in glacier-fed streams than in adjacent glacier-less basins. In 2020, park staff installed gauges in paired glacier-fed streams and glacier-less basins to measure stream temperatures and flow levels over the next few years. Resource staff can use the collected data to calculate the percentage of the flow and the temperature changes that Teton glaciers contribute to late-season stream flows.



The survey of ice loss depth on the Middle Teton Glacier in 2022 showed that ice thinned across 70% of the glacier's surface. Areas with the greatest ice loss are indicated by the dark red dots.

Changes in glacial extent and volume are significant indicators of changing climate and, as in nearly all glaciated areas of the globe, recent studies show significant and rapid retreat and volume loss of glaciers in the Greater Yellowstone Ecosystem (GYE). High-elevation areas of the Rockies are experiencing changes such as rising temperatures and earlier, more rapid snow melt than the region overall.

In 2013, NPS staff created and tested ice surface elevation survey methods on Middle Teton and Schoolroom Glaciers—both chosen for their relative safety and accessibility. Park staff also installed air temperature sensors to provide data for a GYE-wide sensor network, as well as time-lapse cameras to provide images and monitor summer snowmelt patterns on glaciers too difficult or hazardous to monitor directly.

Annually since 2015, physical science staff and climbing rangers conduct GPS elevation surveys of Middle Teton Glacier. These surveys show changes in the glacier surface and measure volume change over time. Results from 2022 indicate ice thinned across 70% of the glacier's surface, and areas with the greatest amount of thinning (near the glacier terminus) had 4.7 meters of ice loss for the year, with a mean loss of 2.1 meters.

In 2022, park physical science staff worked with skilled ski mountaineers to complete the fourth annual spring survey of Middle Teton Glacier to measure snow accumulation on the glacier prior to the summer melt season. On June 10th, 2022, snow depths ranged from 2 meters to over 5 meters. The snow accumulation across the glacier surface is dynamic and variable, and likely results from avalanches and wind distribution of snow from surrounding peaks in addition to the snow falling there directly. During this survey, the researchers drilled through the snowpack and into the glacial ice beneath to place four ablation stakes. The stakes remained through the summer to measure snow and ice melt, as well as glacier movement. At the end of the melt season, only one of stakes had any remaining snow. The total melt at each stake ranged 4.2–4.7 meters. In September 2022, measurements from the movement of the ablation stakes indicated a glacier velocity of up to 7.3 meters per year. Park scientists will be able to use measurements from individual ablation stakes to project water loss and gain across the entire glacier surface, augmenting the GPS surface elevation measurements, which characterize volume (but not mass) change. These surveys illuminate patterns of seasonal snow accumulation and melt on the glacier surface.

Rivers

The rivers and streams of the Upper Snake River Basin and Grand Teton National Park drain the Teton Range, Absaroka Mountains, and Yellowstone Plateau. Major tributaries such as Pacific Creek, Buffalo Fork, Spread Creek, and the Gros Ventre River feed into the Snake River from the east. Spring snowmelt released from the surrounding high elevation areas drive annual floods throughout the park. Yearly peak flows can occur anytime from mid-May to mid-June, depending on snowpack and spring temperatures.

The fluvial backbone of Grand Teton, the Snake River, is managed as a Wild and Scenic River. The Wild and Scenic Rivers Act was created by Congress on October 2, 1968, to preserve rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations. The segment of the Snake River below Jackson Lake Dam, designated as Wild and Scenic in 2009, is one of the longest continuous, naturally-braided river systems in the contiguous United States. This dynamic system transports significant quantities of sand and gravel and has diverse fluvial features like side channels, oxbows, logjams, and floodplains that support critical wildlife habitat. Although the Snake River is managed as a Scenic River, human impacts influence the hydrologic system.

Jackson Lake Dam, built in 1906–07 and reconstructed in 1916 to supply water to Idaho for agriculture, raised the height of the natural lake by 38 feet. The Bureau of Reclamation operates this dam, modifying flows to reduce spring flooding risks and to deliver water downstream for summer agricultural use. Dam operations typically decrease natural peak flows managing instead to retain spring melt waters in the reservoir and disperse it later in the summer as needed downstream. In 2022, the dam regulated peak flow was 3840 cubic feet per second (cfs)—66% less and two weeks earlier than the estimated unregulated peak. In September 2022, dam regulated flow was 80% greater than the estimated unregulated flow (11,520 cfs). Unlike many other US rivers with large dams, the Snake River's altered flow regime is augmented by two large, unregulated tributaries starting 4.5 miles downstream from Jackson Lake Dam—Pacific Creek and the Buffalo Fork River.

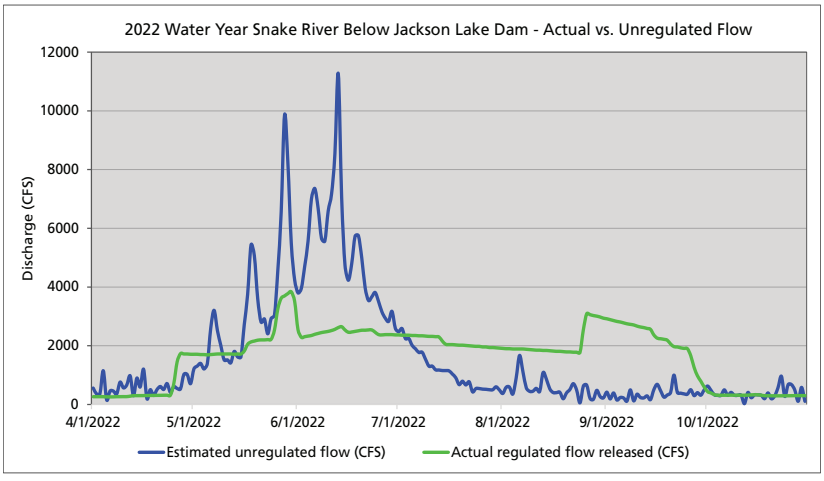


Chart comparing the Snake River's 2022 flow regulated by the dam (green) compared to the estimated unregulated flow (blue).

On June 13, 2022 Grand Teton experienced minor localized flooding, like the side channels and floodplain filling around the Gros Ventre bridge at US Highway 89.

Unregulated rivers are vital to maintain riverine ecosystems, but their wild nature can also be catastrophic to communities. On June 13, 2022, Yellowstone National Park experienced a 0.2% annual chance flood event (1 in 500 years) produced by a combination of several days of warm temperatures followed by intense rainfall that accelerated snowmelt (known as a rain-on-snow event). Northern parts of the Yellowstone received a combined 7.5–9.5 inches of rain and snowmelt in a 24-hour period causing substantial flooding, rockslides, and mudslides. Historic high-water levels caused severe damage to roads, water and wastewater systems, power lines, and other critical park infrastructure. While extreme precipitation and runoff also occurred in the Absaroka and Beartooth mountains north of Grand Teton, this park only experienced minor flooding, not disruptive to infrastructure or operations.

The 2022 Yellowstone flooding raises concerns about future of climate change in the Greater Yellowstone Ecosystem. Current research on climate patterns suggests rain-on-snow events may become more commonplace, as well as a shift from the current snow-dominated watersheds toward rain-dominated ones. Snow-dominated watersheds typically have a relatively predictable single-peak hydrologic pattern like the spring snowmelt period of the Snake River Headwaters region. Rain-dominated watersheds are characterized by individual rainfall events that drive high flows. This shift would increase the likelihood of moderate to extreme flooding.

Greater uncertainty and severity of flooding in Grand Teton concerns park managers. University of Wyoming researchers are working to quantify how changing climate in key headwater regions, like the upper Snake River, will affect streamflows, aquatic ecosystems, and vegetation—and the communities that depend upon them. University of Wyoming scientists met with Grand Teton National Park scientists and leaders, representatives from other federal agencies, local government, and nonprofits in September 2022 to start work on the Wyoming Anticipating Climate Transitions (WyACT) grant. This ongoing collaboration will model climate scenarios and build plans to address them.

Water Quality

Less than 10% of Grand Teton National Park is covered by surface water and all waters within the park are classified as Outstanding Natural Resource Waters. The park contains more than 100 alpine lakes, with surface areas ranging from 1 to 60 acres, and many above 9,000 ft in elevation. All surface and groundwater in the park drain to the Snake River. The Snake River is of considerable significance to the biological diversity and functioning of not only Grand Teton and the Greater Yellowstone Ecosystem, but also to the health and vitality of downstream communities.

The uppermost reaches of the Snake River in Wyoming are characterized by good water quality with relatively low levels of dissolved nutrients and other anthropogenic compounds (e.g., pesticides). Good water quality and the presence of native fish, including cutthroat trout, are not surprising given that the headwaters of the Snake River include parts of Grand Teton and Yellowstone National Parks. Maintenance of high-quality waters and continued support of native freshwater assemblages are among the highest management objectives for Grand Teton National Park. The State of Wyoming also recognizes and values this important resource. The State has designated the upper Snake River and all surface waters within the park as Outstanding or Class 1 waters—recognized for their exceptional quality and therefore "no further water quality degradation by point source discharges other than from dams will be allowed" (WYDEQ 2001). Along with these designations, the Snake River headwaters also received Wild and Scenic River designation by Congress (Snake River Headwaters Legacy Act, 2009), designed to preserve the Snake River headwaters' outstanding natural, cultural, and recreational values for the enjoyment of present and future generations.

The US Geologic Survey monitors flow levels of the Snake River at two locations—Flagg Ranch and Moose, Wyoming. Discharge in 2022 was below the long-term average for the Flagg site (1983–2022) for most of the year, except for peak flows during the spring runoff. Peak flows ranked among 17th in the 40-year monitoring record of the Flagg site and occurred on June 13, 2022, almost 20 days later than the average date (May 25) for this location. Snake River flows at Moose are strongly manipulated by Jackson Lake Dam and reservoir operations but were below average for that site (1995–2022). The total volume of annual flow at the Moose monitoring location was the second lowest in the 28-year record. The date of half discharge (the day marking half the annual flow volume) occurred June 24, 2022, three days before the average date (June 27) for this location.

Good water quality is an important component of a healthy habitat.

NPS resource staff from the Greater Yellowstone Inventory and Monitoring Network also monitor Snake River water quality at the Flagg Ranch and Moose locations. Results from water quality analyses (2006–2022) confirm that concentrations of primary nutrients (nitrogen and phosphorus) remain consistently low or near detection limits at both sites. Nitrogen levels show little variation seasonally; however, total phosphorus shows significant variation and is highest during runoff. Trace metals (i.e., arsenic, copper, and selenium) are often naturally present in measurable concentrations, but typically below the State of Wyoming's aquatic life criteria.

In 2022 copper and selenium were below detection levels at both sites. Total iron concentrations were low at both sites and did not exceed Wyoming's Iron Criteria for Aquatic Life (1.0 mg/L) as they have in previous years. Total arsenic concentrations were measurable at both locations with higher concentrations found at the Flagg site; however, both sites were below the State of Wyoming's Aquatic Life Criterion (0.15 mg/L). Because most of the watershed in the upper Snake River is undeveloped, scientists believe that iron and other trace metals are naturally occurring and that natural fluctuations in metal levels are driven by elevated discharge following snowmelt. Given the role of the Snake River in Grand Teton and downstream communities, it is important to continually monitor flow and water quality for this river system.

Studying Pollinator Connections

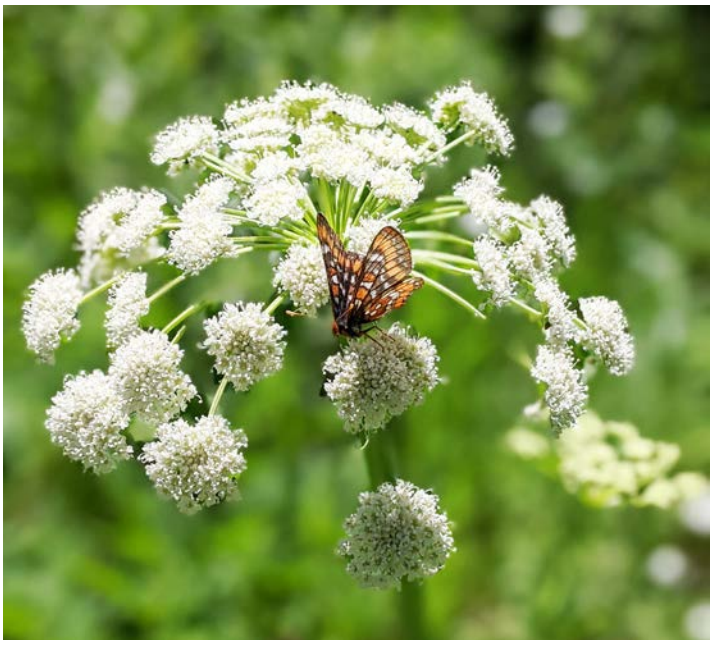
I grew up in Brooklyn New York where my favorite playgrounds were Prospect Park, Central Park, and the Brooklyn Botanical Gardens. The Gardens have one of the oldest collections of bonsai trees in North America and perhaps in the shadows of these tiny trees is where I was inspired to pay attention to the small things. "*Small things tell big stories*" is my research motto but the roots of that saying began with the bonsai trees—miniature and perfect forests where my five year-old mind could clearly see fairies and gnomes running under the gnarled branches. That bend towards fantasy has stayed with me through majoring in art and science in college and blending the ideas of small things telling stories that were otherwise hidden from mere mortals.

Small-sized and highly-mobile pollinators like bumblebees can be hard to study in the natural environment. The western bumblebee (*Bombus occidentalis*) is proposed for listing as a threatened species over parts of its range but populations seem to be persistent in the Tetons.

I came to Yellowstone first as an intern and worked my way up the ranks from biotech to wildlife biologist, studying bison, butterflies and even mice along the way. After 11 years in Yellowstone, I returned to academia to pursue my doctorate in biology at University of Missouri-St. Louis studying black-tailed prairie dogs in Badlands National Park. Almost two decades later and with 8 different parks in my career, I now return to the Greater Yellowstone Ecosystem bringing students as researchers to continue my work on butterflies and other ecosystem processes.

Small things tell big stories: the example of pollinators relationships in sagebrush ecosystems. The sagebrush system stretches across the flats at the foot of the Grand Tetons. As shrubby dry uplands, sagebrush flats are not often the focus of tourists, zooming by to find the perfect view of the mountains or chasing a group of elk up and down the road. But the sagebrush is full of remarkable life, and this ecosystem is one of the focus areas of my research.

Ants are important pollinators on their own; however, their role as pollinators in the sagebrush ecosystem is disproportionately large when their role of raising gossamer wing butterflies is considered.



Nationally pollinators are declining due to habitat loss, climate change, and loss of diversity in the plants they use. The long-term effects of this decline are not yet known.

Pollinator Hotshot programs expose students to science and field studies.

Myrmecophily refers to mutualistic associations with ants and can also refer to commensal or mutualistic relationships. While most people associate ant mutualistic relationships with plants, like the acacia tree, few are aware of their role with the family of gossamer wing butterflies (Lycaenidae), one of the largest groups of butterflies and a dominant species in sagebrush systems. Over 75% of these butterflies are myrmecophilous which means the butterfly larvae are raised by ants! The relationship between the ants and lyceanid butterflies can be facultative or obligate with the ants playing a variety of roles from protectors to caregivers. Larval survival also seems to be directly associated with having ant tenders. Larvae with higher amounts of protection by ants have higher survival rates.

A gossamer wing butterfly.

SCIENTIST SPOTLIGHT

A Ruddy Copper (*Lycaena rubidus)* pollinates a flowering plant.

Sagebrush systems are dominated by blue and copper butterflies, but they also contain many other species of pollinators including the fritillaries and the flashy colias butterflies. At the peak of the emergence, small clouds of blue and copper butterflies crowd around every flower, and a single sweep of a butterfly net can bring up handfuls of individuals. Yet, in restored sagebrush systems, and disturbed ones, these clouds of butterflies seem to vanish and part of our ongoing research is exploring the role of restoration strategies, that often do not account for small things such as ants, with the missing populations of blue butterflies. The presence or absence of the very small ants may be part of a big story of trying to restore sagebrush systems back to their original biodiversity and all the associated and much needed pollinators.

The Pollinator Hotshot crews have researched in the Greater Yellowstone Ecosystem (GYE) since 2016, thanks to a grant from the National Science Foundation. Our goal is not only to sample and document the many pollinator species that occur in the GYE but also to introduce a diverse audience to the GYE as scientists and future stewards of our national park system. Each year we select a group of Pollinator Hotshots through a national competition that looks for leadership, adventure, and a love of our planet to encourage new voices to see our parks as places of science, learning, protection, and love. The Pollinator Hotshot crew represents the demographics of America with cultural richness to add to our quest to document pollinators and to be part of the climate solution and reverse biodiversity loss. We use participatory databases such as iNaturalist to document our findings to both inform park management and also to engage the visiting public in discovering the rich pollinator diversity protected within our parks. Look for the Sagebrush Blues Pollinator Hotshot team who will be exploring the park in their search for pollinators. Help document these fascinating organisms by taking your own pictures and uploading them into iNaturalist to help Grand Teton National Park understand and protect its rich pollinator diversity. More importantly, next time you drive past the sagebrush flats in the late spring or early summer, look for the blue and copper butterflies. They fly low to the ground looking for the best place to lay their eggs so that the ants can discover the larvae and safely escort them underground where they are protected and cared for until their time comes to emerge as a beautiful blue adult the following year.

International exchange students join the field crew from University of Derby in the UK.

Gillian Bowser, Assistant Professor
Colorado State University

Gillian Bowser developed a love for small things as a child and has devoted her research and teaching to helping others understand the critical big connections that are built by small things.

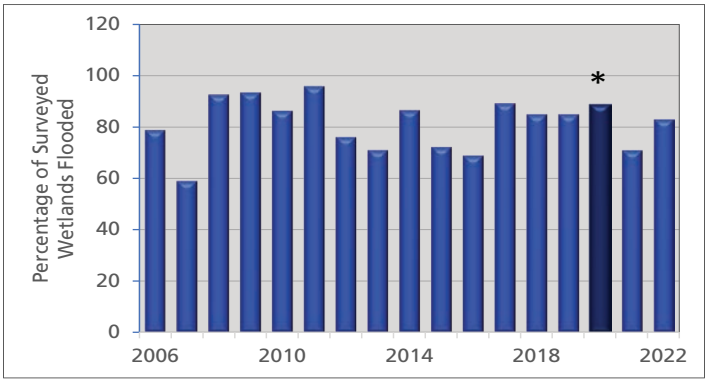
Butterflies like this western pine elfin (*Callophrys eryphon*) are key pollinators. Careful planning and timing is needed to be in the right places to capture pollinators in action.

Amphibians

Each year the National Park Service collaborates with the Northern Rockies Conservation Cooperative, US Geological Survey, and university scientists to monitor amphibians in Grand Teton and Yellowstone National Parks. Biologists identified four species of native amphibians: western tiger salamander (*Ambystoma mavortium*), boreal chorus frog (*Pseudacris maculata*), western toad (*Anaxyrus boreas*), and Columbia spotted frog (*Rana luteiventris*) to monitor. The boreal chorus frog and the Columbia spotted frog are the most widely distributed species each year. The western tiger salamander and western toad appear to be less widespread. The northern leopard frog was historically documented in Grand Teton National Park, but only one confirmed sighting occurred since the 1950s. Plains spadefoot toads (*Spea bombifrons*) were recently documented in Yellowstone's Lower Geyser Basin, but their presence in Grand Teton has not been documented.

Annually since 2006 biologists have monitored and documented amphibian breeding activity in 31 catchments in the two parks. Encompassing about 500 acres each, these catchments or watersheds are defined by topography and vary in amounts of seasonal and permanent water. Biologists document breeding activity using visual surveys to detect eggs, larvae (e.g., tadpoles), and metamorphic forms (i.e., transitional forms between aquatic and terrestrial life stages).

In 2022 field crews were able to visit 30 of the 31 long-term wetlands including all seven in Grand Teton. Two of the 30 contained breeding evidence of all four species. Those that support breeding of all four native amphibians are relatively rare in the sample locations and are referred to as amphibian "hot spots". Finding two hot spots was consistent with 2017–2021 findings (excluding 2020 due to limited surveys during COVID-19 precautions) and up from 2016 when no wetlands contained breeding evidence of all four species. For comparison, biologists found 11 wetlands with breeding evidence of three species, 11 with evidence of two species, and five with a single species in 2022. These results illustrate the breeding variability that takes place even in protected areas.



Percentage of surveyed wetlands with standing water suitable for breeding. The asterisk indicates the restricted 2020 field season due to COVID-19 precautions.

Western toads may spend up to seven months of the year in hibernation usually in natural chambers or burrows below the frost line.

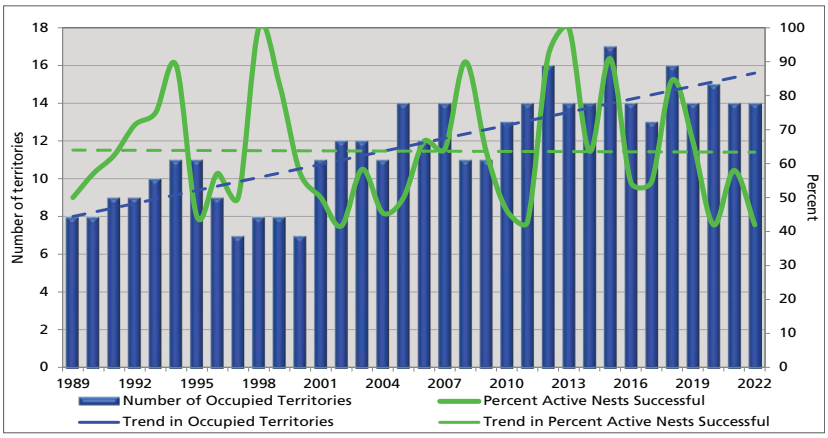
In 2022 researchers visited 317 individual wetlands spread across 30 watersheds and surveyed 263 sites with standing water present. Of the 263 wetland sites surveyed in 2022, approximately 60% were occupied by at least one species of breeding amphibian, compared to 70% out of 230 surveyed sites in 2021 and 56% out of 281 surveyed sites in 2019.

Annual variations in breeding is likely tied to hydrologic fluctuations that are driven by unique meteorological conditions each year. Such annual variations alter the extent and mosaic of wetland breeding sites, which can affect amphibian reproduction. The percentage of visited wetlands that supported surface water suitable for breeding varied between 59% in 2007 and 96% in 2011. In 2022 researchers estimated 83% of the wetland sites were flooded.

All amphibians in Grand Teton and Yellowstone National Parks require wetlands for breeding, 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). The four surveyed species employ diverse strategies to survive the winter requiring both aquatic (unfrozen, oxygenated waters) and terrestrial (digging underground, using logs, trees, rocks, snow layers, and even burrows of other animals) habitat. Suitable overwintering habitat may be near breeding wetlands or may involve significant travel, increasing risks. The predicted warming temperatures and changes in snowpack driven runoff for this region could alter wetland habitats and influence amphibian breeding. These expected impacts will disproportionately affect amphibians because they rely on shallow wetlands and sometimes ephemeral waterbodies.

Bald Eagles

Bald eagles (*Haliaeetus leucocephalus*) are large, primarily fish-eating predators that generally nest in trees, close to water bodies. They also feed on small mammals, waterfowl, and carrion. Within Grand Teton, breeding sites are found along the shores of Jackson Lake and the Snake River. Once listed as endangered under the Endangered Species Act (ESA), bald eagles were delisted in 2007 due to their dramatic population recovery throughout the US. The number of territorial pairs in Grand Teton almost doubled over the past 30 years. In accordance with the Greater Yellowstone Bald Eagle Management Plan (1995), park managers may implement temporary closures around active bald eagle nest sites to minimize disturbances. In 2022, closures were established at nest sites along the Snake River where one new territory was discovered.



The number of territorial and successful bald eagle pairs in Grand Teton National Park.

Of the 28 bald eagle territories monitored in 2022: 14 were occupied and 12 pairs initiated nesting hatching a total of 6 chicks. At the close of the season, five pairs successfully fledged six eaglets.

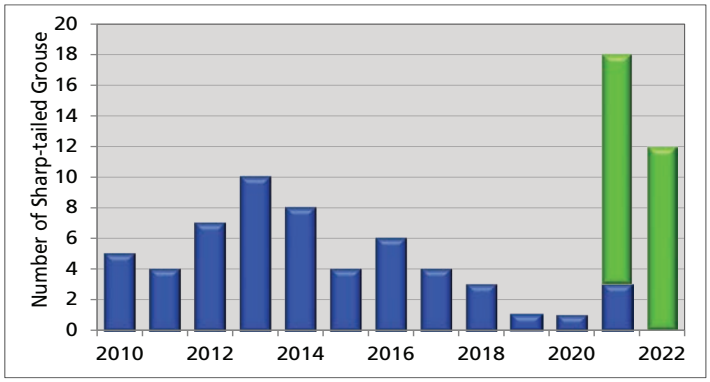
In 2022 the number of occupied territories (14) and nesting pairs (12) were consistent with the 10-year averages (14.5 and 11.6). However, numbers for pairs with fledglings (5), and eaglets fledged (6) were below the 10-year averages (7.6 and 10.1). The number of fledglings per successful nest, 1.21 in 2022, was lower than both the 10-year average (1.31) and 30-year average (1.42). The percentage of successful nests decreased this season (42%) over 2021 (58%). Jackson Lake was at historic low levels during the entirety of the 2022 nesting season. Low lake levels this extreme have only occurred four times in the last 30 years. The low lake levels may have impacted bald eagle nesting success as territories along Jackson Lake produced no fledglings in 2022 compared to three in 2021. Overall data collected in 2022 indicates a stable trend in the breeding bald eagle population of Grand Teton National Park.

Columbian Sharp-tailed Grouse

Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*) are endemic to sagebrush, shrub-steppe, mountain shrub, and riparian shrub communities. Once found in nine states and British Columbia, Canada, this subspecies now occupies less than 10% of its historic range. Excessive hunting in the 19th century combined with habitat alteration and degradation contributed to population declines and range reduction. Sharp-tailed grouse are considered a species of greatest conservation need in Wyoming. The Columbian is the rarest subspecies and has experienced the largest decline of all sharp-tailed species.

Similar to greater sage-grouse, sharp-tailed males display in the spring to attract females to breeding grounds called leks. Leks are typically positioned on elevated sites with flat, open areas. Columbian sharp-tailed grouse leks tend to have taller vegetation and more shrub cover than leks of other sharp-tailed grouse subspecies. Little is known about the sharp-tailed grouse population in Jackson Hole. Recently, incidental observations of small groups of sharp-tailed grouse were recorded in Grand Teton but no leks were found prior to 2010, and the nearest known lek was in Idaho on the western slope of the Tetons.

In the spring of 2010 biologists observed five sharp-tailed grouse displaying on a lek, Elbow West, near the southeast boundary of the park. In the spring of 2021, a University of Wyoming graduate student conducting survey transects found a second lek in the park, Warm Ditch with 15 males. Grand Teton



Counts of male Columbian sharp-tailed grouse are in blue for the Elbow West lek and in green for the Warm Ditch lek.

transect locations were determined by modeling preferred lek habitat for sharp-tailed grouse in other parts of Wyoming. Transect surveys in future years based on this habitat modeling may lead to the discovery of more leks.

In 2022, park biologists counted a maximum of 12 male sharp-tailed grouse at the Warm Ditch lek and observed no males on the Elbow West lek. While females have never been observed at Elbow West, observations of a hen with chicks within two miles of the Elbow West during 2016 indicated successful breeding. The lack of males on Elbow West combined with the close proximity of the Warm Ditch lek could indicate a shift in preference for lek sites.

Bighorn Sheep

Bighorn sheep (*Ovis canadensis*) were once widely distributed throughout the mountains and foothills of the Rocky Mountain west. Today, they persist in small, fragmented populations that are at risk of further decline and extirpation due to disease, human development, and habitat degradation. The Teton Range population is one of Wyoming's smallest and most isolated native sheep herds. Due to loss of migration routes and winter range over the past century, the population now lives year-round at high elevation along the Teton crest and in steep canyon areas on the east and west slopes of the range. Sheep in this population endure harsh winter weather in windblown areas above 9,500 feet. This remnant population faces the threat of extinction due to its small size and isolation. Biologists are working to protect bighorn habitat and minimize other threats.

Biologists have estimated the size of this population using visual counts from winter helicopter surveys. In 2022 Wyoming Game and Fish Department (WGF) personnel counted a total of 104 bighorn sheep (55 in the south end of the range and 49 in the north). Although this represents a slight increase over the 2021 count, it is still well below the minimum population target of 150–200 identified in the 1996 Teton Range Bighorn Sheep Working Group strategic plan. Winter counts since 2020 have ranged 90–104 bighorn. However, from 2015 to 2020, the winter counts showed greater variation (between 46 to 100 bighorn), leading park biologists to evaluate the effectiveness of newer count methods taking advantage of natural gathering areas like mineral licks during the summer months. Using remote cameras and genetic analysis of fecal samples, a more accurate population estimate can be obtained. In 2018, park biologists started using motion-triggered cameras at mineral licks in the Teton Range. To date, biologists have analyzed more than 151,000 photos of bighorn sheep and documented groups making over 2,600 visits to the licks. Initially remote cameras allowed biologists to estimate population size based on observations of radio-collared animals. As radio-collars expired, biologists shifted to documenting the number of sheep at mineral licks, lamb production, and observed health of the animals. From 2019 to 2022, biologists collected fecal pellets near mineral licks and sent them to collaborators with expertise in DNA analysis. The DNA obtained from the fecal material identified individual bighorn sheep and other important genetic attributes like population diversity, inbreeding, and interbreeding between subpopulations. Of the more than 530 fecal samples collected in 2022, 467 were sent to the lab for genotyping and are still being processed. Biologists and collaborators will analyze this data to learn more about the population dynamics and the genetic health of Teton Range bighorn sheep.

Image from a remote camera of a yearling bighorn visiting a mineral lick in the park. Bighorn sheep lick or eat the soil at mineral licks, ingesting minerals and salts that may be missing or deficient in their natural forage.

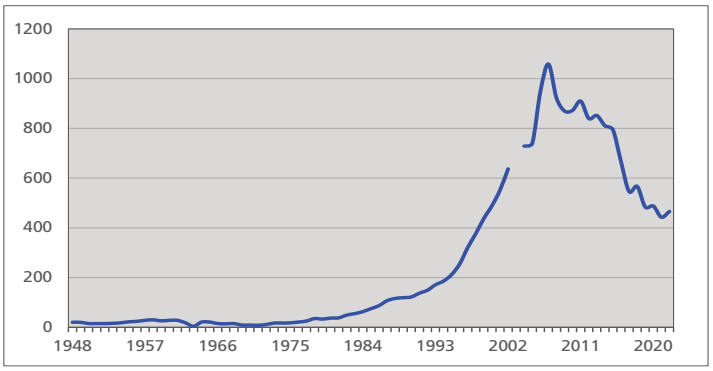
Park biologists also conduct annual ground classification surveys, started in 1990, to provide composition, distribution, and trend information. Biologists from the park, Bridger-Teton, and Caribou-Targhee National Forests counted a total of 24 bighorn sheep during the late August 2022 ground surveys (10 in the south and 14 in the north). Herd ratios were estimated at 50 lambs, 0 yearlings, and 90 rams per 100 ewes. Since ratios derived from summer ground counts are highly variable over time, the counts primarily provide confirmation that the herd is still reproducing and that some of the lambs survive their first year which is considered successful recruitment.

Threats to park bighorn sheep include loss of genetic diversity, respiratory disease, and habitat loss. Nonnative mountain goats compete directly with bighorns for habitat and forage and may displace them from premium habitat. Additionally, mountain goats may transmit deadly diseases to bighorn sheep. In recent years, local bighorn biologists held public workshops to engage the public in helping wildlife management agencies balance winter recreation in the Teton Range with protection of critical sheep habitat. A stewardship campaign emerged with the goal of building community engagement and creating a sense of ownership in protecting the Teton Range bighorn population. The campaign includes "Bighorn Sheep Winter Zones" that winter recreationists are asked to avoid. Grand Teton National Park began an Environmental Analysis to evaluate the impacts of management actions aimed at protecting winter range within the park. The Environmental Analysis is expected to be released for public comment in 2024.

Bison

Bison (*Bison bison*), a species native to Jackson Hole, were extirpated from the area by the mid-1800s. In 1948 twenty animals from Yellowstone National Park were introduced to the fenced 1,500-acre Jackson Hole Wildlife Park near Moran. In 1963 after testing positive for brucellosis, all adult bison in the small herd were destroyed while nine vaccinated yearlings and calves remained. Twelve bison from Theodore Roosevelt National Park were added to the population. The herd escaped from the wildlife park in 1969 and was allowed to reoccupy the valley. Present-day Jackson bison are descendants of those bison and subsequent migrants from Yellowstone. During the winter of 1980, bison moved onto the National Elk Refuge (NER) and began using supplemental feed intended for elk. This altered the herd's natural population dynamics, as they returned annually to feed on this easily obtainable food source.

Bison summer primarily in Grand Teton National Park. Depending on winter severity and native forage availability, most of the herd now moves to the refuge for the winter, where they remain until April or May. In some years, individuals or small groups remain in the park all winter. The joint Bison and Elk Management Plan, approved in 2007 for the park and NER identified a population objective of 500 bison for the herd. The Wyoming Game and Fish Department adopted this objective. With unusually low winter mortality, supplemental winter feed, and no significant predation, the herd grew steadily since the 1980s, reaching more than 1,000 by the winter of 2007. More recently bison hunting, allowed on the NER and the Bridger-Teton National Forest, has reduced bison numbers to slightly below the objective of 500 animals.



Population size of the Jackson bison herd, 1948-2022. (No data for 2003.)

In mid-February 2022, biologists counted 466 bison with almost 93% of the herd (432 individuals) found on the NER and 43 bison on native winter range scattered throughout the central portion of the park. This marked the first winter in four years that the majority of the bison population moved to the NER and used the supplemental feed. Bison recruitment (as indexed by the late-winter calf ratio) in 2022 was 28 calves per 100 cows. This represents a decreased recruitment rate compared to 2021 (49 calves per 100 cows).

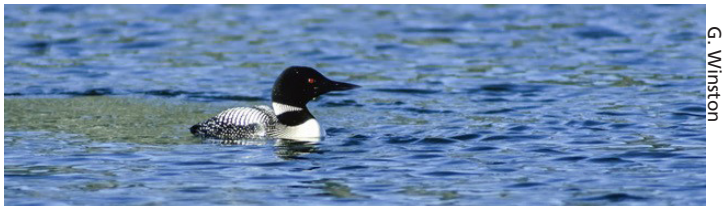
Vehicles collided with five bison resulting in at least four confirmed bison deaths in 2022. In one incident, a vehicle hit three bison. One bison left the scene of a separate accident but may have been injured and died later away from the road. The Shoshone Bannock tribe harvested five bull bison on the NER in April 2022, and hunters harvested another 130 bison outside of the park, including 68 bulls, 46 cows, and 16 calves.

Common Loons

The common loon (*Gavia immer*) is a long-lived waterbird that feeds mostly on fish and prefers to nest on shorelines or floating mats of vegetation in lakes and ponds. Common loons that breed within the Greater Yellowstone Ecosystem (GYE) are rare with only approximately 20 loon pairs. The GYE population of loons is geographically isolated south of the species' core breeding range. Small, isolated breeding populations are vulnerable to local extinction from genetic bottlenecks, habitat loss, and mass mortality events.

Grand Teton National Park has over 150 reports of common loons dating back to 1934. Loons commonly use the Oxbow Bend portion of the Snake River as they stage, waiting for higher-elevation lakes to melt. Loons also forage on Jackson Lake in the spring and fall. Additionally, there are nine other lakes in the park where loons have been observed. Breeding has only been confirmed twice in the park, at Emma Matilda Lake in 2007 and 2013; one chick was produced each time. There are also two unconfirmed reports of loons with young, on Leigh Lake in 2009 and on Jackson Lake in 2016. Overall, the park has suitable habitat for nesting, staging, and migratory stopovers; however, due to loon fidelity to their birthplaces dispersers are infrequent.

In July 2022 Grand Teton biologists partnered with the Ricketts Conservation Foundation and the Biodiversity Research Institute to conduct a 'Loon Blitz' within the park. Biologists surveyed all



G. Winston

potential loon habitat within a short period of time and identified a total of three common loons—an adult and a juvenile in Honeymoon Bay on Jackson Lake and an adult on Emma Matilda Lake (confirmed to be a female previously banded at Arizona Lake).

A territorial breeding pair has consistently occupied Arizona Lake, in the Bridger-Teton National Forest near the park boundary since 1987. Arizona Lake is remote and does not experience visitation on the scale of lakes within Grand Teton. Increased recreation on lakes is suspected to decrease the likelihood for loon breeding. Nesting habitat on Jackson Lake may also be limited by fluctuations in the water level due to dam management. Low water levels expose broad areas of lakebed decreasing the quality of loon foraging and nesting habitat.

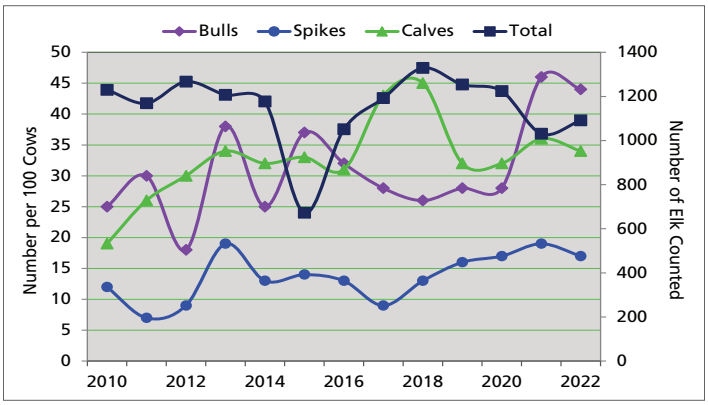
Ensuring the success of common loons in Grand Teton requires protection of potential breeding habitat. Common loons are the rarest breeding bird in Wyoming. Educating the public about these unique birds can increase support for loon conservation and protection in the GYE.

Elk

Grand Teton National Park and the John D. Rockefeller, Jr. Memorial Parkway support a migratory Rocky Mountain elk (*Cervus canadensis*) population that is part of the larger Jackson elk herd. Elk summer throughout these park lands and occur at relatively high densities in low elevation open sagebrush, willow, and forested habitats. Most of the elk migrate to winter range on the National Elk Refuge near Jackson, but a small number winter in the eastern portion of the park. Other portions of the herd migrate through the park and parkway between the National Elk Refuge and summer ranges in Yellowstone and the Bridger-Teton National Forest. The Jackson elk herd is one of the largest in North America. Its migratory routes cross multiple jurisdictional boundaries as elk travel between seasonal ranges. As Grand Teton's most abundant ungulate, elk have significant effects on park ecology. Their grazing and browsing may affect plant productivity and, as prey and carrion, elk provide sustenance to carnivores and scavengers. They are also popular with park visitors for viewing and photographing.

The mid-winter trend count objective for the Jackson elk herd set by the Wyoming Game and Fish Department is a three-year average of 11,000 elk ± 20%. During the 2022 classification count, biologists counted 11,057 elk yielding a three-year average of 10,925, meeting the objective. Estimated at above 19,000 during the early-mid 1990s, the Jackson herd has been intentionally reduced by annual harvest on the national forest and the refuge, in addition to an elk reduction program in the park (authorized by Congress in 1950 to help manage herd size when necessary). Non-harvest mortality (e.g., from winterkill) averages an unusually low 1–2% of the herd. During the 2022 park reduction program a total of 134 elk were harvested.

Monitoring of the park elk herd is done using a variety of tools including GPS collars and aerial overflights. Since elk are herd animals a single collar can give information on the location of a group of elk.



Grand Teton mid-summer elk count and classification, 2010–2022.

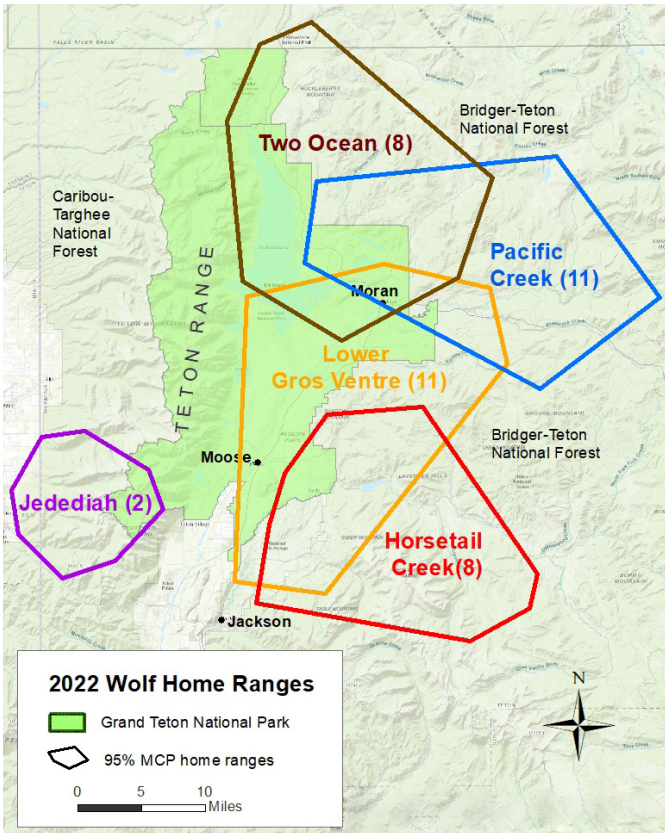
Each summer, park biologists count and classify elk from a helicopter in a portion of the park with high elk density and visibility. The survey is not intended as a census of park elk but provides a minimum count of elk within the area surveyed. In 2022, park biologists counted and classified 1,091 elk. The total number of elk counted was slightly higher than in 2021. For a second year in a row few elk were counted along the Snake River south of Moose. Often, several hundred elk are counted in this area, but radio collar data indicated the elk were outside of the park on the day of the count. Herd ratios were 44 mature bulls, 17 spike bulls, and 34 calves per 100 cows. All herd ratios were slightly lower than in 2021. Calf ratios were 37 per 100 cows in the central valley and 18 calves per 100 cows in the Willow Flats. Biologists also surveyed elk along northeast and west sides of Jackson Lake and counted 159 additional elk with relatively high calf ratios at 41 calves per 100 cows.

Gray Wolves

After the US Fish and Wildlife Service and National Park Service reintroduced gray wolves (*Canis lupus*) into Yellowstone National Park in 1995–96, wolves quickly dispersed to Grand Teton National Park and surrounding areas. In 1999, a wolf pack denned in Grand Teton and produced a litter of pups—the first in the park in over 70 years. Since then, wolves continue to live and reproduce in the Jackson Hole area, including Grand Teton and the John D. Rockefeller, Jr. Memorial Parkway. The reintroduction of wolves restored a predator-prey relationship absent since humans eradicated wolves from the ecosystem in the early 20th century.

At the end of 2022, a minimum of 40 wolves in 5 packs resided in the Jackson Hole area with home ranges in Grand Teton National Park. The Jedediah (2 wolves), Lower Gros Ventre (11), Two Ocean (8), Horsetail Creek (8), and Pacific Creek (11) packs all had home ranges that included the park. No packs denned in the park in 2022.

There were two known wolf mortalities in the park in 2022. An adult male from the Lower Gros Ventre pack was found dead due to unknown natural causes, and a female pup from the Wildcat Ridge pack was killed by other wolves. Seven wolves were captured in 2022 and fitted with five GPS and two VHF collars. In the spring of 2022, the Wildcat Ridge pack was displaced from their territory by the Two Ocean pack, which formed from a group that split off from the Pacific Creek pack.

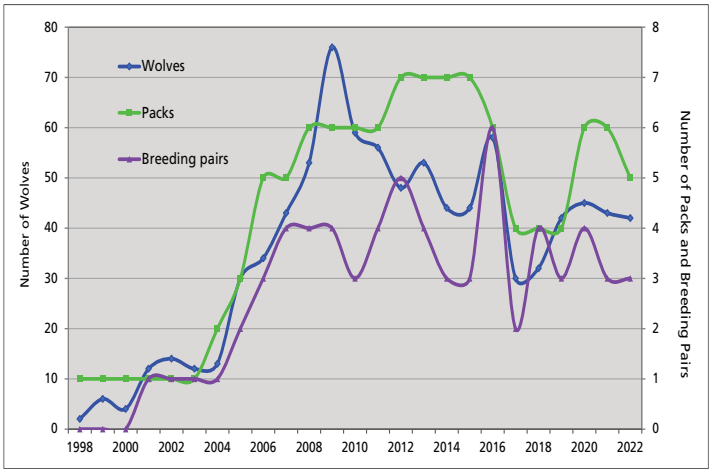


Distribution of Jackson area wolf packs. 2022 MCP (minimum convex polygons) home ranges are based on collared pack members.

The return of wolves to Grand Teton and the surrounding area presents researchers with an opportunity to study the complex relationships of an ecosystem with an intact suite of carnivores and ungulates. Wolves and other predators affect prey populations and behaviors. In a five-year study, biologists found that in the winter when elk densities were relatively low, wolves preyed primarily on elk (71%) and moose (26%) and fed on deer and bison infrequently (3%). In the summer, when elk densities in the park were high, wolves preyed almost exclusively on elk and their calves, representing more than half of the kills in June and July.

Wolves also prey on other species, including livestock which bring wolves into conflict with humans outside the parks. A long history of controversy surrounds wolf management and the effects of wolves on ungulates and livestock. Northern Rocky Mountain gray wolves including those in Wyoming were officially removed from the federal list of threatened and endangered species ion April 25, 2017. Wyoming Game and Fish manages a trophy wolf hunt in the trophy game management area of northwest Wyoming outside national parks, the parkway, national wildlife refuges, and the Wind River Indian Reservation. Wolves traveling outside of the park and other protected areas are subject to the regulations governing that area.

Aerial observation flights during winter are often used for wolf monitoring.



Population of Jackson area wolves, including those in Grand Teton, 1999-2022.

Golden Eagles

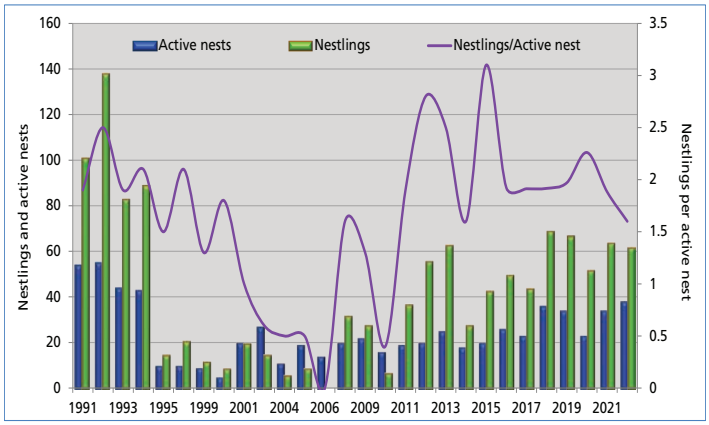
Golden eagles (*Aquila chrysaetos*) are large aerial predators well suited to the Teton Range, with abundant cliff faces for nest sites and diverse prey found in the canyons. In the 1980s, biologists located golden eagle nests in Death, Avalanche, Cascade, and Webb Canyons but did not regularly monitor the Teton Range population. Concerns about golden eagle populations throughout the western US have arisen recently, primarily because of habitat loss and alteration. Like many raptors, golden eagles are sensitive to disturbance around their nest sites.

In 2022, park biologists conducted golden eagle surveys in four of the seven known territories (Granite, Avalanche, and Death Canyons as well as Uhl Hill). Biologists confirmed Avalanche and Uhl Hill were occupied. Uhl Hill was the only territory occupied by adult eagles through the breeding season; this pair initiated nesting but produced no fledglings.

Golden eagles have amazing eyesight, some of the sharpest in the animal kingdom. They are able to see two focal points at the same time, forward and 45 degrees to the side, allowing them to spot something the size of a rabbit running from one to three miles away.

Great Blue Herons

Great blue herons (*Ardea herodias*) are colonial water birds dependent on wetlands for feeding, nesting, and habitat security. Colonial nesters are highly vulnerable to human disturbance. Human activities near heron colonies (heronries) may influence occupancy, disrupt nesting behaviors, change foraging behavior, increase predation, or lead to abandonment. Heronries are also vulnerable to predation. Monitored since 1987 in Grand Teton National Park, heron occupancy and site fidelity has changed over the years with several historically productive heronries, including two along the Buffalo Fork, being abandoned in the last two decades. In 2018, biologists discovered two new heronries in the Oxbow Bend and Moran Junction areas that are geographically separate from historic heron colonies. These heronries remain active since their discovery. In 2021, biologists on an aerial survey located a new heronry near Swan Lake.



Great blue heron productivity in Grand Teton NP, 1991-2022. Arizona Lake heronry, discovered just outside the park's boundary, is included in the park's monitoring program since 2009. Monitoring of heronries was not conducted in 1996, 1997, 2002, or 2008.

Great blue herons are solitary fishers of shallow water. Their patient waiting, watching, and stealthy movements culminate in a lightning-fast strike to spear or grab a fish. Specially-shaped vertebrae allow them to curl their necks into the S-shape and quickly strike fish within their range.

During the 2022 breeding season, park staff monitored six heron colonies. Breeding pairs occupied five of the six colonies. The Sawmill Ponds heronry was unoccupied even though biologists observed one historic nest structure. Three of the heronries had eight active nests each that yielded young, Swan Lake (18 young), Oxbow Bend (14), and Pinto Ranch (13). Arizona Lake heronry had nine active nests that produced 17 young in the northeast nest cluster. The Moran Junction heronry was abandoned partway through the season and did not produce any young, despite having five active nests early in the season.

In 2022, the total number of active nests (38) and nestlings (62) were well above the 10-year average (27.7 and 54.2, respectively), while the number of nestlings per active nest (1.6) was lower than the 10-year average (2.1). Overall numbers of active nests and nestlings remained generally stable or slightly increasing over the last ten years. While heron numbers increased since their historic lows of 1995-2006, current numbers are still well below the historic highs of the early 1990s.

Great Gray Owls

The great gray owl (*Strix nebulosa*) is associated with old-growth boreal forest habitats in western Wyoming and is considered a species of greatest conservation need in Wyoming. Little is known about their population status and trends. Since boreal forests in Wyoming are currently at risk due to drought, insect outbreaks, disease, and logging; concern for the status of great gray owls is growing.

Starting in 2013, Grand Teton National Park partnered with the Teton Raptor Center (TRC) to collect baseline data on territorial occupancy, demographics, nest success, prey use, and year-round habitat use of the great gray owl population in the park. This data will aid area land managers in developing conservation plans and strategies.

During the great gray owl courtship period (mid-February through April) of 2022, TRC biologists deployed automated recorders near all known nests to determine occupancy. These recorders documented two occupied territories prior to nesting. In 2022, biologists only documented one great gray owl pair initiating nesting within the park. The nest was unsuccessful in fledging any chicks. The two occupied territories recorded in 2022 are an increase from 2021, which had a record low of zero occupied territories. In 2018 and 2020, biologists also documented only a single nest initiated by a great gray owl pair. Nest initiation and success varied considerably over the past several years. The highest success rate was recorded in 2016 (8 nests initiated and 17 owlets fledged) while in the last three years biologists recorded no owlets fledged within the park.

Great gray owl's Latin name is very appropriate. *Strix* means to utter shrill sounds and *nebulosa* refers to its gray color meaning cloudy or misty.

Biologists continue to track owls previously outfitted with VHF transmitters to evaluate habitat selection and movement patterns. Additional research includes continued surveys of pocket gophers to assess prey availability and measuring monthly snow depths at several owl territories throughout the valley and park.

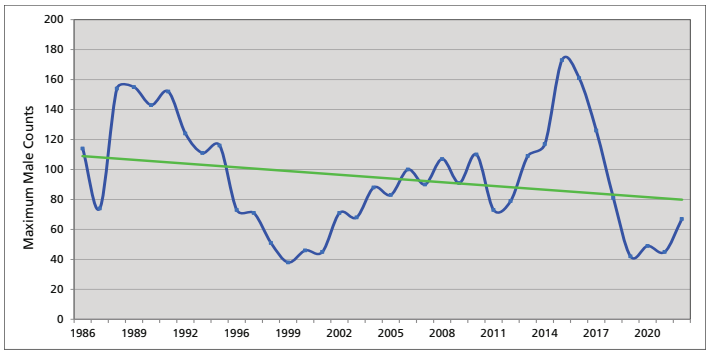
Greater Sage-grouse

Historically, greater sage-grouse (*Centrocercus urophasianus*) occurred in sagebrush habitats across much of Wyoming and the American West. Sage-grouse populations declined up to 80% throughout their range over the past 50 years, most likely due to increased livestock grazing, farming, residential development, invasive plants, and oil and gas development. The Jackson Hole sage-grouse population also declined despite occurring in an area with a high density of public lands and protected habitat.

Sage-grouse congregate on display areas, or leks, during their breeding season each spring. Lek sites are usually open areas surrounded by sagebrush such as rocky slopes, burned areas, or gravel pits. Males perform a unique strutting display to attract females for breeding. Biologists began monitoring sage-grouse leks in Grand Teton National Park in the 1940s to document population trends.

In the spring of 2022, eight leks were monitored weekly [seven in the park and one on adjacent National Elk Refuge (NER) land], and sage-grouse consistently occupied five leks (Airport, Moulton, RKO, Spread Creek, and Timbered Island). The Airport Pit (last active in 2014), Bark Corral (2020), and North Gap-NER (2020) leks were not active during lek surveys in 2022.

For the five active leks within Grand Teton, the total count of all sage-grouse was 92 and the maximum male count was 67, below the 10-year averages of 133 and 94, respectively. Biologists made the highest recent counts in 2015 with 243 total birds and 173 males. Airport (3 males), Moulton (23), and Spread Creek (6) leks were lower than their 10-year averages while RKO (20) and Timbered Island (15) leks were slightly above. The increase in maximum male count totals between 2021 (45) and 2022 (67) is likely due to movement between leks since the total male high counts by day are relatively close between 2021 (44) and 2022 (48). Biologists think these historic lows are caused by limited winter habitat. For four of the past seven winters, Grand Teton experienced well-above average snowfall that decreased the amount of exposed sagebrush which is critical cover and food for sage-grouse.



Counts of male sage-grouse (with a green trend line) on Grand Teton NP leks 1986-2022. No monitoring data for sage-grouse in 1993.

Grizzly Bears

Predator eradication programs eliminated grizzly bears (*Ursus arctos*) from most of the western US by the 1950s. Due to its isolation, the Greater Yellowstone Ecosystem (GYE) became one of the last refuges for grizzly bears south of the Canadian border. During this time, garbage became a significant food source for bears throughout the region. To return bears to a diet of native foods, garbage dumps in the GYE were closed in the 1960s and 1970s. Following the dump closures, conflicts and human-caused mortality increased significantly and the population declined as offending bears were removed. The US Fish and Wildlife Service recognized the status of grizzly bears and federally listed them as a threatened species in 1975.

Intensive conservation efforts over the next four decades allowed grizzly bears to make a remarkable recovery, and the US Fish and Wildlife Service delisted grizzly bears in the GYE twice—0the first time in 2007 and the second in 2017. However, both times the decision was overturned due to litigation and the grizzly bear currently remains a threatened species in the lower 48 states.

Scientists with the Interagency Grizzly Bear Study Team (IGBST) use the best available science to conduct population monitoring and research. To estimate the GYE grizzly bear population size, the IGBST uses a statistical method to estimate the number of unique females with cubs, which becomes the basis for estimating the total population. In 2021, the IGBST adopted a revised approach to this method by redefining what constitutes a unique female. Prior to 2021, scientists distinguished unique females with cubs of similar composition if they were sighted at least 30 km apart, providing a conservative statistical model that could detect small changes in the population which was low at the time. However, as GYE grizzly bear population increased, this method increasingly underestimated the true number of females with cubs. To address this bias, the IGBST began distinguishing unique females with cubs of a similar composition if they are sighted at least 16 km apart. By using the refined 16-km threshold, the population estimate more accurately reflects the true population size in the ecosystem.

In addition to refinements in estimating unique females with cubs, the IGBST transitioned to an integrated population model (IPM) in 2022. This modeling approach is increasingly used to estimate populations of species world-wide. It uses advancements in statistical methods to integrate data from multiple sources in a single inferential framework. IGBST scientists use this modeling approach to monitor population vital rates and estimate the effects of different management scenarios on the population.

Grizzly cubs are born in the den blind, toothless, and furless. They stay in the den nursing for over a month. By the time spring arrives and they emerge, their eyes open; and they have grown teeth and fur.

For 2022, the GYE grizzly bear population was estimated at 965 (95% credible interval = 819–1121) using the IPM approach. It is important to note that the overall population trend has been increasing since the grizzly bear was listed as a threatened species; however, the rate of population growth has slowed in recent years as grizzly bears begin to reach carrying capacity in certain areas of the GYE.

There are more grizzly bears today, occupying a larger area (27,066 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 now occupy areas where they were absent for decades including all of Grand Teton National Park and the John D. Rockefeller, Jr. Memorial Parkway. The high visibility of grizzly bears foraging on native foods in roadside meadows makes Grand Teton a popular bear viewing destination. Management of grizzly bears and their habitat continues to be a high priority in the park.

Harlequin Ducks

The harlequin duck *(Histrionicus histrionicus)* is a relatively small species that breeds in northern boreal regions of eastern Canada, the Pacific Northwest of the US and Canada, Alaska, and the Rocky Mountains. The population status for North American harlequin ducks is variable; however, in the Rocky Mountain region they are considered a sensitive species and Wyoming lists them as a species of greatest conservation need. Harlequin duck core breeding range exists in Alaska, Washington, Oregon, Idaho, Montana, and Wyoming. The population in Wyoming represents the extreme southern and eastern extent of the western North American breeding population. The harlequin duck is one of the rarest breeding birds in Wyoming and its current breeding range appears to be limited to Yellowstone and Grand Teton National Parks and the Bridger-Teton and Shoshone National Forests. Little information is available on survivorship, migration movements, winter habitat use areas, and general breeding ecology. Better understanding of these subjects is needed in order to conserve harlequin ducks in Wyoming.

Biologists captured and tagged harlequin ducks with satellite transmitters and geolocators from 2014-2019; however, no further studies occurred during the past three seasons.

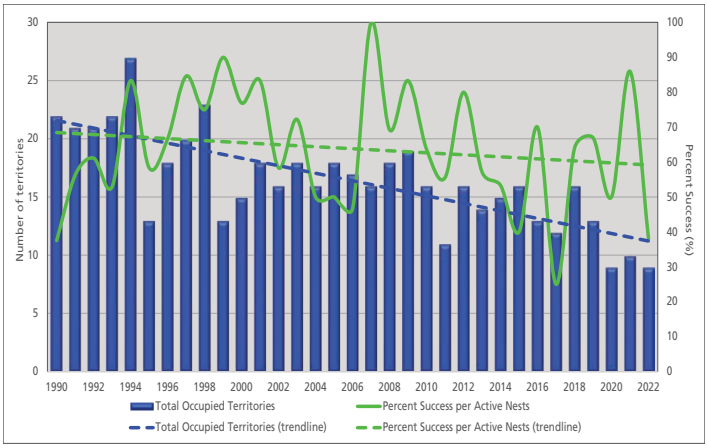
Harlequins thrive in rapids, unlike most ducks they rest perching on slippery rocks instead to floating.

In the spring of 2022, biologists surveyed the lower stretches of Moose Creek for breeding pairs, but none were located. In mid-August, biologists conducted more extensive surveys along sections of Owl, Berry, and Moose Creeks walking over 6.5 miles in the streams. They located one hen with a brood of five ducklings and two solitary hens. This marks another productive breeding year. (In 2018 park biologists documented an especially productive year with three broods producing 11 chicks.)

Ospreys

Osprey (*Pandion haliaetus*) are impressively widespread raptors, found across every continent except Antarctica. In Grand Teton National Park, they are often observed flying over lakes, rivers, and waterways in search of fish. With a diet consisting primarily of fish, osprey nest near low-elevation lakes and along the Snake, Gros Ventre, and Buffalo Fork Rivers and their tributaries. Park staff started monitoring osprey nest occupancy and success in 1972 and later standardized the surveys in 1990. While only 6–8 nests were occupied annually 1972–1981, more recently ospreys occupy approximately 13 territories (10-year average 12.7).

In 2022, ospreys occupied 9 of 18 (50%) monitored territories in the park. Breeding activity occurred at 8 of these sites and 3 pairs successfully fledged a total of 4 young. These numbers are an obvious decline in comparison to nesting success 10-year averages of 6 productive pairs and 9.8 fledglings. The percentage of successful breeding pairs in 2022 (38%) was the lowest since 2017 when only 25% of the nesting pairs successfully produced chicks. Nesting success of breeding pairs within Grand Teton is fairly stable to gradually declining.



Osprey territory occupancy and nest success with trend lines.

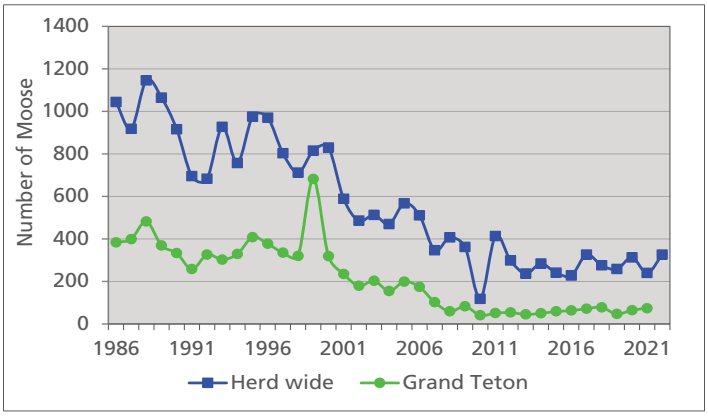
The osprey diet is 99% fish. They are successful hunters catching fish on one-quarter or more of their dives.

It is important to note the absence of successful nests around Jackson Lake in 2022 since these territories make up to 28% of the total monitored territories within the park. Historically large drawdowns of Jackson Lake Reservoir over the past few years drained bays and exposed large mudflats changing lakeshore habitat. Ospreys lost a considerable amount of foraging habitat as a result of the decreased lake levels. Further investigation is needed to understand the long-term effects of fluctuating lake levels on osprey.

Moose

Moose (*Alces alces*) were rare or absent from Grand Teton National Park prior to 1912 but became numerous by 1950. They are better adapted to survival in deep snow than other ungulates in the Greater Yellowstone Ecosystem. Except during the rut, moose are usually found alone or in small family groups. Grand Teton moose are part of the Jackson herd which includes animals outside the park boundaries. The herd experienced a decline from an estimated high of more than 4,000 in 1990 to less than 1,000 since 2008. This partially migratory herd moves between distinct but overlapping summer and winter ranges. The Wyoming Game and Fish Department conducts an annual aerial trend count of the Jackson moose herd. The count for 2022 totaled 326 moose, roughly 86 more than counted in 2021, including 89 in 51 groups within Grand Teton (37 cows, 33 bulls, and 19 calves). Ratios were 58 calves and 91 bulls per 100 cows.

The moose herd decline likely resulted from a combination of interacting factors. The ecological landscape of today is different than the early 20th century when moose populations expanded. At that time, large-scale predator reduction programs were ongoing throughout the west and wildfire suppression was widespread. Today, grizzly, cougar, and wolf populations have recovered. Also, large-scale wildfires affected portions of the herd unit in 1988, 2000, and 2010. Studies suggest that nutritional quality of moose forage in areas burned in 1988 is significantly lower than in unburned areas. Individuals summering in these areas have lower pregnancy and calf survival rates. In contrast, winter habitat availability does not appear to be limiting the growth of the Jackson moose population. Moose have narrow temperature tolerances. Temperatures above 57°F trigger moose to seek cooler locations. Many of the shady mature forests bordering the riparian forage areas preferred by moose have not regrown following large-scale wildfires. Additionally, warming temperatures associated with changing climate may be affecting moose by altering their feeding and other activities, potentially affecting caloric intake, and providing favorable conditions for parasites.



Jackson moose herd mid-winter counts, 1986-2022 (data from Wyoming Game and Fish Department). These counts are used to estimate overall herd size.

Moose fur is made up of two different layers—the longer hollow guard hairs that repel moisture and use trapped air as insulation and a shorter denser underfur. Guard hairs are thicker and longer in the winter coat.

Biologists continue to assess hair loss in moose presumed to be caused by winter tick loads. Winter ticks are a small, ectoparasites that feed on mammal blood with infestations most commonly found on moose. In fall, the ticks amass on vegetation and transfer onto moose. In mid-winter to early spring, adult ticks irritate the moose causing moose to groom excessively thereby resulting in loss of insulating hair, blood loss, and changes in foraging behavior. In 2022, biologists made visual observations of 116 moose and assigned each to a hair loss rating category (1=no loss [0-5%], 2=slight loss [5-20%], 3=moderate loss [20-40%], 4=severe loss [40-80%], and 5=ghost [80-100%]) for 116 moose. Slight hair-loss was the most frequently assigned category with 6 moose in the north and 30 in the south. No moose were categorized as ghost moose. Biologists continue to study the relationship between weather indices (e.g. fall/spring temperatures and amount of snow-on-the-ground) and hair loss in moose as these variables may influence tick survival. Studies elsewhere demonstrated that severe winter tick infestations can negatively impact moose calf survival and tick reproductive success is positively affected by earlier springs and milder winters. Park staff will consider the potential for local studies to better understand winter tick impacts on area moose.

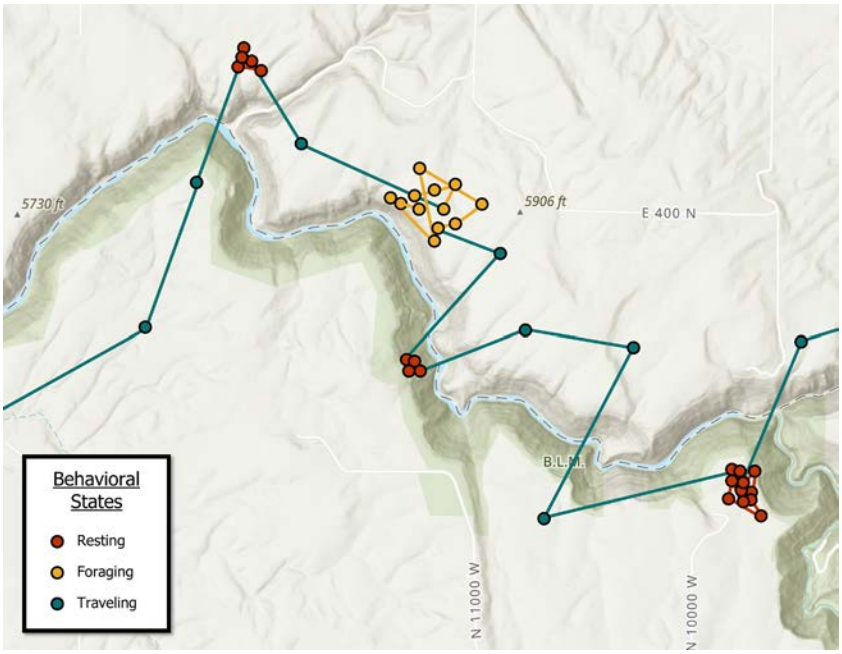
Mule Deer

Mule deer (*Odocoileus hemionus*), one of many park animals that are seasonal residents, undertake annual migrations to distant wintering areas throughout the Greater Yellowstone Ecosystem to meet their biological needs. Migrations showcase the behavioral strategies species use to exploit seasonal resources in otherwise inhospitable environments. Despite their intrinsic and ecological value, animal migrations have received little conservation attention until recently. Documenting animal movements is essential for meaningful conservation actions. Specific objectives for park mule deer migration research include: identifying important migration routes and seasonal use areas both inside and outside the park; determining the timing of migrations and assessing the variations in mule deer movements; evaluating land use patterns along migration routes to identify potential movement barriers, important deer stopover areas, habitat preferences, and conservation needs; and working with partners to conserve migration routes and important seasonal habitats.

Since the project began in 2013, park biologists collared 54 adult female mule deer on summer range in the park and parkway. They partnered with Idaho Fish and Game to capture and collar 66 mule deer on Idaho winter ranges including 21 at Sand Creek Wildlife Management Area, 38 along the Teton River, and 7 near the Teton Front outside of Victor and Driggs, ID. Collectively, biologists recorded 375 complete migration sequences that describe eight population-level corridors (seasonally used travel paths).

The travel paths form a far-ranging migration network spanning multiple land jurisdictions in two states. In each corridor, mule deer cross a minimum of three land jurisdictions. Routes traversing the western front of the Wind River Range crossed seven. Migratory distances ranged from 10 miles in several of the Jackson and Teton River routes to over 150 miles in routes traversing the western front of the Wind River Range. To date, the longest migratory movement recorded by this project was 190 miles traveled by was a mule deer between Spalding Bay summering grounds in Grand Teton and wintering grounds northeast of Rock Springs and the Interstate 80 corridor. The migration covers a wide variety of habitat types from sand dunes and sagebrush steppe to montane forest and alpine meadows, as well as range of terrain. Elevations within the eight corridors ranged from 5,000 feet on wintering grounds to over 10,000 feet on the mountainous routes. The highest elevation recorded was 11,496 feet along a route crossing the Absaroka Range with several other mule deer crossing elevations between 10,500 to 11,300 feet during their journeys.

Migration presents many challenges for mule deer as they cross physical and jurisdictional boundaries encountering people, vehicles, and domestic animals while still needing to find forage and resting spots.



An example of how the GPS locations gathered from migrating mule deer show the behavioral states of the deer.

In 2022, researchers working on the project shifted from the data collection phase to focus on analysis and communicating research findings. Biologists further performed spatial movement studies focused on eastern Idaho's Teton River Canyon to assess winter range habitat selection patterns in the predominately agricultural landscape. Those mule deer showed a strong preference for native shrubs, grasses, and tree canopy over agricultural crops. Specific preferences depended on the behavioral state of the individual deer (resting, foraging, or migrating, as determined by movement patterns). The results provided land managers with an understanding of the complex matrix of land cover types—including native vegetation—preferred by mule deer to meet their biological requirements and highlighted the need for further conservation to protect these habitats.

2022 Field Notes

Park staff share some of their more interesting field adventures.

Becca Fernandez: Studying peregrine falcons in Grand Teton can lead you to some of the most beautiful places in the park. Peregrine falcons nest and raise their young in high cliffs bands, and in my opinion Garnet Canyon takes the cake. The canyon, frequented by hikers and climber's alike, offers an abundance of great nesting habitat and incredible views. On a hot June day, I began my journey at Lupine Meadows. Hiking past platoons of other hikers, I turned the corner into Garnet Canyon, my observation spot for the next four hours.

While scanning the cliffs looking for a bird that's a mere speck in the sky, I went through waves of emotion. Will I ever see these birds? What if I missed them? How did it get to be so hot out? Is that rock a bird? With just thirty minutes left of my observation time, I was scanning the cliffs and saw a peregrine swoop into my scope's view. It landed on a ledge next to some white rocks. I thought FINALLY some action, then these white rocks started to move along the cliff. Hmm interesting moving rocks, I guess I had gone crazy. Then, in a state of pure joy, I realized that they were small peregrine falcon chicks! Only about a week old, since they still had their white downy feathers, the chicks moved along the ledge. I watched as the adult fed them and the chicks began picking at a small prey item. Seeing chicks at this age on a miles long cliff band is a rare sight, and I was so happy to have found them. A couple weeks later our crew went back to see how the chicks had progressed and saw 3 near fledglings stretching their wings perched on rocks awaiting their first flight. The Garnet Canyon pair was the most productive pair in 2022, a testament to the ongoing recovery of this impressive bird.

To spot peregrines falcons staff hike high into Garnet Canyon.

Carley Tsiames: In late August each year, park and forest wildlife staff head into the backcountry for a week on the annual bighorn sheep survey. Some folks hike in the south end of the range near Marion Lake, Mt Hunt Divide, the Death Canyon Shelf, and Darby Canyon; while others hike up north to Colter, Waterfalls, and Webb Canyons. This season, Hannah Booth and I ventured on a completely off-trail journey into Colter Canyon to climb 3 peaks (10515, Ranger, and Doane) in search of sheep.

We shuttled across Jackson Lake by boat to the mouth of Colter Canyon. Clouds remained in the canyon, so we knew our time bushwhacking would be wet. We navigated on and off elk trails through the canyon and were pleasantly surprised when our bushwhacking took us through stands of the largest huckleberries I've ever seen. We channeled our inner bears and munched our way through. We may have only hiked about 5 miles to our camp in the north fork of Colter Canyon, but it took most of the day.

The wildlife crew uses spotting scopes to scan for and count bighorn sheep.

The next morning, we climbed straight up a steep slope to the top of a peak measuring 10515 feet. We set up our scopes and scanned nearby ridges and cliff bands for sheep. Throughout the 4-hour survey, we repeatedly asked, "Rock or sheep?" That day, it was only rocks. We wondered, "Am I sure all those sheep-like rocks were just rocks? Am I missing the sheep?" Our fellow surveyors wondered the same from across Webb Canyon on a small bump which they coined as "Mount St. Nubbin." We communicated over the radio; although, we did not see any sheep that day, it was fun to see friends in the distance.

That evening, storms rolled in. We sheltered in our tents and listened to the forecast. Luckily, there was a break in the storm so we could emerge for dinner, but the forecast sounded ominous. With daily afternoon storms likely, we had to change our plans. We would day hike to the farthest site and climb the saddle next to Ranger Peak twice instead of moving camp. Starting sharply at 6 am the next day, we packed up our stove and instant coffee for our hike to Doane Peak. We had both looked over at Ranger and Doane on Moose Basin trips and were excited to reach this new and exciting sheep land. We cheered with hot beverages atop the

Hannah Booth collects bighorn sheep fecal samples for genetic studies.

Camping in the backcountry with your crew can be both challenging and memorable.

mountain and cheered again when we saw 5 sheep through our scopes in a nearby meadow. We regained faith in our ability to distinguish rock from sheep and had hopes that we would spot more sheep if they were not bedded down, hidden from sight. We rewarded ourselves with a dessert of instant chocolate pudding and bunny grahams at camp.

Sadie Textor: At the beginning of the Elk Reduction Program in November, I walk to my car at 5:30 am. All I can hear is the snow crunching beneath my feet and all I can see are the stars shining brightly against a dark sky. The world is still asleep. I start the truck engine, turn up the heat, and start scraping ice. I wonder to myself if I will ever be a "morning person".

It is a long, lonely drive to the south end of the park from Colter Bay and my tire tracks are the first to disturb the snowy highway. I pray nothing decides to leap across the road. As I get closer to Hunt Area 75, I scan for hunters in pullouts and elk in the flats. Through the dawn fog, I catch a glimpse of orange vests in the sagebrush sea. Where will the elk be today? The seemingly featureless topography of Antelope Flats is surprisingly variable in elevation, easily obscuring elk traveling through low-lying areas. As I start down Craighead Hill, I see a few elk heads appear at the top of the ridge to the east. Before I know it, a herd of five hundred elk, strung out for what seems like a mile, comes pouring down toward Highway 89/191. They come to a halt and look both ways, hesitating. At first, the haze surrounding them looks like kicked up snow, but I quickly realize it is a growing cloud of breath. I turn on my flashing lights to stop traffic and watch as the lead cow finally commits her herd toward the road. My gaze gets lost in two thousand hoofed legs crossing the pavement in perfect synchronization. They have made it out of the hunt area and will soon be in the refuge of the river bottom—safe at least until tomorrow.

Sadie Textor spent her winter safeguarding and studying elk.

I turn off my light bar and continue down the highway. The pink sunrise is soon washed away as the light hits the tip of The Grand. Powder-dusted moose forage along the road, grouse fly erratically overhead, and the steam of Warm Ditch reaches ethereally toward the sky. What a privilege it is to live and work in this winter paradise. Despite my unfortunate aversion to waking up early, I am grateful for the opportunity to help the largest elk herd in North America complete its migration to wintering grounds and to watch the world come alive.

K. Cieszkiewicz/USFWS

Peregrine Falcons

Peregrine falcon (*Falco peregrinus*) are found globally and primarily feed on birds captured in flight. The lower elevations of the major Teton Range canyons provide peregrine with excellent cliff-nesting and diverse foraging opportunities. Decimated by the insecticide DDT used in the US until the 1970s, peregrine falcon disappeared from the Greater Yellowstone Ecosystem by the 1960s. From 1980 to 1986, biologists released 52 fledgling falcons in Grand Teton National Park and the John D. Rockefeller, Jr. Memorial Parkway. Following reintroduction, park staff have monitored the local peregrine population since 1987. The first nesting attempt was at Glade Creek that year and young successfully fledged the next year. Peregrine, once listed as threatened under the Endangered Species Act, were delisted in 1999. To date peregrine occupy territories in Garnet, Death, Cascade, and Webb Canyons; Blacktail Butte; Glade Creek; Steamboat Mountain; and near the Gros Ventre River in Kelly.

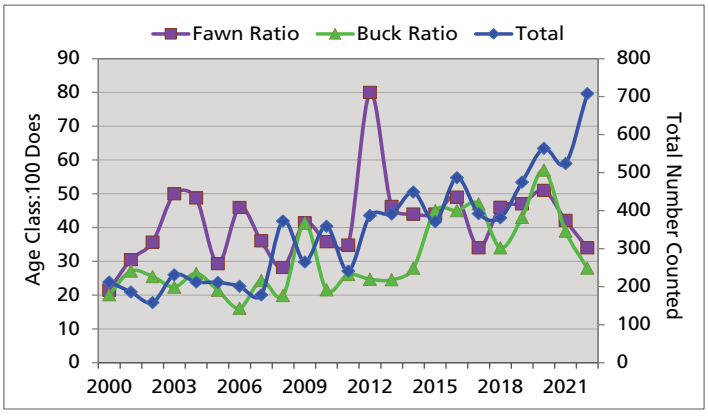
In 2022, peregrine occupied 5 of the 8 territories monitored within the park and parkway. Of those occupied territories, four breeding pairs successfully fledged a total of 7 chicks at Garnet Canyon (3), Cascade Canyon (2), Webb Canyon (1), and Kelly (1) eyries. Park managers established a temporary closure in the Baxter's Pinnacle climbing area of Cascade Canyon to limit human disturbance to that eyrie. Once the young fledged, the area was reopened. The successful Garnet Canyon pair nested on the south side of the canyon after several years of nesting on the north side. While biologists observed courtship behavior at Glade Creek and the adults continued to occupy the site, ultimately the territory was not successful. The Blacktail Butte and Steamboat territories were not occupied. Biologists only observed a single peregrine in Death Canyon not associated with a nest and therefore recorded the territory as unoccupied.

The breeding statistics for 2022 were above the 10-year averages: 5 nesting pairs (10-year average 3.8), 4 pairs with young (2.7), 7 chicks fledged (4.9), and 80% of the documented pairs were successful (56%). Historically the percent of successful pairs is highly variable. Overall, the peregrine falcon population in Grand Teton is stable and the trend in occupied territories and successful nests has increased gradually over time. There is potential for peregrines to occupy territories outside of the current survey area. Due to a report of peregrines in Granite Canyon during the breeding season, it will be monitored in 2023. As new territories are identified, they will be added to the park's monitoring program.

Pronghorn

The pronghorn (*Antilocapra americana*) that summer in Grand Teton National Park are a segment of the Sublette herd that undertakes one of the longest terrestrial mammal migrations in the Western Hemisphere. In the fall, these fleet-footed animals cover up to 30 miles a day on a roughly 100-mile route one-way that follows the Gros Ventre River to its headwaters and down to winter range in the upper Green River drainage. Pronghorn bones found at the Trappers' Point archeological site suggest animals may have been using this narrow pathway for 6,000 years. This migratory route of the pronghorn herd is threatened by development (residential and energy) which is occurring along the southern portion of the route and in their winter range.

Park biologists track the number of pronghorn summering in the Jackson Hole and the Gros Ventre River drainage by conducting aerial line transect surveys. This survey technique corrects for groups missed and provides an estimate of pronghorn abundance with a desired level of precision. The annual June survey was not conducted in 2022 due to the Jackson Hole Airport closure during the survey period.



Pronghorn count and age/sex ratios during late summer classification counts, 2000-2022 (data from Wyoming Game and Fish Department).

Pronghorns males have scent gland in their black cheek patches. They rub these glands on vegetation to mark their territory.

Grand Teton, National Elk Refuge, and Wyoming Game and Fish Department personnel conduct ground surveys in late summer to count and classify pronghorn after fawns are born. A total of 708 pronghorn were counted during the 2022 survey. Ratios were estimated at 34 fawns and 28 bucks per 100 does. The reproduction rate in this herd segment is typically low but varies widely. Low pronghorn fawn counts are often seen following a severe winter or a cool, wet spring. Both fawn and buck ratios were lower than the previous year. In general, a ratio of 25 bucks per 100 does will maintain recruitment for the population.

Red Fox

Red fox (*Vulpes vulpes*) live year-round in Grand Teton National Park. Increased visitation and an observed increase of foxes has led to more frequent human-fox interactions in the park. Red fox can often be seen in highly visited park areas, possibly attracted by the availability of human food sources. These include the purposeful feeding of individual foxes by park visitors, ingestion of fish remains left by anglers, and opportunistically acquiring unsecured food in developed areas.

A red fox that has learned, through prior food reward, to associate people including their activities and areas of use or food/trash containers as sources of anthropogenic foods is food conditioned. Once a wild animal is food conditioned, human safety can become a concern. Food-conditioned behavior can cause numerous problems for humans and wildlife alike. These issues include harm to wildlife by ingesting processed foods, increased traffic hazards as wildlife are drawn to road corridors and developed areas, and safety concerns (e.g., aggression and disease transmission) for park visitors and employees. Food-conditioned behaviors may lead to the animal having to be destroyed. Therefore, park resource managers work to minimize the potential for human-fox conflicts while maintaining this valued ecological and wildlife viewing resource.

In 2022 park managers implemented two closures to protect adult fox and kits at dens near trails, roads, or human development. Biologists installed remote cameras to capture data about denning chronology, kit survival, and den attendance by the adult foxes. During the busy summer season, staff recorded three instances of foxes receiving food rewards: two occurred at Jenny Lake where a fox approached visitors and was observed eating human food and one occurred at Signal Mountain Campground where a fox received a food reward when visitors left food unattended. Education is the most important tool in combating the negative impacts of intentional and unintentional feeding of wildlife. Park staff and signs in busy areas remind visitors to secure food properly and maintain a safe distance from wildlife. Increased ecological understanding of foxes coupled with expanded outreach and education efforts will help mitigate human-fox conflicts in Grand Teton National Park.

Fox are opportunistic feeders, open to finding new sources of food. Habituation to humans brings foxes into close contact with people and food conditioning can result in the need to euthanize especially bold individuals.

Ice fishing is a popular human activity on Jackson Lake. Fishermen often discard their fish gut piles on the frozen lake surface unintentionally providing a food source for foxes to exploit. Unfortunately fox can quickly overcome their natural fear of humans in interest of easy food in the lean season.

Sagebrush Steppe

The sagebrush steppe community is one of the most widespread and diverse native plant communities in Grand Teton National Park, as well as across the greater western United States. Where intact, this ecosystem hosts an variety of native plant and animal life, including several species of concern, such as the greater sage-grouse. However, the sagebrush steppe faces numerous threats including invasion by nonnative plants, fire, destruction for human development, and climate change. Today sagebrush steppe communities comprise less than 50% of their historic range across the west, while much of the remainder is modified or under threat.

Monitoring this resource is a priority for park staff. Starting in 2010, Grand Teton biologists partnered with NPS Inventory and Monitoring Network scientists to adopt a standardized protocol for annually tracking sagebrush plant community composition. In 2021 park staff expanded using this same protocol to monitor sagebrush restoration sites for better comparison of plant community characteristics between intact sagebrush communities and restored sites. In 2022 park staff took measurements at 500 plots in intact sagebrush communities and 100 plots in restored areas.

Generally, plant composition in intact sagebrush plots shows minimal change over the last decade. Despite droughts, climate change, and increasing competition from invasive plants, sagebrush steppe species are proving to be resilient in the park. This resiliency also benefits park wildlife that depend on sagebrush steppe habitats. Dominant plant species in Grand Teton sagebrush steppes include mountain big sagebrush (*Artemisia tridentata vaseyana*), buckwheat (*Eriogonum spp*.), antelope bitterbrush (*Purshia tridentata*), and bluebunch wheatgrass (*Pseudoroegneria spicata*). The intact sites also have high cover of native forbs (30%), native grasses (18%), native shrubs (27%) and minimal cover of nonnative species (1.1%). The prevalence of nonnative species is increasing slightly, but at a rate of less than one percent over the last decade.

In restored sites, native grasses are establishing well, comprising 30% cover. However, the representation of cover by native forbs (6%) and shrubs (2%) is lower than in the intact sagebrush sites. Biologists found most nonnative species in the restored sites are short-lived annuals taking advantage of open ground exposed by disturbance that will be outcompeted by native species and disappear as the seeded plants establish. Monitoring park restoration units is important for adaptive management; comparing differences between the intact and restoration sites allows park staff to modify their restoration strategies. For example, in response to trends noted in restoration plots, park vegetation biologists started increasing the percentage of wildflowers in their seed mixes and using more container plants. The sagebrush monitoring program provides concrete goals for restoration work and protecting intact ecosystems.

Snake River Fine-spotted Cutthroat Trout

Grand Teton National Park is home to 12 species of native fish along with 9 nonnative fish (4 trout and 5 warm or tropical species). Two distinct looking but genetically undifferentiated cutthroat trout (*Oncorhynchus clarkii*), the Snake River fine-spotted and Yellowstone cutthroat, are native to the park. Historically the Wyoming Game and Fish Department stocked both lakes and streams with game fish including nonnative species: lake, brook, brown, and rainbow trout. With strong support from the park, the last nonnative fish stocking program ended in 2006. The state manages the recreational fishing licenses and catch limits of both native and nonnative fish within the park, with input from the National Park Service. The potential impacts of nonnative trout species on native trout in Grand Teton National Park continues to be a concern.

In 2019, Grand Teton National Park fisheries staff developed a new tool to census cutthroat trout in the park with the support of the Grand Teton National Park Foundation and the One Fly Foundation. To assess the population status of the Snake River fine-spotted cutthroat trout, they constructed a video weir and installed it at Upper Bar BC Spring, one of the primary spawning springs in the park and the location for decades of cutthroat recruitment studies. Fisheries personnel fabricated the aluminum weir to funnel fish through a chute past a video camera that records footage 24 hours a day. The lights, video camera, and recorder are powered by a solar array. The recorder uses security software to highlight time periods when movement is detected, allowing staff to quickly review footage and count the number of fish passing through the chute. This video weir is the first one constructed in Wyoming. It allows biologists to make accurate counts of fish without handling them, causing minimal stress and disruptions to fish activities. As the tool is refined and used on other springs and streams, it will provide more accurate park cutthroat surveys. Understanding the number of fish moving through spawning springs and streams helps park managers improve their knowledge of park cutthroat populations.

In May 2022 park biologists set up the video weir at Blacktail Spring. Biologists recorded 373 cutthroat entering the spring May 31 to July 15. On the peak day, June 25th, 53 cutthroat entered the spring to spawn. These numbers are higher than biologists anticipated. This monitoring effort is in its infancy; however, the results are encouraging.

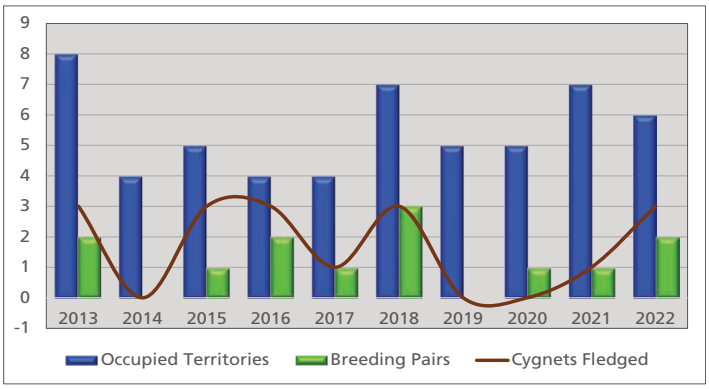
Trumpeter Swans

Nearly extirpated in the contiguous 48 states by the turn of the 20th century, trumpeter swans (*Cygnus buccinator*) made a comeback after intensive captive breeding programs, habitat conservation measures, and protection from hunting. Despite these efforts, swan population growth is low in the tri-state region (the Greater Yellowstone Ecosystem and surrounding areas in MT, ID, and WY). Many factors likely inhibit recovery, including competition with migratory swans, marginal winter range, variable reproduction rates, limited nesting habitat, and high cygnet mortality. Monitored since 1987, Grand Teton National Park provides important nesting and foraging habitat for swans.

The number of occupied swan sites, nesting pairs, and young hatched and fledged has fluctuated widely since monitoring began. Swan pairs abandoned some traditional park nesting sites, which could be attributed to predation, increased human activity, or decreased water levels due to drought and hydrologic changes. During the 2022 breeding season, a total of six territories were occupied by swans within Grand Teton National Park and John D. Rockefeller, Jr. Memorial Parkway. Swans occupied four of the territories in the spring but did not initiate nesting: Glade Creek south, Glade Creek slough, Cygnet Pond, and Elk Ranch Reservoir. Swans at Hedrick Pond and Swan Lake both initiated nesting, but only the Swan Lake pair was successful, fledging three cygnets.

In the early spring of 2022, park biologists relocated and maintained the swan nesting platform at Elk Ranch Reservoir. Originally installed in partnership with the Wyoming Wetland's Society and Wyoming Game and Fish Department during 2020, the platform mitigates the effects of fluctuating water levels within the reservoir on nesting swans improving chances of reproductive success. Park managers also placed a closure around the reservoir to prevent human disturbance; however, biologists observed no nest initiation. Swan pairs have occupied the reservoir annually since 1980, but only successfully fledged young during three years in the 1990s.

Trumpeter swans lay 4–6 eggs incubating them for just over a month. When the cygnets hatch, they face high mortality rates between weather conditions and predators.



Trumpeter swan productivity in Grand Teton over the last ten years.

A breeding pair of trumpeter swans initiated nesting at Hedrick Pond early in the season. Because of swan sensitivity to human disturbance, park managers placed a closure around the pond to protect it—trails to the pond are frequented by horseback riders. Despite the closure, the pair did not successfully produce cygnets. Water levels at Hedrick Pond have differed over the years, with some years being completely dry. A shift in water level could have attributed to the pair's failure.

Fluctuating water levels may also factor in swans' failure to nest on Jackson Lake and Glade Creek, where swans are frequently observed. Glade Creek, a historically productive territory, has not been used in recent years when Jackson Lake reservoir was drawn down to very low water levels. Further investigation into the possible loss of trumpeter swan nesting habitat would help biologists understand the impacts of reduced water levels in Jackson Lake and along the upper Snake River on surrounding areas like Glade Creek.

After observing nest initiation at Swan Lake, biologists placed a closure on the popular Swan Lake Trail to protect those trumpeters from disturbance during the sensitive cygnet-rearing phase and lifted it once the cygnets fledged. Three cygnets successfully fledged, an increase in comparison to the 10-year average of 1.70. On average over the past decade, swans occupied 5.5 territories with 1.3 breeding pairs nesting in the park.

On the late September observation flights, biologists spotted 13 swans in the park and adjacent lands. Two swans were still on the Elk Ranch Reservoir while the rest including the three Swan Lake cygnets were on Jackson Lake.

Parameter	2022	10-Year Average
Occupied Territories	6	5.50
Total Adults	12	20.70
Breeding Pairs	2	1.30
Pairs with Cygnets	1	0.90
Percent Pairs Successful	50%	69%
Cygnets Fledged	3	1.70
Cygnets Fledged per Productive Pair	3	1.89

Ten-year averages for swans monitored by Grand Teton biologists.

Whitebark Pine

Whitebark pine (*Pinus albicaulis*) is a slow growing, long-lived, five-needle pine, often the only conifer species capable of establishing and surviving on high-elevation sites with poorly developed soil, high winds, and extreme temperatures. As a keystone species, whitebark pine plays a significantly greater ecological role disproportionate to its abundance, because it influences biodiversity, forest structure, and ecological function. These trees maintain surface and groundwater availability by trapping snow, promoting snowdrift retention, protracting snow melt, and preventing erosion of steep sites. Whitebark pine also produces seeds that are an important food source for wildlife such as Clark's nutcrackers, grizzly and black bears, squirrels, and other species.

In December of 2022, whitebark pine was listed as a threatened species under the Endangered Species Act due to declines rangewide. In the past two decades, whitebark pine has experienced severe overstory mortality due to an unprecedented epidemic of native mountain pine beetle (MPB), nonnative white pine blister rust, and increased wildfire. Of these, wildfire and MPB are affected by climate change.

The Greater Yellowstone Ecosystem (GYE) contains over 2.5 million acres of whitebark pine forests. Grand Teton National Park and the John D. Rockefeller, Jr. Memorial Parkway comprise over 28,500 acres of whitebark pine forests. In 2004, the Interagency GYE Whitebark Pine Monitoring Program started tracking whitebark pine condition and trends across the ecosystem. Grand Teton staff began annual whitebark pine monitoring in 2007. The park works collaboratively with other agencies on whitebark pine conservation both in the GYE and across its range. Overflights of the GYE in 2019 found 100% of whitebark pine stands have MPB activity: 18.4% have low mortality, 49.3% have moderate mortality, and 32.3% have severe mortality.

The MPB were at epidemic levels in the GYE approximately 2004–2012. Another notable increase of MPB began in 2019. Targeted surveys in 2022 found 54% of overstory whitebark were dead from beetle attack; 35% of the dead sampled were attacked during 2019–2022. During the 2004–2012 epidemic, healthy whitebark stands were reduced to relatively low numbers of mature cone-bearing trees, yet enough remained to provide some recruitment. However, those seedlings will take 25–30 years to produce cones. Experts are concerned that the second outbreak will create an ecological imbalance that could collapse the mutualistic relationship between whitebark and its primary seed disperser, the Clark's Nutcracker.

In addition, nonnative white pine blister rust continues to infect additional trees causing broader impacts. The results of this are intensified and extensive loss of cone-bearing capacity and mortality of remaining mature whitebark pines.

Recently biologists analyzing data collected during 2016–2019 on GYE trees infected with white pine blister did not detect a significant change in the proportion of trees infected when compared to 2012–2015 data. However, the probability of an individual tree becoming infected with blister rust has increased since 2004. Biologists also found an increased number of bole cankers in infected trees. A blister rust bole infection is more consequential than a canopy canker because it compromises not only the overall longevity of the tree, but its reproductive output as well.

Verbenone hormone packets on whitebark trees deter beetle infestations.

Protecting remaining seed trees from MPB and wildfire is a high priority. Identification and protection of rust resistant, mature seed-producing whitebark pines is key to the species' continued existence.

Priority actions also include collecting seeds from rust resistant trees, growing out the seedlings, and planting them. Areas with high severity canopy mortality, low blister rust severity, and scant natural regeneration should be targeted for restoration sites. Managers are targeting areas of beetle-caused mortality because they provide excellent habitat for natural and planted regeneration with less competing understory compared to areas of fire disturbance.

Conserving and restoring whitebark pine is crucial to preserving the resilience, health, and the integrity of these high-elevation ecosystems. Conservation of this slow-growing, long-lived species requires protecting the precious remaining healthy trees with verbenone to deter beetle infestations, collecting seeds for replanting, promoting genetic and physiological health, and continued monitoring. Conservation and restoration of whitebark must be a priority now to protect the persistence of the species.

Archeological Sites

Grand Teton National Park and the John D. Rockefeller, Jr. Memorial Parkway contain an array of archeological resources that reveal the extent of human occupation in the area. Most of the park and parkway's 333,700 acres has not been surveyed, and knowledge about archeological resources comes from inventory of less than 5% of that area. Within that small surveyed area, archeologists documented over 510 sites that provide a diverse array of information about Jackson Hole's human past. The oldest sites provide evidence of Native American peoples occupying the park around 11,000 years ago, roughly marking the transition from the Pleistocene (Ice Age) to Holocene (current) geologic time periods. Glaciers and the flows of glacial meltwater had recently receded northwards, exposing the valley floor as well additional areas of the Teton Range. Glacial meltwater formed piedmont lakes that proved to be desirable base locations for hunting and gathering activities of early people in the valley.

In 2022 Grand Teton archeologists worked with a local geoarcheologist to study the specific geologic events that created the local landscape. Understanding the conditions in which soil is deposited, preserved, and eroded by natural processes provides the context for park sites that contain preserved artifacts (stone tools, grinding stones, and steatite bowls), ecofacts (palaeobotanical evidence like pollen, seeds, charcoal, and charred roots), and features (hearths, depressions, and stone circles that mark habitation areas). Native American use of the park continued and changed adaptively for millennia.

A group of Shoshone-Bannock Tribal youth, accompanied by tribal archeologists, revisited a park site that was preserved through tribal collaboration with park staff during a park infrastructure project. The group also collaborated with Grand Teton archeologists to develop a new cultural inventory that resulted in the discovery, documentation, and site naming (in Shoshoni Language) of precontact Native American sites.

By the 1800s a small number of European American trappers arrived including Beaver Dick Leigh and Jenny, his Shoshone wife. A site dating to this protohistoric period, called the "Post Horse Site", was identified for avoidance and preservation during one of many new cultural resource inventories conducted by a private archeology company contracted to assist park planning efforts.

Park archeology and vegetation staff examine an area with holes from historic removal of sagebrush by homesteaders to extend pastures. These holes may be used for sagebrush replanting efforts.

Archeologists survey and record information on a prehistoric lakeshore site in Grand Teton National Park.

In the 1890s the first European American settlers began to create a community in the now designated Mormon Row Historic District. New cultural resource inventories are made in and around the district for future road work, new utility projects, and revegetation projects. Documenting and interpreting archeological remains in a homesteaded area is challenging. Archeologists document both features (irrigation ditches, fence lines, roads, and buildings) and artifacts (historic bottles and cans, agricultural equipment, and prehistoric artifacts) with mapping, photos, field notes, and completed Wyoming State Historic Preservation Office forms. This new field data must take in to consideration existing adjacent archeological studies, historic references, land patents, plat and water right maps, aerial photographs, historic photographs, and district landscape studies in order to identify which remains are historically significant. Park cultural staff worked with a Youth Conservation Corps to expose them to cultural research and contemplating the lives, hardships, and stories of the homesteaders who "proved up" on federal land to make it their own. The students also made the connection of the contrast between that historic opportunity and current local home ownership challenges.

Park archeologists collaborated with the park vegetation staff on the sagebrush steppe restoration project, planned to restore some of the landscape level impacts from historic homesteading. They discussed possible impacts to the cultural remains that are protected under the National Historic Preservation Act and strategies to avoid or minimize those impacts. Park leadership consulted with the Wyoming State Historic Preservation Office on the project before planning was completed and implementation began in the fall.

Historic Structures

There are different levels of designation for important historic sites made by the United States government. The most familiar designation are sites on the National Register of Historic Places, which is the official list of the nation's historic properties worthy of preservation on local, state, and national levels. When a historic property is deemed to be of exceptional national significance by the Secretary of the Interior it can be listed as a National Historic Landmark (NHL). NHLs demonstrate and represent important themes in the history of the nation. Both the National Register and NHL programs are administered by the National Park Service for all federal-, state-, and privately-owned properties. Visitors can often identify NHL properties due to the presence of a bronze plaque that specifies the name and Landmark status of the property with the date of designation.

Grand Teton National Park has two NHL-listed properties: the Jackson Lake Lodge and the Murie Ranch. The park and the partners who manage each of these sites take great care to ensure the properties are treated with respect and follow the Secretary of the Interior's Standards for the Treatment of Historic Properties.

During the summer of 2022, the park and Grand Teton Lodge Company conducted major preservation work on Jackson Lake Lodge. The lodge underwent a roof replacement, exterior concrete restoration, and re-staining to the building's façade. This project required seven years of planning involving architectural conservation and material science studies (in collaboration with the University of Pennsylvania) to determine the appropriate treatment of the concrete for removing paint and re-staining to restore the character-defining architecture and design of the NHL. Park staff worked together with the Wyoming State Historic Preservation Office to replace the original tar and gravel roof with a modified bitumen roof, which is a more modern, energy-efficient, sustainable, and attainable material that does not impact the historic integrity of the structure.

Jackson Lake Lodge was designed by architect Gilbert Stanley Underwood. His exterior design used reinforced poured concrete, molded with "shadowood," a wood grain textured plywood or wall board, so that exaggerated wood grain was cast into the surface, then the concrete was stained brown to give it a wood-toned appearance. This style helped set the tone for the massive building projects of the NPS Mission 66 Program.

This multi-million-dollar preservation project involved years of collaboration, historic research, and interdisciplinary expertise. The building now reflects the architect's original design intent, and the staining highlights the original "shadowood" decorative concrete exterior of the building, which is a character-defining feature. The concrete and roof repairs will also ensure that water infiltration does not further damage or degrade the original building materials. As with all preservation projects, the goal is to preserve the structure in perpetuity for the enjoyment of the American public.

Jackson Lake Lodge was designed to showcase the view of the Teton Range through the huge lobby windows.

Museum Collection & Archives

Grand Teton's archival and museum collections document the complex history of Grand Teton National Park. The park's Scope of Collection Statement guides park staff on what items are appropriate to place into the museum and archives collections based on existing objects and identified gaps in the collections.

The archives—the two-dimensional paper based unpublished materials—include reports, photographs, and maps documenting subjects ranging from land management, park history, and natural resources generated by park staff. As specified by NPS records management requirements, the park retains permanent records onsite for long-term preservation, management, and access for research by appointment.

The museum collection—the three-dimensional objects—includes natural history specimens, archeological artifacts, historic vehicles, fine art, regional handmade furnishings, and the David T. Vernon Collection of ethnographic materials. All items require preservation and long-term management once accessioned and cataloged permanently into the park's collections.

No notable acquisitions to the archives or museum collections occurred in the past year. Staffing and budget restrictions require careful considerations before adding any additional items to the collections due to the long-term care and preservation needs of each item. A Collection Advisory Committee was recently formed to ensure that any new accessions are relevant to the park's history.

When a large chunk of ice punctured the exterior wall and penetrated the interior space of the Colter Bay Visitor Center, the structural damage extended into the museum storage area, pushing four museum cabinets forward and jeopardizing the collections held there. The park curator requested assistance from the National Park Service regional museum staff at the Western Archeological and Conservation Center to pack and move the collections stored in those cabinets to another storage area in the park. In the fall of 2022, a conservator from the center came and assisted the park curator with the emergency removal of those items. Museum collections require specialized storage facilities and specific climate conditions to best preserve fragile items. The park curator is constantly monitoring and adapting to provide the best solutions for protecting the impressive park collection.

The damaged interior wall of the collection room at Colter Bay.

The park collection includes delicate items like beaded and fringed Native American dresses as well as durable items like wooden wagons.

Many items in the park collection require specialized handling. The park relies on assistance from regional conservators like Audrey Harrison for moving part of the collection or other large projects.

Second Tower Rockfall

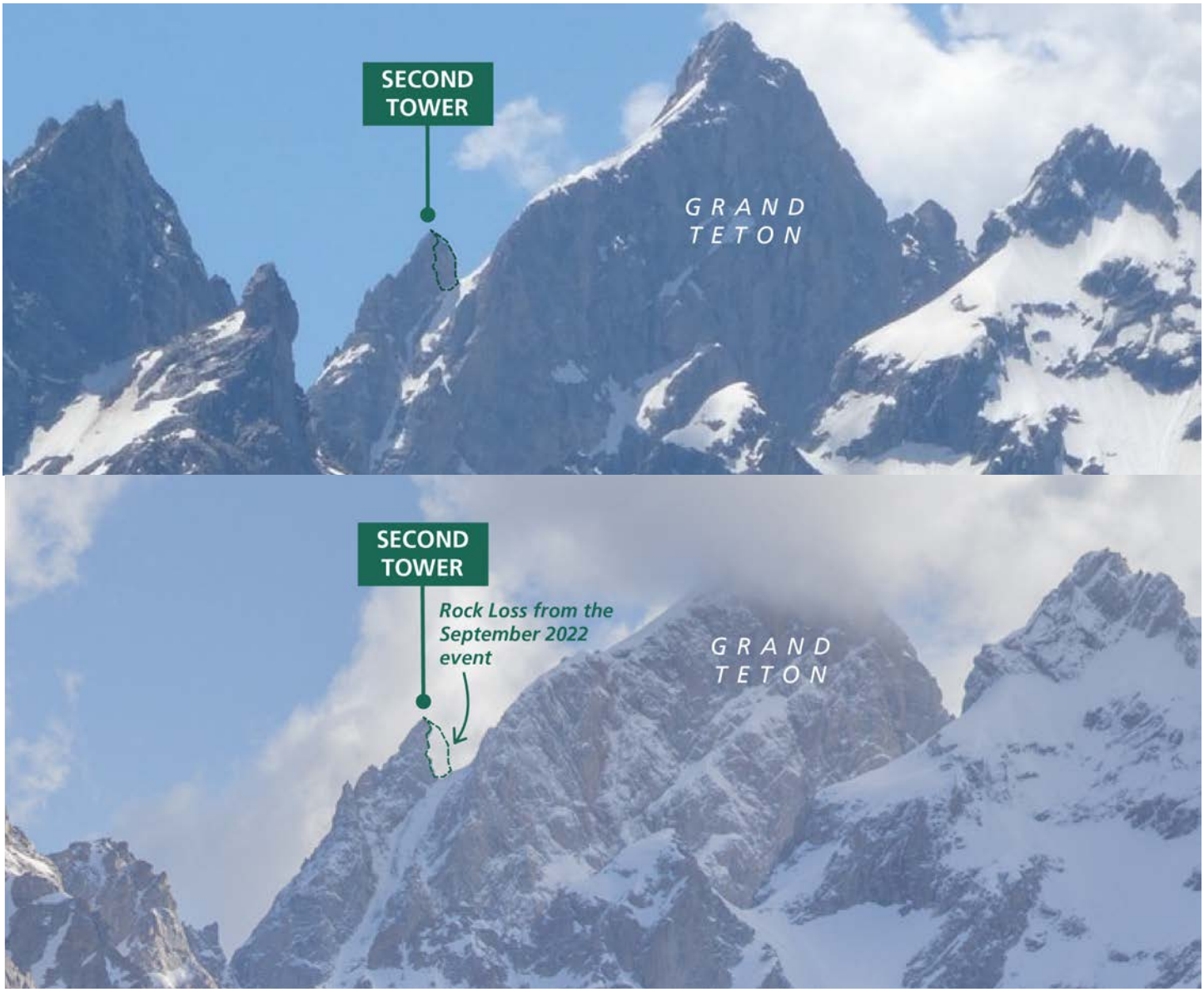
In September 2022 a major rockfall event dramatically altered the Teton skyline by bringing a sizable chunk of the Second Tower crashing down on Teepe Glacier. Located on the east ridge of the Grand Teton this rockfall is easily viewed from the valley floor.

Rockfalls are a natural geologic process of erosion involving the detachment and rapid fall of rock. The iconic block-fault formation of the Teton Range experiences many rockfalls each year; however, most are not dramatic. Massive piles of "talus" or rock debris on the slopes of the Tetons are evidence of this ongoing erosional process.

A number of geologic processes set the stage for rockfalls, including glaciation, weathering, and bedrock fractures. Tectonic stresses and erosion cause rock to fracture. Rockfalls later occur along these fractures. Triggering mechanisms like water, ice, temperature fluctuations, earthquakes, and vegetation growth are among the final forces that cause unstable rocks to fall.

Weathering is the constant process of breaking down rocks and minerals on the earth's surface through precipitation and temperature changes. Weathering loosens bonds that hold rocks in place and causes cracks to grow. One common type of weathering occurs when water seeps into the fractures, freezes, and further pries the rock apart in a process called "frost wedging" or "freeze-thaw". This can incrementally lever loose rocks away from cliff faces. Recent research suggests that daily temperature variations and extreme heat can also cause rock slabs to become unstable. Additionally, a variety of vegetation grows into the cracks where their roots expand and pry apart the rock. For any given rockfall, there is always a large degree of uncertainty about what exactly triggered it.

Another recent documented rockfall occurred in the Hidden Falls area of Cascade Canyon during the fall of 2018. Most rockfall is undocumented and often unnoticed. However, when an iconic mountain landscape changes in a way that is noticeable to the naked eye, it is a huge event.



Aquatic Invasive Species

Aquatic invasive species (AIS) are aquatic organisms that are not native in a particular water body. These species vary in size and type and are most often, but not solely, introduced to a new watershed via watercraft or human activity. Once introduced, many species will thrive without the presence of their natural predators or competitors. This can result in major alterations to native ecosystems, and in some cases adversely affect recreation, water utilization, and the local economy. A few examples of species that have recently been inadvertently introduced near Grand Teton National Park include curly leaf pondweed (*Potamogeton cripus*), flowering rush (*Butomus umbellatus*), and fish species such as burbot (*Lota lota*). Quagga and zebra mussels (*Dreissena bugensis and D. polymorpha*, respectively) are two of the most impactful invasive species have advanced westward across the US in the last 10–20 years but fortunately have not yet been found in the park or parkway. These exotic mussels are known to be particularly damaging to the water infrastructure and ecology after becoming established.

The park has enacted measures to prevent the introduction of AIS consistent with guidance from the Department of Interior and in collaboration with the State of Wyoming. Preventative actions include inspecting watercraft and educating boaters and visitors about diligence to prevent further spread. In 2022, the park had watercraft inspection stations at two locations selected to intersect with arriving watercraft. They operated daily during prime visitation periods. Crews inspected 24,148 watercraft passing through the stations. Staff preformed 36 decontaminations on suspect watercraft to ensure minimal the risk of AIS introduction.

During 2022, zebra mussel infestations were discovered in Pactola Lake, a South Dakota reservoir less than 30 miles from Wyoming's eastern border, and Highline Lake, a Colorado reservoir near Grand Junction. These lakes are an 8–hour drive from Grand Teton National Park and represent a greater risk of mussel introduction to northwest Wyoming.

Boaters and owners of any type of watercraft, including paddleboards, can help prevent AIS introductions and speed inspections by ensuring they drain, clean, and dry their watercrafts and gear after every use.

In 2021 another source of live invasive mussel introductions was identified in the US when decorative aquarium Marimo moss balls were found contaminated with dressenid mussels. The contaminated shipment reached pet stores in five Wyoming towns and two of those had live mussels. In response park staff placed signs at Kelly Warm Springs to inform visitors of the issue and prevent aquarium dumping, a practice that resulted in the introduction of many invasive species at that site.

Granite Supplemental Ditch

Irrigation ditches draw from several drainages in the park for agricultural purposes within or adjacent to the park. Water drawn from these streams can trap fish in the ditches which can result in their death. The Granite Supplemental Ditch draws water from the Snake River (10%–15% of the flow at the point of diversion) to irrigate lands in the "West Bank" region of Jackson Hole. This large ditch traps fish throughout the season. Additionally, this ditch intersects two perennial park streams. To understand the effects of this ditch on fish, park fisheries staff teamed with the Wyoming Game and Fish Department and Trout Unlimited to implant transmitters in 45 adult cutthroat in 2017–2018 to monitor their movement. Data analysis suggests that the mortality rate for trout is up to 73% after entering the ditch. High numbers of other fish species also get stranded in this ditch and are often less capable of escaping the high water velocities at the headgates, likely resulting in even higher mortality rates. In 2019 park staff initiated a project to quantify the number of fish entering the ditch during the summer. Using nets on the downstream end of the headgate culverts, biologists identified, measured, and counted fish entering the ditch. Biologists used the data to estimate the number of fish entering the ditch throughout the irrigation season. Data showed that more than 50,000 fish enter the ditch each summer, about a third of which are cutthroat.

The Snake River's stream bed elevation has dropped since the installation of the headgate several decades ago increasing the maintenance needed to keep water flowing into the headgate. In 2018 water right holders commissioned a redesign of the headgate structure to support both water delivery and fish passage. When the new headgate is installed, resource managers plan to study fish movement and use of the structure. This information will shed light on fish population dynamics and inform further fish management options.

Biologists place nets on the Granite Ditch headgates to capture, count, and measure fish being swept into the irrigation diversion.

Chronic Wasting Disease

Chronic wasting disease (CWD) is a naturally occurring prion disease of cervids (species in the deer family). The disease attacks the brain causing animals to become emaciated, display abnormal behavior and poor coordination, and eventually die. Since the 1967 discovery of CWD in a captive mule deer herd in Colorado, the disease has spread geographically and increased in prevalence. CWD is currently found across the majority of Wyoming and continues to expand westward. The spread of CWD in elk generally lags behind deer.

CWD spreads through direct contact between free-ranging animals, through movements of captive animals between fenced facilities (and occasionally via escaped animals from captive facilities), or infrequently as a result of spontaneous protein misfolding. Animal-to-animal transmission is likely a primary means of disease transmission early in an outbreak. CWD also spreads indirectly via prions on the landscape shed in feces, urine, and saliva, as well as decomposing carcasses. Scientist have found prions in plant tissues, suggesting that plant material may serve as an environmental reservoir in addition to soils. Prions are highly resistant to decomposition in the environment and may persist and remain infectious for many years.

In November of 2018, a sample collected in the park from an adult male mule deer tested positive for CWD, marking the first detection of CWD in Grand Teton National Park and Teton County. In response, park biologists completed a CWD Action Plan to address and manage the disease including enhancing surveillance efforts, minimizing disease spread, conducting applied research, and increasing communication and outreach efforts. One action identified to limit disease spread was to hold and test deer carcasses before disposing of them. To that end, the park uses a large walk-in freezer, to store mule deer carcasses while test results are pending. In 2020 the Grand Teton National Park Foundation aided the park by purchasing a freezer specifically for this use. To enhance surveillance efforts, the park initiated mandatory CWD testing of all hunter-harvested elk during the Elk Reduction Program in 2019. Intensified sampling continued in 2022.

A Scientist in the Park Intern collects tissue samples for chronic wasting disease monitoring from hunter-harvested elk killed during the Elk Reduction Program.

In 2022, 171 samples were submitted to the laboratory for testing: 36 from road-killed cervids, 132 from hunter harvested elk, and 3 from carcasses found on the landscape. Of those samples 147 were collected from elk, 22 from mule deer, 2 from white-tailed deer, and 2 from moose. Two mule deer tested positive for CWD (one found in the town of Kelly and the other on the shore of Leigh Lake). Jackson elk herd managers have been intensively sampling the elk herd for more than a decade. The fact that only one elk in the park has tested positive for the disease suggests that CWD is likely present at a low prevalence. Recent modeling suggests that CWD will probably result in a decline in elk numbers over time, particularly as disease prevalence increases.

Chronic wasting disease is 100% fatal and has an extended incubation period averaging 18–24 months between infection and the onset of noticeable signs. During the incubation period animals may look and act normal, but slowly, signs of the disease may develop, including dramatic weight loss, impaired coordination, stumbling, drooling, excessive thirst or urination, and aggression.

Elk Reduction Program

In the late 1800s, elk populations across North America were being hunted to extirpation. During this time, Jackson Hole, home to one of the largest concentrations of elk on the continent, also experienced development and land use changes that reduced access for elk to native winter range. Severe winters in the valley in the late 1800s and early 1900s made foraging difficult and substantial die-offs occurred in the Jackson elk herd. Local conservationists took action creating a supplemental feeding program in 1910 and the National Elk Refuge (NER) was created by Congress in 1912 to protect elk wintering grounds where feeding takes place. Since then, the Jackson elk herd has grown significantly. While there are benefits to large wintering herds, the unnatural concentration of elk stemming from the feeding program has consequences for other species, habitat quality, mortality rates, and creates potential for disease outbreaks.

The legislation that expanded Grand Teton National Park in 1950 included a provision for controlled reduction of elk in the park, when necessary, for proper management and protection of the elk herd. Management of elk in the park and on the NER is guided by the Bison and Elk Management Plan (BEMP), completed and implemented by the US Fish and Wildlife Service and the National Park Service in 2007. The plan calls for working collaboratively with the Wyoming Game and Fish Department (WGF) to achieve an objective of 11,000 elk in the Jackson herd, a wintering population of 5,000 elk on the NER, and working toward bull to cow ratios in the park that are reflective of an unhunted population. It projected that roughly 1,600 elk would summer in the park given plan implementation. Also outlined in the BEMP is a strategy to restore previously cultivated lands in the park to improve habitat condition on elk winter and transitional range. Additionally, the plan calls for a phased transition from supplemental feeding on the NER to encourage greater reliance on natural forage and reduce the risk of disease transmission.

The need for the ERP is evaluated and determined jointly by Grand Teton and WGF staff on an annual basis, based on data collected during the previous year mid-summer classification count in the park and the mid-winter trend count that includes elk wintering outside of the park. The long-term objective is to reduce the need to harvest elk in Grand Teton National Park.

Both the annual mature bull ratio and the five-year running average were below the threshold identified in the BEMP, at 31 bulls per 100 cows. At this level biologists recommended no bull harvest for 2022. The 2022 mid-winter trend count was 11,057 elk and the three-year running average 10,925, which the WGF considers at objective. The trend is stable; however, elk wintering on the refuge number well above the 5,000 elk objective. The mid-winter calf ratio, which is strongly tied to the level of population growth, was 21 calves per 100 cows. With the trend for the Jackson elk herd stable, antlerless harvest in 2022 was intended to slow herd growth.

In 2022, 475 permits were authorized in Hunt Area (75) compared to 400 in 2021. In addition to population counts, the number of permits issued annually is based on harvest success (a running average of the percentage of elk harvested to the permits issued). Hunters that filled their permits during the 2022 ERP came from 19 different states; the majority were from Wyoming (59%) and California (22%), with other states accounting for less than 2% each. The ERP was structured similarly to the last two seasons with no permits offered in HA 79. The productivity of these elk is lower compared to more southern residents—a pattern similar to the northern migratory elk in the Teton Wilderness and southern Yellowstone National Park. The reduction in hunting pressure on antlerless elk in HA 79 is generally consistent with management objectives in adjacent hunt areas 70 and 71.

Park managers use the Elk Reduction Program to ethically manage the herd and avoid excessive winterkill caused by too many animals for the available forage.

The 2022 ERP was conducted for 37 days, November 5th–December 11th, with the Antelope Flats portion of HA 75 closing on November 21st. Early snowfall pushed elk south during the opening stage of the ERP. About 60% of the harvest occurred during the first two weeks of the season and over 90% of the harvest had occurred by the start of the last week. A total of 134 elk were harvested, a considerable increase compared to 104 harvested in 2021. Most elk harvested were adult cows (72%) followed by calves (25% of which 19% were female and 7% were male). Four accidental/illegal harvests took place—one bull and three spikes, two of which were unclaimed. A bison calf and a mule deer were also harvested in cases of mistaken identity.

The high concentration of elk wintering on the NER increases the risk for major disease outbreaks. In recent years, the ERP in the park has provided an opportunity for monitoring disease in the Jackson elk herd. Grand Teton's Chronic Wasting Disease (CWD) Action Plan mandates that hunters must turn in harvested elk heads for surveillance testing. Retropharyngeal lymph nodes, and alternatively tonsils or obex, are collected for testing at a WGF laboratory. During the 2022 hunt, none of the 132 samples tested were positive for CWD. In the park's history, only one elk has tested positive for CWD, detected in 2020 during the ERP surveillance testing. (Since 2018, only three deer in the park have tested positive for CWD; all three were found dead and tested as part of the park's targeted surveillance program.) Although the detection of CWD in the Jackson Elk herd is low, CWD is a significant management concern as prevalence is projected to increase over time.

Human-Bear Interface

Grand Teton National Park and the John D. Rockefeller, Jr. Memorial Parkway provide ideal habitat for free-ranging black and grizzly bears. Grand Teton receives more than five million visitors per year, most of whom visit during the peak summer season. Consistently high levels of human recreation in bear habitat creates a high potential for human-bear interactions. To minimize the potential for human-bear conflicts, park staff focus on preventative education and proactive management including: educating visitors on safe recreation in bear country, enforcing food storage regulations, installing bear-resistant infrastructure, and temporarily closing areas of high bear use. A common theme and a key factor in all these efforts is keeping attractants away from bears. Since 2008 the park with generous support from the Grand Teton National Park Foundation installed 1,067 modern, bear-resistant food storage lockers in campgrounds and other popular use areas to provide visitors the infrastructure necessary to secure attractants.

Park staff monitor human-bear confrontations and conflicts every year to analyze trends and adapt strategies used to manage the interface between visitors and bears. A confrontation is defined as an incident when a bear enters a frontcountry development or backcountry campsite as well as occasions when bears approach, follow, or charge people without inflicting injury. In contrast, human-bear conflicts are incidents when bears obtain human foods, damage property, or injure/kill humans. In 2022, park staff recorded 73 human-black bear confrontations and 22 human-grizzly bear confrontations. Most of these confrontations involved bears moving through developed areas or campsites without incident, which is common as bears search for seasonally-important natural foods. Thirteen confrontations included bear spray deployment; however, park staff have observed a recent increase of unwarranted use of bear spray in situations where the bear never charged the person or presented a threat to human safety. In many of these instances, the bear was simply walking or foraging near a hiking trail. Biologists recommend use of bear spray only as a last line of defense when a bear is actively charging a person. Additionally in 2022, park staff recorded six human-bear conflicts, all involved black bears: 3 obtained human foods, 2 caused property damage, and 1 accessed trash. A notable number of human-black bear conflicts continue to occur along lakeshores when visitors leave backpacks and other items to swim or wade. Park staff are focusing new strategies on educating lakeshore users about the importance of securing attractants or having someone always attend their items. No conflicts involving grizzly bears were reported.

Grand Teton staff work diligently to prevent bears from developing nuisance behaviors. When humans fail to secure their food, bears can become food-conditioned and begin to exhibit dangerous habits. Trained staff follow an established protocol to haze bears from developed areas and roadways when warranted and safe to do so. Park staff hazed bears 95 times in 2022 using a spectrum of tools, including vehicle threat pressure, noise deterrents, and firing bean bag rounds. During the 2022 season, park staff proactively relocated two yearling black bears from the south Jenny Lake area. Both bears were exhibiting bold behavior

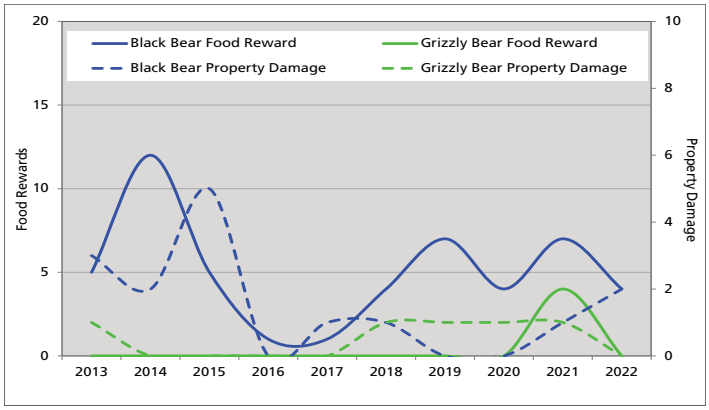
Bears are curious and will explore anything they find interesting.

(e.g., climbing on picnic tables, frequenting campsites, etc.). With the high likelihood of imminent food rewards, resource managers made the decision to relocate these young animals to a less human-dominated area for a better chance of long-term survival.

Another strategy park managers use to minimize human-bear conflicts is implementation of temporary area closures to protect high-use bear habitat and provide for human safety. In addition to the annual closures (motorized use of Grassy Lake Road April 1–May 31 and public entry on Willow Flats May 15–July 15), seven short duration closures were enacted to minimize disturbance of bears accessing seasonally-important natural foods or protect visitor safety around known carcasses.

Since 2007, the Wildlife Brigade has been the primary team managing the human-wildlife interface in Grand Teton by facilitating safe wildlife viewing opportunities, patrolling developed areas for attractants, and educating visitors on safety in bear country. In 2022 the team was composed of a permanent bear biologist, 2 seasonal wildlife management rangers, and 31 volunteers. Team volunteers collectively contributed 12,105 hours to bear conservation and wildlife management efforts. Brigade staff responded to a minimum of 840 wildlife jams: 210 for grizzly bears, 325 for black bears, 1 for a bear of unknown species, 168 for moose, and 136 for other species (e.g., elk, red fox, and owls).

Park staff recorded two motor vehicle collisions involving bears in 2022. Both involved black bears struck and killed while attempting to cross park roadways (a 26-year-old female and a 19-year-old male). Both bears had a research history having been captured and marked during a black bear study in the early 2000s.



Bears obtaining food rewards and causing property damage in Grand Teton.

Invasive Plants

In 2022 the Vegetation Ecology and Management Branch prioritized 7,145 acres for survey and treatment of invasive plants based on the greatest threats posed to ecological systems and on the likelihood of successful treatments. When population numbers are small and the seed bank is not well established, eradication of invasive plants is achievable. When invasive species have spread across a landscape, containment of infestations becomes the primary goal. Invasive species management is multifaceted, and success is challenging with outcomes often species or site specific.

The introduction of nonnative plant species has the potential to alter natural systems by displacing native vegetative communities. When nonnative plants cause economic impacts, environmental harm, or harm to human health, they are considered to be invasive. Invasive plants listed as Federal, State, or county "noxious weeds" are particularly aggressive plants legally deemed to be detrimental to agriculture, waterways, fish and wildlife, and/or public health. Park vegetation staff focus efforts on locating and using the best treatment practices to address listed noxious plant species. Treating invasive plants continues to be a high priority for resource managers at Grand Teton, but eradication is often not possible particularly after species are established over large areas.

To apply targeted invasive plant treatments during ideal stages in phenological development, Grand Teton welcomed groups of youth conservation corps to work on vegetation management projects throughout the park. These groups came to work alongside NPS staff for periods lasting between 8-days to 3-months. The crews gained hands on skills in invasive plant treatment, seed collection, restoration, plant salvage, and nursery operations. In total this season, NPS staff spent 11,840 hours training 29 young people in various aspects of federal land management.

Conservation corps crews learn work skills alongside National Park Service staff.

Partnerships continue to prove to be integral to successfully treating and controlling invasive plants at Grand Teton. The invasive plant program is fortunate to collaborate with Wyoming Conservation Corps, American Conservation Experience, and Utah Conservation Corps to accomplish the heavy workload. Local partners include Teton County Weed and Pest District, Northern Rockies Invasive Plant Management Team, Jackson Hole Weed Management Association, and the Greater Yellowstone Coordinating Committee. Controlling the spread of nonnative invasive plants benefits the native plant communities and enhances wildlife habitat in Grand Teton National Park.

Livestock Grazing

Grand Teton National Park, like several other National Park Service units, allows livestock grazing due to traditional land use that existed prior to the park's establishment. When Grand Teton was expanded in 1950, the enabling legislation allowed ranches on inholdings to retain their grazing allotments indefinitely while another 26 ranches were granted grazing privileges for the lifetime of immediate family members and heirs. Collectively, these provisions allowed livestock grazing and trailing on about 69,000 acres (22% of the park). Over time, these grazing allotments were substantially reduced through attrition and the park's acquisition of inholdings through purchase or donation.

Prior to 2019, grazing allotments totaled approximately 4,300 acres within park boundaries for livestock grazing. In 2022 one Park inholding, the Moosehead Ranch, grazed 64 horses on a special use grazing permit. Pinto Ranch, another park inholding, had been grazing on the East Elk Ranch pasture but took non-use in 2020–2022 due to COVID interruptions in 2020 and needed infrastructure repair in 2021 and 2022. Triangle X Ranch, a concessioner operating a historic dude ranch within the park, grazed 120 horses; and Teton Valley Ranch, operating on an agricultural lease that dates back to the 1940s, grazed approximately 34 longhorn steers. Grand Teton National Park maintained another 19 horses and mules to support backcountry operations in the park, and the State of Wyoming owns a 640-acre inholding that is leased for grazing.

The park began forage production monitoring in 2021, testing a clipping and weighing protocol at the Elk Ranch pastures. Biologists estimated forage production at East Elk Ranch as 1,444 lb/acre in 2021 and 1,848 lb/acre in 2022. These years had no cattle grazing and no irrigation but had wildlife grazing including bison. In 2021 the key growing months of June and July had very low precipitation and warmer temperatures when compared to the historical average, while May and August had high precipitation and close to average temperatures. These production estimates likely represent a low end of production potential given the low water inputs during that year. In contrast, precipitation was higher than normal in the spring of 2022. The 2022 estimates were similar to 2000 Kelly Hayfields production measurements on 13 unirrigated fallow pasture, which averaged 1,956 lb/acre. The park plans to continue and expand forage production monitoring on park grazing allotments.

Current livestock grazing in the park has been reduced by approximately 89% from historic grazing use. Park staff manage the remaining horse and cattle grazing with the goals of minimizing conflicts between stock and park wildlife, maintaining healthy range and pasture forage, and reducing the spread of invasive nonnative plant species.

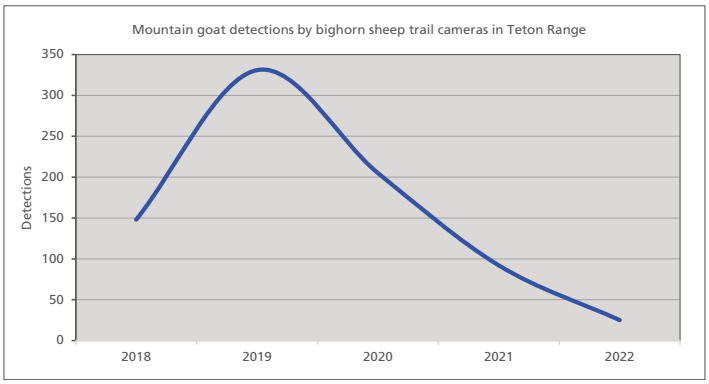
Mountain Goats

Mountain goats (*Oreamnos americanus*) are not native to the Greater Yellowstone Ecosystem. Observations of mountain goats in the Teton Range began in 1977, less than a decade after the Idaho Department of Fish and Game introduced about a dozen individuals from central Idaho to eastern Idaho's Snake River Range. Transplanting wildlife to create populations for the benefit of hunters was a common practice at the time. Until 2005 when a breeding population of mountain goats established itself in the Teton Range, observations of goats were sporadic and thought to represent transient individuals. Genetic evidence suggests that the Teton Range mountain goat population originated from the population of mountain goats introduced to the Snake River Range.

Mountain goats in the Snake River Range have tested positive for *Mycoplasma ovipneumoniae* (*M. Ovi*) a pathogen linked to pneumonia in bighorn sheep (*Ovis canadensis*). Pneumonia in bighorn sheep causes die-offs in all age groups followed by significant lamb mortality for varying lengths of time, sometimes decades. Pneumonia in bighorn sheep involves multiple bacterial pathogens that all play a role in the disease, but *M. Ovi*, appears to be necessary for persistent population level impacts. Although limited disease testing of Teton Range mountain goats has not documented the presence of *M. Ovi*, other pathogens were detected raising concerns that resident mountain goats or dispersing Snake River Range individuals could introduce pneumonia causing pathogens to bighorn sheep with devastating consequences. Competition for space and forage between mountain goats and bighorn sheep on limited winter range is also a concern.

In the fall of 2019, the National Park Service completed a Management Plan/Environmental Assessment (EA), which recommended removing mountain goats from Grand Teton National Park using lethal and non-lethal means. The plan and the associated EA were finalized after an extensive planning process, begun in 2013. The plan identified the goal of removing the mountain goats as quickly as possible to minimize impacts to native species, ecological communities, and visitors. When the EA was written in 2018, biologists estimated the population at over 100 mountain goats in the Teton Range, mostly within the park.

An nonnative mountain goat is caught on remote camera visiting a natural salt lick that is used by bighorn sheep as well.



Mountain goats use some of the same habitat as bighorn sheep so remote cameras placed to monitor bighorn sheep often capture images of the goats.

National Park Service-led removal efforts began in February 2020, when a contract helicopter crew lethally removed 36 mountain goats from Cascade, Paintbrush, and Leigh Canyons in half a day. Following concerns raised by the Wyoming Game and Fish Commission and the Wyoming Governor to the Secretary of Interior, this operation shifted to a ground-based removal program using qualified volunteers starting that fall. Volunteers could retrieve edible meat from the culled animals whenever possible—an action authorized by the John D. Dingle Conservation, Management, and Recreation Act in 2019. Concurrent with the NPS efforts, Wyoming Game and Fish Department (WGF) increased mountain goat hunting licenses for the Teton Range outside Grand Teton National Park starting in 2019. The combination of aerial efforts, ground-based volunteers in the park, and WGF licensed hunters outside the park lethally removed 134 mountain goats from the Teton Range 2019–2021. Following the conclusion of the 2021 qualified volunteer program, Grand Teton National Park consulted with the WGF to inform possible next steps, as efficiency and success-rate of ground-based approaches diminished from 2019 to 2021. Without objection from WGF, the park carried out lethal aerial removal efforts in February 2022, culling 58 mountain goats from the park in two days. Most of these animals were culled from rugged, trail-less areas that were not covered in the 2020 aerial removal and were challenging for volunteers to access on foot. The total number of goats removed represents a substantial portion of the estimated population. After this initial wide-scale removal effort, it is standard to move to a rapid response method to minimize potential mountain goat population growth.

Few mountain goat sightings were reported in the Teton Range following the last removal operation; however, in 2022 mountain goats were documented near Death Canyon, the Cathedral Peaks, and outside the park in Teton Canyon. Timing and location of the sightings suggest a minimum of seven mountain goats occupy the Teton Range, leading biologists to estimate a total of 10–20 animals remain across the range. Park staff are working to develop a rapid response plan to be implemented in 2023 and guide the park's responses to future mountain goat observations.

Native Plant Materials

Grand Teton National Park is committed to using native plant materials (seeds and live plants) of local ecotypes for ecological restoration projects and rehabilitation of disturbed and altered lands. Over 1,000 species of native plants can be found growing in Grand Teton National Park, and each one has adapted over time to the environmental conditions found on the landscape. Research shows that using local ecotypes, native plants that are adapted to the local environment, results in greater restoration success. Over the past five years, park vegetation biologists restored and rehabilitated over 100 acres annually using locally adapted native plant materials. This native plant materials strategy includes hand collection of native seed in the wild, seed increase production, nursery plant propagation, and plant salvage. Achieving this ambitious goal requires a diversified strategy and thousands of hours of work from park staff, volunteers, partners, and contractors each year to obtain this material.

A central piece of that strategy is hand-collection of native seed from wild plant populations. In 2022, 780 bulk pounds of seed were collected throughout the park from 52 native plant species thanks to the efforts of NPS staff, partners, volunteers, conservation corps, and contractors. Collectors adhere to strict protocols to avoid overharvesting, ensuring that source populations will persist long-term. Another method for obtaining native seed is seed increase—planting hand-collected seed in an agricultural field setting, and harvesting seed produced from those plants for several consecutive years. In 2022 contractors planted six species (6.8 acres total) in Idaho and Colorado for seed increase production.

2022 was also a year of innovation, applying new approaches to optimize native plant materials development. With funding from the Grand Teton National Park Foundation, park staff purchased a walk-in seed cooler to protect the valuable native plant seeds by keeping them at optimum temperature and humidity. The vegetation staff also relocated their seed shed adjacent to other vegetation facilities to increase operational efficiency. Additionally, they expanded the park nursery to grow more plants in-house. Using seed collected in the park, they propagated 1,300 new forb, shrub, and tree seedlings, while maintaining an additional 2,200 plants to allow for future planting in restoration and land rehabilitation projects. The park reinvigorated a program of plant salvage—removing live plants from construction sites prior to disturbance and keeping them alive in the nursery until they can be replanted. In 2022 vegetation crews and contractors salvaged over 800 native plants, from three planned construction sites. Using these techniques to obtain plant materials, vegetation staff can support park project needs by providing a diverse selection of native plant species to repair disturbed landscapes.

Using native plants is critical to the success of park rehabilitation projects. The time-consuming investment of growing out plants is aided by having the appropriate facilities like the park greenhouse.

Collecting native plant seed requires a variety of different techniques depending on the plant species. Park staff experiment to develop the most efficient methods. For sagebrush the best method is to use a collection bucket underneath while gently batting the bush.

Restoring Ditch Creek

Ditch Creek flows out of the Gros Ventre Mountains, through Antelope Flats to meet the Snake River about a mile north of Moose. The creek is inhabited by several species of spawning fish including Snake River fine-spotted cutthroat trout, bluehead sucker (categorized as extremely rare by Wyoming Game and Fish), Utah and mountain sucker, and other small-bodied native fish species. Settlers started manipulating the stream's 9.4-square mile alluvial fan on Antelope Flats in the early 1900s, adding 150 miles of irrigation ditches and channelizing the stream to better facilitate agriculture. In 1957 and 1960 two bridges with culverts were installed across the stream, thereby preventing access to spawning habitat upstream.

In 2012 and 2014, park staff installed baffles in the culverts to improve passage for fish. The stream channel shifted west of Mormon Row Road in 2014, complicating efforts to restore fish passage. The terraced nature of the terrain and the bedload naturally cause aggrading, degrading, and a shifting channel. A similar event occurred in the same area in 1998. Channel instability presents a problem when working to improve fish passage.

After analysis of stream dynamics, the park partnered with the Grand Teton National Park Foundation, One Fly, and Patagonia to stabilize and reconnect the primary channel to restore Ditch Creek as connected fish habitat. Starting in spring of 2018, fish from the Snake River could access more than 23 miles of the stream's headwaters for the first time in nearly six decades.

From 2016 to 2022, biologists captured and inserted Passive Integrated Transponder (PIT) tags into 182 fish (Snake River fine-spotted cutthroat trout, bluehead suckers, mountain suckers, and Utah suckers) to track how the fish used the newly accessible habitat. Biologists placed antennas and recorded tagged fish swimming past the former barriers. In 2019 additional work was done to reinforce the stream bank at three locations. By reconnecting upstream habitat on a tributary of the Snake River to the mainstream, fishery staff increased the resiliency of the native fishery and restored ecological function.

Kelly Warm Spring

Kelly Warm Spring is a thermal feature that has a long history of aquarium dumping leading to the proliferation of nonnative species in the spring. Nonnatives persisted throughout the warm spring effluent and in 2012 biologists found goldfish (*Carassius auratus*), native to east Asia, and tadpole madtoms (*Notorus gyrinus*), native in much of eastern North America, in Ditch Creek, some within ten yards of the Snake River.

Park biologists also found an abundance of American bullfrogs (*Lithobates catebeianus*), another species with a wide latitudinal native range, that were introduced throughout the west and to this spring in the 1950s. The bullfrog is implicated in declines of native amphibian populations throughout the world due to both direct and indirect factors. In Grand Teton National Park, native amphibians are nearly absent in the bullfrog's occupied range. In recent surveys, biologists only documented a couple western toads, a native species on the decline regionally, on the periphery of bullfrog inhabited waters. An NPS study of fall movements and over-wintering habitat found American bullfrogs made more upstream movements than downstream movements with their largest movements occurring before the first cold snap of the season. The winter range was more widespread than managers had hoped leaving the species less vulnerable to mechanical removal efforts.

After several years of environmental analysis, park resource managers moved forward with a plan to restore Kelly Warm Spring to a more natural state. NPS staff with vital assistance from Wyoming Game and Fish Department personnel used rotenone, a chemical lethal to organisms with gills, to treat the nonnative infested spring and its effluent in 2018. The treatment successfully reduced the quantity of invasive species in the spring but failed to remove all nonnative fish present, a necessary first step in restoring a native assemblage to the spring. Bullfrog tadpoles experienced high mortality rates but were not completely eliminated from the system. The control action was an important step in improving the condition of Kelly Warm Spring but is not a long-term solution.

While native to the upper Snake River, the pilose crayfish is a nocturnal hunter rarely spotted by park staff. This was living in a thermal feature near the Gros Ventre River.

Since the 2018 effort, fisheries biologists have continued to develop strategies to efficiently remove invasive species while minimizing collateral impacts. Understanding bullfrog life histories, beyond fall migrations, is a focal point. Other national parks and agencies in the western US have successfully extirpated nonnative bullfrogs and Grand Teton staff are working on a removal plan. Fisheries staff use antiquated irrigation ditches to dewater large portions of the spring's effluent, thereby limiting the spread of invasive fish populations without chemicals and reducing the overall area that requires future rotenone treatment. Successful removal of nonnative aquatic species may require repeated treatments.

Sagebrush Restoration

Sagebrush steppe is a diverse plant community that covers about one-third of the park and much of the valley floor. It provides habitat for sage-grouse, bison, pronghorn, birds, insects, and many other wildlife species. Maintaining and restoring native sagebrush habitat is a high priority for park managers. Approximately 15% of the park's sagebrush steppe has been impacted by human activities over the past two hundred years. Park vegetation biologists work to restore impacted areas by removing nonnative pasture grass, surveying for and treating invasive plants, collecting and spreading native seed, and monitoring effectiveness of restoration.

Vegetation staff with support from partners like the Grand Teton National Park Foundation are making progress on the long-term Antelope Flats Restoration Project aimed at restoring 4,500 acres of sagebrush steppe habitat that was converted for agricultural use at the turn of the 20th century prior to establishment of the park. Converting former hayfields from nonnative smooth brome pasture grass to native sagebrush habitat takes decades to achieve. In June 2022 vegetation staff completed the second smooth brome (*Bromus inermis*) treatment across the 94-acre Slough South section. After smooth brome removal, Canada thistle (*Cirsium arvense*) emerged in large patches and staff focused on treating it along with other broadleaf invasive plant species. The smooth brome removal and invasive plant treatments were the result of highly coordinated collaboration among park staff, multiple youth conservation corps, and regional NPS invasive plant management teams.

Eighty acres were treated successfully with almost no pasture grass remaining and were seeded with native species; 14 acres will need follow up treatment to remove smooth brome in 2023. Vegetation crews sowed native seeds collected within Grand Teton using a tractor mounted seed drill. Recent research by the University of Wyoming and park ecologists showed that the restoration sites had lower forb (wildflower) and shrub cover than desired. As a result, biologists explored approaches to increase these species through different seed mixes and application treatments. The group identified soil tilling and designed two new high shrub and forb seed mixes to test on a pilot basis. Biologists established 42 plots (30 x 30 meters) to observe the effectiveness of tilling compared to no tilling and randomly tilled experimental plots to eight-inch depths using a disk harrow and seeded with broadcast seeding or left untilled and seeded using a seed drill. Each plot received one of the two seed mixes. Plants grown in the park nursery or salvaged from construction areas were added to increase species diversity and planting success. By the end of the 2022 field season, crews had planted 863 nursery grown shrubs and forbs in the plots using site features like existing sagebrush or rocks to shelter and protect the young plants.

In 2024 park ecologists will monitor outcomes of the new approaches and will use the information to adapt their techniques to improve restoration results. Healthy sagebrush habitats are comprised of more than sagebrush alone. They are an interdependent mosaic of plant, animal, and microbial life integrated by complex ecological processes. Therefore, park biologists are exploring the feasibility of implementing a innovative whole-ecosystem restoration approach by including non-vascular biological soil crust (mosses and lichens) and soil microbes in park nursery stock for future plantings. By integrating microbial processes into the restoration sites, biologists hope to increase seed germination and plant growth while promoting a healthier sagebrush ecosystem.

Restored sagebrush steppe provides remarkable diversity, both in plants and animal habitat.

Spread Creek

The 2010 removal of the diversion dam built on Spread Creek in the 1960s allowed fish to access 65 miles of upstream habitat; however, the newly installed irrigation infrastructure still entrapped some fish as they migrated downstream. The park partnered with the Wyoming Game and Fish Department, Trout Unlimited (TU), the Snake River Fund, and volunteers to help return 21–499 fish to Spread Creek annually, including 14–310 cutthroat trout. Other notable species saved include the rare bluehead sucker.

Fish entrainment was not the only challenge experienced at the rebuilt structure. The structure is situated in a dynamic stretch of the stream—a canyon with erosive walls is upstream of the diversion; a slow-moving landslide is adjacent to the structure; and an expansive alluvial fan is downstream. Together these features create instability and design challenges for building a water diversion structure. Rock weirs, a channel spanning series of boulders, were placed when the structure was installed; however, after a few years the weirs deteriorated causing the streambed to drop in elevation. This degradation created a need for construction of a wing dike to direct water into the headgate of the diversion structure. These manipulations further changed stream dynamics directing fish to enter the irrigation infrastructure.

After analyzing alternatives to address the suite of problems, the park and its partners commissioned the design of a more persistent stream gradient stabilization structure and a fish screen. A rock ramp and several smaller details were installed to fortify the stream gradient and steer the water's energy. Completed in 2021, the rocks of the ramp are laid over an extended stretch of the stream allowing them to lock together as opposed to moving when spring freshets race through the channel.

The improved Spread Creek structure is designed to prevent fish entrainment. Fish are caught by the fish screen and funneled back into the creek through the pipe with the red flap (irrigation water is routed out the larger opening).

In the summer of 2022, the irrigation infrastructure was retrofitted with a fish screen. The screen structure conveys fish entering the headgate back into Spread Creek regardless of the amount of water drawn by right holders. Because streams carry a lot of material and debris in their flow, fish screens are difficult to engineer. Without the partnership and significant support from TU this improvement would not be possible.

Post-construction Revegetation

Grand Teton National Park and the John D. Rockefeller, Jr. Memorial Parkway contain infrastructure—buildings, roads, trails, and utilities—necessary for visitor services and administrative functions. This infrastructure requires regular repair, replacement, and new construction resulting in ground disturbance and destruction of vegetation, which impacts native plant communities. The Vegetation Ecology and Management Branch collaborates with the Facility Management Division prior to these projects to help avoid, minimize, and mitigate ecological impacts. Before project implementation, this is achieved by recommending ways to reduce the physical footprint of a project, surveying for rare plants so they can be avoided and preserved, salvaging individual native plants from a site, and caring for them until they can be replanted. Vegetation staff will also survey for invasive plants and treat them to reduce the potential for their spread during the ground disturbance. As the project progresses, staff inspect equipment and construction materials entering the park to ensure they are free of harmful weed seeds. Efforts are made to conserve and reuse the native topsoil in order to preserve the valuable microorganisms and the native plant seed bank.

After a project is completed, vegetations crew rehabilitate the disturbance by reestablishing native plants, which in turn stabilize the soil, reduce erosion, prevent the spread of nonnative plants, and provide habitat for wildlife. The locally adapted plant materials used for reseeding and planting originate from within the park. Vegetation biologists will monitor site conditions for 2–5 years post-construction to document invasive plant species and treat them as needed to support the native plants that are re-establishing.

In 2022 vegetation crews seeded a total of 4.9 post-construction acres with native seed mixes before the onset of winter conditions. Sites completed include a structure demolition in Kelly, water system replacement in Moran, and fiberoptic installations throughout the park. The vegetation staff also provided 890 pounds of native seed mix to contractors for application on the 60 acres disturbed by reconstruction of the Jackson Hole Airport runway. Park staff also installed irrigation to maintain 490 trees and shrubs salvaged for the Moose-Wilson Road Corridor project, which will be replanted post-construction.

Trail Use & Pathway Use

The visitor monitoring program in Grand Teton National Park, led by the park social scientist, collects information about the use of park trails and pathways. Since 2009, there is generally an increasing trend in visitor use for trails leading to the backcountry. Infrared trail counters are installed at key locations throughout the park and estimate the number of visitors entering the backcountry via the trail system during the summer months (June–September). There are also counters located further into the backcountry. Trail counters count visitors traveling in both directions, and data is aggregated by the hour. Some trail counters are validated by comparing the counter-recorded visitor use and actual counts taken by a research technician; most counters have a low error rate.

Monitoring visitor use of the trail system gives insights on park visitor experiences. Trail counters indicate an overall increase in trail use on the nine trails monitored since 2008. Use on those trails increased 106% since monitoring began and 65% since 2019.

In addition to trails, park staff monitor the multiuse pathway system within Grand Teton National Park. Construction on the first section of the paved pathway, between Moose and Jenny Lake, was completed in May 2009. Completion of a second section of pathway along US Highway 89 between the park's south boundary on and Moose followed in May 2012. Starting in 2009, researchers installed infrared counters and trail cameras at key locations to understand the timing and volume of use, including potential effects on wildlife. In the summer of 2022, five infrared counters were installed along the pathway at the same locations used since 2012: Jenny Lake, north of Taggart parking, west of Dornan's, north of the airport, and south of Gros Ventre junction (from approximately June to August).

Visitors enjoy recreating in the park in all seasons.

These counters provide an approximation of use and also batch the total number of users in one-hour periods. Counters cannot determine the direction a visitor is traveling or if one user is triggering multiple counters along the pathway (which is likely). Overall, there were a total of 63,617 detections on the five pathway counters between June and August of 2022. This is a 9% decrease in use over 2021.

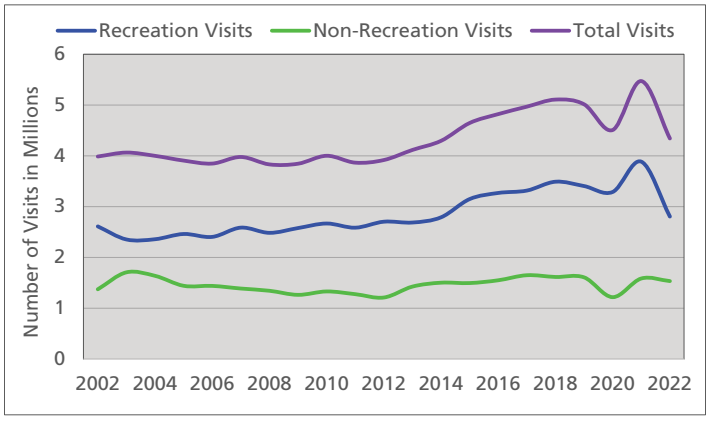
Analysis of trail and pathway data helps park managers to better understand visitor use (including levels of use, timing of use, and distribution of use). This in turn aids park managers in decision making to meet the objectives of providing for visitor enjoyment while protecting park resources.

Visitor Use

Use of Grand Teton National Park and the John D. Rockefeller, Jr. Memorial Parkway by visitors is both a primary reason for their establishment and a factor influencing resource condition. Increases in visitation may affect natural and cultural resources, as well as the quality of visitor experiences. Some factors that may influence visitation to parks include economic conditions, natural disasters, weather, gasoline prices, and public health.

In 2022 public lands provided visitors with opportunities for outdoor experiences and domestic recreation during the ongoing COVID-19 pandemic. Outdoor places provide opportunities to safely recreate and promote both physical and psychological health. National parks played an important role by hosting more than 311 million recreation visits in 2022. This number is a 5% increase from 2021. Recreation visits are defined as visits where the visitor entered lands or water administered by the National Park Service to use the area (alternatively, examples of a non-recreation visit include commuters, employees going to work, access to inholdings, etc.).

Grand Teton National Park had over 2.8 million recreation visits in 2022. Most recreation visits occurred between June and September. Although there are no day-use limits, lodging and campgrounds in the park have limited space available for overnight stays. On most July and August nights, one or more forms of accommodation are full.



Annual Grand Teton National Park visitation 2002–2022.

In 2022 the social science team conducted a socioeconomic monitoring study gathering information on visitor demographics, activities, motivations, and spending profiles. The link to the study is: https://irma.nps.gov/DataStore/DownloadFile/687423 This study guides park managers in making wise management decisions.

Wildlife-Vehicle Collisions

Wildlife casualties from motor vehicle collisions on Grand Teton National Park and the John D. Rockefeller, Jr. Memorial Parkway roads are common occurrences. Since 1991 park staff have recorded data on wildlife-vehicle collisions to document impacts and help identify appropriate measures to lower the number of collisions and improve the safety of park roads for humans and wildlife.

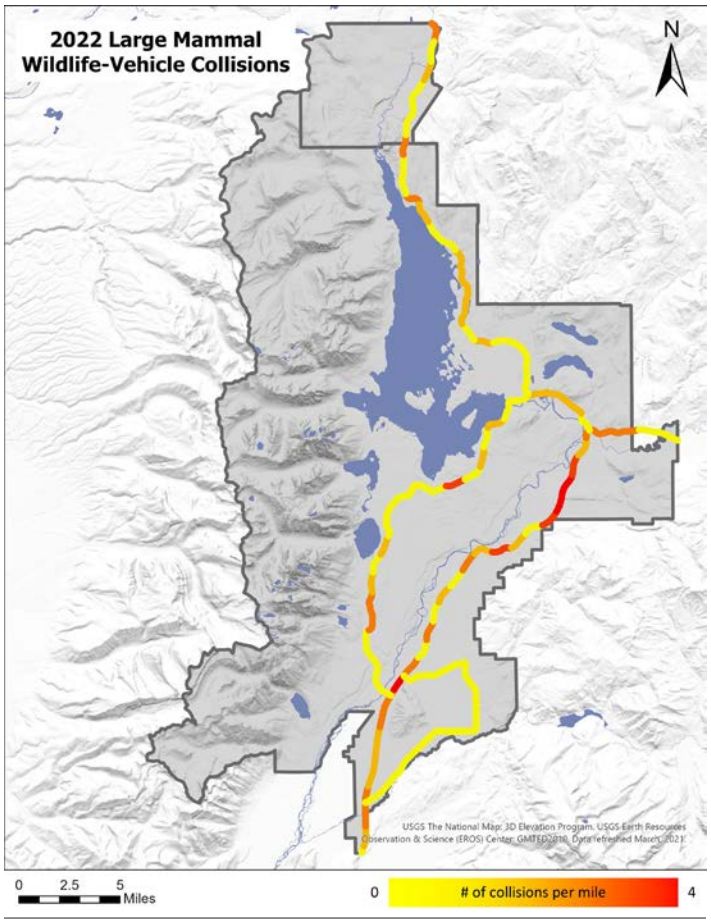
In 2022, 125 collisions occurred involving 129 animals, a 21% decrease in collisions and a 24% decrease in animals involved from 2021. Park visitation was significantly lower in 2022 compared to 2021, which likely contributed to the lower number of collisions. In 2022, 81% of all collisions resulted in a confirmed animal death. In incidents where a carcass could not be located near the road, some animals may have died later from injuries sustained in the collision. Most collisions (103) occurred during the snow-free months (May–Oct.) and peaked in July, the highest visitation month for both the park and parkway.

A minimum of 29 species (20 mammals and 9 birds) were involved in collisions in 2022. Large mammals accounted for 84 of the 129 (65%) animals involved. While the overall number of wildlife-vehicle collisions decreased in 2022, the number involving ungulates increased by 5% compared to 2021; ungulates comprised 60% of all individuals (77) involved in wildlife-vehicle collisions. Mid- to large-sized carnivores accounted for 5% (7- 2 black bears and 5 coyotes), small mammals 20% (26), and birds 15% (19). Collisions involving birds and small mammals rarely cause property damage, are less conspicuous, and as a result are under reported. There are likely significantly more birds and small mammals struck by vehicles, and it generally remains unknown how these mortalities influence their population demographics.

When possible, park staff also record the time of day that a wildlife-vehicle collision occurred. For the 27% of incidents with a known time of day, 100% of those collisions involving mule deer and 57% involving pronghorn occurred during the day. All incidents with a known time of day involving bison, elk, and moose occurred at night.

M. Gocke/WGF

It is common for animals to walk in the roadways especially in winter when it is easier to travel there than through deep snow. This creates significant dangers for both wildlife and humans.



Park staff documented the highest number of wildlife-vehicle collisions (60%) on US Highway 89/191/26 (Hwy. 89), followed by the North Park Road (22%), Teton Park Road (11%), and other roads (7%). On Hwy. 89 most incidents occurred between Moose Junction to Snake River Overlook (24%), followed by Spread Creek to Moran Junction (19%), Snake River Overlook to Triangle X Ranch (8%), and Triangle X Ranch to Spread Creek (8%). The majority (73%) of incidents with bison, moose, and elk occurred on Hwy. 89. For deer, 54% of collisions occurred on Hwy. 89, 25% on North Park Road, and 9% on Teton Park Road. For pronghorn collisions, they were split between Teton Park Road (55%) and Hwy. 89 (45%). Collisions involving all species of large mammals most often occurred on Hwy. 89 (60%; see map).

The park implemented several mitigation measures in the last decade to address wildlife-vehicle collisions, including the permanent reduction in nighttime speed limit from 55 to 45 mph on Hwy. 89; continued use of variable message signs at strategic locations to inform drivers of current wildlife activity near roads; the installation of permanent digital speed readers at Moose Alley, Elk Ranch Flats, Snake River Hill, and the Gros Ventre River; and painting wider road surface lines to delineate narrower travel lanes that indirectly encourage motorists to follow designated speed limits.