

Yellowstone National Park
Yellowstone Wolf Project 2020
Wyoming, Montana, Idaho

Yellowstone Center for Resources
National Park Service
Department of the Interior



Yellowstone Wolf Project Annual Report

2020

Summary

At the end of December 2020, there were at least 123 wolves in nine packs (seven breeding pairs¹) living primarily in Yellowstone National Park (YNP). This census was the highest park count since 2008 (124 wolves) and marked a one-year increase of 31% after a decade of very little population change year to year. Much of the growth was attributed to successful pup production and survival in multiple packs, most notably the Junction Butte pack which produced four litters and raised 18 pups through the end of the year. The 2020 total is 29.3% lower than the high count of 174 wolves in 2003.

The number of packs and breeding pairs was the same as the average over the last decade. Pack size in 2020 ranged from 4 to 35, averaging 13 in size. This average was higher than the long-term average pack size of 9 to 10. Again, this average was largely driven by the exceptional size of the Junction Butte pack at 35 members. Average pack size not including Junction Butte was 11. Two other packs, 8 Mile and Wapiti Lake, had 21 and 20 members, respectively, making 2020 the only year with three packs of 20 or more members in mid-winter. The only year with two packs that large was 2000 when the Druid Peak pack had 27 and Nez Perce pack had 22 members. Every other year's official count has had no packs (15 years) or one pack (eight years) with at least 20 members.

Parkwide, at least 62 pups were produced, with an additional four litters that were known to be born but all died before they could be counted. Of the 62 pups counted, 54 survived (87%) to year end with far more in northern YNP (41) than the interior (13) of the park. At the end of 2020, pups comprised 44% of the park population, the same as 2019 but higher than the last decade average of 32%.

January 2020 marked the 25th anniversary of wolf reintroduction to YNP. The first wolves were brought through the Roosevelt Arch at the park's north entrance on January 12, 1995, and several other shipments occurred in the following days. The wolves were kept in acclimation pens for approximately ten weeks, and then pens were opened in late March. The first wolves to leave the pens on March 24, 1995, marked the first wild wolf packs in YNP in nearly 70 years. More information about the reintroduction can be found in previous annual reports and dozens of books, documentaries, and scientific publications. The anniversary was celebrated by YNP and many conservation organizations and private groups throughout early 2020. The book *Yellowstone Wolves: Science and Discovery in the World's First National Park*, edited by YNP Wolf Project Leader and Senior Biologist Douglas W. Smith, YNP Wolf Project Biologist Daniel R. Stahler, and Utah State University professor and collaborator Daniel R. MacNulty, was published in December 2020.

The spread of SARS-CoV-2 throughout the world resulted in many shutdowns, including YNP from March 24 through May 18 when the south and east entrances opened. The three entrances in Montana were closed until June 1. Despite the time closed and reduced park facilities the rest of the year, visitation was high and set records for both September and October. The Yellowstone Wolf Project scaled back many aspects of research including, for the first time, stopping late winter study early and minimizing efforts for both summer predation and early winter study to ensure the health and safety of staff.

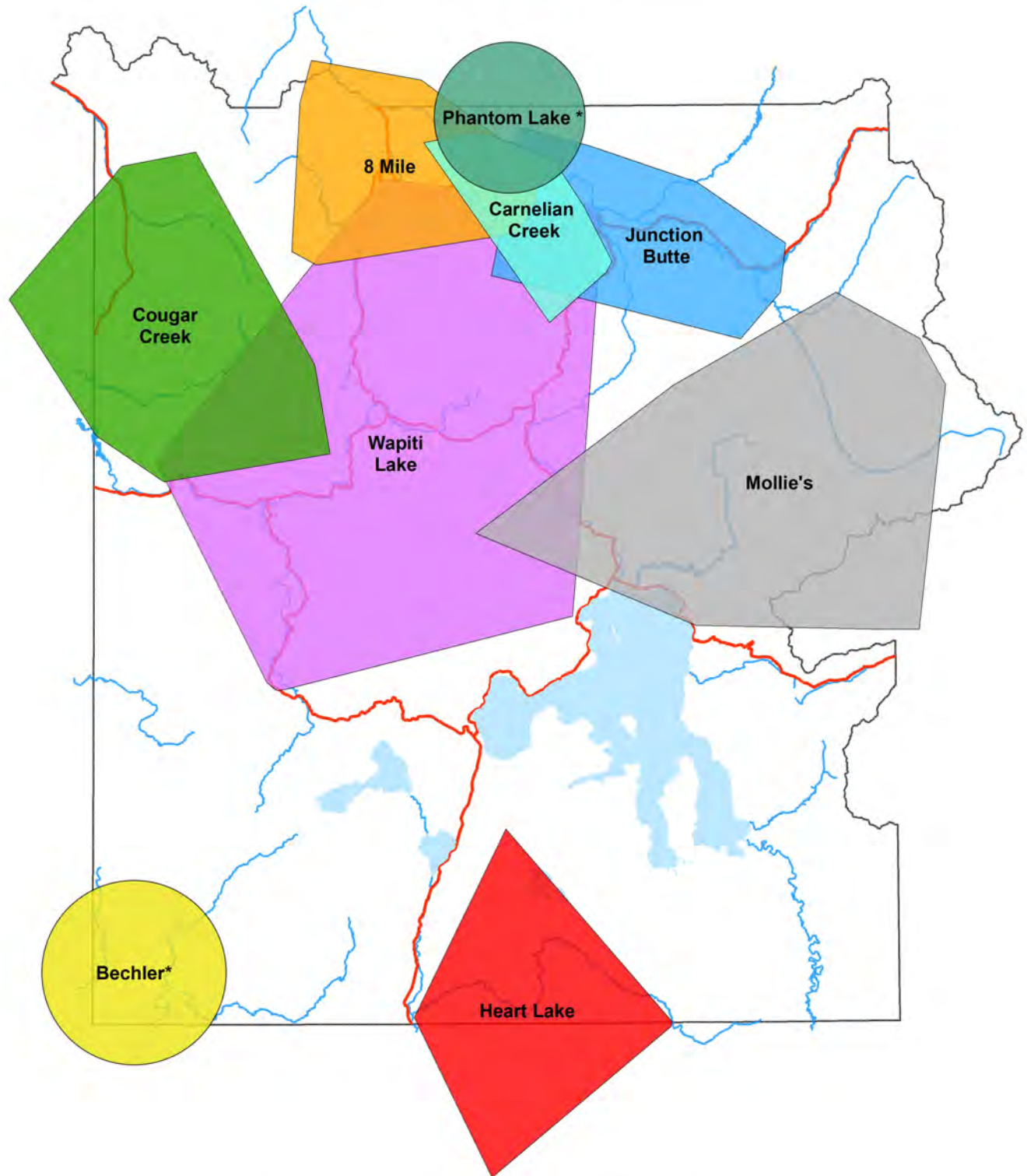


Junction Butte pack in winter with long-time pack member gray female 907 at left. 907 was born in this pack in 2013. She did not disperse, and became the dominant breeder. She lost her status in 2019, but bred in 2020 at age 7. She is blind in her left eye (detected 2017) due to an unknown injury. NPS Photo/K. Cassidy.

¹A breeding pair is defined as an adult male and an adult female with at least two pups that survive through the end of the year.

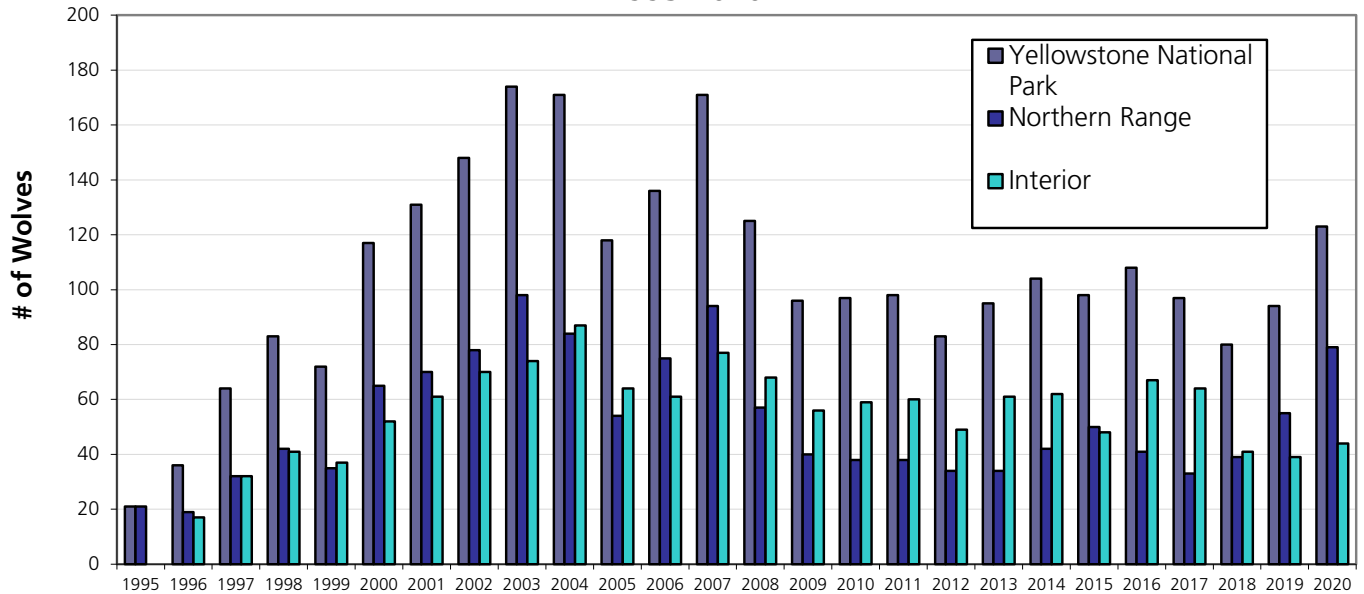
2020 Yellowstone Wolf Pack Territories

(95% minimum convex polygons of aerial locations)



* No radio collars present, unable to estimate territory size.

Yellowstone National Park Wolf Population 1995-2020



YELLOWSTONE WOLF POPULATION (as of 12/31/2020)	Adults	Pups	Total
Northern Range			
8 Mile	9	12	21
Phantom Lake (no working collars)	7	7	14
Junction Butte	17	18	35
Carnelian Creek	2	4	6
Other (1198F, 1155M, 1154F)	3		3
Northern Range Totals	38	41	79
Non-Northern Range			
Heart Lake	3	3	6
Bechler (no collars)	4		4
Cougar Creek	4	2	6
Mollie's	7		7
Wapiti	12	8	20
Other (1239F)	1		1
Non-Northern Range Totals	31	13	44
YNP Total	69	54	123

YELLOWSTONE WOLF MORTALITY (in 2020)

Wolf #/Sex	Date of Death	Age	Pack	Cause of Death
969F	1/10/2020	Old adult	Junction Butte	Intraspecific
1105M	1/16/2020	Adult	8 Mile	Infection/Disease
1049F	5/5/2020	Adult	Carnelian Creek/Loner	Intraspecific
1119F	6/1/2020	Adult	Phantom Lake	Unknown
uncollared	9/9/2020	Pup	Phantom Lake	Harvest
uncollared	9/10/2020	Pup	Phantom Lake	Harvest
1236M	10/26/2020	Yearling	recently dispersed from Wapiti Lake	Illegal
1201F	12/12/2020	Adult	recently dispersed from Wapiti Lake	Harvest
1277U	12/12/2020	Pup	Carnelian Creek	Intraspecific

YELLOWSTONE WOLF CAPTURE (in 2020)				
Wolf #/Sex	Date of Capture	Age	Color	Pack
1264M	12/14/2020	Yearling	Black	Wapiti Lake
1265F	12/14/2020	Yearling/Adult	Gray	Wapiti Lake
1266M	12/14/2020	Pup	Black	Wapiti Lake
1267F	12/14/2020	Pup	Black	Wapiti Lake
1268M	12/14/2020	Yearling	Black	8 Mile
1269F	12/14/2020	Yearling	Black	8 Mile
1270M	12/14/2020	Pup	Black	8 Mile
1271F	12/14/2020	Pup	Black	8 Mile
1272M	12/14/2020	Pup	Gray	Junction Butte
1273M	12/14/2020	Yearling	Black	Junction Butte
1274M	12/14/2020	Pup	Black	Junction Butte
1275M	12/14/2020	Pup	Black	Junction Butte
1276F	12/14/2020	Adult	Black	Junction Butte
1278M	12/14/2020	Pup	Gray	Junction Butte
1279M	12/14/2020	Pup	Gray	Carnelian Creek

Wolf-Prey Relationships

Project staff detected 162 kills definitely, probably, or possibly made by wolves in 2020: 98 elk (61%), 28 bison (17%), four mule deer (3%), three moose (2%), three deer but undetermined which species (2%), three coyotes (2%), three wolves (2%), two pronghorn (1%), one white-tailed deer, one golden eagle, one grouse, and 15 unidentifiable animals (9%). The composition of wolf-killed elk was 29% calves, 1% yearlings, 36% adult females, 27% adult males, 3% adults of unknown sex, and 5% of unknown sex and age. In January 2020 wolves killed female elk #1125, who had worn a radio-collar since 2011. Elk 1125 was 25.6 years old and born in 1994, the summer prior to wolf reintroduction to YNP. The chances an elk is killed by wolves can be relatively high for the first year of an elk's life, but after that they are often too fit and strong for wolves to successfully hunt. Predation risk starts to increase when a cow elk reaches approximately 12 years old and continues to increase with age as fitness declines. The average age of a wolf-killed adult female elk in YNP has changed little since reintroduction and remains around 12 to 14 years old. The composition of wolf-killed bison was 32% calves, 11% yearlings, 25% adult females, 21% adult males, and 11% adults of unknown sex. The Junction Butte pack, buoyed by their frequent ground-based observation, used both their large pack size and presence of five adult males to regularly hunt bison and accounted for 86% of the total bison kills.

Wolf predation is normally monitored intensively for five months of the year— one month in late winter (March), three months in the summer (May through July), and one month in early winter (mid-November to mid-December). However, due to the outbreak of SARS-CoV-2, we scaled back effort during all three study periods, aborting parts of the late winter study on March 16, and reducing study goals over the summer and early winter study to approximately half the normal crew size and effort. In addition, we did not accompany the fixed-wing aircraft pilot as observers, but instead relied on the pilot to track the wolves and collect data. All these adjustments influenced our monitoring effort and resulted in fewer data points collected when compared to previous years.

Winter Studies

During the 16-day March 2020 late winter study period, air and ground teams discovered 44 ungulate carcasses fed on by wolves. To assist air and ground crews the GPS cluster crew searched 158 GPS clusters (locations GPS collared wolves spend ≥ 1 hour) for two wolf packs (Junction Butte and 8 Mile) and hiked or skied 254 kilometers (158 miles). Thirty-three (75%) of the ungulates were killed by wolves, including 22 elk, four bison, three deer, two moose, one pronghorn, and one unknown species. Of the elk, seven were calves (32%), four were adult females (18%), and 10 were adult males (46%). The wolves also scavenged on nine bison, one elk, and one bighorn sheep they did not kill. This 30-day study was cut short by two weeks in response to the outbreak of SARS-CoV-2.

During the November-December 2020 early winter study period, air and ground teams discovered 46 ungulate carcasses fed on by wolves. The GPS cluster crew hiked over 530 kilometers (330 miles) while searching 69 GPS wolf clusters for one wolf pack (Junction Butte) and two mountain lions. (Wolf Project and Cougar Project teams work together and overlap in staff and research.) Thirty-nine (85%) of these ungulates were killed by wolves, which included 21 elk, 13 bison, three deer, and two unknown species. Of the elk, four were calves (19%), six were adult females (29%), 10 were adult males (48%), and one was of unknown age and sex (5%). The wolves also scavenged on four elk, two bison, and one unknown species they did not kill.

Summer Predation

We assessed wolf predation from May through late June by searching for prey remains at GPS clusters (a location other than a wolf den or rendezvous area where a wolf spent 30 minutes or more). In 2020, we searched 65 clusters for wolf 1200M of the Carnelian Creek pack. Crews hiked over 185 kilometers (115 miles) and detected 17 suspected kills or fresh carcasses of ungulate prey, which included 16 (94%) elk and one (6%) bison. The Carnelian Creek pack had only one adult male (1200M) and one adult female (1005F) raising six pups. This was the first year we have done an intensive predation study where the focus wolf was part of such a small pack with pups and was often hunting alone.

Mortality

Six radio-collared wolves died in 2020. After two years of recording no radio-collared wolves killed by other wolves, this year we recorded two. This may be due to increased wolf densities or a random anomaly due to the small sample size of radio-collared wolf deaths each year. Wolf 969F, a six-year-old female, was driven out of the Junction Butte pack due to aggression from higher ranking females. After a few weeks she was in poor shape and one night encountered the pack again. The next morning 969F was seen with injuries and she died later that day. Her injuries were caused by other wolves and she weighed only 33 kilograms (73 pounds). Wolf 1049F encountered members of the 8-Mile pack (her natal pack that she left almost two years prior) and although she was seen interacting in a friendly way with some of them, she was found dead with wolf-caused injuries a few days later. The only other radio collars nearby were from the 8 Mile pack.

In addition, 1105M from the 8 Mile pack died of a severe infection in his abdominal cavity. The cause of the infection could not be confirmed due to decomposition but was

likely from a bacteria or parasite. Dominant female 1119F of the Phantom Lake pack (with a non-working radio collar) was found dead by a hiker just outside the YNP boundary and cause of death was unknown due to advanced decomposition. Two radio-collared wolves died of human-causes. Wolf 1236M, originally from Wapiti Lake but starting his dispersal, was illegally shot in Grand Teton National Park. Wolf 1201F, also from Wapiti Lake but just starting her dispersal, was legally hunted near West Yellowstone outside of YNP in Montana Wolf Management Unit 310.

In addition to the six deaths of radio-collared wolves, staff recorded four deaths of uncollared wolves. Three of these were human-caused: two gray males (likely pups) from the Phantom Lake pack were hunted outside the YNP boundary in Montana Wolf Management Unit 313 and a gray female adult from the 8 Mile pack was found illegally killed just outside the park boundary after the Montana wolf hunting season was closed. The last mortality was naturally-caused: an uncollared black pup from the Carnelian Creek pack was killed by the Junction Butte pack. Staff witnessed the fatal attack during early winter study.

Three other wolves disappeared under suspicious circumstances. On the night of March 10, the 8 Mile pack travelled near the northern boundary of YNP and by the next morning the pack was missing four members. The missing uncollared beta female was found dead (illegally shot and described above), but the three radio-collared wolves (dominant breeder 1015M, subordinate adult 1156M, and 11 month-old 1231M) were not seen or heard again. 1015M's collar was later found in the Yellowstone River. (See 8 Mile pack summary on page 12.) Ground crews and pilots searched extensively for signals for several weeks. Due to the location of the one wolf that was found, the investigation is led by Montana Fish, Wildlife and Parks. Please call 800-TIP-MONT if you have any information related to this crime.

2019 Annual Report Update

In November 2019, two pups from the Junction Butte pack were hit by a vehicle and both died immediately. The driver left the scene and YNP Law Enforcement later contacted him in Cooke City by using the license plate cameras on the entrance station. The driver admitted to purposely hitting something that he believed to be coyotes. The rangers charged him with failure to report an accident and failure to maintain control of a motor vehicle. The defendant plead guilty to the count of failing to report a motor vehicle accident. That carried a \$140 fine, 6 months of probation, and the defendant was ordered to pay \$8,000 in restitution for the intentional loss of the wolves.

Disease

There was no evidence of any major disease mortality in 2020. However, reduced field time and far fewer tracking flights during the spring and summer (because of SARS-CoV-2 mitigation) likely caused us to miss counting some litters soon after den emergence, which is when we get our best information about pup production. Wolf density in northern YNP is consistently higher than most other places wolves live. The abundance and density of predator species in the Greater Yellowstone Ecosystem leaves open the possibility of diseases such as canine distemper virus to occasionally cycle through. The last documented outbreak of canine distemper virus in wolves in YNP was 2017.

By late December several members of the Junction Butte pack showed signs of hair thinning and loss, which may be an early indication of mange infection. We will continue to monitor to track the changes in infection at the individual, pack, and population levels.

Reproduction

This year documenting early pup counts was challenging due to SARS-CoV-2 closures in YNP and scaling back contact between field technicians and with the fixed-wing pilot. However, we were able to get early counts on some of the packs, finding 62 pups born to eight different packs. Five packs produced multiple litters: 8 Mile (12 pups from at least two litters), Phantom Lake (nine pups from two litters), Junction Butte (18 pups from three litters and a fourth litter of unknown size), Wapiti Lake (eight pups from two or three litters), and Mollie's (zero pups counted but two litters were believed to have been born and died before they could be counted). The prevalence of multiple litters in wolf packs in YNP (~25% of packs annually) has varied little over the last two decades. Large, socially-complex packs, higher wolf densities, and food abundance are believed to influence the prevalence of multiple litters and may partially explain this year's increase. Both the Mollie's and Bechler packs produced pups but observations indicated the pups either died early (Mollie's) or died by the end of the year (Bechler) so these packs did not count as official breeding pairs in 2020. Of the minimum 62 pups produced in all packs, 54 (87%) survived to the end of the year. This percentage is higher than true survival due to the unknown number of pups that died before the litter could be counted.

Wolf Capture

Fifteen wolves in four packs were captured and collared in 2020. This is lower than the previous year because the 2019-2020 capture season was completed before January 1, which

is rare. As a result, all captures in 2020 occurred in December as part of the 2020-2021 season. All fifteen collars were placed on previously uncollared wolves because the wolves with old or malfunctioned transmitters were mostly living in large packs and were difficult to target during capture operations. Also, the high percentage of pups and yearlings in the population led to a high proportion of collars placed on those age groups. New collars were deployed on nine pups, four yearlings, one adult (two years old), and one wolf with an estimated age between yearling and three years old. Sex ratio of newly collared wolves was skewed with 10 males and five females. In addition to the radio collar, staff took measurements and biological samples while the wolves were under the effects of the capture drugs. It is unknown how SARS-CoV-2 might affect gray wolves, but it has had detrimental effects on some mustelids. In addition, captive felids and domestic dogs have tested positive for the virus. Handling staff wore masks to protect the wolves and each other and, as is procedure, frequently disinfected all equipment.

Wolf Management

Wolf management in 2020 was primarily focused on reducing habituated behavior from some individuals in both the Junction Butte and Wapiti Lake packs. The spring months are generally the time of year with the most recorded habituated behaviors as wolves just turning one year old explore on their own for the first time. Additionally, denning females are focused on newborn pups and the rest of the pack is split in smaller groups pursuing smaller prey (e.g., elk calves, deer). Park closures due to the outbreak of SARS-CoV-2 coincided with this time period which reduced habituated wolf encounters with visitors and allowed for staff to haze the habituated wolves. Aversive conditioning the wolves escalates from honking and yelling, to paintballs, to rubber bullets and cracker shells, depending on the severity of the behavior. Catching a wolf approaching vehicles or people, lingering in developed areas, or showing interest in human items (e.g., tripods left near the road) and hazing it while in the act has the potential to change the wolf's behavior if it associates the fear or mild pain with the proximity to humans. Staff hazed at least five wolves from the Junction Butte pack and three from the Wapiti Lake pack, and continues to monitor their behavior.

Park staff closed the areas around the Junction Butte, Carnelian Creek, and Wapiti Lake pack's dens to protect the young pups from disturbance. The Junction Butte pack was visible nearly every day of the summer and fall, using Slough Creek and later Lamar Valley to raise their pups. Even long-

time visitors and staff were amazed to watch the rare scene of 18 pups raised by one pack, to later form the third-largest pack recorded in North America. In Hayden Valley, management closures and signage near the Wapiti Lake pack homesite were required to reduce resource damage. Large numbers of visitors hoping to see wolves were creating eroded, braided social trails and flattening vegetation in some high-use areas.

Outreach

Public outreach was necessarily adjusted this year with many presentations switched to virtual platforms. Technicians still worked in the field during the busy summer season but were advised to maintain social distance and not to share scopes, as was normally done in years past to help visitors see and learn about wolves in YNP. However, our outreach remained high and staff gave 123 formal talks (four at virtual scientific conferences), 53 interviews, and led 25 field trips. Staff also helped educate at least 10,600 people while viewing wolves, made at least 17,700 visitor contacts, and gave 29 informal talks in the field.

The YNP Strategic Communications office developed a Facebook Live series to celebrate and highlight wolf research

in YNP. The series began in March 2020 to coincide with the 25th anniversary of wolf reintroduction. Five episodes, totaling 2 hours and 14 minutes, can be found on the YNP webpage and Facebook page. In the first month the broadcasts and posts were seen over 10.3 million times and had 870,000 engagements. At least 31 news stories were published about the anniversary. Episodes explore the history of wolves in YNP, the latest wolf research, the phenomena of wolf-watching, and how the YNP wolf reintroduction can inform conservation efforts around the world.

In December 2020, the book *Yellowstone Wolves: Science and Discovery in the World's First National Park* (University of Chicago Press) was released. Editors Douglas W. Smith, Daniel R. Stahler, and Daniel R. MacNulty, along with over 80 collaborators began working on the book plans in 2014. The book synthesizes 25 years of science and management of wolves following their reintroduction to YNP, integrating personal essays, infographics, and photos from wolf biologists around the world. Videographer Bob Landis also produced a documentary to accompany the book release which can be viewed online with book purchase. The first printing sold out even before pre-orders were fulfilled and by the end of 2020 the second printing was in progress.



The 8 Mile Pack tangles with a grizzly bear in classic fashion. Bears can easily overpower a wolf if they can catch them. The to and fro is on display here with wolves harassing and outnumbering a bear in a contest over a carcass in a mudhole. The bear resorts to jumping in with the carcass. NPS Photos/J. SunderRaj.



Strength in Numbers

By Jeremy SunderRaj

The morning of May 19, 2020, I found myself, along with several other wolf project staff, standing along the Slough Creek campground road. We were looking toward the Junction Butte pack's den. Several females had been pregnant, and the presence of the pack near the den over a long period of time indicated they had produced pups a few weeks earlier.

Junction Butte was already a big pack. In the winter, they had as many as 21 members but entered the denning season with 17 individuals. Over the last 25 years, wolf pack size in Yellowstone has averaged around 10 individuals and ranged from 2 to 37.

Upon setting up our spotting scopes, we could already see a handful of pups milling around the den. 907F, one of the mothers in the pack as well as the oldest wolf, approached the den. Pups rushed out of the den to nurse. From the road corridor, it was extremely difficult to count them because there were so many and they were still so small, about the size of a small cat. By the time all was said and done, we counted 18 pups, with 11 being black and 7 gray. If all the pups survived, that would make 35 members in the Junction Butte pack, one of the largest ever recorded. But there was no way all of them could survive. Right? Typically, the survival rate of wolf pups in Yellowstone is around 60%.

Large wolf packs typically don't last long. Every wolf has the natural desire to breed, therefore many wolves disperse from their natal packs at two to three years of age. Basically, each wolf wants to leave and start a pack of their own. Some may find a dominant position in the pack they were born in (907F is a good example). Others may disperse hundreds of miles before successfully forming a pack, risking being killed by other wolves or humans in the process.

However, there are some key advantages to being in a large pack. Wolves in larger packs have a distinct advantage in territorial conflicts with other packs. They also have reduced likelihood of dying when infected with mange, but there are also disadvantages. Wolf packs are most successful at killing elk when four wolves participate in the hunt but do best killing bison with 10 or more pack members. As packs get larger than eight individuals, female wolves whelp fewer pups; however, those that are born have increasing survival with increasing adult pack size. Finally, wolves in larger packs also acquire less food than wolves in smaller packs.

The largest group of wolves recorded together was seen from a plane in Wood Buffalo National Park. Biologist Lu Carbyn observed 42 wolves, but he was not sure it was one pack. Different wolf packs in Wood Buffalo National Park are known to spend time near each other in winter due to concentration of prey in specific areas. Therefore, it is possible this observation was of multiple packs.

In 2001, Yellowstone's Druid Peak pack reached 37 wolves, and long-time employee Rick McIntyre also noted an additional pup separate from the pack to make 38. The entire pack was only observed together twice before they splintered into several other new wolf packs, including the core Druid Peak, Buffalo Fork, Geode Creek, and Agate Creek packs.

As 2020 wore on, we were shocked at the high survival rate of the Junction pups. By the end of the year, all 18 from the first count were still alive. The pack was also extremely cohesive for their size. We observed a total of 34 wolves together multiple times, missing only 1109F, who had produced a fourth litter separate from the other 18 pups. They did not survive, and 1109F still returned to the pack from time to time.

The winter of 2020 also brought about another unexpected realization: the Junction Butte pack was hunting bison. Frequently. Typically, elk have made up about 80% of the diet of wolves in northern Yellowstone. However, in our November-December winter study, we found the Junction Butte pack fed on 14 bison, most of which they killed. They only preyed on eight elk over the same time. This is the first winter study in the Wolf Project's history that found elk was not the highest percentage of the diet.

Although intriguing, this new discovery leaves us with more questions. Why is the Junction Butte pack killing more bison than elk? Is it solely because the pack is so large they need larger prey to feed them? If this is true, why didn't we observe this shift

with the Druid Peak pack in 2001? Is this shift due to more bison and fewer elk on the landscape than in previous years? If this is true, why haven't other wolf packs turned to hunting bison? The answer is likely a combination of all these factors. Fewer elk and more bison in the Junction Butte pack's territory, especially in the winter, has likely led to them taking more bison than elk, but being part of a large pack helps facilitate this. These new questions are a firm reminder that despite studying wolves for over 26 years, we are continuously learning in the incredible outdoor laboratory that is Yellowstone National Park.



The Junction Butte Pack numbered 35 wolves in 2020, the second largest pack recorded after the Druid Pack at 37 members. Average pack size for all packs for the first 25 years since reintroduction is about 10. This large pack size was due to three females breeding combined with high pup survival. NPS Photo/J. SunderRaj.

Wolf Pack Summaries

8-Mile (21 wolves: 9 adults, 12 pups)

In mid-March, four members of the 8-Mile pack, three of them with radio-collars (including the dominant breeding male), were tracked by staff near the park's northern boundary. This was the last time the three radio-collars were heard despite extensive searching. An uncollared wolf matching the description of the fourth wolf which disappeared was found dead of a gunshot wound less than 300 meters from the park boundary. The Montana wolf hunting season in this area had been closed for three months. The location and timing of the dead wolf matched the disappearance of the other wolves and this incident is being investigated by Montana Fish, Wildlife and Parks. Please call 800-TIP-MONT if you have any information. In early 2021 the collar of 1015M was found in the Yellowstone River by an angler. The collar belting had been cut and the battery had a bullet hole and was not transmitting.

About a month after this event, three pregnant females produced a total of 12 pups, and the pack successfully raised them all through the end of the year. Lone wolf 1154F rejoined the pack temporarily during the denning season but by fall had dispersed again. A large, silvery male wolf joined the pack sometime in early winter and it is unknown if this readjusted the dominance hierarchy or not. Several yearling males made short dispersal forays by the end of the year, with one of them joining the Carnelian Creek pack. The 8-Mile pack has held a stable territory in northern YNP since 2011 and has been exceptionally successful producing dispersers that have joined or formed new packs in the study area. Just in the last six years, wolves born in the 8-Mile pack have been breeders in the Lamar Canyon, Prospect Peak, Crevice Lake, Phantom Lake, Carnelian Creek, Slip N Slide (MT), and Junction Butte packs.

Phantom Lake (14 wolves: 7 adults, 7 pups)

When both subordinate females with working radio collars dispersed in January, the Phantom Lake pack became difficult to monitor due to an absence of working collars. Their territory along the Black Canyon of the Yellowstone made observing them difficult. Previously the pack used the Cottonwood and Hellroaring Creek areas, but they were not observed that far east and may be avoiding the area as the Junction Butte pack expands west. Trail camera videos confirmed the pack had two pregnant females; however, the dominant female 1119F was found dead of unknown cause in late summer. A month later, two young male wolves (likely six month-old pups) were killed during the hunting season outside YNP in Montana. Sightings and trail camera videos

captured at the end of the year confirm the dominant male remains 1106M (with a non-working collar) and the pack has six other adults and about seven pups. One yearling female with an injured shoulder remains with the pack and seems to be healing slowly. This injury was first recorded in late 2019 when the wolf was a pup, immediately after several of her pack mates were harvested outside the park boundary in Montana. She was likely hit by a bullet but suffered a non-fatal injury.

Carnelian Creek (6 wolves: 2 adults, 4 pups)

This new pack formed when two subordinate females, 1005F and 1049F, from the Phantom Lake pack dispersed in January and met a male, 1200M, from the Cougar Creek pack. 1200M had been wandering alone for almost a year and travelled through Phantom Lake pack territory frequently. It is likely the wolves had met before and certainly they knew each other's scents well. 1049F was killed by other wolves in May and it did not appear she had been nursing pups. 1005F and 1200M raised six pups, a major feat for only a pair, especially as their small territory was surrounded by much larger packs. Early winter saw the pack's difficulties become deadly as dominant male 1200M disappeared (likely killed) after an encounter with the 8-Mile pack. 1005F and her pups were temporarily joined by an uncollared male. After one pup disappeared, and another was killed by the Junction Butte pack, the small group wandered widely from Tower to Mammoth Hot Springs, trying to avoid other packs. We were able to radio-collar one of the pups near the end of the year but the GPS collar malfunctioned after only a week. A yearling from the 8-Mile pack, 1230M, joined 1005F and her four remaining pups towards the end of the year, but it is unknown if this small pack will be able to persist among their larger neighbors.

Junction Butte (35 wolves; 17 adults, 18 pups)

While we anticipated the large Junction Butte pack might split during 2020, they mostly remained together and by the end of the year the pack was the third largest ever recorded in North America. One of the major changes occurred when long-time pack member 969F, who was born in 2013 and was the dominant female from May 2017 to May 2018, left the pack. After declining in condition, she was killed during an encounter with her former pack mates. The remaining three older adult females plus a two-year-old female all produced pups in spring. The dominant female, beta 907F, and the two-year-old used their traditional, easily visible den at Slough Creek and produced 18 pups. All three females nursed them together and many visitors were able to view the pups as they grew. For the third year in a row 1109F denned

alone. At first the pack attended both dens but 1109F moved or lost her pups around June. She spent most of the summer up the Lamar River with the uncollared black male adult. In September the same male returned to the main pack and began to dominate long-time alpha male 1047M. This type of hierarchical switch is not common but has been recorded several times between females in the Junction Butte pack since 2017. 1047M remains with the pack as a subordinate. After a few months wandering alone, 1109F returned to Junction Butte territory and is considered a satellite pack member. She is the target of aggressive dominance from several pack females but sometimes travels with the pack males and yearlings in a sub-group, where she is temporarily the dominant female. This year the Junction Butte pack expanded their territory to the west, going as far as Mount Everts. Perhaps this will enable the pack to finally split and establish adjacent territories. However, remaining cohesive has its benefits and allows Junction Butte to dominate every other pack and regularly hunt bison.

Mollie's (7 wolves; 7 adults, 0 pups)

Despite having two pregnant females (1090F and 1239F), no pups survived in 2020. Former dominant female 978F (whose collar dropped in 2018) disappeared in February. She had an injury to her front paw and may have had a hard time keeping up with the pack. The pack used a similar area they have in past years: Pelican Valley up through the upper Lamar River down to Lamar Valley and Cache Creek. The dominant male, 890M is the second oldest wolf in YNP, born in the Blacktail pack in 2011. As a yearling he joined the Junction Butte pack, which was established by his brothers in mid-2012, and spent some time from 2014 to 2015 as the dominant male. He dispersed to join Mollie's in the summer of 2016. He has fathered approximately 12 litters of pups throughout his life, but for various reasons, they have had fairly low survival to adulthood.

Wapiti Lake (20 wolves; 12 adults, 8 pups)

The Wapiti Lake pack continues to be led by the oldest wolf in YNP, an easily-recognizable uncollared white female who was born in the Canyon pack in 2010. The dominant male is 1014M who was born in the Mollie's pack in 2014. As the dominant pair ages the pack leadership is likely shared between many adults, especially since the pack includes several age classes with a four-year-old beta female, several three-year-olds, several two-year-olds, and at least five yearlings. The pack produced two or three litters, and in late summer eight pups were counted. It is unknown which females were the mothers and if the pups were from one litter or a few small litters mixed together. All eight pups lived through the end of

the year. The pack continued to expand their territory south to West Thumb, west to West Yellowstone, and followed their typical winter movements north to Tower and Mammoth Hot Springs. Several subordinate adult pack members dispersed in late fall and winter. Two of them died soon after dispersal (see Wolf Mortality section) but likely others survived and will attempt to establish new packs outside of YNP.

Cougar Creek (6 wolves; 4 adults, 2 pups)

Fortunately, the only collared wolf in the Cougar Creek pack, subordinate 1199F, remained with the pack and her collar was not chewed off, as has happened to several other collars in the Cougar Creek pack the last few years. The dominant pair are uncollared, but tracking flights saw two pups at one of the pack's traditional den areas. This small pack's territory includes the southern Gallatin Mountains to the Madison River, and the boundaries have changed little since the pack formed. This territory has been held for nearly 20 years by female descendants of the pack's original dominant female 151F, born in the Leopold pack in 1997, making it the second oldest pack in YNP.

Heart Lake (6 wolves; 3 adults, 3 pups)

This new pack formed in vacant territory in southern YNP where the Snake River pack used to live. The pair (1104F and an uncollared male) produced four pups and were joined by a third adult in mid-summer. Three of the four pups were still alive by the end of the year, and the pack was successful finding elk to hunt in the upper Snake and Heart rivers in early winter. By mid-winter previous packs living in this area often shift outside of YNP, following available prey to lower elevations just south of the park boundary for a few months before returning for the denning season. We expect Heart Lake will move in similar ways.

Bechler (4 wolves; 4 adults, 0 pups)

Similar to 2019, collaborating technician Aaron Bott gathered data on wildlife use and movements in the Bechler region. Bott hiked 675 kilometers (420 miles) and spent 45 days in the field in every season throughout the year. Trail cameras recorded the same breeding pair as the previous year plus two yearlings and three small pups in June. Bott, in cooperation with Idaho Fish and Game, attempted to capture a wolf from the Bechler pack outside of YNP using cable restraints and foothold traps. These efforts were unsuccessful, and we will continue to monitor the Bechler pack's territory with trail cameras and fixed-wing flyovers searching for tracks. In November one such flight found the four adults but saw no sign of pups. Presumably they died between June and the end of the year and, while the pack still persists in the park, it does not count as a breeding pair for 2020.

Other wolves

1154F and 1155M, possibly loners or a pair

Wolf 1154F temporarily rejoined the 8-Mile pack during the denning season. She likely produced pups, but by fall she was travelling alone again. 1155M, also dispersed from the 8-Mile pack, spent most of the year with a gray female who may have produced pups. After she and the pups disappeared, 1155M and 1154F were tracked together or in the same general area in northern YNP through the end of the year.

1198F

Originally from the Cougar Creek pack, 1198F has travelled alone quite often since she was collared as a pup. Now two years old, she has been a lone wolf for 18 months and is most often found in the Gallatin Mountains.

1239F

Born in the Mollie's pack in 2018, 1239F started to disperse in late 2020 but still used some of the same areas as her former pack.

Lamar Canyon (0 wolves; 0 adults, 0 pups)

The Lamar Canyon pack was not seen in YNP in 2020. The pack did not have any radio collars, but reports of a small group of black wolves persisted well east of the park border into the spring. This pack has likely disintegrated or taken up a new territory. If a few of the wolves remain, they are monitored by Wyoming Game and Fish staff. The territory they left in YNP is partly used by the Junction Butte pack, with occasional use by dispersing wolves or the Mollie's pack travelling down the Lamar River.

Transboundary packs

Several packs seasonally use YNP, but the majority of their movements are outside the park boundary. The Hoodoo Creek, Pahaska, and Hawk's Rest packs all occasionally use YNP in summer and fall but are officially monitored by Wyoming Game and Fish and count towards the Wyoming wolf population estimate.



A fourth Junction Butte female, 1109, denned alone in a dirt den dug into the side of a hill (a very common den construction). None of her pups survived. NPS Photo/J. SunderRaj.

VOLUNTEER HOURS FOR 2020	
Name	Hours
Sidney Brenkus	210
Carly Segal	598
Dylan Sanborn	320
Grace Smith	210
Hunter Stier	150
Maeve Tuley	430
Micah Jaffe	210
Rylee Jensen	150
Sara Madsen	150
Taylor Bland	853
Total	3281

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Sara Madsen, a volunteer technician for the March winter study, lost her life in a tragic car accident on September 2, 2020. From Teton, Idaho, Sara had a diverse skill set from her past experiences as field technician, trail crew member, ski instructor, and wildland firefighter. Although Sara only worked for the Wolf Project for a short time, her warm personality, hard work, and passion for wildlife and wildlands was of tremendous value to our project and community. We are grateful to have known her.

Publications

Anton, C.B., D.W. Smith, J.P. Suraci, D.R. Stahler, T.P. Duane, and C.C. Wilmers. 2020. Gray wolf habitat use in response to visitor activity along roadways in Yellowstone National Park. *Ecosphere* 11(6):e03164.

DeCandia, A.L., E.C. Schrom, E.E. Brandell, D.R. Stahler, and B.M. vonHoldt. 2020. Sarcoptic mange severity is associated with reduced genomic variation and evidence of selection in Yellowstone National Park wolves (*Canis lupus*). *Evolutionary Applications* 00:1-17.

Metz, M.C., J. SunderRaj, D.W. Smith, D.R. Stahler, M.T. Kohl, K.A. Cassidy, and M. Hebblewhite. 2020. Accounting for imperfect detection in observational studies: modeling wolf sightability in Yellowstone National Park. *Ecosphere* 11(6):e03152.

Smith, D.W., D.R. Stahler, and D.M. MacNulty, editors. *Yellowstone Wolves: Science and Discovery in the World's First National Park*. Chicago: University of Chicago Press. 2020.

Stahler, D.R. 2020. Biologist's life parallels that of the wolf he studies. *International Wolf Center Magazine*, Spring 2020 issue.

vonHoldt, B.M., A.L. DeCandia, E. Heppenheimer, I. Janowitz-Koch, R. Shi, H. Zhou, C.A. German, K.E. Brzeski, K.A. Cassidy, D.R. Stahler, and J.S. Sinsheimer. 2020. Heritability of interpack aggression in a wild pedigreed population of North American grey wolves. *Molecular Ecology* 29:1764-75.

Wilmers, C.C., M.C. Metz, D.R. Stahler, M.T. Kohl, C. Geremia, and D.W. Smith. 2020. How climate impacts the composition of wolf-killed elk in northern Yellowstone National Park. *Journal of Animal Ecology* 89:1511-19.



Wes Binder hoping not to get wet crossing Lava Creek. NPS Photo/C. Meyer.

For a complete list of our publications, please visit: go.nps.gov/yellwolves



NPS Photo/J. SunderRaj (FRONT COVER)

NPS Photo/K. Cassidy (BACK COVER)

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*All photos are NPS unless noted.