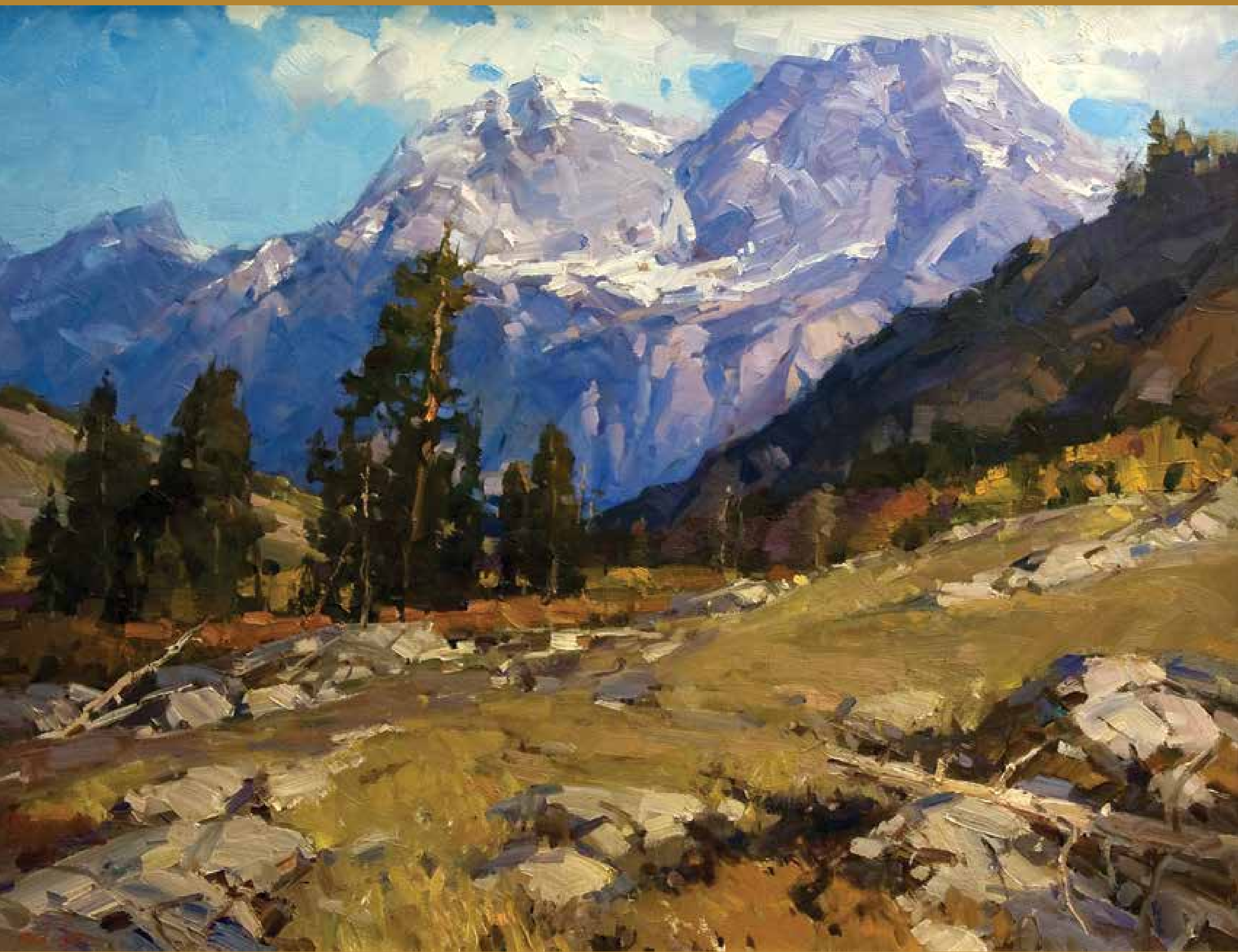
Science and Resource Management
Grand Teton National Park
& John D. Rockefeller, Jr. Memorial Parkway

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 2020

This report is made possible through generous support from Grand Teton National Park Foundation and Grand Teton Association. It shares natural and cultural resource data collected during the calendar year 2020 and compiled in 2021.

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Cover painting: Fall in the High Country, Grand Teton, WY 2003 by Xiangquan Jie. Gift from the Grand Teton Association to Grand Teton National Park.

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

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Grand Teton resources include migratory pronghorn 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, and peregrine falcon).
  - 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, trumpeter swan, and whitebark pine).
  - have relatively small populations in the park and are considered vulnerable (bighorn sheep, Columbia sharp-tailed grouse, harlequin, pronghorn, and red fox).
  - 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, and climate change (sagebrush steppe, amphibians, cutthroat trout, and osprey).
- **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, plant and habitat restoration, wildlife collisions, and the human-bear interface) are generally caused or largely influenced by human activity.
- **Human Factors** (park visitation and use) have significant impacts on park resources 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 2020 (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)	24°F, 52°F 21.69″	22°F, 53°F (1959–2020 average) 21.81″ (1959–2020 average)
Fire	Acres burned per year by wildfire	0.8 acres	1–19,211 (2001–2020 range)
Glaciers	Extent of 10 named glaciers	1.5 km² (2016)	Long-term decline
Water Quality	Basic water quality parameters- 2 river sites	Iron exceeds state standards	State water quality standards
Natural Resources			
Amphibians	% of potential sites suitable for breeding	89%	TBD
Bald Eagle	Breeding pairs	12 pairs	11.8 pairs (2011–2020 average)
Bighorn Sheep	Teton Range herd estimate	≈125 sheep	100–125 sheep (1970–2000 estimate)
Bison	Jackson herd winter count (includes areas outside park)	488 bison	500 bison
Common Loon	Breeding pairs	0 pairs (2020)	TBD
Elk	Jackson herd winter count (includes areas outside park) Summer count (portion of park herd)	10,985 elk ≥1224 elk	11,000 elk ≤1600
Gray Wolves	Wolves in Wyoming (outside of Yellowstone) Breeding pairs in WY (outside of Yellowstone)	204 wolves (37 in park) 15 pairs (2 in park)	≥100 wolves ≥10 pairs
Great Blue Heron	Active nests	23 nests	24.4 nests (2011–2020 average)
Greater Sage-grouse	Active lek	7 leks (6 in park)	8 occupied leks (7 in park)
Grizzly Bears	GYE population estimate Distribution of females with cubs	727 18 bear management units	≥500 grizzly bears ≥16 bear management units of 18
Moose	Jackson herd winter count	≥313 (65 in park)	TBD
Osprey	Breeding pairs	6 pairs	11.8 pairs (2011–2020 average)
Peregrine Falcon	Breeding pairs	2 pairs	3.6 pairs (2011–2020 average)
Pronghorn	Jackson Hole/Gros Ventre herd estimate	564 pronghorn	350–900 (modeled range)
Trumpeter Swans	Occupying breeding territories (includes areas outside park) Pairs producing young	3 pairs (2 in park) 2 pairs (6 cygnets hatched)	18 historic territories (13 in park) TBD
Whitebark Pine	Blister rust infection (% of trees in park)	65% of trees	TBD
Cultural Resources			
Archaeological Sites	Percentage of park inventoried	5% of the park	75–100%
Historic Structures	Percentage assessed in good condition	73% (2017)	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 0 (limit spread & effects on native sp.)
Human-Bear Conflicts	Injuries, food obtained, or property damaged	6 in park	8.6 (2011–2020 average)
Invasive Plants	Species present Acres treated	30 invasive species 4349 acres	0 (limit spread & effects on native sp.)
Mountain Goats	Estimated number in park	≈50 goats	0 (limit spread & effects on native sp)
Plant Restoration	Restoring native plant communities in former agricultural fields (Kelly hayfields)	1320 acres under restoration treatment	100% of 4500 acres in the former Kelly hayfields area

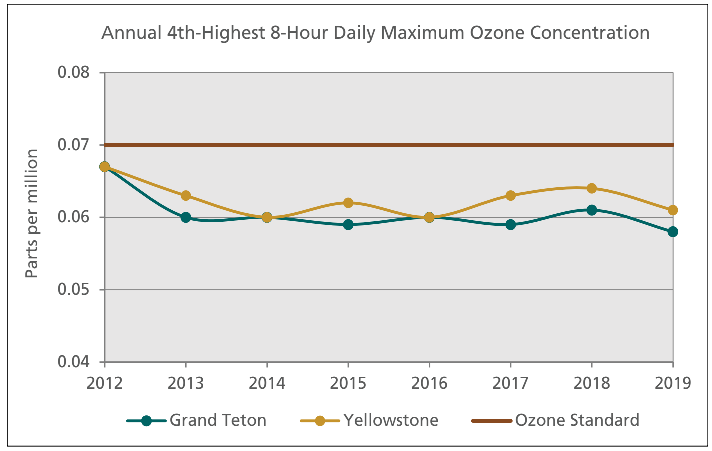
Reference condition specified by government regulation or management plan.

Air Quality

Grand Teton National Park experiences good air quality; however, both distant and local sources of air pollution 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, such as scenery, ecology, and public health.

Air pollutants of concern include sulfur and nitrogen compounds deposited by precipitation and by 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. Alpine plant communities are also vulnerable to nitrogen enrichment, which may favor some species at the expense of others. 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.

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 real-time results from this station, including a webcam is https://www.nps.gov/subjects/air/webcams.htm?site=grte. Annual wet deposition of nitrogen measured at the Grand Teton station from 2012 through 2018 varied from 1.1 to 2.1 kilograms per hectare per year. The Grand Teton deposition monitor is located at an elevation of 6,900 feet; higher elevation areas of the park are likely experiencing higher levels of deposition as a result of higher annual precipitation.



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 and reported in order to minimize the impact of short-term variations in weather conditions in any given year. (2020 statistics not available.)

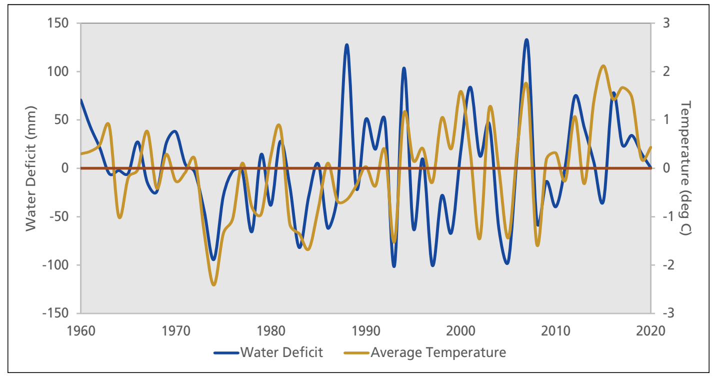
Some air pollutants while still in the atmosphere react in the presence of sunlight to form ozone (O_3). Ozone is harmful to humans as well as vegetation and is regulated under the Clean Air Act. Ozone monitoring in Grand Teton began in 2012. The Environmental Protection Agency has established a standard for ozone that is based upon the three-year average of the fourth-highest eight-hour average concentration that occurs during the year. Data collected by the park ozone monitor from 2012 through 2019 indicate that the park meets the ozone standard. Due to the short span of time that the Grand Teton monitor has collected data, it is not possible to determine whether or not there is a trend.

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. In the region, average natural visual range is reduced from about 180 miles (without the effects of pollution) to about 120 miles because of pollution. The visual range is reduced to about 70 miles on the haziest days and can be even less on days with smoke. While natural fire is recognized for its ecological benefits, smoke from wildfires significantly contributes to particulate matter in the region. Periods of reduced visibility from wildland fire smoke are typical in late summer and were a factor even prior to human occupation.

Park staff maintain the air quality station which includes a webcam that shows current visibility.

Climate

Weather records at Moose, WY collected since 1960 show that 2020 annual temperature and water deficit, a measure of drought stress, were close to average conditions for the 60-year period of record. After three years of above average temperature and drought stress, climate conditions remained close to normal for a second year. Fluctuations above or below the horizontal line on the graph indicate the timing and the amount of deviation from the long-term averages.



Temperature and water deficit (drought stress) anomaly at Moose, WY in Grand Teton NP compared to the 1960–2020 long-term average conditions, shown as the brown horizontal line. Data from Climateanalyzer.org.

Fire

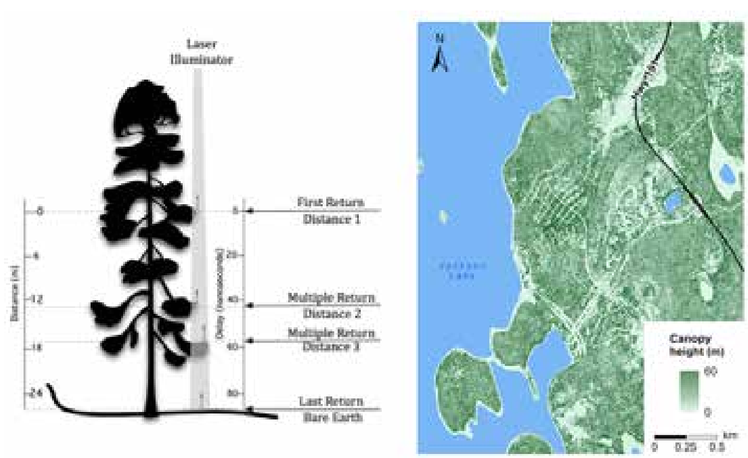
In 2014, Grand Teton obtained Light Detection and Ranging (LiDAR) data for the entire park created by instruments fitted to aircraft and satellites for surveying and mapping. LiDAR uses pulsed light to create a three-dimensional image of the surveyed area. This data gives the heights of features on the surface at a fine scale, so detailed that the measurements of how light passes through the forest canopy are used to calculate the heights of trees and understory features.

The Grand Teton Fire Management Branch contributed funds to acquire the LiDAR data. Park fire staff wanted to use the LiDAR maps of the park's fuels to plan prescribed fires and inform responses to wildfires. Starting in 2018, the park fire ecologist began collaborations with a University of Wisconsin graduate student to test if the collected data on fuel types could be used to predict how fire spreads. The graduate student collected field data from ground plots in the park for comparison to the LiDAR data and digital aerial photos from the National Agricultural Inventory Program. She then used this data to build mathematical models of the park's fuels and vegetation structure. The results show promise for mapping park fuels with more accuracy and detail than existing sources. The data provide a measurable difference in areas where fuels were thinned for wildfire defense around developed areas. Ecological characteristics like forest age and species may also be derived from the data.

Additionally, the models show the distribution of shrub cover and height in the sagebrush-covered valley. Preliminary comparisons to prime sage-grouse winter range indicate that those are the areas with the tallest sagebrush according to the models. Being able to distinguish and map these habitats may assist wildlife managers.

In 2016, two years after the LiDAR mapping, the Berry Fire burned a large area of northern Grand Teton National Park and the John D. Rockefeller, Jr. Memorial Parkway. A University of Wisconsin team of researchers is examining the fire's severity in comparison to the 2014 LiDAR-derived fuel models. This research led to some interesting discoveries. They found that young lodgepole pine forests that had previously burned in 1988 and 2000 had similar or greater forest canopy fuels than mature forests. Since the younger forest canopy was denser and lower to the ground, fires there burned with high severity effects under dry and windy conditions. The comparison of the Berry Fire burn severity map with pre-burn fuel loading showed that fuels are weak predictors of fire effects, especially on days when conditions are moderate. Young lodgepole forests did not limit fire spread. Fuels did not determine fire severity patterns. Under extreme burning conditions, fuels had more influence because dense canopy fuels in the young forests promote rapid, intense fire spread through crown fire.

The collaboration between park scientists and academic researchers is valuable to both parties. Park staff can ask researchers to seek information on specific park issues and researchers are able to see their studies develop into important resource management strategies.



Multiple return LiDAR can characterize the vertical profile of a forest based on the time between emitted pulses and reflected returns (tree figure Garcia-Feced et al.2011). The map shows the detail within canopy height model (1 m resolution) created from 2014 LiDAR data collected in Grand Teton NP.

Glaciers

Ablation stake results from fall 2020: Oblique view of Middle Teton Glacier with 3 of 5 ablation stakes locations depicted with the amount of ice melt or snow remaining and glacier velocity.

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 for 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.

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.

Park staff mount PVC pipes containing a gauge onto boulders to collect stream temperatures and flow levels in glaciated and non-glaciated basins.

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 2020 indicate a negligible volume change across the 31,000 square meter area measured (approximately 17% of the entire glacier surface) compared to 2019.

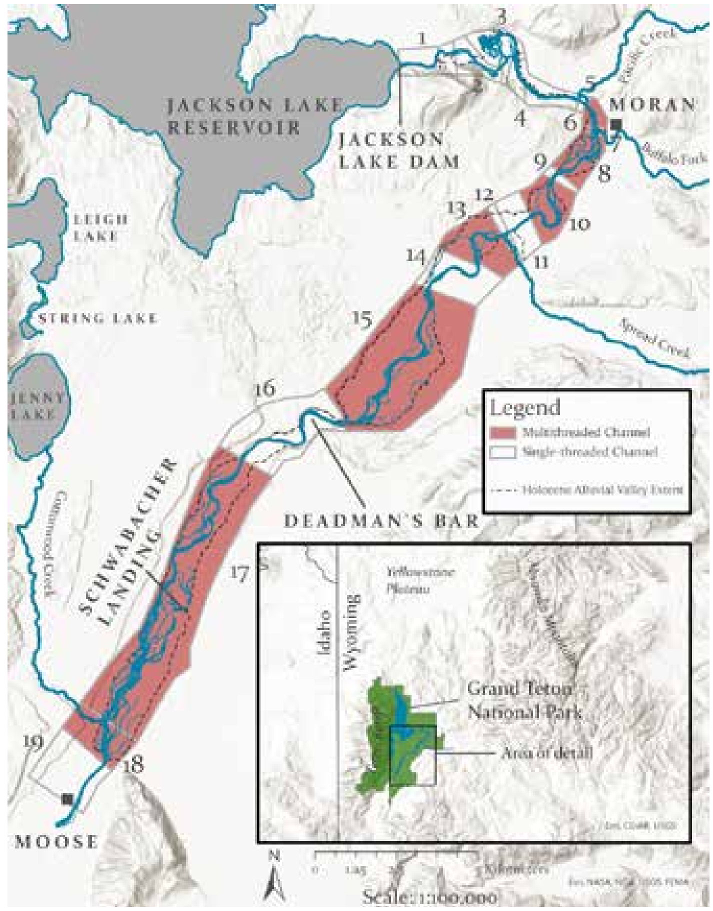
In 2020, physical science staff worked with skilled ski mountaineers to complete the second annual spring survey of Middle Teton Glacier to measure snow accumulation on the glacier prior to the summer melt season. Snow depths were similar to 2019 with accumulation deeper than the 8.5 m (27.9 ft) snow probe could reach. This impressive snow accumulation likely results from avalanches and wind redistribution of snow from surrounding peaks onto the glacier surface 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 five 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, four stakes still had up to a meter of snow (a gain of 0.25 m water equivalent likely because of significant avalanche input at these locations). The middle, western stake showed a net loss 3.1 m of ice (2.8 m water equivalent). In September 2020, researchers located and measured the movement of the ablation stakes placed in 2019. Their measurements indicated a glacier velocity of up to 6 m 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 is one of the longest continuous, naturally-braided river systems in the contiguous United States. This dynamic system transports significant quantities of gravel and has diverse fluvial features such as side channels, 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, originally 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. Dam operations completely dictate the flow of the Snake River until the Pacific Creek confluence 4.5 miles downstream. In 2020 the Bureau of Reclamation, which operates the dam, released a daily peak flow of 5,520 cfs, about half of the estimated unregulated peak flow of 10,776 cfs. This prevents an important part of the peak runoff which scours the riverbed and transports material including downed trees from occurring. Another significant change resulting from dam operations is the shift in the maximum flow from the estimated May 31st to June 7th. These factors affect the ecology of river plants, animals, insects, and fish in ways park scientists do not yet fully understand.



Map of the Snake River showing the locations of the channel studies. The river was divided into 19 reaches between Jackson Lake Dam and Moose for analysis.

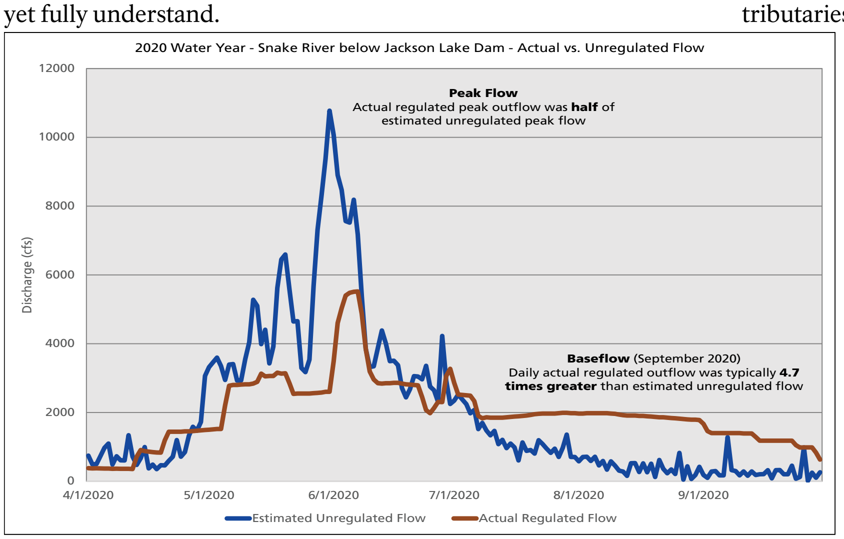
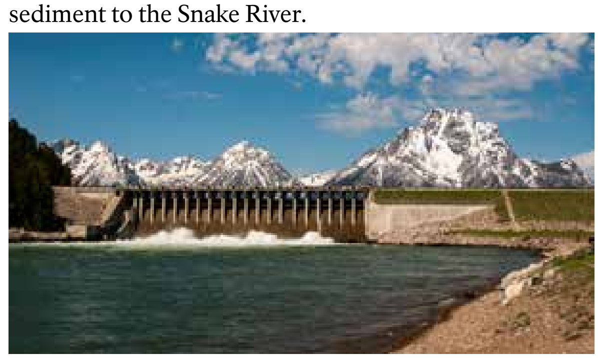


Chart comparing the Snake River's 2020 flow regulated by the dam (brown) compared to the estimated unregulated flow (blue).

Recently university researchers sought to identify whether operations of Jackson Lake Dam caused long-term changes to the downstream channel. Using aerial imagery spanning from 1945 to 2015, they found that the Snake River channel downstream of the dam narrowed when floods coming into the river from its tributaries were small and widened following periods of larger floods. Channel width in braided, multi-threaded sections near tributaries fluctuated greatly. These studies did not find that dam operations correlated with changes in channel width; instead they suggested that the hydrologic changes from the dam are muted downstream as major tributaries contribute water and sediment to the Snake River.



Jackson Lake dam affects the Snake River's flow.

Water Quality

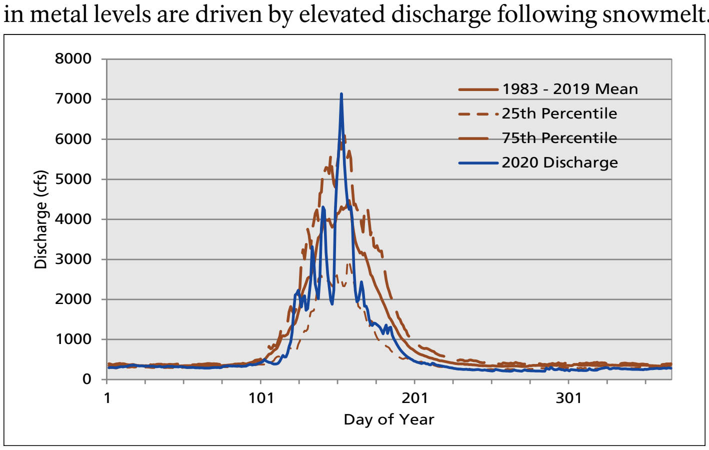
The Snake River provides important habitat.

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 drains 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 gateway and downstream communities.

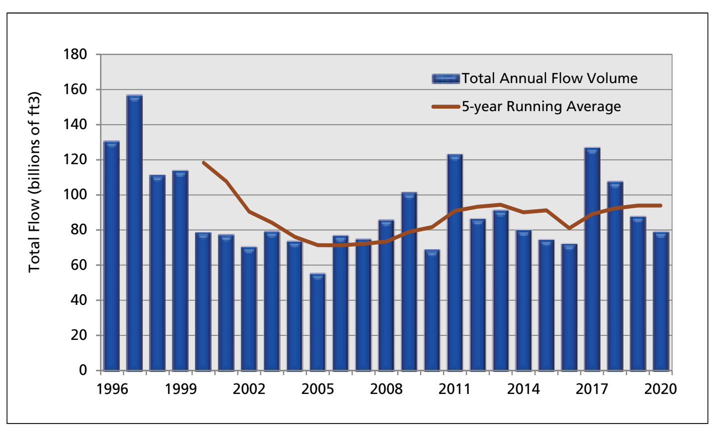
The uppermost reaches of the Snake River in Wyoming are characterized by good water quality with relatively low levels of dissolved nutrients and other anthropogenic compounds (e.g., pesticides). Good water quality and the presence of native fish, including cutthroat trout, are not surprising given that 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 and 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 2020 was near the long-term average at the Flagg site (1983–2020), while peak flows ranked as the 16th in the 37-year monitoring record. Those peak flows occurred just 6 days later than the average for the site. Snake River flows at Moose were near average for that site (1995–2020) early in the season, but dropped as the season progressed. Flows at Moose are strongly modified by Jackson Lake Dam, and reservoir operations may have contributed to the 2020 pattern. Total volume of annual flow at the Moose monitoring location ranked 15th out of the 25-year record, but the date of half discharge (the day marking half the annual flow volume) occurred June 16, 2020, approximately ten days before the average date (June 26) for this location.

NPS resource staff from the Greater Yellowstone Inventory and Monitoring Network also monitor water quality at these same Snake River locations. COVID-19 pandemic safety protocols limited travel but they were able to sample sites twice. 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 showed significant variation and was highest during runoff. Trace metals (i.e., arsenic, copper, and selenium) are found in the watershed and are often naturally present in measurable concentrations, but typically below the State of Wyoming's aquatic life criteria. In 2020, copper and selenium were below detection levels at both sites. Total iron concentrations were low but measurable on both sampling dates. 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. 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.



Summary of the average daily discharge in the Snake River near Flagg Ranch, Wyoming by day of year.



Annual Snake River flow totals (in billions of cfs) at Moose, WY. A 5-year average smooths annual variations for a clearer examination of trends.

Counting Sheep in the Tetons

A trail camera captures photos of bighorn sheep licking natural mineral deposits that contains high concentrations of calcium, magnesium, and sodium.

After driving an hour, canoeing across Jackson Lake and up a swollen stream, slogging through a quagmire, hiking two miles up a canyon, and climbing 1,000 feet straight up a steep south facing slope, my field partner and I drop our packs on a tiny strip of flat ground at the base of a cliff. I wonder how this could possibly be our most accessible site to monitor bighorn sheep in Grand Teton National Park. The treasure we seek at this site is not gold; it is brown. We are collecting scat left behind by bighorn sheep at one of their mineral licks.

Collecting scat has been a fairly regular task in my career as an aspiring biologist. I've previously worked on projects collecting bison scat to determine pregnancy, elk scat to evaluate stress levels, bighorn sheep scat to measure internal parasite loads, and mountain goat scat to help confirm the origin of Grand Teton's nonnative population. This is just a sample of the growing list of things we can learn from scat. Our current aim is to obtain DNA from bighorn sheep scat to evaluate their genetics and estimate how many bighorn sheep remain in the Tetons.

Bighorn sheep in the Tetons today are a remnant of a past population. Historic records give clear indication that bighorn sheep were once far more common in the Tetons than they currently are. Those that remain spend the entire year at high elevation and never congregate on low-elevation winter ranges like most ungulate populations in the ecosystem, which makes censusing them a challenge. Traditionally, biologists have relied on minimum counts from winter helicopter surveys as an index of how many bighorn sheep exist in the Tetons. Finding and counting a cryptic animal dispersed across a mountain range amid generally inhospitable flying conditions is no easy task and population-trends have been difficult for biologists to track. As many as a hundred animals have been counted in a year, leading biologists to surmise that 100-150 bighorn sheep exist in the Tetons. This is a perilously low abundance and several strokes of misfortune could push this population into an extinction vortex (yes, it's a real thing). Biologists need to be able to track trends in this population because there's a small buffer of decline before irreparable losses happen, which gets us to why we are collecting scat at mineral licks.

Carson Butler collecting scat.

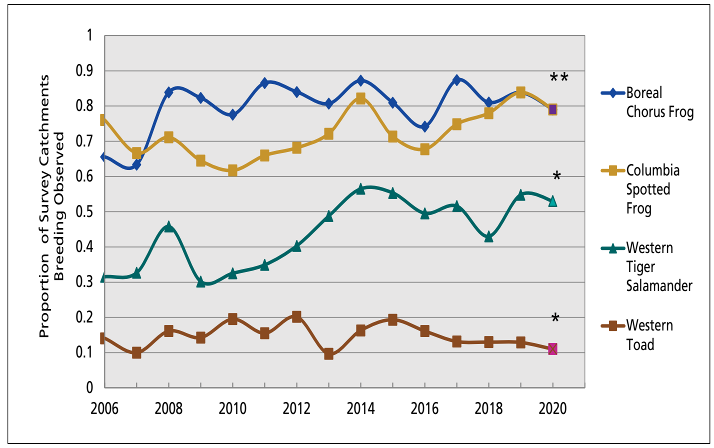
Advances in the genetics field allow us to obtain DNA from fecal pellets that have sat on the ground for weeks. This allows biologists and researchers to use non-invasive methods to obtain genetic and demographic information about wildlife populations that just a decade ago required capturing and handling the animals. DNA allows us to identify the unique animals whose pellets we collect while also looking at measures of genetic health such as genetic diversity and inbreeding, the number of breeding animals, and connectivity with adjacent populations. By collecting scat at the same sites repeatedly over a summer we can accomplish something that seems like alchemy at first consideration: estimate how many animals exist that we never detected, which is the crux of estimating abundance. Our aim is to refine this approach into a monitoring program that provides an accurate population estimate each year it is applied so that biologists can better track the trend of bighorn sheep in the Tetons. This information, along with the measures of genetic health, will help guide decisions regarding bighorn sheep in the Tetons as managers weigh the relative risks and benefits of different actions. Thanks to the dedication and hard work of volunteers, local partners, and seasonal wildlife crews, we've collected over 1,500 scat samples from ten sites across the Tetons since the project began in 2019. In the project's first year, 97 unique adult bighorn sheep were detected and 127 were identified in 2020. We are currently working to translate the minimum counts into a population estimate.

In addition to collecting fecal samples at mineral licks, we also use trail-cameras to monitor the licks. When there are enough radio-collared animals in the population, the cameras offer another approach to estimate how many bighorn sheep are in the Tetons. In the absence of radio-collared animals, the cameras still provide information that complements what we learn from the fecal genetics data. For example, the cameras tell us that there are typically more lambs per ewe in the northern Tetons compared to the southern Tetons, that young rams use the mineral licks most, and that there are no overt signs of signs of disease in the population. The amount of biological information that can be obtained through non-invasive methods is truly impressive and just continues to grow as technology progresses.

As we descend from the mineral lick with a bounty of sheep scat and trail-camera photos, Scatman (ski-ba-bop-ba-dop-bop) plays on repeat in my head and I know the hard work of counting sheep in the Tetons will help me fall asleep quickly tonight.

Carson Butler, Wildlife Biologist

Amphibians



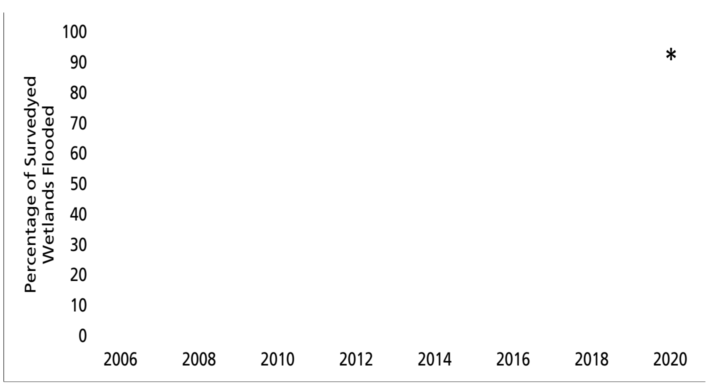
Proportion of surveyed catchments where breeding was observed for each species. Asterisks indicate that 2020 represents a restricted field season due to COVID-19 precautions with only 19 of the 31 long-term catchments visited.

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*). 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. 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).

While the 2020 field season presented unique challenges, the crews adopted new protocols to stay healthy during the COVID-19 pandemic and visited 19 of the 31 catchments, including all seven Grand Teton catchments. In 2020, two of the 31 catchments contained breeding evidence of all four species (referred to as amphibian "hotspots"). This was consistent with the past three years and up from 2016 when no catchments contained breeding evidence by all four species. For comparison, biologists found two hotspot catchments in 2015 and four in 2014, illustrating the breeding variability that takes place even in protected areas.

In 2020, researchers visited 163 individual wetlands from the 31 catchments and sampled 145 sites with standing water present. This is approximately half of the number of sites surveyed in a normal year. In contrast during the 2019 field season, unaffected by the pandemic, crews visited 336 wetlands and sampled 281 sites with water. Of the wetland sites surveyed in 2020, 57% were occupied by at least one species of breeding amphibian compared to 56% in 2019.



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

Annual variations in breeding may be 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 2020, researchers estimated 89% of the wetlands were flooded. Note, however, that some 2019 surveys were delayed up to 2 weeks due to high spring water and compared to previous years this likely increased the overall number of dry wetlands.

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 predicted increasing temperatures and changes in snowpack driven runoff for this region could alter wetland habitats and influence amphibian breeding. These expected impacts will disproportionately impact amphibians relying on shallow wetlands.

Adult western tiger salamanders eat insects, earthworms, and other small invertebrates.

Bighorn Sheep

Bighorn sheep (*Ovis canadensis*) were once widely distributed throughout the mountains and foothills of the Rocky Mountain west. They persist today in small, fragmented populations that remain at risk of further decline and extirpation. The Teton Range population is Wyoming's smallest and potentially most isolated core native sheep herd. 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 due to the loss of low-elevation winter ranges to residential and recreational encroachment. The Teton Range bighorn sheep population faces the serious threat of local extinction and biologists are working to address the most pressing concerns.

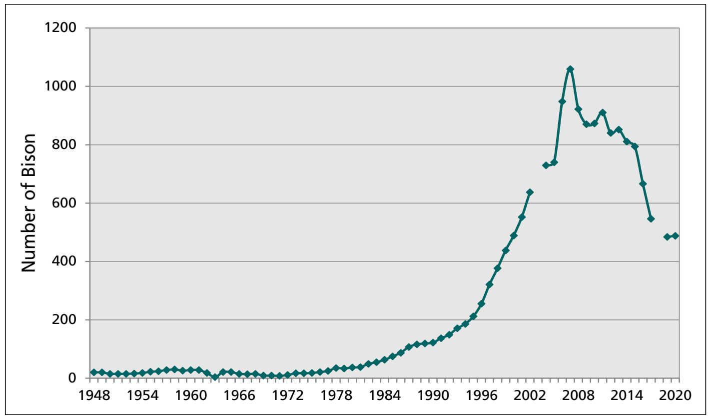
Traditionally, biologists estimate the size of this population from winter helicopter surveys. In 2020, Wyoming Game and Fish Department (WGF) personnel counted a total of 100 bighorn sheep (40 in the south end of the range and 60 in the north) which represents an increase over the numbers counted in 2019. Over the last few years, the winter counts varied widely from 46–100 bighorn. Such dramatic variation is unlikely to represent true population increases or decreases, but indicates the traditional count method does not provide a reliable estimate. Consequently, park biologists are evaluating the effectiveness of two non-traditional count methods based on bighorn use of mineral licks during the summer months: analysis using remote cameras and analysis based on fecal DNA. Beginning in 2018, park biologists placed motion-triggered cameras at mineral licks scattered across the Teton Range to monitor bighorn sheep. To date, biologists have analyzed more than 84,000 photos of bighorn sheep and documented over 1,400 groups visiting the licks. Initially the cameras were used to provide a population estimate based on observations of radio-collared animals, but as the number of radio-collared individuals declined the purpose shifted to documenting mineral lick use, lamb production, and visible health of the animals. In 2019, biologists started collecting bighorn fecal pellets at natural mineral licks to estimate population size. Also DNA obtained from the fecal samples can be used to identify individual bighorn sheep and evaluate genetic attributes such as diversity, inbreeding, and population structure. Of the more than 500 fecal samples collected in 2020, just over 400 were genotyped. The genetic analysis identified 127 adult individuals (60 in the south and 67 in the north). For comparison, biologists on the February 2020 helicopter survey observed 83 adult bighorn.

Annual ground classification surveys started in 1990 provide composition, distribution, and trend information. Biologists from the park, WGF, Bridger-Teton and Caribou-Targhee National Forests counted a total of 45 sheep during the late August ground surveys (19 in the south and 26 in the north). Observers were unable to classify five animals. Herd ratios were estimated at 67 lambs, 17 yearlings, and 39 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.

The curved horns of the bighorn ram can weigh up to 30 lbs, as much as the weight of all the bones in their body.

The Teton Range Bighorn Sheep Working Group has become increasingly concerned about the status of the Teton Range bighorn sheep population and its long-term prospects for persistence. The Working Group considers the population to be at a breaking point where the management agencies must take conservation actions soon or risk losing the population. In 2019, the Working Group convened an expert panel to help identify and prioritize management, conservation, and research for the population. At their recommendation in February 2020, the Working Group held collaborative public workshops addressing the issues of backcountry winter recreation and protecting winter habitat for bighorn sheep. They hired Dr. Jessica Western from the University of Wyoming Ruckelshaus Institute to facilitate the workshop series with the purpose of: building community awareness for Teton Range bighorn sheep and the impacts of winter recreation; and identifying community-supported solutions that balance bighorn sheep habitat needs with recreation access. A total of 158 people attended at least one of the workshops and many attended multiple sessions. Two follow-up virtual meetings were held in June to gather additional input. The Working Group reviewed and compiled community input, identified and prioritized actions to move forward, and drafted a summary report. Final results of this collaborative process will be shared with the public in 2021.

Bison



Population size of the Jackson bison herd, 1948-2020.

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 remain free. Present-day Jackson bison are descendants of those bison and some 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 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 National Elk Refuge identified a population objective of 500 bison for the herd. The Wyoming Game and Fish Department (WGF) adopted this objective. With unusually low winter mortality 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 outside the park on the National Elk Refuge and the Bridger-Teton National Forest, reduced bison numbers to slightly below the objective of 500 animals.

In mid-February 2020, biologists counted 488 bison with almost 40% of the herd (182 individuals) found on native winter range scattered throughout the central portion of the park and 306 bison (75 bulls, 164 cows, and 67 calves) found on the National Elk Refuge. In late January 2020, several large groups of bison moved south via their traditional movement corridor that connects the Snake River floodplain south of Spread Creek with the broad sagebrush outwash plain of Antelope Flats. These bison likely made it to the NER as no reports of bison between Kelly and Shadow Mountain were received for the remainder of the winter.

2020 marked the third year that a significant segment of the bison herd did not move to the NER and use the supplemental feed. Bison recruitment (as indexed by the late-winter calf ratio) in 2020 remained low for a second year in a row (2019: 38 calves per 100 cows, 2020: 39 calves per 100 cows) compared to 2018 (50 calves per 100 cows). Whether this reflects overwinter calf mortality or cow/calf groups missed during the count is unknown. Since large numbers of bison wintered on native winter range in 2020, higher overwinter mortality is anticipated. The herd-wide bull ratio was 88 bulls per 100 cows.

Vehicles collided with three bison resulting in at least two confirmed deaths in 2020. The other bison was injured and may have died later away from the road. The Shoshone Bannock tribe harvested five bull bison on the NER in April 2020. Hunters harvested another 109 bison outside of the park, including 72 bulls, 30 cows, and 7 calves. A research team investigating wolf predation found four other bison carcasses. One of these was identified as a possible wolf kill, but the cause of death for the other three could not be determined.

Researcher in the Park

Interview of researcher Kristin Braziunas by Diane Abendroth, Grand Teton Fire Ecologist. *Kristin and Diane collaborate on research involving remote sensing and fuels. In this interview Diane is asking Kristin about her perspectives on scientific research in the national parks and in the Greater Yellowstone Ecosystem (GYE).*

Diane Abendroth (DA): **How did you become interested in doing research in national parks?**
Kristin Braziunas (KB): I spent a lot of time in national parks when I was growing up. My dad is a geologist, so we went to look at the rocks, but I fell in love with the wide-open spaces, the plants, forests, and animals. Two things make parks compelling places for me to do research. One is that national parks are natural laboratories, large areas with relatively intact ecosystems and less human intervention. This is particularly important when it comes to understanding how things like changing climate and fire activity will affect forests in the future, both in national parks and in places where people live. The second thing that appeals to me about national parks is the relationship people have with these iconic landscapes. They may have visited as kids, but remain interested and passionate about the future of these special places. I love that my research can be one small part of understanding why forests come back the way they do, how they interact with fire, and what our parks might look like in the future.
DA: **Could you give a summary of your research in Grand Teton and the Greater Yellowstone?**
KB: I research how changes in climate and fire activity will affect both forest ecosystems and the people who live in or near them. I combine multiple approaches including collecting data in the field; using remotely sensed data from satellites, airplanes, or even drones; and using computer models to anticipate how forest landscapes might change throughout the 21st century. I use these approaches to ask questions like: 'If dense conifer forests burn more frequently than they have in the past, how will this affect forest fuels, forest recovery, fire severity, and fire risk to houses?' Or I can ask, 'How different forest management strategies affect ecosystem services, which are the benefits people get from nature like recreation, timber, scenic landscapes, and clean water?'
DA: **Why research in the GYE and Grand Teton in particular?**
KB: It goes back to my decision to go to grad school. I spent eight years working professionally in the nonprofit sector in sustainability planning and I was also a part-time structural firefighter. When I decided to pursue a long-term career in science, I wanted to combine my passions for the environment, forests, and fire. I feel very fortunate that through my professional network I found Dr. Monica Turner, whose research in Yellowstone aligned with my interests. The GYE is a perfect location to combine my passions and research the rich history of interplay between mountains, forests, and fire. It's a critical foundation for me and my long-term career goals, and in some ways I feel Yellowstone found me.
DA: **Tell us what it is like to do fieldwork in the Tetons.**
KB: Field work involves a lot of planning and coordination, long days, physical exertion, and constant situational awareness particularly in these parks. In spite of all this, it never actually feels like work since I always find it fun, exhilarating, and rewarding to spend time in these beautiful landscapes. Fieldwork can be very low-tech or very high-tech. My work in recently burned areas often involves using pen and paper to count tree seedlings and hand tools to measure the diameters of downed logs that make up the forest fuel load, but we're also blending this with newer technology. We use high precision GPS to get within inches or centimeters, depending on your choice of unit, of an exact location to match remotely sensed data from burn severity or forest fuels maps. I'm also starting to explore data collection using drones to measure forest biomass in GYE national forests. So fieldwork can be very low tech, but there's also emerging technologies that are allowing us to measure things in new and exciting ways. Another thing that I love about fieldwork in the GYE is that I get to interact with many people. When people see our University of Wisconsin van, they ask what we are doing. It is fun to talk science with the visitors, but then I can also walk a mile into the backcountry and there are no people for as far as the eye can see. I love that mix. Another real joy of working in the Tetons, is working with local managers like you, Diane. I have developed such rich collaborations with folks at the parks and national forests of the GYE. These collaborations have made my work better, more meaningful, and hopefully more impactful.
DA: **What are some of the things you've learned from your time exploring the landscape?**
KB: I feel it's important to have different kinds of experiences with the places you're studying. I do a lot of my work with computer modeling, but if I only worked at home on the computer, I would not have any clue of how to relate that to a landscape. When I'm exploring the landscape I'm able to make connections, these Aha! moments, that come when I'm able to relate my experience in the field back to the modeling I've done. It's a gut check, being out there and seeing connections in these two different ways of learning about forests. There are things that I've only fully understood after collecting data and analyzing it back at my office. For example in the forest fuels project we worked on together, I compared the fuels in the young (less than 30 years) and mature (greater than 125 years) lodgepole pine forests and found they had similar canopy fuel loads, which is the amount of live foliage that is capable of being consumed in a crown fire. In young forests, canopy fuels were shorter and more densely packed closer to the ground compared to older forests. That relates to my experience of swimming through these dense young lodgepole pine stands as I was trying to measure them. These forests historically burned every 100–300 years when conditions were hot and dry. These conditions are expected to be more common in the future with climate change, meaning that forests are likely to burn more frequently. My research suggests that subalpine forests, which cover most of Grand Teton and Yellowstone National Parks have plenty of fuel to burn and are fully capable of supporting high severity crown fire only 30 years after previously burning. I also learn unexpected lessons from my experiences in the field. For example, when I was sampling in the Tetons' Berry Fire and Yellowstone's Maple Fire—I was surprised

Kristin and Diane hike through an area burned by the 2020 Wilcox Fire.

by how hot and dry these recently burned areas are compared to the surrounding forest. Those two fires reburned young forest with short trees that were 16 to 30 years old and after the fires there were areas where everything was gone. It was just a field of stumps. We were sampling those areas, surrounded by blackened soil. The charred layer was absorbing all the heat from the sun, and it was windy, increasing the rate of moisture evaporation from the soil. I was just baking in these sampling places and then I'd go into the nearby unburned forest and the temperature was totally different. We weren't out there to measure temperature or aridity that day, but I learned about them viscerally, just by being in these different locations.

DA: **When you return to the University of Wisconsin what do you tell people about the Tetons?**

KB: I tell them it's beautiful. I tell them to go visit and I also talk about my research. I like to highlight two big take-home messages that I learned from studying forest ecology in the Tetons: The forests in the Tetons are a wonderful example of forests that have historically experienced severe large fires that occurred infrequently. This is a natural phenomenon that the tree species are adapted to and have experienced over thousands of years. The landscape is not destroyed by fire; it is renewed by fire. I like to talk about how lodgepole pine trees have serotinous cones that accumulate over the course of their life. And when these cones are heated by fire, they open to release vast quantities of seeds that allow for abundant post-fire recovery. A second message I focus on is that different forest types are adapted to different fire frequency and severity. For example, the moist, productive forest of the Tetons are not the same as the drier, open forests of California. In the Tetons, abundant forest fuels are relatively continuous and capable of supporting high severity fire under the right climate and weather conditions unlike areas that are more heavily influenced by past fire suppression. The Teton forests with abundant fuels just need hot, dry, and windy conditions to support large severe fire. This is something that often surprises people because recent news has focused on the impact of fire suppression and fuels accumulation in drier forests.

DA: **What sort of career do you see in your future?**

KB: I would like to pursue a career in forest and fire ecology, working for a government agency where that I can focus on doing research that will help us understand how forests are going to change and inform land stewardship decisions. It's also particularly important to me to be a role model for other young women during my career. Science, fire, and natural resource management are fields where women have been underrepresented and historically excluded. I am hoping to continue the trend of being a strong female role model to others who are entering these fields. I hope that through my career path I can create opportunities and address systemic issues related to diversity, equity, and inclusion. I feel very fortunate that I've had many strong, inspiring, and trailblazing women mentors throughout my career from my mom to my advisor Dr. Turner, to fire colleagues such as you and Becky Smith at Yellowstone, who have been important during my PhD experience.

DA: **If you weren't graduating, what are some of the other things you'd like to study in the Greater Yellowstone Ecosystem?**

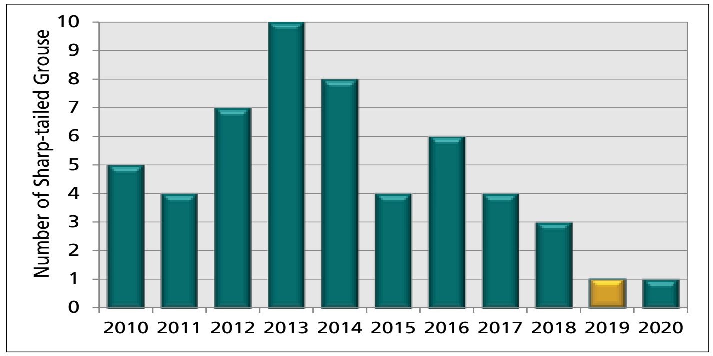
KB: I'm still in the process of undertaking one final project. As I mentioned earlier, subalpine forests in this region historically burned every 100–300 years but are expected to burn more frequently in the future as the climate warms and dries. These more frequent fires, I define as having less than 30 years between fires. There has been some recent research in this region that documented a decrease in forest recovery after short-interval fire versus long-interval fire. There's also been a lot of research throughout the western US showing that hotter and drier climate can also lead to lower post-fire forest recovery. Seedlings just aren't able to survive under these harsher conditions. My next project that I'll be undertaking this summer is to look at the intersection between those two potential threats to post fire recovery. I'll be sampling short-interval fires throughout the GYE, that have burned within the past 20 years and cover a range of post fire climate conditions. I'll be comparing forest recovery following long- and short-interval fire asking, 'Does hotter drier climate amplify effects of short-interval fire and further diminish forest recovery?' That's my project for this summer and I'm really excited for this study.

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 local population declines and range reduction. The Columbian is the rarest sharp-tailed subspecies and has experienced the most severe declines in population and distribution. Sharp-tailed grouse are considered a species of greatest conservation need in Wyoming.

Similar to greater sage-grouse, sharp-tailed grouse 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. Several incidental observations of small groups of sharp-tailed grouse were recorded in Grand Teton over the years but no leks were found prior to 2010, and the nearest known lek was in Idaho along the western slope of the Tetons.

In the spring of 2010, biologists located a sharp-tailed grouse lek near the southeast boundary of the park, where they observed five males displaying. This marked the first known sharp-tailed grouse lek in the park in over 40 years. In 2020, biologists observed one male sharp-tailed grouse displaying on the lek. This lone male marks the second consecutive year with the lowest number of birds observed on this lek since its discovery in 2010. (Surveys in the 2020 season were limited due to the COVID-19 pandemic.) Over the last five years, maximum counts of sharp-tailed grouse on this lek declined from six males in 2016 to a lone bird in 2019 and 2020 (the sex of the individual was not evident in 2019). While staff never observed females on the lek during surveys, the longevity of lek activity as well as three observations of a hen with chicks within two miles of the lek in 2016 suggests that successful breeding occurs.



Counts of male Columbian sharp-tailed grouse on the Grand Teton lek, 2010-2020. The gold bar indicates the bird of unknown sex observed in 2019.

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. These data will aid area land managers in developing conservation plans and strategies.

During the great gray owl courtship period (mid-February through April) of 2020, TRC biologists deployed automated recorders near all known nests to determine occupancy. These recorders documented owl activity in seven territories prior to nesting season. In 2020, only one great gray owl pair within the park initiated nesting, but it failed due to predation. Nesting success in 2020 decreased after the higher success of 2019 (5 nests initiated and 5 owlets fledged). Nest initiation and success has varied considerably over the past several years. The highest success rate was recorded in 2016 (8 nests initiated and 17 owlets fledged). In 2017, no nests were initiated and in 2018 there was one nest initiated and one owlet fledged.

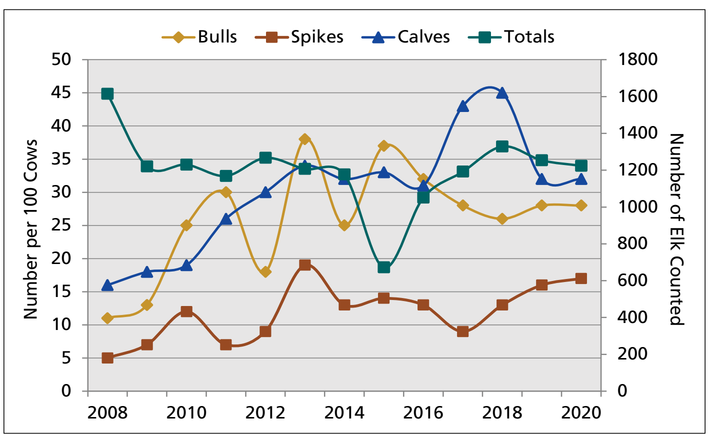
Biologists continued to track owls previously outfitted with VHF transmitters to evaluate habitat selection and movement patterns. Additionally, researchers continued surveys of pocket gophers to assess prey availability and measured monthly snow depths at several owl territories throughout the valley and park.

The eyes of the great gray owl are very large in proportion to the size of its head. The enormous eyes allow the owls to see in near darkness. They can see in daylight as well, but probably have poor color vision. Owl eyes are fixed in their sockets so they must rotate their necks to look around.

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 (WGF) is a three-year average of 11,000 elk ± 20%. During the 2020 classification count, biologists counted 10,985 elk yielding a three-year average of 10,514. Estimated at above 19,000 during the early–mid 1990s, the Jackson herd is 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 2020 park reduction program a total of 161 elk were harvested.



Grand Teton mid-summer elk count and classification, 2008–2020.

The furry skin that covers antlers as they grow is called velvet. The velvet is full of capillaries that supply oxygen and nutrients to the antlers allowing for about an inch of growth each day.

During the 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 2020, park biologists counted and classified 1,224 elk. The total number of elk counted was slightly more than in 2019. Overall numbers remained remarkably consistent from 2009–2014, but abruptly declined in 2015 and rebounded to near the previous level the last several years. Herd ratios were 28 mature bulls, 17 spike bulls, and 32 calves per 100 cow elk. Calf ratios decreased compared to 2018 (45). The calf ratio was highest along the Snake River south of Moose and lowest in Willow Flats and the Three Rivers Ranch area in the Pacific Creek drainage.

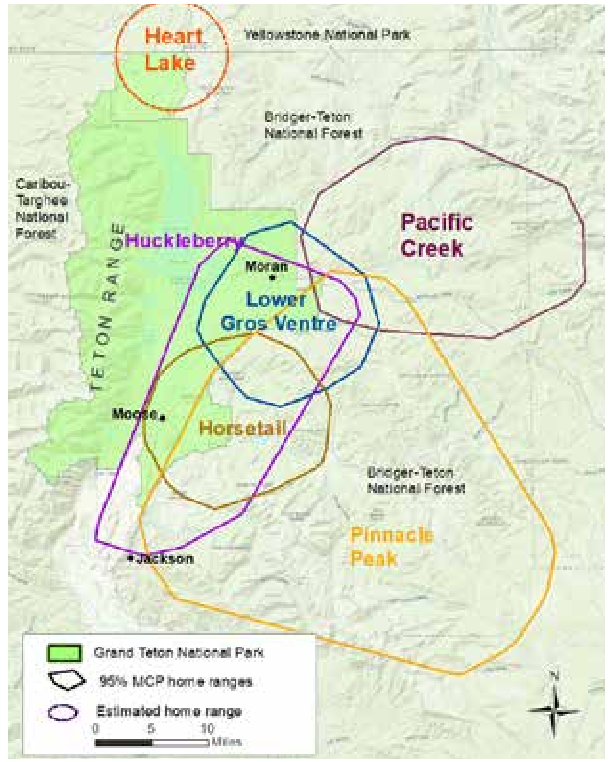
Gray Wolves

After the US Fish and Wildlife Service and National Park Service reintroduced gray wolves (*Canis lupus*) into Yellowstone National Park in 1995–96, wolves 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 2020, a minimum of 37 wolves in 7 packs resided in the Jackson Hole area with home ranges in Grand Teton National Park. The Lower Gros Ventre (11 wolves), Huckleberry (3), Horsetail Creek (4), Heart Lake (6), Long Hollow (4), and Pacific Creek (6) packs all had home ranges that included the park. The Wildcat Ridge pack (3) formed near the end of the year in the north end of the park. The Pinnacle Peak pack, which formed in 2007, had 4 pups outside the park but dissolved by the end of the year.

Three packs produced pups in 2020 that survived through the year: Lower Gros Ventre (5 pups), Horsetail Creek (1), and Heart Lake (4); and only the Lower Gros Ventre pack denned in the park. To minimize human disturbance to wolves raising young, park managers implemented closures around den and rendezvous sites for the Lower Gros Ventre pack.

The Huckleberry pack, which had 17 wolves at the end of 2019, only numbered three wolves at the end of 2020, and one collared female dispersed and remained alone at year's end. The Heart Lake pack used part of the territory vacated by the Huckleberry pack and ended the year with two adults and four pups. The Pacific Creek pack spent a small amount of time in the eastern part of the park, but its den and most of its home range were outside the park. There were two known wolf mortalities in the park in 2020. Both were illegally shot, one in January and one in October. One male dispersed from the Pinnacle Peak pack and settled in southeast Idaho.



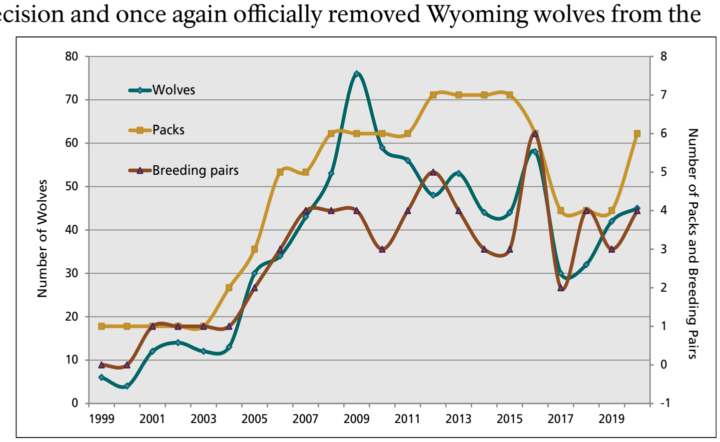
Distribution of Jackson area wolf packs, 2020 MCP (Minimum convex polygons) are home ranges based on collared pack members.

Four wolves were captured in December 2020 and fitted with two GPS and two VHF collars.

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, with 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. Wolves in Wyoming were removed from the federal list of threatened and endangered species in September 2012. In 2013, the State of Wyoming implemented a wolf hunt in the trophy management area of northwest Wyoming outside national parks, the parkway, national wildlife refuges, and the Wind River Indian Reservation. In September 2014, a court ruling suspended the hunt and again granted Wyoming wolves federal protection. However, the US Court of Appeals for Washington DC ruled to reverse the 2014 decision and once again officially removed Wyoming wolves from the endangered species list on April 25, 2017.

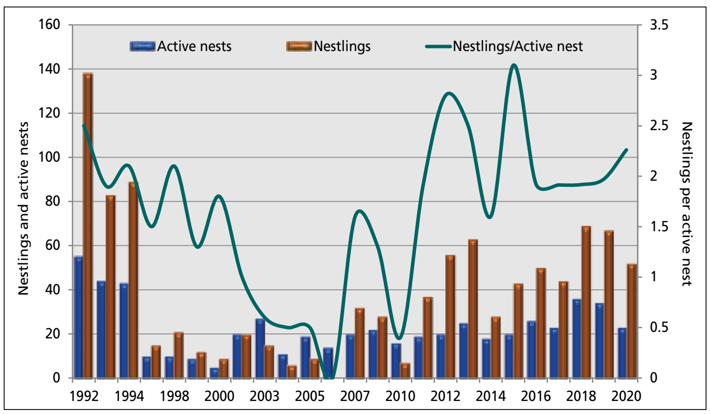
Aerial view of a wolf chasing a herd of pronghorn.



Population of Jackson area wolves, including those in Grand Teton, 1999-2020.

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 reproductive success vary widely with long-term productivity declining but fairly stable within the last decade. Over the last decade herons abandoned several historic heronries, most recently two along the Buffalo Fork. Bald eagles in particular can have devastating impacts on the survival of young herons. Biologists do not know if bald eagles nesting near the Buffalo Fork led to the demise or displacement of heronries in that area. In 2018, biologists discovered two new heron nests in the Oxbow Bend and Moran Junction areas that are geographically separate from historic heron colonies.



Great blue heron productivity in Grand Teton NP, 1991-2020. Arizona Lake heronry, discovered in 2007 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 nest in colonies located in isolated areas away from human disturbance. They build their nests in the tree tops for safety and work together to monitor predators such as eagles.

During the 2020 breeding season, park staff located and monitored five heron colonies. The Arizona Lake and Pinto Ranch heronries both had eight active nests. Herons produced 24 young at Arizona Lake and 13 young at Pinto Ranch. The Moran Junction heronry had four active nests which produced eight young. The Oxbow Bend heronry had three active nests, yielding seven young. The Sawmill Pond heronry was unoccupied, despite one nest still being present in this area.

In 2020, the total number of active nests (23) was slightly below the 10-year average (24.4), while the number of nestlings (52) and nestlings per active nest (2.3) were slightly above the 10-year averages (50.9 and 2.1 respectively). Overall numbers of active nests and nestlings remained generally stable or slightly increasing for the past 10 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.

Greater Sage-grouse

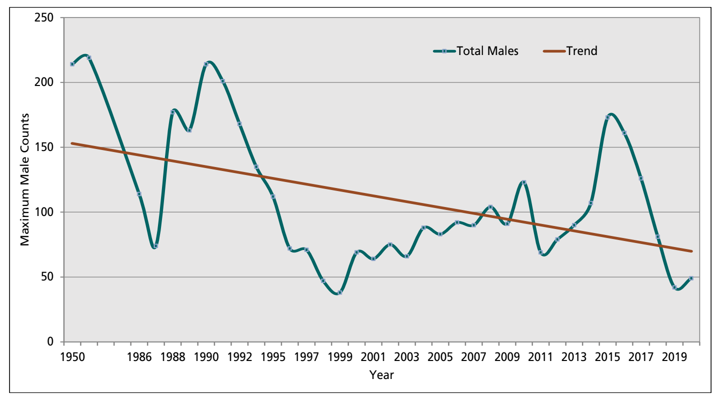
Historically, greater sage-grouse (*Centrocercus urophasianus*) occurred in sagebrush habitats across much of Wyoming and the American West. Sage-grouse populations declined up to 80% throughout their range over the past 50 years, most likely due to increased livestock grazing, farming, residential development, 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 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 2020, eight leks were monitored weekly [seven in the park and one on adjacent National Elk Refuge (NER) land] and sage-grouse consistently occupied seven leks (Airport, Bark Corral, Moulton, RKO, Spread Creek, Timbered Island, and North Gap-NER). The Airport pit, last active in 2014, was inactive again in 2020.

Sage grouse observed were at historic low numbers in 2020. For the six active leks within Grand Teton, the total count of all sage-grouse was 88 and the maximum male count was 49; well below the 10-year averages of 141 and 97, respectively. Biologists made the highest recent counts in 2015 with 304 total birds and 174 males. All leks within the park had counts much lower than their 10-year averages except for Bark Corral. Biologists think these historic lows are caused by limited winter habitat. For the past three of four winters, Grand Teton experienced well-above average snowpack that decreased the amount of exposed sagebrush which is critical cover and food for sage-grouse. This is possibly exacerbated by the loss of >2100 hectares of mature sagebrush habitat since 1998 due to wildfire.

While sage-grouse typically move by walking, they are capable of flying fast, up to 50 mph, but usually will not sustain flight for more than a few miles.



Counts of male sage-grouse with a trend line on Grand Teton NP leks 1948-2020. No monitoring data for sage-grouse in 1952–1985 and 1993.

Sage-grouse gather on a lek in the spring for their annual courtship display. Males prefer areas of lower vegetation so they can be seen by the females.

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. In the first half of the 20th century, garbage became a significant food source for bears throughout the region. In an effort 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, human-caused mortality increased significantly and the population declined from an estimated 312 grizzly bears, prior to the dump closures, to 136 bears in 1975. That same year the grizzly bear was federally listed as a threatened species.

Intensive conservation efforts over the next 40 years allowed grizzly bears to make a remarkable recovery. For 2020, the GYE grizzly bear population was estimated at 727 (95% confidence interval = 648–806). This estimate is based on the estimated number of unique female grizzly bears with cubs in the demographic monitoring area. There are more grizzly bears today, occupying a larger area (25,038 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 bears foraging on native foods in roadside meadows makes Grand Teton a popular bear viewing destination.

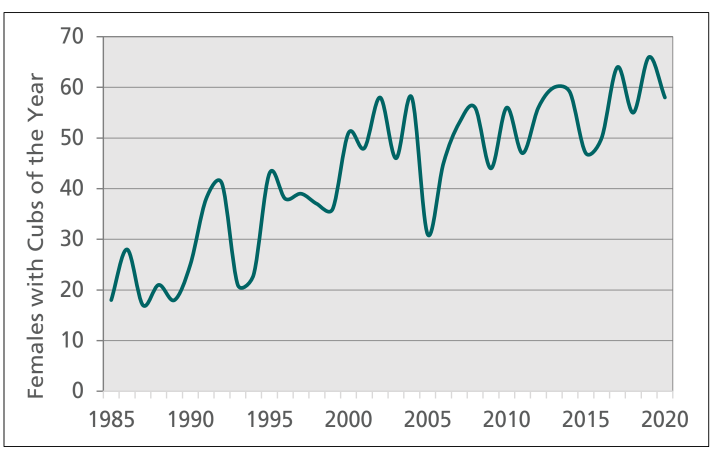
Grizzly bear population recovery in the GYE coincided with increased human occupation on the periphery of the ecosystem and human visitation to public lands. As part of its enabling legislation in 1950, Grand Teton National Park administers an Elk Reduction Program (ERP) cooperatively with the state of Wyoming, when necessary, in portions of the park. Increasing grizzly bear numbers in ERP hunt areas over the last 20 years have created a unique and substantial challenge for national park managers. Given the availability of elk remains from this program, grizzly bears may be attracted to areas where this program is


B. Roberts

One of the more visible grizzly bears in Grand Teton NP is a female known by her research number as 399. She frequents the roadsides with her cubs foraging for natural foods. In 2020, the 24-year-old mother drew additional attention by producing four cubs. Cubs will stay with their mother for two years.

administered. Although uncommon, human-bear conflicts within Grand Teton, including the mauling of an elk hunter in 2011 and the death of a grizzly bear in an elk hunting-related incident in 2012, receive substantial local, regional, and national attention. As a result, park managers sought new, science-based information to help reduce the potential of conflicts. Park biologists established a collaborative research project with USGS scientists. From 2014–15, intensive genetic sampling showed that while non-resident grizzly bears made temporary movements into the study area during hyperphagia prior to the annual start date of the ERP. Resident bears appear to be specializing on the availability of elk remains from the ERP. The current timing of the ERP, helps reduce risks by limiting the availability of elk remains to a small number of resident bears only. Existing measures to reduce risk of human-bear conflicts are effective; however, the risk of encountering resident bears remains for hunters in the field.

This new, science-based research is the first published effort to help inform managers about the ERP conflict potential. The researchers plan to continue their collaborative study through 2021 to better understand the distribution of elk remains on the landscape and how that relates to grizzly bear use. This research will help inform decisions about ungulate hunting in bear country and is applicable to other agencies. Management of grizzly bears and their habitat continues to be a high priority in the park and parkway to ensure human safety and contribute to the population's recovery.



Estimates of grizzly bear females with cubs of the year, 1984–2020, are used to calculate the total grizzly population estimate within the USFWS-designated Yellowstone Ecosystem Suitable Habitat. One recovery criteria is a population of at least 48 grizzly bears females with cubs of the year.


T. Brasington

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 are needed in order to conserve harlequin ducks in Wyoming.

For the last five years, biologists captured breeding pairs in the spring and used satellite transmitters and geolocators to track their movements from the breeding grounds. Due to the COVID-19 pandemic, no monitoring or captures of breeding pairs were done in 2020. In early August, biologists surveyed Berry, Owl, and Moose Creeks to locate females and their broods. Biologists observed one hen with three ducklings on Moose Creek.

The male harlequin's showy plumage is unmistakable while the female is identified by the white patch behind the eye. These small ducks feed by dabbling and diving. Their densely packed feathers trap a lot of air that both insulates them from the cold water and makes them exceptionally buoyant, popping them back to the surface like corks after dives.

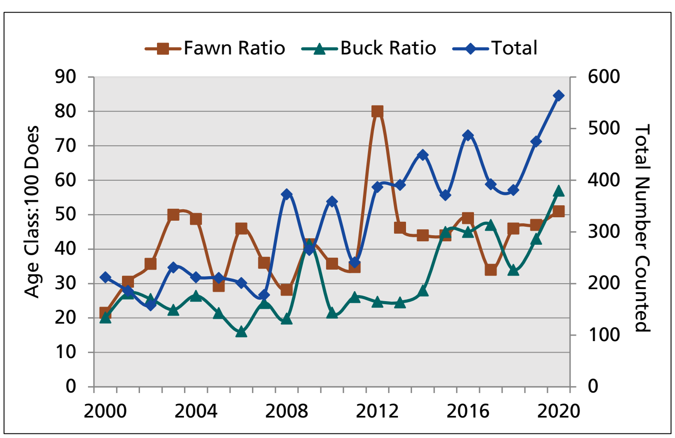
Pronghorn

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 support that animals have been using this narrow pathway for at least 6,000 years. Concern for this migratory segment of the pronghorn herd exists because development (residential and energy) occurs along the southern portion of the route and in the 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 level of precision. Biologists did not conduct the aerial line transect survey in 2020 due to the pandemic.

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 564 pronghorn were counted during the 2020 survey. Ratios were estimated at 51 fawns and 57 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. Fawn ratios returned to average after reaching the highest level seen in more than a decade in 2012. In general, a ratio of 25 bucks per 100 does will maintain good recruitment for the population.

Pronghorns have the largest eyes in relation to body size of any North American ungulate. The placement of their eyes allows for a 300° view without moving their heads. Prominent lashes protect their eyes from the sun in open habitat.



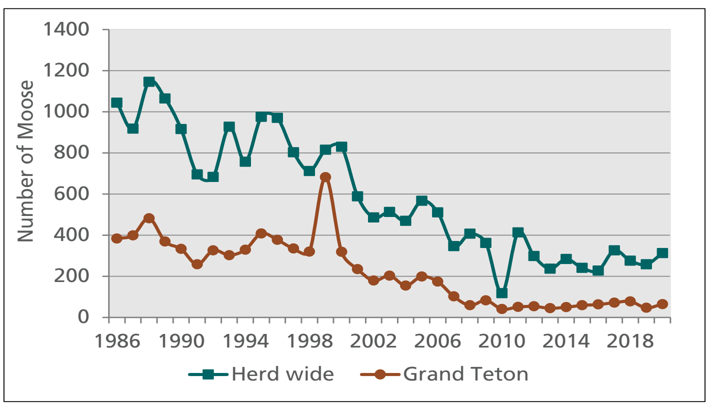
Pronghorn count and age/sex ratios during late summer classification counts, 2000-2020 (data from Wyoming Game and Fish Department).

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 2020 totaled 313 moose (roughly 55 more than counted in 2019), including 65 in 39 groups within Grand Teton (31 cows, 20 bulls, and 14 calves). Ratios were estimated at 50 calves and 71 bulls per 100 cows.

The moose herd decline likely resulted from a combination of interacting factors. The ecological landscape of today is dramatically different than the turn of the 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, and 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. Conversely, 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 remain absent after large catastrophic fires. Additionally, warming temperatures associated with changing climate may be affecting moose, by altering their feeding and other activities, potentially affecting food intake.

The heavy muzzle of the moose helps seal the elongated nostrils (up to 4" wide) when the moose plunges its head underwater to eat pond vegetation. The specialized structures close automatically and tightens with increased water pressure allowing moose to dive, chew, and swallow underwater.



Jackson moose herd mid-winter counts, 1986-2020 (data from Wyoming Game and Fish Department). These counts are used to estimate overall herd size.

Biologists continued to photograph hair loss in moose, a project initiated in 2012. Researchers analyze the extent of hair loss caused by winter ticks loads on moose because hair loss can leave moose unable to properly thermoregulate. Due to the COVID-19 pandemic, seasonal staff did not start until June and did not have time to complete the photo analysis; therefore, results from 2020 moose tick surveys will be reported in 2021.

2020 Field Notes

Park staff share some of their more interesting field adventures.

Reba McCracken: I was out with Luxianna Watkins visiting hydrology monitoring sites near Elk Ranch Reservoir. Going there is often an interesting wildlife experience, mostly because of the bison that frequent the area. We always call John Stephenson (wildlife biologist) before we head that way in case there is something for us to worry about—I mean, be aware of. This time, he told us, there was a nesting pair of swans on the reservoir, and he asked if we could note the reservoir level and let him know how the birds were behaving. We gladly took this on, and with all of our attention devoted to the swans, we did not notice the wolf that was observing us from ~75 yards away. We both looked up to see it all of a sudden. I can't remember what sort of frightened gibberish we said to one another, but we hurried back to the vehicle as calmly as we could and called John immediately. Of course, he was nowhere near as excited as we were and seemed surprised to hear we'd left so quickly. Personally, I'm glad the things I study can't eat me.

Another time on an overnight trip in upper Death Canyon, I woke up suddenly—something was rustling around the campsite. I tried to reassure myself that it was nothing. Eventually, however, my paranoia got the better of me, and I unzipped my tent to find myself face to face with the business end of a porcupine. I quietly tried to shoo it away, but every time I convinced it to leave, it would come right back. In the morning, I found that it left a calling card: a single quill protruded from the edge of my vestibule.

Erin Shanahan: Early one July morning, we were hiking to a monitoring transect along the Cascade Canyon trail in the park. I stepped off the path to check out a possible pika hay pile (it was not) at the bottom of a scree field. When I popped back on the trail, I completely frightened three young women, each carrying a large backpack, coming down the trail from the opposite direction. After apologizing for scaring them, I asked if they had been camping overnight. They had and after two nights in the backcountry, were returning to their vehicle at the trailhead. Since backpacking/camping would be the last thing I would do for fun, I asked if they were with some sort of group that required them to camp in the backcountry. They explained that no, they just wanted to get outdoors after being cooped up at school and had planned this trip together. I was impressed that they went camping under their own volition as I never would have done something like that when I was in college or even after college for that matter!

I asked where they went to school and what they studied. One young woman said she was an Environmental Science major. I told her that I worked for the NPS's Greater Yellowstone Inventory and Monitoring Division and that we typically hired college interns to work with us during the summers. I gave her my contact information and told her to get in touch over the winter if she was interested in finding out more. She did and is going to work with us in 2021. Serendipitously, she possesses science communication talents that will benefit us, and in turn, she will acquire valuable field experience to build her skill set and resume.

Mike Canetta: Toward the end of each field season (late September/early October), we typically attempt to deploy PIT tags (microchip tags) in Taggart Lake cutthroat trout. This is part of a long-term effort to study where and when these native fish spawn in Taggart Lake. The process of tagging fish is relatively simple: 1) capture fish using highly sophisticated methods such as rod-and-reel; 2) place fish in a bucket of fresh water so it can breathe; 3) insert PIT tag into the fish's pelvic girdle using a specialized syringe; and 4) release it back into the lake. Because most people get into fisheries science to work directly with fish, these are some of our favorite days. But not all field days go according to plan…

Park resource staff spend long hours in the field observing, collecting samples, and managing park resources. Field work is often a favorite task.

Jesse Risinger and I hiked to the inlet of Taggart Lake, where we would spend the afternoon attempting to catch cutthroat trout for tagging. It was an idyllic autumn day: cool, crisp air; sunshine and rich blue skies interrupted only by a few fast-moving clouds; and a gentle breeze that made the aspen leaves rattle. Jesse and I donned waders and marched to knee-deep water about ten yards off-shore with rigged rods in hand. Fishing was slow, but it still beats a good day in the office. At least that's what I told myself until we heard the crashing and snapping in the willows behind us.

From the woods near the inlet three cow moose emerged pursued by a large, hormonal bull moose. The cows didn't seem to appreciate the bull's advances, and unfortunately for Jesse and me, all three decided that wading into the lake was their best escape route. Jesse and I began backing away, but we were quickly up to the top of our chest waders and cornered by the four ungulates. Eventually, they all stopped running, but now their attention was firmly fixed on us. We stood quiet and still, in hopes that they would deem us a non-threat. The four moose (now only 20 yards from us) stood motionless and stared directly at us. The entire time, my mind raced through a variety of scenarios that ranged from swimming in hypothermia-inducing water to standing in that exact spot for another twelve hours. Thankfully, the moose tired of the stand-off after about 45 minutes and went on their way, back into the forest. Jesse and I retreated hastily, packed up our gear, and hiked out - the fish tagging would have to wait for another day.

In retrospect, we can laugh when recounting the day's events. With each retelling, the moose get a few inches bigger and the water gets a few degrees colder. It was a humbling experience; a great reminder of just how wild the place we live and work in is. It also serves as a lesson to those of us who have the privilege of working in the field: be aware of your surroundings, be prepared for everything, and be safe.

Mule Deer

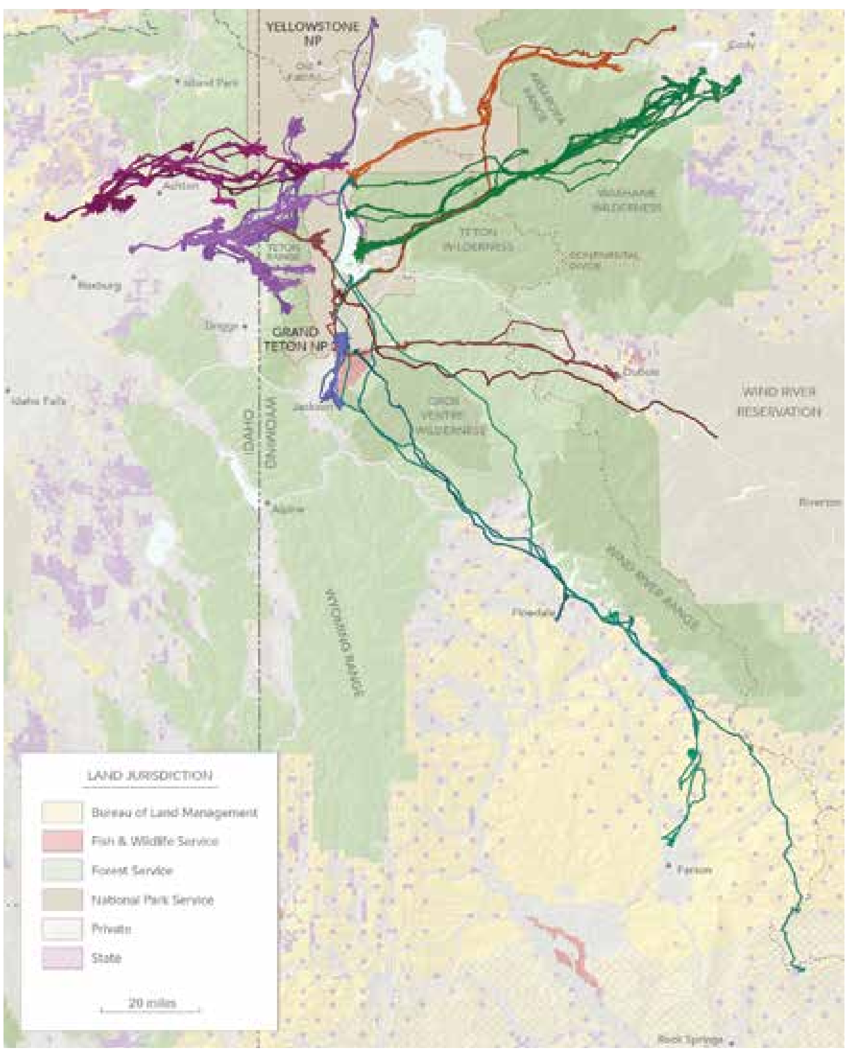
Mule deer (*Odocoileus hemionus*), one of many park animals that are seasonal residents, undertake annual migrations to distant wintering areas to meet their biological needs. Migrations showcase the behavioral strategies species use to exploit seasonal resources in otherwise inhospitable environments. Despite their intrinsic and ecological value, animal migrations have received little conservation attention until recently. Documenting animal movements is an essential first step to meaningful conservation actions.

Park mule deer research provides information essential to protecting important animal migration corridors in the Greater Yellowstone Ecosystem. Park scientists are documenting the migrations of mule deer moving between summering grounds in Grand Teton National Park and the John D. Rockefeller, Jr. Memorial Parkway (JDR) and crucial wintering areas throughout the ecosystem. Specific objectives for the 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, and conservation needs; and working with partners to conserve migration routes and important seasonal habitats.

Born with spots for camouflage, a mule deer fawn only weighs about six pounds at birth.

Since the project began in 2013, park biologists collared 54 adult female mule deer on summer range in the park and parkway. Our Idaho Fish and Game partners captured and collared 62 mule deer on Idaho winter ranges (including 21 at Sand Creek Wildlife Management Area, 38 along the Teton River, and 3 near the Teton Front outside of Victor, ID). Collectively, biologists have recorded 341 complete migration sequences that describe eight population-level corridors (travel paths of differing groups). The travel paths form a far-ranging migration network spanning multiple land jurisdictions in two states. In all but one of the corridors, there were a minimum of four land jurisdictions. Four of the corridors included six jurisdictions while the routes traversing the western front of the Wind River Range crossed seven. The migration encompasses a wide variety of habitat types from sand dunes and sagebrush steppe to montane forest and alpine meadows.

Within the eight corridors tentatively described to date, elevations ranged from 5,000 feet on wintering grounds to over 10,000 within 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. 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 was a mule deer traveling between Spalding Bay in Grand Teton and wintering grounds northeast of Rock Springs and the Interstate 80 corridor.



Travel paths of 68 mule deer that migrate seasonally from Grand Teton National Park and the Teton Range and cross multiple of land management jurisdiction boundaries.

Raptors

Golden eagles have wing spans that can reach over 7 ft. They eat both fresh kills and carrion. They often have cycles of feast or famine, going for days without food and then gorging up to 2 lbs in one sitting.

More than 14 raptor species reside in Grand Teton either seasonally or year-round. Bald eagles (*Haliaeetus leucocephalus*), ospreys (*Pandion haliaetus*), peregrine falcons (*Falco peregrinus*), and golden eagles (*Aquila chrysaetos*) are of special interest because of their ecological importance or vulnerable population status in Wyoming or the western US. With relatively small populations and limited distributions, these top aerial predators remain sensitive to human disturbance and are monitored annually.

Bald eagles are large, primarily fish-eating predators that 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 Greater Yellowstone Ecosystem (GYE) and 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 2020, closures were established at nest sites along the Snake River and at the Wilcox Point campsite.

Of the 22 bald eagle territories monitored in 2020, 12 pairs initiated nesting and hatched 6 chicks. At the close of the season, 5 pairs successfully fledged 5 eaglets. The 2020 trend was average in 15 occupied territories (10-year average 14.8) and 12 nesting pairs (11.8), but the 5 fledglings were half of the number fledged in 2019 and half the 10-year average (10.9). The number of fledglings per successful nest in 2020 (1.0) was lower than both the 10-year average (1.33) and 30-year average (1.43), and has only been this low three other times. While successful nests decreased this season, 2020 data indicates a stable breeding population.

Ospreys are medium-sized hawks that prey almost exclusively on fish. The osprey population in Grand Teton is migratory and research documents that ospreys from the park migrate to the Mexican gulf coast and Cuba for the winter. Park staff started monitoring osprey nests in 1968. While only 6–9 nests were occupied annually 1978–1981, more recently ospreys occupy approximately 13 territories (10-year average 13.5). Generally, ospreys nest near low-elevation lakes and along the Snake, Gros Ventre, and Buffalo Fork Rivers and their tributaries. Osprey are occasionally found in park canyons from mid-to-late summer, but nesting in these areas has never been documented.

In 2020, ospreys occupied 9 of 17 (52.9%) monitored territories. Breeding activity occurred at 6 of these sites and 3 pairs successfully fledged a total of 6 young. These numbers are almost half of the 10-year averages (6.8 successful breeding pairs and 11.4 young) and marks the lowest number of occupied territories to date (previous low of 11 in 2011). Of special note, the shorter field season due to the 2020 COVID-19 pandemic presented monitoring obstacles. One pair of osprey was not counted in the total of nesting pairs since their nesting activity is unknown and three chicks are not included in the fledged total as their survival is also unknown.

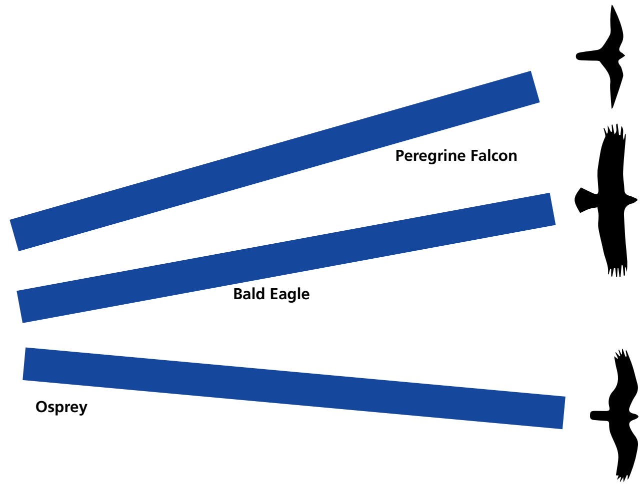
Although the number of territorial pairs has declined since 1990, the trend in active nests that are successful is more stable. The decline in the number of occupied territories coincides with an increase in the number of territorial bald eagles. Compared to bald eagles, osprey populations recovered relatively quickly following the banning of DDT and now that eagles are once again more prevalent, osprey populations may be responding by stabilizing at a lower level.

Peregrines are cliff-nesting falcons that mainly eat other birds. The lower elevations of the major Teton Range canyons provide peregrines with excellent cliff-nesting and diverse foraging opportunities. Decimated by DDT, peregrine falcons disappeared from the GYE by the 1960s. From 1980–1986, 52 fledgling falcons were released at sites in Grand Teton National Park and the John D. Rockefeller, Jr. Memorial Parkway. Following reintroduction, peregrine falcons first attempted nesting in 1987 at Glade Creek and successfully fledged young the next year. Peregrines, once listed as threatened under the ESA, were delisted in 1999. Recently, peregrines occupied territories in Garnet, Death, Cascade, and Webb Canyons; Blacktail Butte; and Glade Creek.

In 2020, peregrines occupied 4 of the 6 territories monitored within the park and parkway. Of those occupied territories, peregrines successfully fledged one chick in Webb Canyon. Biologists observed peregrines in the Blacktail Butte territory copulating, but the eyrie failed to reproduce and was vacated. The Glade Creek territory was occupied throughout the summer, but no nesting activity was observed. Both Garnet Canyon and Steamboat eyries were not occupied in 2020. After adult peregrines displayed courtship behavior near Baxter's Pinnacle in Cascade Canyon, park managers established a temporary closure to protect the eyrie located close to a popular rock climbing route, but reopened it after biologists confirmed that the pair did not initiate nesting. The Death Canyon territory was not monitored in 2020. The breeding statistics for 2020 were below the 10-year averages with just 2 successful territories (2.4) and 1 chick fledged (4.4). Due to the pandemic, very limited spring surveys were completed. Spring is a crucial time to detect territory occupancy and nest initiation for peregrines. While the percent of successful pairs is highly variable, the peregrine falcon population in Grand Teton is stable and the trend in occupied territories and successful nests has increased over time.

Golden eagles are large aerial predators well suited to the Teton Range, with its abundance of cliff faces for nest sites and diversity of 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.

Due to a shortened 2020 field season caused by the pandemic, park biologists only conducted golden eagle nesting surveys in three of the seven known territories (Granite, Avalanche, and Uhl Hill). Biologists confirmed Avalanche Canyon was occupied but did not observe any sign of reproductive success. No eagles were observed in Granite or Uhl Hill territories but surveys were not extensive enough to confirm positive or negative occupancy.



The trend for raptor occupancy in the park is increasing for peregrines and bald eagles while the slight decrease for osprey may be stabilizing at a lower level.

Red Fox

Habituation of red foxes (*Vulpes vulpes*) to humans in national parks appears to be increasing in recent years. Habituated foxes have been documented at Acadia, Crater Lake, Grand Teton, and Mount Rainier National Parks. Anthropogenic food sources undoubtedly attract foxes. This includes the purposeful feeding of individual foxes by park visitors, ingestion of fish remains left by anglers during winter, and opportunistically acquiring unsecured food in developed areas. Habituation increases the chances of an animal becoming food conditioned which creates health and safety concerns (e.g., aggression and disease transmission) for park visitors and employees. Therefore, park resource managers aim to minimize the potential for human-fox conflicts while maintaining this valued ecological and wildlife viewing resource.

To address habituation issues and make effective management decisions, park staff began a research project in 2016 to gain a better understanding of fox ecology. Data collected from this project aids in assessments of temporal and spatial movements, distribution, foraging patterns, and diets of this resourceful and charismatic species. Increased ecological understanding of foxes coupled with enhanced outreach and education efforts help reduce human-fox conflicts in Grand Teton, as well as provide a template for addressing this wildlife management issue in parks throughout the country.

Due to known dens near trails, roads or human development, two closures were implemented in 2020 to protect the denning foxes and kits. Remote cameras were set up to capture data about denning chronology, kit survival, and den attendance by the adult foxes.

Grand Teton biologists continued to collaborate with research partners from the University of Wyoming (UW), Haub School on fox research. In the winter of 2020, UW biologists trapped, collared or marked, and collected samples from four foxes in park developed areas. Blood and hair samples were collected for disease and diet analyses, and foxes were individually marked with ear tags and/or fitted with a collar. Samples were also collected from any known fox mortalities (primarily from vehicle collisions).

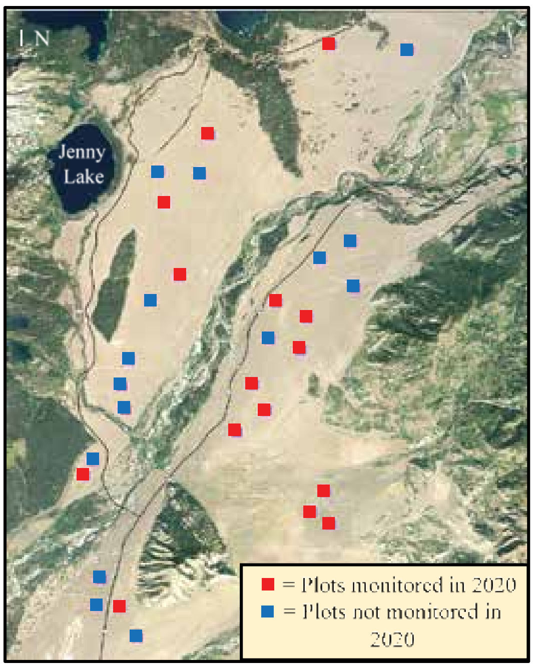
To date, a total of 29 individual foxes have been captured and a total of 28 collars have been deployed. UW graduate students with the Holbrook Team will analyze the disease, diet, and movement data that is being collected. They may partner with biologists to capture additional foxes and deploy more GPS collars in the winter of 2021.

The thick winter coat of the red fox provides remarkable insulation against the cold. It contains three types of fur: fine dense underfur that traps air and provides insulation, long guard hairs that provide water resistance, and intermediate hairs. All three grow together in bundles.

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 a 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. As of 2020, approximately 50% of the historic range of the sagebrush steppe community across the western US is gone, while much more is modified or under threat. In an effort to track changes to this community and monitor its health over time, several NPS Inventory and Monitoring (I&M) Networks use a standardized protocol for long-term monitoring of plots within the sagebrush steppe environment.

Biologists inventory vegetation present in a sagebrush monitoring plot.



Locations of the sagebrush plots monitored on a rotating basis.

In 2010, vegetation biologists established 30 sagebrush steppe monitoring plots in Grand Teton and developed protocols in coordination with the Greater Yellowstone I&M. Since 2020, biologists conducted annual monitoring studies of intact sagebrush communities within the park. This year, biologists monitored ten permanent plots, selected from a rotation cycle. An additional five plots were selected for comparison of the sagebrush restoration occurring in the large-scale Antelope Flats Restoration Project. University of Wyoming and National Park Service scientists assessed the additional sample plots in a collaborative project. Across the 15 total sample units, over 780 distinct quadrats were examined and evaluated for presence/absence, abundance, and cover class of targeted native plant species. The data collected in 2020 was added to a database containing over ten years of information about sagebrush communities in Grand Teton. This information will be used in continued analyses to track changes in community composition across the entire Greater Yellowstone Ecosystem and relate them to environmental and anthropogenic changes over time.

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 species 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 the easily accessible valley lakes and the remote backcountry lakes with game fish including nonnative species: lake, brook, brown, and rainbow trout. With strong support from the park, the last 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.

Grand Teton National Park fisheries staff initiated efforts to develop new tools to census cutthroat trout in the park with the support of the Grand Teton National Park Foundation and the One Fly Foundation. In order 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. The spring is one of the primary spawning springs in the park and has been a location for cutthroat recruitment studies for decades. By understanding the number of fish entering spawning springs and streams, managers improve their knowledge of park cutthroat populations.

In order to achieve a non-invasive census of the fish entering the spring, fisheries personnel fabricated an aluminum weir that funnels 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.

In June 2020, park biologists set up the video weir and recorded numerous fish passing through the weir; however, staff shortages due to COVID-19 resulted in the weir being erected partway through the spawning season negating useful counts.

This video weir is the first one constructed in Wyoming. In the future, this tool is expected to make accurate counts of fish annually without the need to handle them, causing minimal disruptions to their activities. As the tool is refined the fisheries staff plans to use this method on other springs and streams for a more accurate survey of cutthroat in the park.

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 flocks of swans, marginal winter range, variable reproduction rates, limited and low-quality nesting habitat, and high cygnet mortality. Monitored since 1987, Grand Teton provides important nesting habitat for swans.

The number of occupied swan sites, nesting pairs, and young hatched and fledged fluctuated widely since monitoring began. Biologists monitor 18 historic nesting territories: 13 within the park and parkway plus 5 outside but adjacent to park boundaries. Swan pairs have disappeared from some traditional park nesting sites that were occupied for decades. Substantially decreased water levels due to drought and other undetermined causes likely led to abandonment of some sites while increased human activity and predation may affect occupancy and productivity at other sites.

While Jackson Hole's breeding population of trumpeters remains relatively stable since the 1980s (40-64 mature birds), wintering swans from the interior of Canada swell the valley population to about ten times more during the cold months.

In the spring of 2020, park biologists partnered with the Wyoming Wetlands Society and Wyoming Game and Fish to install a swan nesting platform at the Elk Ranch Reservoir. Swan pairs have occupied the reservoir annually since 1980, but only successfully fledged young during three years in the 1990s. In 1991, park staff made modifications to the reservoir to improve nesting conditions for trumpeters as part of the Jackson Lake Dam Mitigation Project. These modifications included a dike and several small islands in the SW corner of the reservoir; however, the dike has since failed.

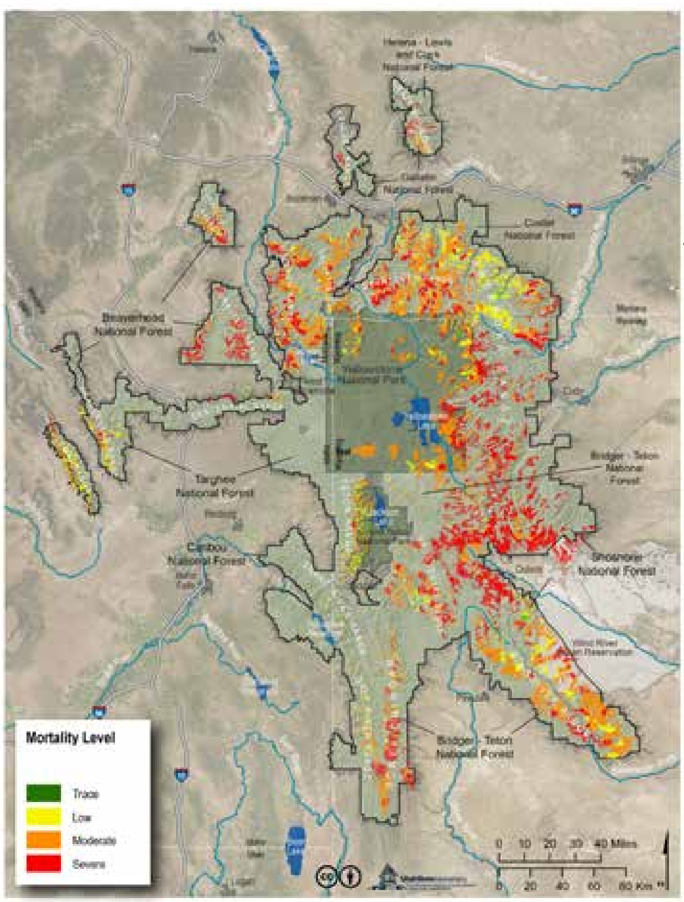
In 2020, nesting territories were primarily monitored from the air. In early April, biologists observed 59 swans. By the breeding season in early June, 14 swans were observed, including three nests. Swan pairs exhibited nesting behavior at three territories: Colter Bay Slough, Pinto Pond, and Elk Ranch Reservoir. The pair at Elk Ranch failed before hatching. Biologists observed a total of six cygnets hatched from the remaining two active territories, but could not confirm that any cygnets survived to the end of summer. In late September, biologists observed 19 swans in four different locations in the park.

Whitebark Pine

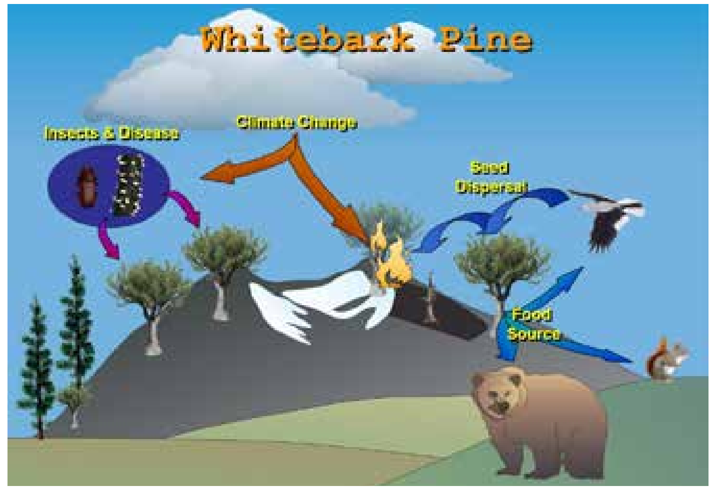
Whitebark pine (*Pinus albicaulis*) is a slow growing, long-lived pine, often the only conifer species capable of establishing and surviving on high-elevation sites with poorly developed soil, high winds, and extreme temperatures. As a keystone species with a significantly greater ecological role compared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

In the past two decades whitebark pine has experienced unprecedented mortality due to the combined effects of native mountain pine beetle, nonnative white pine blister rust, and changing climate conditions. As a result in December 2020, the US Fish and Wildlife Service proposed to list whitebark pine as a threatened species under the Endangered Species Act.

Grand Teton and the John D. Rockefeller Memorial Parkway encompass over 28,500 acres of whitebark pine forests. Of these, 9,726 acres are dominated by whitebark pine and 18,775 acres are stands in which whitebark is co-dominant with other conifer species. The park works collaboratively with other agencies on whitebark pine conservation in the Greater Yellowstone Ecosystem (GYE) and nationally, which increases the opportunities for range-wide protection.



USFS/Utah State University



Whitebark pine, a keystone species, has a large ecological role.

Grand Teton began annual whitebark pine monitoring in 2007 using 26 permanent transects. Park staff monitor five of these transects annually and the remainder in rotation. Ground surveys by park staff in 2020 indicate that many areas of active pine beetle infestation remain and are increasing once again. Blister rust, found throughout the park and parkway, is causing extensive damage to whitebark pine of all sizes. It affects survival of seedlings, the ability of mature trees to grow into large cone bearing trees, and those large trees to produce cones when branches are infected.

Blister rust is present in 90% of the 26 total sampled transects. In 2020, of the 119 whitebark pines sampled 42% were dead, 38% attacked by beetles, 65% of live surveyed trees were infected with blister rust, and 15% produced cones. Whitebark regeneration was present on all transects and seedling density range from 100 to 2,000 whitebark <1.4 meters tall per 100 acres. Beetle activity and blister rust severity (i.e., the amount and location of blister rust on a tree) are greater at elevations below 9,500 feet and on transects with a south aspect. Blister rust severity is greatest on larger diameter trees. Individual whitebark with greater rust severity tend to have a higher incidence of mountain pine beetle attack. The annual ground survey illustrates the dynamic nature of whitebark ecosystems over time: as blister rust and beetle disturbances continue to increase, new trees grow into the overstory, and regeneration density fluctuates.

Overflights of the GYE in 2009 found visible beetle activity in 90% of all watersheds containing whitebark pine. In 2018 and 2019 the overflights were repeated, and the results indicate that 100% of whitebark pine stands in the GYE have pine beetle activity: 18.4% have low mortality; 49.3% have moderate morality, and 32.3% have severe mortality.

Both the ground and overflight data indicate the critical need for conservation and restoration of whitebark pine in the GYE. This ecosystem contains a significant portion of whitebark found on public land throughout the entire range of the species. The remaining seed trees and whitebark habitat in the GYE are critical to the preservation of the species. Continued monitoring of this foundation species and ecosystem provides crucial data to successful conservation and restoration.

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 over time. This diverse archeological record of over 500 sites provides a view into Jackson Hole's past, ranging from 11,000 years of American Indian habitation to historic sites from the last 150 years that are still in use today. 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.

Prehistoric sites include lithic raw materials such as obsidian, used to make tools, and steatite, used to create stone bowls for cooking. More common lithic sites are those with evidence of stone tool manufacture and use. Other sites contain the remains of stone circles indicating the presence of tipis and are found in association with hearths used to prepare a wide variety of plants gathered from the diverse area.

European American presence in Jackson Hole began in the early 19th century with explorers and trappers frequenting the area. By the latter half of the 1800s, government expeditions documented the sparsely occupied valley. Individuals and families followed, determined to establish themselves in the harsh but beautiful environment of Jackson Hole by "proving up" to obtain federal land through the Homestead Act. Sites relating to the historic occupation of the park beginning in the late 19th century and include homesteads, roads, trails, irrigation ditches, and trash dumps.

A primary emphasis of archeological work in Grand Teton is to support park planning and compliance with the National Historic Preservation Act (NHPA). A goal of cultural resource compliance is to integrate research with historic preservation laws to identify, document, and interpret the remaining physical evidence of past human use in project areas, and ultimately consider how proposed projects may potentially impact sites important to our nation's

One side of this obsidian scraper tool, found in Grand Teton NP, is natural to facilitate grasping while the other is flaked to scrape hides or sharpen sticks.

past. The goal of NHPA compliance is to consider options to avoid, minimize, or mitigate potential project effects to significant sites that are either listed in, or eligible for listing in, the National Register of Historic Places. In 2020, archeological compliance work included new inventories in the Moose-Wilson Road area to support road project development and fuels reductions. Cultural staff also assisted Yellowstone National Park in Archeological Resources Protection Act damage assessment of a National Historic Landmark.

Grand Teton conducts formal tribal consultation and informal information sharing with 24 traditionally associated American Indian tribes about ongoing and new projects within the park, as well as listening to tribal feedback and perspectives. The goal of tribal collaboration is to inform decision-making, and interpretation of archeological sites. While the COVID-19 pandemic significantly impacted tribal communities and park operations resulting in decreased communication with tribes in 2020, tribal monitors assisted park staff with implementation of a major park development project.

Historic Structures

Years of bat guano and debris had to be removed to restore the building.

With over 700 documented historic structures located within the park boundaries, management of these important resources requires a lot of collaboration, teamwork, and community support. Park staff remain committed to following Grand Teton's Historic Properties Management Plan, developed to help prioritize care for these aging structures. Despite the 2020 pandemic, preservation work on important buildings continued to conserve and protect the park's National Register-listed and eligible structures.

The rehabilitation of the Snake River Land Company building in 2020 is an excellent example of successful historic preservation work. Constructed around 1927, the building served as a lodge for the Hogan guest ranch/fox farm. The ranch was sold to the Snake River Land Company in 1930. It served as the headquarters for J.D. Rockefeller Jr.'s venture to purchase private lands in support of the expansion of Grand Teton National Park. The company then transferred ownership of the property to the park in 1950.

The Hogan Ranch/Snake River Land Company building is listed in the National Register of Historic Places because of its association with conservation, as well as its late-period vernacular architectural style. The building's interior also contributes to its architectural significance, but the building sat empty for many years, became uninhabitable, and lost its charm under years of accumulated bat guano. In order to bring the structure back to its former glory, it was important to make the building functional again. Adaptive reuse is one of the best ways to preserve a historic structure and ensure it gets routine maintenance and care. Park managers decided to repair the former residence and use it as a law enforcement office and visitor contact station. The work required to make that happen included major exterior and interior work—foundation stabilization; fire and accessibility code modifications; pest remediation; window, door, and log preservation; and landscape improvements. Once the new waterline is completed and interpretive materials are installed in the structure, the building will be ready for use.

Historic preservation work requires collaboration between the park's divisions of Science and Resource Management and Facilities Management, as well as regional support staff. Historic building rehabilitation projects are often complex, requiring input and effort from not only historical architects, but project managers, engineers, landscape architects, historians and skilled preservationists. Thanks to the efforts of the Grand Teton project management team, this important historic structure will continue serving the park for years to come.

The rustic architecture of the old Hogan Ranch lodge includes a unique chimney.

Museum Collection & Archives


Ascent of Hangover Pinnacle.

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.

A recent acquisition to the archives was a scrapbook created by Dick Pownall (1927-2016), one of the first climbing guides for the Exum-Petzoldt School of American Mountaineering. In 1948 during his second season in the area, he began documenting his Teton adventures in a scrapbook. The determination to include the scrapbook in the park's collection was based on the significance of the scrapbook for its documentation of early mountaineering in Grand Teton National Park. There were few guides in the Tetons in the late 1940s, making the scrapbook both unique and a rare piece of local history.

The scrapbook is 127 pages and includes 91 photographs, with numerous typed accounts of ascents and first ascents of peaks in the Teton Range. Of specific detail is the eleven-page narrative of Pownall, Glen Exum, and Mike Brewer's first ascent of the east face of Thor Peak. Other ascents included are the south face of the Grand and the Otter Body snow field; the north face of Cloudveil Dome; and a detailed account of series of ascents known as "The Grand Traverse". The Pownall party did the traverse in reverse of what is currently done, going from Nez Perce to Teewinot, summiting Cloudveil, South Teton, Middle Teton, Grand Teton and Mount Owen in between. The Pownall scrapbook is now cataloged and scanned allowing for long term preservation of the original document and broader access.


Dick Pownall and Mike Brewer - Mount Owen, 1949.

Herb Pownall, Dick's cousin, climbs through sun-cupped snow formations ascending the east ridge of the Grand.

Climate Change in the Tetons

David Thoma is a NPS ecologist who works for the Inventory and Monitoring Network and monitors the health of several parks on a broader scale.

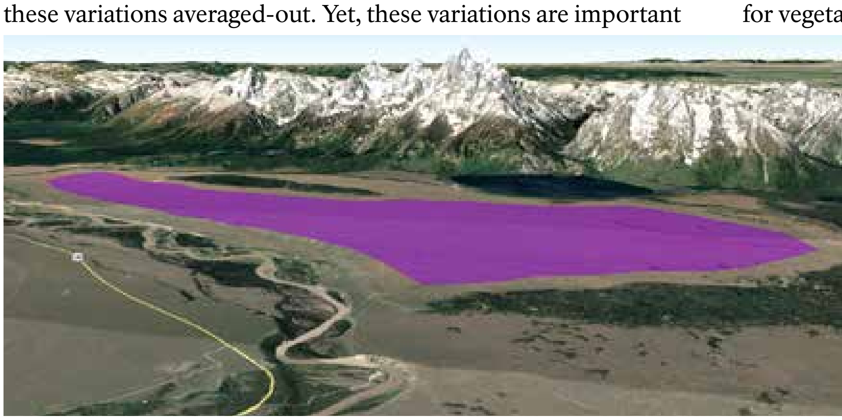
There's a lot in the news about climate change these days, especially this year as the drought in the western US intensifies. Unless things change soon, we can expect more hardship for ranchers, farmers and firefighters. Extreme events are attention grabbing, because they result in obvious hardship for people and nature. But when conditions aren't obvious, how sensitive is nature to climate? A gardener could look at their tomato leaves or feel the soil to know when to water, while a golf course manager might have more sophisticated sensors in the ground that tell her when to turn on the sprinklers. But what about park managers, how can they know when plants are a little thirsty, or really suffering? And, what does the future hold? Specifically, where and when might vegetation change in response to drought stress? Will it be abrupt or gradual, and is there anything park managers can do to mitigate change, or should they? These questions will determine how park managers respond to climate change and indeed what parks will look like in the future.

Our research is motivated by questions like these, and our long-term monitoring is revealing answers because monitoring is the key to understanding the future. The NPS Inventory and Monitoring program measures the condition of vital signs, or indicators of park health. Like your own vital signs of heart rate and blood pressure, park vital signs indicate general conditions that might need further investigation, but are not necessarily a diagnosis. Some of our monitoring is done on the ground through field work. But we can't reach every corner in every park, every year or so we also use satellite imagery to monitor broad areas as they change, responding to both good and bad years. We're moving beyond just paying attention to disasters or extreme conditions and getting closer to identifying just how sensitive vegetation is to weather.

In spite of all the talk about drought and its consequence, such as the 2016 Berry Fire, our ground-based monitoring from 2012 through 2018 found no evidence of change over time in vegetation composition or cover in the Baseline Flats sagebrush habitat that encompasses a large portion of the park's valley floor. Sure, there were ups and downs in the greenness recorded in the satellite imagery which indicated that vegetation production increased in wet years and decreased in dry years, but over long periods of time these variations averaged-out. Yet, these variations are important though because they allow us to calculate the critical water need of the vegetation on Baseline Flats. It's like the recommended eight glasses of water per day for a person, but for a large native landscape that performs important ecological functions for sage-grouse, pronghorn, bison, and elk. We call this critical water need a pivot point because it's a minimum need (like eight glasses) where more water is okay, but with less water vegetation condition begins to decline and eventually suffer. In addition to the quantity needed we also calculated the sensitivity to water abundance which tells us how much the vegetation greenness changed when it got more or less water. This level of specificity about water needs and drought tolerance answers two important questions about climate impacts to this place in the park: what is the critical water need, and how sensitive is it to deviations from the critical need?

Interestingly, we found precipitation was poorly related to vegetation greenness, but the relationship with soil moisture was strong. This is because about 40% of annual precipitation runs off or infiltrates deeply and is not available to plants; however, soil captures and stores water for plant use. It may seem obvious, that soil stores water, but it's so important that we can't understand the fate of vegetation in the future without considering the role of soil, even when we're talking about water.

The most important thing we learned in that the critical need for vegetation growing on Baseline Flats is 43 mm (1.7 inches) of soil water during the growing season. The vegetation greenness teeters above or below average around that value and it can be used to determine when vegetation gets stressed. From this research we learned that we can use a climate variable (soil moisture) to determine vegetation stress and furthermore since it's a climate variable we can model it into the future to determine frequency and amount of stress in the future.

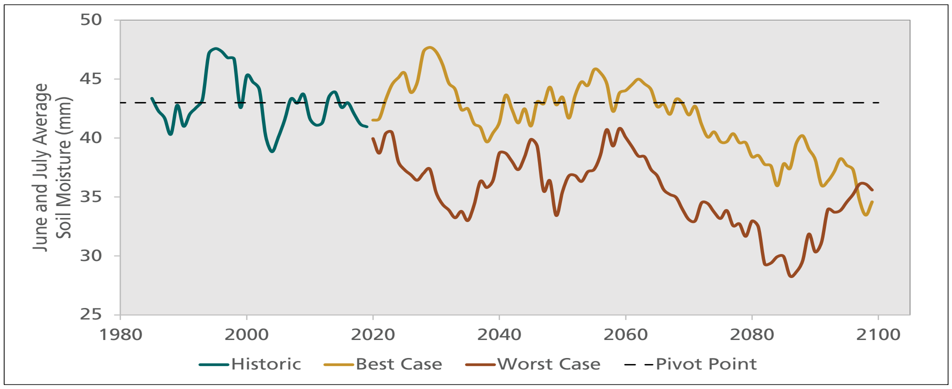


Google Earth

The Baseline Flats sagebrush habitat (indicated in purple) analyzed for historic and projected response to climate change in Grand Teton NP.

Climate models that depict alternate futures (e.g. high greenhouse gas emission scenarios vs. low emissions scenarios) help us consider the likely range of conditions. For example, two models represent a warmer and wetter future (MIROC5 RCP 4.5) and a hotter and drier future (MRI-CGCM3 RCP 8.5). These two models represent what we call a best and worst case scenario that bracket most of the future possibilities.

As shown in the graph, climate projections show soil moisture will decline under both scenarios in the future (colored lines fall below the dashed line). By late century soil moisture conditions that sustained average June and July production in the past will rarely occur. Even though snow melt and spring rain will continue to top-off soil moisture each spring, warming will result in an earlier start to the growing season which means a longer dry season in most years. Our findings are similar to other studies in sagebrush ecosystems across the west. The decline in future soil moisture suggests declines in vegetation condition and cascading effects on animals that depend on it. As these changes play out, the vegetation and animals that call Baseline Flats home will adapt to those changes, move on to other habitats, or perish. How that plays out, whether it's abrupt or gradual is uncertain. In the meantime, looking to places where the climate today is like that projected for Jackson Hole in the future can provide some insight.



June and July average soil moisture projections relative to the critical soil moisture needed by vegetation (43mm) on Baseline Flat area east of Jenny Lake. By 2060 soil moisture conditions will rarely be sufficient to maintain average production achieved during the early 2000s.

Is this a big deal?

Baseline Flat is among the lowest, warmest and driest habitats in Grand Teton NP and vegetation growing there today is adapted to those conditions and relative to other vegetation types it is among the most drought tolerant. For this reason, this habitat is considered relatively robust to drought and may persist in the absence of fire or severe drought into mid-century. But the strength and frequency of drought after mid-century (and declines in soil moisture April through July not shown) suggest vegetation transitions may be inevitable. However, on the bright side, if change occurs slowly in this habitat due to its drought tolerance or societal choices that reduce carbon dioxide (CO_2) emissions that would be fortunate because it gives time to proactively plan for change. That's a distinct advantage over having to reactively respond to big changes like the recent mass mortality of whitebark pine in the Greater Yellowstone Ecosystem due to climate warming.

What can or should be done?

First and foremost that depends on management goals for the resource, in this case Baseline Flats and whether it's appropriate to resist, accept or direct change. Understanding the expected change in climate (declines in growing season soil moisture) is a first step in determining the appropriate management response to ecological transitions. Understanding the expected changes in climate and how that affects plants supports management planning and helps develop strategies for the future. Critical to successful proactive management is knowing what, where, when and why natural resources are likely to change. For example, change is likely coming to the vegetation and dependent animals on Baseline Flat, by mid-century or sooner, due to reductions in growing season soil moisture. That sets the stage for planning and additional monitoring or studies that fill gaps needed to develop strategies that can achieve management goals. This stepwise process is formalized in the Climate Smart Conservation planning framework which is being used in Southwestern parks to manage grasslands and pinyon-juniper forests and locally in the Greater Yellowstone Ecosystem to develop management strategies for aquatic resources and whitebark pine.

David Thoma, Landscape Ecologist

Antelope Flats Restoration

2019/2020 Antelope Flats Restoration Accomplishments	
Antelope Flats restoration seeded in 2019	168 acres
Mechanically harvested seed in 2019	407 lbs
Acres surveyed for cheatgrass in 2019 (Henrie Unit)	323.5 acres
Acres surveyed for cheatgrass in 2020 (Aspen/Hunter)	275 acres
Acres spayed for cheatgrass in 2020	4.4 acres

Eleven years ago, Grand Teton National Park planted the first seeds to begin the restoration of native sagebrush shrubland plant communities in the relic agricultural lands known as the Kelly hayfields. Park vegetation crews continue the long-term restoration of Antelope Flats (formerly known as the Kelly hayfields) from nonnative pasture grass to native plant communities that provide important resources for elk, bison, antelope, sage-grouse, pollinators, and other grassland species. Over the subsequent 11 years, restoration has progressed on the 4,500-acre Antelope Flats Restoration project, resulting in 1,320 acres transitioned from smooth brome monoculture to native forb and shrub plantings.

Maintaining and expanding the Antelope Flats Restoration footprint includes using herbicide to remove nonnative grasses, surveying and treating noxious weeds, collecting and spreading native seeds, monitoring restoration trajectory, and implementing follow-up treatments in response to data. This season, the Park's restoration team partnered with the Botany Department at the University of Wyoming to initiate a comprehensive evaluation of the past 10 years of vegetation data to evaluate the ecological function and trajectory of the Antelope Flats Restoration project. This partnership enables the Park to identify ways to improve restoration success based on species establishment, plant functional traits, and weather variables such as precipitation. The information gained from this research will help guide and prioritize restoration efforts for the next ten years. In support of this collaboration, GRTE vegetation staff collected data from 88 monitoring sites throughout the restoration project to help inform and develop native plant establishment models.

In addition to research and monitoring, the vegetation crew and contractors continued to manage noxious weed populations in the project area, thoroughly mapping and treating undesired plant species. The vegetation crew surveyed 275 acres across four restoration units for cheatgrass and chemically treated 4.4 acres. Cheatgrass is a nonnative, cool season, annual grass that has severely altered rangeland ecosystems throughout the West over the last 50 years. Although it does not occur in large, thick stands like it does in warmer climates, cheatgrass is encountered sporadically throughout the Antelope Flats hayfields and can potentially outcompete native species within restored areas. The vegetation management crew will continue to monitor these mapped and treated cheatgrass populations into the future to protect restoration efforts and uphold the goal of providing functional habitat for wildlife.

Bison graze on restored grasslands in the Antelope Flats Restoration. August 5, 2020.

Aquatic Invasive Species

Aquatic invasive species (AIS) are aquatic organisms that are not native in a particular watershed. These species vary in size and phylum and are most often, but not solely, introduced to a new watershed via watercraft. Once introduced, many species can thrive without the presence of their natural predators or competitors. This can result in major alterations to native ecosystems, and adversely affect recreation, water utilization, and the local economy. A few examples of species that have recently expanded their range 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 in the US and significantly expanded their range in the last 10–20 years, but have not been found in the park or parkway.

The park has enacted measures to prevent the introduction of AIS, inspecting watercraft and educating boaters on practices to prevent the spread of unwanted species. In 2020, for the fifth year, the park had watercraft inspection stations at two locations operating daily during prime visitation periods (June 5–September 27). Crews inspected 29,933 watercraft passing through the stations. (Commercial rafts are only used on the Snake River and therefore are not inspected.) In the summer of 2020, 305 boats/day came through the stations an increase from previous years (197 boats/day in 2019 and 189 boats/day in 2018). Staff preformed 59 decontaminations to reduce the risk of AIS introduction and documented at least one boat with dead mussels.

An AIS inspector uses a hot-water sprayer tool to decontaminate a boat that was last on Lake Powell, a quagga mussel infested lake.

The COVID-19 pandemic contributed to a later start of the season and likely the dramatic increase in the number of watercraft entering the park to recreate. The increase (>54%) in boat numbers is also partially attributable to the Wyoming Game and Fish Department reclassifying stand-up paddle boards (SUPs) as watercraft and requiring SUPs be inspected when passing watercraft inspection stations, mandated by Wyoming law. While SUPs contributed to the increase in volume, they did not account for the overall increase in volume (SUPs represented 19.3% of inspections in 2020).

Boaters can help prevent AIS introductions and speed inspections by ensuring they drain, clean, and dry their watercrafts and gear after every use.

Recreating on park lakes is a popular activity for park visitors. They arrive from all over the country with small watercraft like stand-up paddle boards, kayaks, and canoes increasing the chances that they will also bring an aquatic invasive species to park waters.

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 mis-folding. Animal-to-animal transmission is likely a primary means of disease transmission early in an outbreak. CWD also spreads indirectly via prions 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 a road-killed 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 rented a large walk-in freezer in 2019, to store mule deer carcasses, while test results were pending. A permanent freezer, funded by Grand Teton National Park Foundation, was installed in 2020. To enhance surveillance efforts, the park initiated mandatory CWD testing of all hunter harvested elk during the elk reduction program (ERP) in 2019. Intensified sampling continued in 2020.

One-hundred ninety-nine samples were submitted to the laboratory for testing: 32 from road-killed cervids, 165 from hunter harvested elk, and 2 from targeted individuals (1 mule deer and 1 moose). Of those samples 177 were collected from elk, 20 from mule deer, and 2 from moose. In December 2020, the Wyoming Wildlife Health Laboratory confirmed a CWD positive detection of an elk within Grand Teton National Park. This represents the first detection of CWD in the Jackson elk herd. The sample was submitted by a participant in the ERP and was harvested in the Kelly hayfields. No other positive detections occurred. Jackson elk herd managers have been intensively sampling the elk herd for more than a decade. The fact that this marks the first detection 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.

Testing

All samples were tested using enzyme-linked immunosorbent assay (ELISA) at the Wyoming Wildlife Health Laboratory in Laramie, WY. All suspected positives via ELISA testing were subsequently retested via ELISA and further confirmed via immunohistochemistry (IHC).

Road-kills: CWD samples are collected from road-killed cervids throughout the park by NPS staff.

Mandatory sampling of hunter-harvested elk: Samples are obtained from elk harvested in the park during the Elk Reduction Program. Samples were collected from 1) elk heads deposited at a drop location, 2) field sampling by NPS employees, and 3) collection of heads at the meat processer.

Sick/Targeted individuals: Samples are collected from cervids that appeared sick or died of unknown causes.

Elk Reduction Program

The legislation that created the expanded Grand Teton National Park in 1950 included a provision for controlled reduction of elk in the park, when necessary, for the proper management and protection of the elk herd. A long-term objective of the program is to reduce the need to harvest elk within the park. Management of elk in the park and on the National Elk Refuge (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. Also outlined in the plan is a strategy to restore previously cultivated lands in the park to improve habitat condition on elk winter and transitional range. The plan projected that roughly 1,600 elk would summer in the park given plan implementation.

The need for the elk reduction program (ERP) is evaluated and determined jointly by Grand Teton and WGF on an annual basis, based on plan objectives and data collected throughout the previous year during both the mid-summer classification count in the park and the mid-winter trend count that includes elk wintering outside of the park.

Both the annual mature bull ratio and the five-year running average were below the threshold identified in the BEMP, at 28 bulls per 100 cows. At this level biologists recommended no bull harvest for 2020. The 2020 mid-winter trend count was 10,985 elk and the three-year running average 10,514, 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 20 calves per 100 cows. With the trend for the Jackson elk herd remaining stable, the antlerless harvest in 2020 was intended to slow growth of the herd. Park managers are discussing with other agency partners conditions under which an ERP would not be warranted in some years since the population has been at objective since about 2013.

The 2020 elk reduction program was structured similarly to the 2019 season with no permits offered in Hunt Area (HA) 79. The number of permits authorized in HA 75 increased to 550 from 375. The ERP was conducted for 36 days from November 7–December 13. The Antelope Flats portion of HA 75 closed on November 22th. Hunt Area 79 was not open because biologists observed fewer elk during summer surveys in that area and the productivity of these elk was reduced 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.

A total of 161 elk were harvested during the ERP in 2020. The majority (84%) of elk taken were adult cows. More than half of the harvest occurred during the first two weeks of the season.

While some bull elk were harvested during past years, the ERP is structured to manage population numbers and currently is limited to antlerless elk.

Fish Passage

Park biologists monitor the health of park fisheries. Of special concern is the fragmentation of fish habitat, usually the result of human actions. Alterations to a water course can make it difficult for fish to travel to critical portions of the waterway. Mitigating obstacles can facilitate fish passage. Irrigation ditches draw from several drainages in the park for agricultural purposes within or adjacent to the park. Water drawn from streams also hosts fish that may end up trapped or entrained in these ditches. Once entrained, fish have difficulty finding their way back into streams and often die prematurely. Fisheries biologists monitor fish passage and/or entrainment especially in Spread Creek, the Granite Supplemental Ditch, and Ditch Creek.

The 2010 removal of the diversion dam built on Spread Creek in the 1960s allowed fish to access 65 miles upstream; however, the newly installed irrigation infrastructure still captures some fish as they migrate downstream. The park partners with the Wyoming Game and Fish Department (WGF), Trout Unlimited (TU), the Snake River Fund, and volunteers to help return about 100–300 cutthroat trout back to the stream annually. By 2018, deteriorating rock weirs on the structure caused significant challenges with flow changes and fish entrainment. Biologists plan to address these issues by constructing a new structure in 2021.

Another irrigation system, the Granite Supplemental Ditch, draws 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 draw of river water entrains all species of fish at varying life stages each summer. To understand how this ditch, which crosses paths with some perennial streams, affects the fish that enter the ditch from the river, park fisheries staff teamed with WGF and TU to implant transmitters in 15 adult cutthroat in 2017 and another 30 in 2018 to monitor their fate. Data analysis suggests that the mortality rate for trout is up to 73% after entering the ditch. Some adult cutthroat are able to escape the ditch. High numbers of other fish also get stranded in this ditch and are less capable of escaping the high water velocities at the headgates, likely experiencing 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. The 2019 data suggested significant entrainment occurred at the headgate, though there was some suspected bias due to the lack of night sampling. In 2020, sampling occurred at all hours throughout the season. While analysis of the 2020 data is still in progress, initial review shows that data on cutthroat entrainment gathered in 2019 was not dramatically biased.

The Granite Creek Supplemental Ditch draws fish in when the headgates are open, and then as the water recedes, fish become trapped in shallow pools with no exit.

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 hosts several species of spawning fishes including Snake River fine-spotted cutthroat trout, bluehead (categorized as extremely rare by WGF), Utah and mountain sucker, and other small non-game 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 agricultural pursuits. In 1957 and 1960 two bridges with culverts were installed across the stream. These culverts were too long and steep for fish to negotiate when attempting to access spawning habitat upstream of these obstacles.

In 2012 and 2014, park staff installed baffles in the culverts to mitigate the obstacle for fish. Unfortunately the stream also avulsed west of Mormon Row Road in 2014, stalling the efforts to restore fish passage. While aggrading and avulsing is the stream’s natural tendency, the ditches and repeated channelization of the stream caused a new series of barriers to materialize. In 2017, the park partnered with the Grand Teton National Park Foundation, One Fly, and Patagonia to successfully raise funds and hire an excavation company to reactivate the primary channel and restore Ditch Creek as a fish-passable stream. 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. Over five years, biologists captured and Passive Integrated Transponder (PIT) tagged 170 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.

Habitat connectivity is vital in maximizing the resiliency of the fishery. Working with water rights holders to increase the efficiency of irrigation ditches and reduce entrainment are strategies that could help keep the fishery healthy.

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 create a high potential for human-bear interactions.

To decrease conflicts, park staff strictly enforce food storage regulations, all park facilities have bear-resistant garbage receptacles, and the park emphasizes "Bear Aware" public educational messages. The primary focus is to keep human foods away from bears. Since 2008, the park, with generous support from Grand Teton National Park Foundation, has installed 911 bear-resistant food storage lockers in park campsites and picnic areas toward that goal.


A black bear scared a family away and helped herself to dinner.

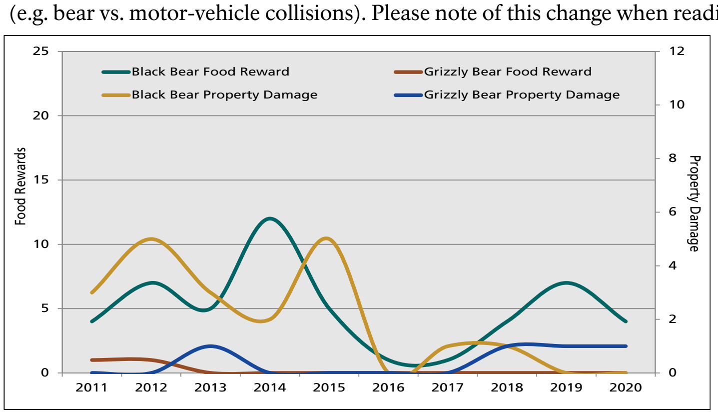
Human-bear confrontations are defined as incidents when bears approach, follow, charge, act aggressively toward people, enter front-country developments, or enter occupied backcountry campsites without inflicting human injury. Human-bear conflicts* are incidents when bears damage property, obtain human foods, or injure (or kill) humans. In 2020, park staff recorded 151 human-bear confrontations and 6 human-bear conflicts. In these conflicts: a grizzly bear caused property damage at two Moose, WY residences breaking a door window and damaging another door's screen; a bear of unknown species ripped up a motorcycle seat; and four black bears received human food-rewards. The food rewards included a black bear that entered an occupied campsite on July 22 and obtained a significant food reward when the family abandoned their dinner and retreated to their car. The bear remained on site for close to an hour. This bear was caught and euthanized on July 23, 2020.

Grand Teton staff work diligently to prevent bears from developing nuisance behaviors. When humans fail to secure their food, bears can develop unwanted behaviors. Trained staff follow an established protocol to haze bears from developed areas and roadways, when necessary. Park staff hazed bears 130 times in 2020, using noise (yelling, horns, sirens), vehicle threat pressure, throwing small rocks, sticks, and firing bean bags.

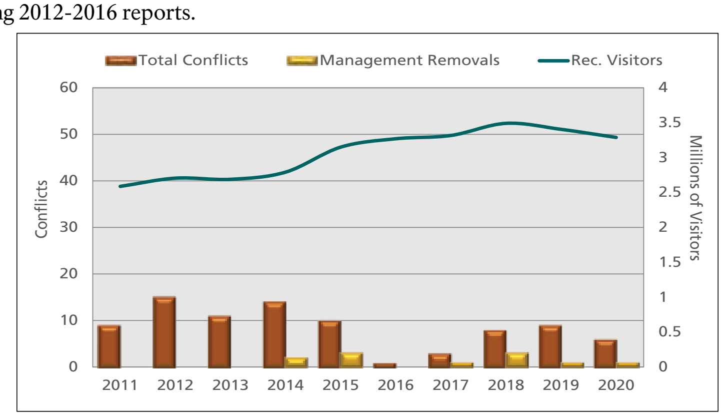
In 2020, several yearling black bears began frequenting developed areas in the park and exhibiting bold behavior (e.g. investigating picnic tables, placing paws on vehicles, roadside begging). To stop such behavior from escalating to the extent where euthanasia may have been warranted, bear management staff relocated three yearling black bears (two males, one female) to areas with minimal human presence. To date, none of these bears have returned to developed areas or been involved in further conflicts.

Park staff recorded three motor-vehicle collisions involving bears; a yearling male black bear was hit on the highway north of Colter Bay and dispatched by rangers; a 20–25-year-old female black bear was hit and killed on the highway south of Moose; and a bear of unknown species was hit on the highway near Wolf Ranch Road and ran away. The extent of injuries or deaths from collisions where bears are able to run away is unknown.

Park managers also implement seasonal closures to protect bear habitat and to address human safety concerns. In addition to regular annual closures (Grassy Lake Road closed to motorized use April 1–May 31 and Willow Flats closed to public entry May 15– July 15 to protect grizzly bear foraging opportunities), ten temporary closures were implemented (e.g. around carcasses) to provide for visitor safety and/or protect foraging opportunities for bears. Since 2007, the Wildlife Brigade, a corps of paid and volunteer staff, manages traffic and visitors at roadside wildlife jams, promotes ethical wildlife viewing, patrols developed areas to secure bear attractants, and provides bear information and education. In 2020, they recorded 602 wildlife jams including 231 for grizzly bears, 172 for black bears, 33 for bears of unrecorded species, 98 for moose, and 68 for other species such as bison, elk, and great gray owls. *Starting in 2017 reports define human-bear conflicts as instances when bears damage property, obtain human foods, or injure (or kill) humans. Human-caused bear mortality will be listed separately (e.g. bear vs. motor-vehicle collisions). Please note of this change when reading 2012-2016 reports.



Bears receiving human-food rewards or causing property damage in Grand Teton.

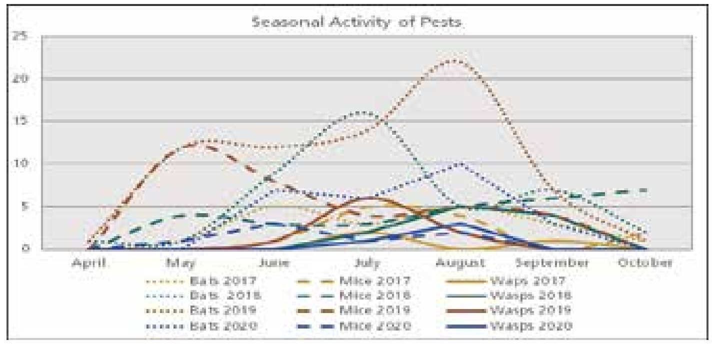


Bear conflicts and removals in Grand Teton.

Integrated Pest Management

Integrated Pest Management (IPM) is a science-based decision-making process used by Grand Teton National Park managers to protect the safety, health, and well-being of park visitors and employees. The park's IPM program works to prevent, respond to, and mitigate pest related issues throughout the park. A 'pest' is defined by the National Park Service as any organism that interferes with the purpose of a park or threatens human health and safety. Often, organisms considered pests in one circumstance are considered essential parts of the natural ecosystem in another. Determining the status of a pest is a multi-faceted process.

Most pest interactions in Grand Teton involve intrusions into structures. In 2020, IPM staff responded to calls of birds, insects, and mammals (including bats, beavers, and mice) in structures. The park's biggest pest issue is the ingress of bats into employee quarters. At least eight species of bats are native to Grand Teton and are indispensable members of the natural ecosystem. Despite their vital natural role, bats entering housing units can threaten human health and safety through transmission of rabies, batbugs, and other diseases. In 2020, the IPM team responded to 24 bat related incidents in park facilities, representing nearly 41% of all IPM cases. Previous efforts to exclude bats from vulnerable housing units proved successful, resulting in a sharp decrease in exposures.



The influx of common pests vary by the season.

Due to planned renovations and the COVID-19 pandemic, the University of Wyoming/National Park Service Research Station housed in the historic AMK Ranch, a site of past bat-human exposures, was closed to residents during the summer of 2020. The renovations included removing rotten logs and re-daubing the log chinking to exclude pests from inside the buildings. Preventative structural exclusion measures like these are instrumental strategies of the IPM program and will continue in vulnerable housing units at Lupine Meadows, Moran, and Colter Bay. Park staff also continue to educate and raise awareness of the severity of bat exposure to employees, partners, concessioners, and visitors.

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 10 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 for unknown reasons 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 wholly absent in the bullfrog's occupied range with only a couple western toads, a native species on the decline regionally, being found 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 (WGF) personnel used rotenone, a chemical that is 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 fishes present, a necessary first step in restoring a native assemblage to the spring. Rotenone tolerant and intolerant species survived the application. 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.

A bison herd grazes around the spring as the weather turns colder. The grass around the spring stays greener longer because of the moist warm fog.

Alternative treatment strategies are being considered for future efforts. Resource managers plan additional treatments to achieve complete restoration. In 2010, park biologists worked with WGF personnel to test mechanical removal methods of bullfrogs in the spring and its outlet. They found the frogs were most vulnerable following spring warm up and prior to the proliferation of macrophytes, algae, forbs, and grasses that act as increased cover for the bullfrogs. This information will aid future restoration efforts.

Invasive Plants

The survey and control of invasive nonnative plants is a high priority for the management of Grand Teton's ecosystem. Invasive plants alter habitats by displacing native vegetation communities, affecting wildlife distribution, and limiting foraging opportunities for ungulates, invertebrates, and other native wildlife. During the 2020 field season, vegetation staff, along with partners and contractors, actively surveyed 4,349 acres for invasive plants. Of the area surveyed, biologists treated 1,018 acres for 30 invasive nonnative plant species. The most abundant weeds were musk thistle, spotted knapweed, houndstongue, and Canada thistle.

Invasive plants get introduced to the park in a variety of ways. Early homesteaders planted nonnative cultivar and ornamental plant species prior to establishment of the park, and many of these species persist as undesirable plant populations today. Additional paths of introduction include accidental spread from cultivation, transport by wildlife, domestic stock, and livestock feed, as well as human travelers. Weed seeds are notorious for hitchhiking to remote locations on vehicles, clothing, and construction materials. Areas particularly at risk to invasive plant infestations include disturbed areas along roads, levees, and pathways, as well as trails, utility corridors, and building sites. Formerly disturbed sites within the park such as homesteads, hayfields, and gravel pits remain a management challenge.

Grand Teton vegetation biologists prioritize control efforts based on threats posed to ecological processes and prospects for successful treatment. Treatment considerations include plant species, abundance, and site characteristics. Some infestations can be eradicated if treated when an outbreak is still small and the seedbank is not well established. Other invasive species have become so common that containment of current infestations is now the primary goal. Invasive plants listed as federal, state, or county "noxious weeds" are particularly aggressive plants. These plants are legally deemed to be detrimental to agriculture, navigation on inland waterways, fish and wildlife, and/or public health. Park staff focus efforts on locating and using the best treatment practices to address listed noxious plant species.

Management actions in 2020 included herbicide treatments and mechanical removal, primarily in the sagebrush-steppe communities of the park. Park staff carefully select herbicides to minimize impacts to non-targeted species and water sources. Vegetation management continues to focus on invasive plant treatment in the Antelope Flats restoration project, which aims to return nearly 4,500 acres of former agricultural land to native habitat. For a second year, park staff used a herbicide specifically designed for treating cheatgrass with longer-lasting results. Results from areas treated in 2019 show that the treatment was very successful at preventing the re-growth of cheatgrass. Vegetation crews surveyed 275 acres of the Antelope Flats restoration project fields for cheatgrass, recording parameters of infested sites within the larger project. These sites, specifically Riniker and Henrie Hayfields, were treated to mitigate the spread of cheatgrass. In total , crews spent 93 person-hours spraying 175 gallons of herbicide on 4.4 cheatgrass-infested acres.

Weed crews practice spraying techniques with water-filled equipment to ensure efficient application of products in the field.

Weed crews painstaking search park vegetation to target and spray invasive plants while leaving native plants like Arrowleaf Balsamroot undisturbed.

Partnerships with Teton County Weed and Pest District, the Northern Rockies Invasive Plant Management Team, the Jackson Hole Weed Management Association, and the Greater Yellowstone Coordinating Committee are integral to successfully managing invasive plants in the region. Interagency collaborations with the Bridger-Teton National Forest and the National Elk Refuge are equally essential. In 2020, the park vegetation management program collaborated with partners to improve wildlife habitat and manage noxious weeds treating 732 acres with 10,482 gallons of herbicide. Park vegetation crews also continued rehabilitation work on waterline projects at Moose, Moran, Beaver Creek, and the Climbers Ranch. Other disturbed areas treated included wireless internet lines and the fiber-optic line that runs from Moose to the southern entrance of Yellowstone, a 46-mile disturbance. Crews prioritized monitoring and treating these telecom sites to promote native species growth and keep invasive plants from spreading along this transportation corridor. Controlling the spread of nonnative invasive plants benefits the park by supporting the native plant community and enhancing wildlife habitat in Grand Teton.

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 translocated about a dozen individuals from central Idaho to the eastern Idaho's Snake River Range where they were not native. 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 translocated 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. (Biologists documented transmission of pathogens from wild mountain goats to wild bighorn sheep in Nevada.) Competition 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.

In February 2020, the first removal operations began. A contract helicopter crew lethally removed 36 mountain goats

The occurrence of twin kids in most established mountain goat populations is unusual. In the Teton herd, twins are fairly common and park biologists even observed a set of triplets. This indicates an expanding herd.

from Cascade, Paintbrush, and Leigh Canyons in a four-hour period. Following objections raised by the Wyoming Game and Fish Commission and the Wyoming Governor to the Secretary of Interior, this operation was abruptly halted. Compelled by the Governor's wishes, the NPS switched to using ground-based, qualified volunteers to lethally remove mountain goats and retrieve edible meat from the culled animals whenever possible—an action authorized by the John D. Dingle Conservation, Management, and Recreation Act in 2019.

The ground-based removal program began in mid-September and concluded at the end of October, culling a total of 43 mountain goats within the park. Ultimately, 30 teams consisting of 108 individual volunteers supported the removal effort. Culling operations lasted for six weeks with the final period cancelled due to deteriorating backcountry travel conditions. Mountain goats were killed during each operational period and from seven of the ten established management zones.

Both aerial and ground-based methods were successful at removing mountain goats, but aerial methods were more cost-effective, had less exposure for participants, and required significantly less staff time. Approximately a third of the population was removed in 4.1 hours of flight time for a per goat cost of $1,086. A comparable number of mountain goats was removed by qualified volunteers after six operational periods (~one month) and about 4,426 volunteer hours in the field. The cost per goat was approximately $1,890 (excluding volunteer hours).

Native Plant Restoration

In 2020, field crews collected 6.1 bulk pounds of *Campanula rotundifolia*, a native purple-flowered perennial. One pound of pure live seed contains between 8 and 11 million individual seeds.

Native plant revegetation and ecological restoration return degraded or damaged habitats to functioning ecological systems. A primary goal of vegetation management in Grand Teton National Park and the John D. Rockefeller, Jr. Memorial Parkway is to protect the integrity of the native plant communities and the wildlife species that depend on them. Successful work to reestablish native plant communities must also include efforts to minimize the establishment of nonnative invasive species. Conserving local topsoil and using plant materials that originate from within park boundaries is essential to the success of all revegetation and restoration projects. Research shows that using native plant materials adapted to the local environment translates into greater success of restoration for ecosystem function.

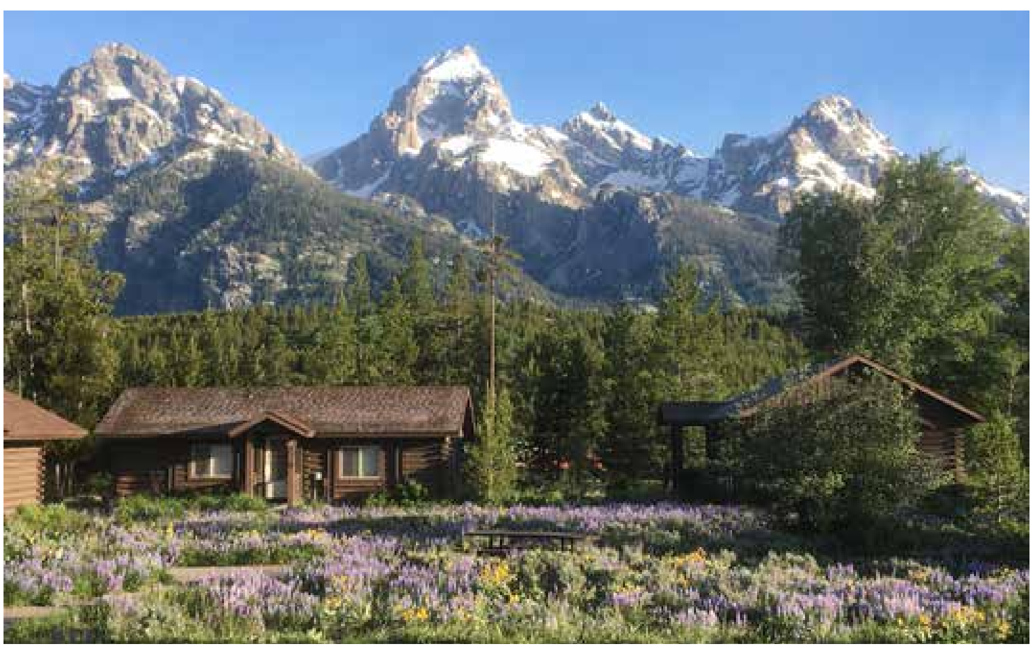
In 2020, the revegetation program used native, locally-derived seed mixes to reseed 22 disturbed sites comprising a total of approximately 21 acres. Installation of telecommunications infrastructure was the year's largest contributor of disturbed acres. The project created ground disturbance on an estimated 40 acres between the Moose Entrance Station and Yellowstone's South Gate. Vegetation staff worked to mitigate the ecological impacts of disturbed project sites through communicating best practices to contractors, treating invasive plants, reseeding construction sites, and careful monitoring post construction. Vegetation crews seeded completed sites in the fall before the onset of winter conditions. In the spring once the ground is free of snow, they will place container plants in the sites.

Restoration sites are planted with native seed mixes structured to match the local plant community while providing adequate competition against invasive plants. These mixes are composed of a combination of native bunchgrass, forb, and shrub seed collected from plant populations within the park. In 2020, park employees and contractors collected 565 pounds of plant material from 47 native species at 56 collection sites. Dispersing collection sites throughout the park promotes genetic diversity while preventing seed bank depletion.

2020 Revegetation Accomplishments	
Acres seeded (after ground disturbance)	21.3 acres
Hand-collected native seed (bulk weights)	47 species
Park Staff	250.9 lbs
Contractor Collections	153.45 lbs
Mechanically harvested seed	160.65 lbs

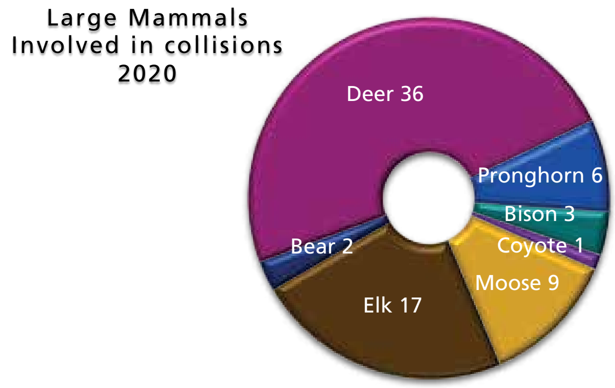
Seed increase plots are a sustainable restoration strategy used by the Grand Teton revegetation program to propagate more seed from hand-collected native seed. Seeds are planted in a plot to grow and produce more seeds, streamlining the collection process. Increase plots in the Antelope Flats Restoration Area (commonly known as the Kelly Hayfields), 4 Lazy F Ranch, and external plant materials centers augment seed quantities available for Grand Teton restoration projects. In 2020, vegetation staff collected 160.65 bulk pounds of mountain brome (*Bromus marginatus*) and 7.6 pounds of basin wildrye (*Leymus cinereus*) from the 4 Lazy F increase field.

In the 2020 field season, vegetation staff implemented facility improvements and adapted seed collection and processing practices, expanding the capacity of the Grand Teton seed program to supply local, native seed to future projects.



Lupine and arrowleaf balsamroot bloom in the Beaver Creek JY Cabins revegetation site, pictured in June 2020 prior to installation of a cell tower just west of the historic cabins.

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 record data on wildlife-vehicle collisions to help identify appropriate measures to lower the number of collisions and improve the safety of park roads for humans and wildlife.

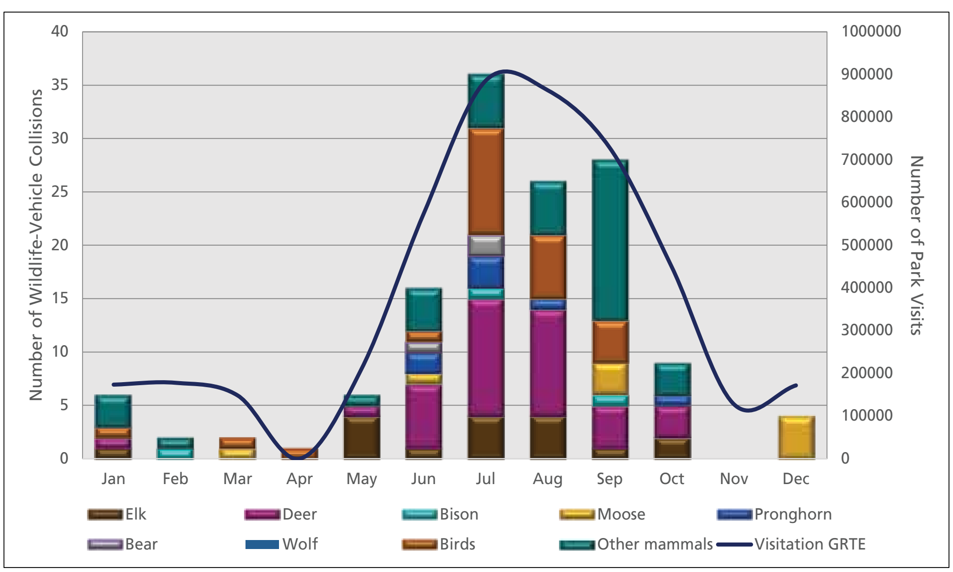
In 2020, 136 collisions occurred involving 140 animals, a 17% decrease from 2019. Due to the global pandemic, the park was closed from late March through mid-May, which may have contributed to the decrease in collisions. In 2020, only 10 wildlife-vehicle collisions were recorded from March–May. The ten-year average for those months is 14 collisions, with more than 20 occurring during this period for each of the last 3 years (2017-19). Although, the number of collisions decreased between 2019 and 2020, the long-term trend is increasing. The increase may reflect, in part, greater efforts in recent years to document collisions, including those involving smaller bodied species. Interestingly over the last 20 years, the trend in collisions involving ungulates, a subset of roadkilled fauna with high observability and therefore consistent recording, is slightly declining. The trend is noteworthy given the increase in total annual visitation over the last 20 years indicating that there may be multiple factors (e.g., ungulate population size, timing of migrations, winter severity, traffic volume, etc.) that influence the number of collisions. In 2020, 88% 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. The majority of collisions occurred during the snow-free months (121 from May–Oct.) and peaked in July, the highest visitation month.

A total of 32 species (18 mammals, 13 birds, and an amphibian) were involved in collisions in 2020. Large mammals accounted for 77 of the 140 animals involved. Ungulates comprised 53% of individuals (74) involved, a 19% increase from 2019. Mid- to large-sized carnivores accounted for 3% (4), small mammals 27% (38), and birds 17% (24). Collisions involving birds and small mammals rarely cause property damage, are less conspicuous, and 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 43% of incidents with a known time of day, more than 80% of those collisions involving mule deer and all involving pronghorn occurred during the day. All incidents involving elk, 83% involving moose, and 66% involving bison occurred under diminished light (twilight/night).

Park staff documented the highest number of wildlife-vehicle collisions (46%) on US Highway 89/191/26 (Hwy. 89), followed by the North Park Road (28%), Teton Park Road (16%), Gros Ventre-Antelope Flats loop (6%), Moose-Wilson Road (1%), and other roads (4%). On Hwy. 89 most incidents occurred between Moose Junction and Snake River Overlook (25%), followed by Triangle X to Spread Creek (16%), and Spread Creek to Moran Junction (16%). The majority (59%) of incidents with bison, moose, and elk occurred on Hwy. 89. For deer, 44% of collisions occurred on Hwy. 89, 39% on North Park Road, 11% on Teton Park Road, and 6% on other roadways. For pronghorn collisions, more than half occurred on Hwy. 89, 29% on Teton Park Road, and 14% on Gros Ventre-Kelly Loop Road.

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 Gros Ventre Junction; and painting wider road surface lines to delineate narrower travel lanes that indirectly encourage motorists to follow designated speed limits.



Animals involved in wildlife-vehicle collisions by month during 2020, Grand Teton NP and the JDR Parkway.

Trail Use & Pathway Use

Visitors hike on the popular trail up to Inspiration Point, above Jenny Lake.

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 to 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.

In 2020 during the COVID-19 pandemic, monitoring visitor use of the trail system gave insights in the changed park visitor experience. Many indoor locations within Grand Teton National Park were closed in 2020, and trail counters indicate an overall increase in trail use compared to the five-year average. Between June and September of 2020, the Cascade Canyon trail counter detected the highest number of people compared to other trail counters, with an estimated 74,718 visitors (a 52% increase in visitor use compared to 2019). The Jenny Lake trail counter recorded the next highest number with an estimated 69,721 visitors (a 15% increase in detections compared to 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, between the park's south boundary on US Highway 89 and Moose, followed in May of 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 2019, 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).

These counters give 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 73,332 detections on the five pathway counters between June and August of 2020. This is a 4% increase in use over 2019. Given the limitations of the counters, a liberal estimate would be that pathway use comprises approximately 3% of the park's total recreation visits during the same time frame.

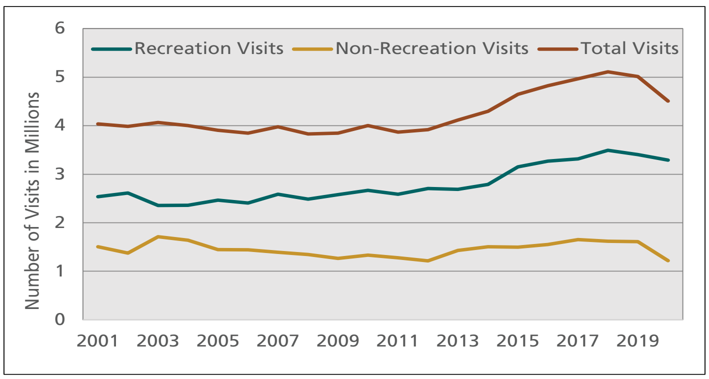
Analysis of trail and pathway data helps park managers to better understand visitor use (including levels of use, timing of use, and distribution of use). This in turn aids in decision making to meet the objectives of providing for visitor enjoyment while protecting park resources.

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 even a pandemic.

During the COVID-19 pandemic, public lands provided visitors opportunities for outdoor experiences and domestic recreation. The importance of outdoor places was highlighted in 2020, as many people looked to outdoor spaces to safely recreate and promote physical and psychological health. National parks played an important role and hosted more than 237 million recreation visits in 2020. This number is a 28% decrease from 2019 due mainly to temporary park closures, restrictions, and the changes in park operations that were implemented in response to the pandemic. 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.).

A ranger helps visitors orient themselves using a three dimensional park map.



Annual Grand Teton NP visitation 2001–2020.

Grand Teton National Park had approximately 3.3 million recreation visits 2020. This is the fourth highest number of recreation visits on record. The park was closed from March 24 to May 18, 2020 in response to the COVID-19 pandemic. The majority of recreation visits occurred between June and October. Although there are no day-use limits, lodging and campgrounds in the park have limited available space and during the pandemic many options were further restricted. On most July and August nights, one or more forms of accommodation are full.