# Natural Resource Programs

The Branch of Natural Resources helps preserve and increase knowledge of Yellowstone's resources in these areas:

- · Air, Land, and Water
- Aquatic Resources
- Geology
- Vegetation
- Wildlife



Pygmy owl.

# Air, Land, and Water

#### **Air Resources**

GYA Clean Air Partnership. The Greater Yellowstone Area (GYA) Clean Air Partnership began in 1997 as a cooperative effort by the National Park Service and the U.S. Forest Service to advise the Greater Yellowstone Coordinating Committee and facilitate air program coordination and the implementation of consistent air quality management strategies. Current membership includes Yellowstone and Grand Teton national parks, Gallatin, Custer, Beaverhead, Shoshone, Bridger-Teton, and Targhee national forests, Red Rock Lakes National Wildlife Refuge, the Idaho National Environmental and Energy Laboratory, the Bureau of Land Management in Wyoming, and the Montana, Idaho, and Wyoming Departments of Environmental Quality. The group focuses on addressing the four primary GYA air quality threats: 1) urban and industrial emissions, 2) oil and gas development in southwest Wyoming, 3) prescribed and wildfire smoke, and 4) snowmobile emissions.

The 10<sup>th</sup> annual meeting was held in Bozeman, Montana, in October 2006. Park staff gave updates on the park's greening program and wildland and prescribed fire programs. Discussions focused on smoke from prescribed and wild fires. Public concerns about visibility, nuisance smoke, greenhouse gasses, together with the Environmental Protection

Agency's proposed revisions on particulate matter criteria (the 24-hour standard would change from 65ug/m³ to 35ug/m³) all have implications for prescribed burning. In high wildland fire years, the opportunities for prescribed fires could be restricted in order to minimize smoke.

Air Quality Monitoring. Yellowstone participates in a nationwide interagency air quality monitoring network designed to determine levels of air pollutants, trends in air quality, and compliance with National Ambient Air Quality Standards. Park rangers collect samples and data on atmospheric deposition and wet (acid rain) and dry atmospheric deposition at Tower Ranger Station, visibility (fine particulates, PM<sub>2.5</sub>) and gaseous pollutants (ozone and sulfur dioxides) at the Lake water tank, and carbon monoxide and fine particulates at Old Faithful and at the West Entrance. The samples and raw data are sent to various national programs for analysis.

The NPS Air Quality Division's 2005 Annual Performance and Progress Report (available at www2.nature.nps.gov/air) noted that no measured Clean Air Act standards were exceeded in Yellowstone; the park's air quality, including visibility, is generally considered excellent. The NPS continues to work with the Environmental Protection Agency and with state air quality agencies to deal with the external sources of air pollution, such as oil and gas development and coal-fired power plants. Results of the 2006 Annual Performance and Progress Report will be available in 2007.

Most of Yellowstone's efforts in regard to air quality involve monitoring winter use at the West Entrance and Old Faithful. Air quality has been stable or improving over the last three winters when the Best Available Technology (BAT) requirement has been in affect. The highest hourly carbon monoxide (CO) concentrations at both locations occur during the winter even though summer traffic volumes are nearly 60 times higher, but the combination of reduced emissions by the snowmobiles using BAT and fewer winter vehicles entering the park has greatly reduced CO concentrations to be less than twice as high as the summer concentrations. Data for the winter of 2005-2006 showed a direct correlation between the decrease in total oversnow traffic and a decrease in air pollutants. Air quality at both locations was good during the winter and well below the National Ambient Air Quality Standards. The CO concentrations were about the same as the previous winter year despite an increase in the total number of winter vehicles entering at West Yellowstone. Even though summer traffic volumes are nearly 60 times higher, the highest hourly CO concentrations at both locations occur during the winter. However, the mean CO concentrations in winter have decreased over the last several years to be less than twice as high as the summer concentrations. Concentrations of fine particulate matter (2.5 micrometers or less) now correlate only weakly to traffic counts at the West Entrance and not at all at Old Faithful. The question of how much CO concentrations will increase if snowmobile traffic is allowed to increase up to the winter use plan limit is unresolved. (Source: Ray, J.D. 2007. Winter Air Quality in Yellowstone National Park: 2005-2006. Air Resources Technical Report NPS/ARD-2007/D-1207, National Park Service, Denver, CO.)

#### **Snow Survey**

More than 75% of the surface water supply in the West is derived from snowmelt in the region's higher mountainous areas. Conditions from year to year and region to region can range from extreme drought to severe flooding, putting hundreds of millions of dollars at risk annually in agriculture, hydropower, dam operation, flood control, drought mitigation, and recreation. To help manage this resource for public safety, health, and economic viability, the Natural Resource Conservation Service

(NRCS), under the federally mandated Snow Survey and Water Supply Forecasting Program, maintains an extensive monitoring system to collect snow pack and related climate information. As the headwater areas for two major river systems (the Yellowstone River east of the Continental Divide that feeds into the Mississippi River system, and the Snake River on the west that flows into the Columbia River), YNP has 10 NRCS SNOTEL (SNOpack TELemetry) stations and 5 manual snow course sites.

In addition to collecting data on long-term snow water equivalent, precipitation, and temperature, NRCS has been adding snow depth sensors at the SNOTEL stations over the past three years. This information will provide a more accurate assessment of hydrologic and climate conditions relating to water supply conditions. The data is used to assess avalanche potentials and winter severity and range conditions for wildlife. Plans call for adding soil moisture and soil temperature sensors to the SNOTEL network over the next few years to better forecast both the quantity and timing of spring and summer stream flows.

#### **Fens Study**

Fens are wetland habitats in which a constant supply of surface or ground water maintains permanently saturated soils and, over thousands of years, causes thick layers of partially decomposed organic matter to accumulate. This organic soil, called peat, is common in far northern climates. In Yellowstone National Park, although fens occupy little land area, they include a diverse range of areas occupied by plant and animal species that rely on permanently moist environments, and they serve as examples of how complex fen ecosystems function in a pristine state. Many of the major wildlife species of the park spend at least some of their time in fens, which provide both forage and a cool, moist place to go in the heat of the summer.

A major goal of the Yellowstone Fens Project is to understand how different landscape-scale environmental variables affect the distribution of plant species in fens. With a grant from Canon U.S.A., researchers from Colorado State University led by Dr. David Cooper, spent the summers of 2004 and 2005 mapping and describing 170 fens in watersheds across the park to study the influence of different geologic formations near the road network and in

remote backcountry locations. Geology, including geothermal activity, is a key variable because it has a strong influence on groundwater chemistry, which has a strong influence on the plant species found in fens. Groundwater in a predominantly sedimentary watershed will have high pH and high ionic concentrations, volcanic watersheds will have lower pH values, and geothermal activity can create very acidic, low pH groundwater.

In addition to geology, the main environmental variables of interest are elevation and mean annual precipitation. While values for elevation and mean annual precipitation can be easily obtained for each fen site from GIS (geographic information system) maps provided by the park's Spatial Analysis Center, isolating the influence of geologic formations is complicated by a long history of volcanism and uplift, and fens are often located in valley bottoms and depressions that have been covered by glacial or fluvial deposits. Groundwater within a fen travels through different formations and more recent deposits before entering the fen. The researchers identified six main geologic types in the locations where fens were sampled: 1) glacial till containing sedimentary rocks in the Northern Range and below the Gallatin Mountains, 2) volcanic rhyolite in the central core of the park, 3) volcanic basalt in the southwest Bechler River drainage, 4) volcanic andesite in portions of the Gallatin and Absaroka mountains, 5) acidic geothermal water, and 6) neutral high chloride geothermal water. From the original 170 fen water chemistry samples, a subset of samples was selected from sites that were clearly dominated by one of the six geologic types. Statistical analysis of these samples provided a water chemistry signature of each geologic type. The relationship between water chemistry parameters and plant species diversity can be linked to these water chemistry signatures.

Through statistical analysis of the more than 500 stands of vegetation that were surveyed during the two-summer field effort, the researchers have built a classification system using the hierarchical agglomerative clustering technique. They identified 31 different vegetation communities in seven major groups defined by gross physical characteristics, such as small sedge-dominated community types or willow-dominated community types. In the final part of the analysis, which will be completed in 2007, they are examining how important the vari-

ables of elevation, mean annual precipitation, and groundwater chemistry are in determining which plant species grow in which fen.

#### **Restoration Projects**

Gardiner Basin Restoration Workshop. In 1926, Congress added several thousand acres to the northern part of the park to "provide the winter range and winter feed facilities indispensable for the adequate and proper protection, preservation, and propagation of the elk, antelope, and other game animals of Yellowstone National Park" (Game Ranch Addition Act of May 26, 1926). Known as the Boundary Line or Gardiner Basin area, it is dominated by exotic vegetation introduced through homesteading, railroading, and gravel mining activities, but it is still an important feeding ground, especially for Yellowstone's dwindling pronghorn population. Yellowstone's initial experiments in reestablishing native vegetation to improve winter forage there have been largely unsuccessful, partly because of the staff's limited experience with the semi-desert environment found in the rain shadow of the Gardiner Basin.

With funding obtained from Canon U.S.A., Inc., through the Yellowstone Park Foundation, the Greater Yellowstone Coordinating Committee, and the Rocky Mountains Cooperative Ecosystem Studies Unit, a workshop was held in April 2005 with 10 arid land restoration specialists and 20 park and Gallatin National Forest staff. The workshop report, which included recommendations for both agencies applicable to specific sites, was presented during field trips for the 2006 Billings Land Reclamation Symposium, held in June, and the 28th annual conference of the National Association of Abandoned Mine Land Programs, held in Billings, Montana, in September. Park staff continue to seek funding for an initial pilot program that could begin in 2008.

Turbid Lake Road Restoration. When the East Entrance Road was reconstructed in the 1930s, a 6.5-mile segment known as the Turbid Lake Road was abandoned. Lack of funding put off removal of the road and restoration of the area to its natural state (especially wetlands and grizzly bear habitat) until wetlands impacts resulting from the recent reconstruction of the Dunraven and East Entrance roads required mitigation. The Army Corps of Engineers' Clean Water Act Section 404 project permits require that such projects result in

no net loss of wetlands; wetlands that are impacted or destroyed in the process of reconstructing the roads must be compensated for through the restoration of disturbed wetlands elsewhere in the park. A grant from Canon U.S.A. in 1997 provided the seed money for a multi-funding source project to remove culverts, de-compact the roadbed, and re-establish the original contours and natural drainage patterns, salvage and replace topsoil and plant material to speed revegetation, transplant grasses, forbs, and small trees, and re-route part of the Turbid Lake Trail to avoid the restored wetlands.

The heavy equipment phase of the Turbid Lake Road restoration project was completed in 2005 with gratifying results. On the oldest restoration segments, it is already difficult to see where the road was. The native plants have re-established and grizzly bear, elk, bison, and even wolves are frequent visitors. In keeping with the requirements of the 404 permit, vegetation staff continued to document the revegetation progress with groundwater monitoring wells, revegetation monitoring plots, and repeat photography.

Mining Impacts. Park staff continued to monitor proposed and ongoing reclamation projects associated with two historic mining sites outside the park: the New World Mining District and the McLaren mine tailings. Environmental cleanup of historical mining impacts in the New World Mining District adjacent to the park's Northeast Entrance is proceeding. The U.S. Forest Service continues to identify sources of pollution and conduct site investigations to refine cleanup activities.

Discussions about cleaning up the McLaren tailings site continued. The Montana Department of Environmental Quality is seeking funding and is monitoring groundwater in the proposed repository site. Three groundwater monitoring wells were installed in 2005 with funding from the NPS Water Resources Division to determine whether there is adequate separation between the groundwater and the bottom of the proposed repository—one of the criteria necessary to determine whether the site is suitable.

# **Aquatic Resources**

**Yellowstone Cutthroat Trout Preservation** 

Upper Yellowstone River Basin. In spring of

2006, Mountain and Howell creeks were surveyed to determine the timing of Yellowstone cutthroat trout (Onchorhynchus clarkii bouvieri, YCT) spawning runs, location of spawning grounds, and upstream extent of spawning migration. Visual surveys were conducted throughout the Mountain Creek drainage in mid-June to determine the distribution and habitat use of spawning cutthroat in the system; fish were seen spawning throughout. In September, our focus switched to determining cutthroat trout distribution and habitat use in the Mountain Creek drainage and the main stem of the Yellowstone River. One-hundred meters per kilometer of stream in Mountain and Howell creeks and their tributaries were sampled using a backpack electrofishing unit and habitat assessments were conducted using the U.S. Forest Service R1/R4 fisheries habitat assessment method.

Snorkel surveys were conducted in conjunction with electrofishing surveys in early September in the main stem of the Yellowstone River from the park's southern boundary to the mouth of the river at Yellowstone Lake. By conducting both electrofishing and snorkel surveys, we were able to get a clearer picture of fish distribution and habitat use. Juvenile cutthroat trout were collected throughout the river, while adult cutthroat trout were found concentrated in a few sections of the river often associated with deep pools. Analysis of electrofishing data shows distinct size differences between the main stem of the Yellowstone River and tributaries to the river. Age analysis must be completed to determine if tributaries are used simply for spawning or if a difference in growth rates is causing the size differences.

Lake Trout Removal. Preservation of cutthroat trout in Yellowstone Lake continued to be a top priority in 2006. More than 59,000 non-native lake trout (Salvelinus namaycush) were removed, bringing the total number removed to almost 200,000 during 1994–2006 (Figure 1). The removal effort has undoubtedly saved hundreds of thousands of YCT from predation, changed the size and age structure of the lake trout population and slowed its rate of increase, but it remains questionable whether current levels of effort will suffice to collapse the lake trout population. We removed the largest lake trout yet (22.25 pounds) in 2006, and the catch of younger lake trout has slowly increased over the last five years. We have countered the recent increase in

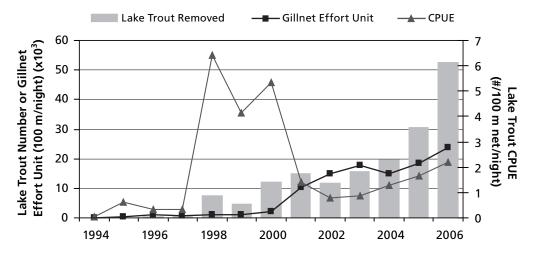


Figure 1. Number of lake trout removed, gillnet units of effort used, and lake trout catch per unit of effort (CPUE) obtained by the lake trout removal program on Yellowstone Lake during the entire gillnetting season, 1994–2006.

the catch of mature lake trout on spawning grounds (three times as many as in earlier years) by specifically targeting those fish through increased netting and electrofishing. The cutthroat trout population has yet to demonstrate a strong positive response. Although we have seen an increase in numbers of juvenile cutthroat trout recruiting to the population in recent years, it will take several more years for these fish to replace the lost reproductive potential caused by lake trout predation, whirling disease, and drought.

Population Monitoring at Clear Creek. Annual monitoring of spawning Yellowstone cutthroat trout was conducted at Clear Creek for the 18th consecutive season. Between May 1st and July 4th, aquatics personnel counted and sampled 471 mature trout, making 2006 the second consecutive year that fewer than 500 spawning trout were recorded migrating past the trap near the mouth of the stream. Fewer than 20 fish were counted on most days and the peak of the migration appeared to be in mid-May (Figure 2). All of the captured trout were longer than 400 mm and 56% were greater than 500 mm in length, suggesting that the trend of record lengths of spawning fish continues.

#### **Native Trout Restoration**

Westslope Cutthroat Trout. The East Fork Specimen Creek (EFSC) westslope cutthroat trout (Onchorhynchus clarkii lewisi, WCT) restoration project moved ahead in 2006 with completion of the National Environmental Policy Act (NEPA) process

and the initial phases of project implementation. In August, YCT that had contributed to the degradation of WCT within the EFSC watershed were removed from High Lake using the piscicide rotenone, and initial observations indicated that the treatments were successful. In 2007, restocking of WCT in High Lake will begin, and the barrier in lower EFSC will be completed in anticipation of chemical removal of fish from the stream in 2008.

The way was cleared for the WCT discovered in an unnamed tributary of Grayling Creek to be used in WCT restoration projects in 2006 when genetic analyses confirmed that the population has not hybridized with rainbow trout or Yellowstone cutthroat trout and a complete health screen detected no pathogens. A second potential source of genetically pure WCT within Yellowstone's boundaries for utilization in WCT restoration efforts was identified in 2006 in the Oxbow/Geode Creek complex in the Yellowstone River drainage.

Yellowstone Cutthroat Trout. Resource surveys began on streams identified as high priority for YCT restoration: Rose Creek, Blacktail Deer Creek, and the Elk Creek complex. However, data collection on other streams throughout Yellowstone's northern range also continued in 2006. Genetic samples from Amphitheater, Antelope, Crystal, Pebble, and Rose creeks were delivered to the Idaho Fish Genetics Laboratory for analysis; the results will lend further insight into the genetic status of YCT on Yellowstone's northern range.

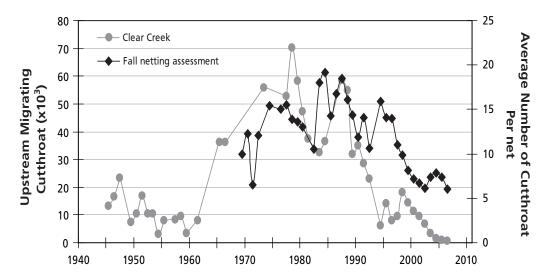


Figure 2. Upstream-migrating cutthroat trout counted at Clear Creek spawning trap (1945–2006), and mean number collected per net on Yellowstone Lake during the fall (1969–2006).

#### **Amphibian Surveys**

A critical element of the native fish restoration initiative is to better understand how piscicide use affects non-target wildlife including amphibians and aquatic invertebrates. The park's four native amphibian species are the Columbia spotted frog (CSF), Rana pretiosa; the boreal chorus frog (BCF), *Pseudacris triseriata maculate*; the boreal toad (BT), Bufo boreas boreas; and the blotched tiger salamander (BTS), Ambystoma tigrinum melanostictum. During the summer of 2006, fisheries and aquatic sciences staff surveyed current and proposed restoration sites (i.e., westslope cutthroat trout in the Specimen Creek drainage and Yellowstone cutthroat trout in the Yellowstone River drainage) to document the resident amphibian breeding populations and aquatic invertebrate distribution and community structure, and to assess the effects of piscicides on these species. For a complete synopsis of survey results, refer to the Yellowstone Fisheries and Aquatic Sciences 2006 Annual Report.

East Fork Specimen Creek. Surveys from 1997–1999 found all four amphibian species in the northwest portion of the park but only CSF in the Specimen Creek watershed. Within the East Fork Specimen Creek drainage in July 2006 we observed amphibians at 12 of the 40 sites sampled, including CSF (11 sites), BCF (3 sites), and BT (2 sites).

Breeding populations (identified by the presence of eggs or larvae) were recorded at six sites, including three within the vicinity of High Lake at the headwaters of the drainage: one breeding population of CSF in the High Lake outlet with 100–200 tadpoles, and two breeding sites for both CSF and BCF in wetland areas approximately 200 m from the lake that are not being treated with piscicide. One of the latter sites is connected intermittently to High Lake via a wet meadow that may serve as a dispersion corridor to High Lake for newly emerged frogs.

The piscicide (1 ppm) applied to High Lake in August to eliminate the YCT proved lethal to larval (gill-breathing) amphibians, while adults (non-gill breathers) did not appear to be affected. Immediately after application, tadpoles deviated from their normal cryptic behavior and were seen swimming in open water, followed by erratic swimming and passive floating. However, effects of the piscicide may be reversible. Tadpoles that had progressed to the "floating" stage were revived by placing them in a clean water source.

*Northern Range.* We documented CSF, BCF, and BTS at 11 of the 40 wetland sites sampled within the Elk Creek drainage, including seven sites with a total of eight breeding populations, although two of the four BTS sites dried out before the larvae completed their metamorphosis. At the seven wetland

sites sampled within the Blacktail Deer Creek drainage, one adult CSF was found at each of two sites.

#### **Aquatic Invertebrates**

Monitoring aquatic invertebrate communities is important because they are relatively immobile, sensitive to environmental changes and can live from one to four years. The results of aquatic invertebrate sampling at six stream sites on East Fork Specimen Creek, three sites within the Elk Creek drainage, and at four sites within High Lake before and after the piscicide application are being processed at an independent laboratory. Cursory observation at East Fork Specimen Creek indicated that aquatic worms (annelids) and stonefly larvae (Plecoptera) were among the most impacted stream dwelling species. Both groups experienced some mortality and were seen accumulating within pooled areas of the stream. Effects of the piscicide on lake dwelling insects were more difficult to discern because of the abundant aquatic vegetation and the cryptic behavior of many species. Dead caddisfly larvae (Trichoptera) and fingernail clams (Psidium compressum) were observed during the days following treatment. Conversely, beetle species (Coleoptera sp.), dragonflies and damselflies (Odonata), and midges (Chironomidae) were abundant both before and after the piscicide application.

In addition to the 13 stream and lake sites sampled in areas targeted for native fish restoration, aquatic invertebrates were sampled at four sites associated with water quality monitoring stations and four sites near road construction projects.

Invasive Aquatic Species. Invertebrate settling plates were deployed on Yellowstone and Lewis lakes from June to October in boat launching areas to detect the presence of zebra mussels (*Driesenna polymorpha*). Watercraft are the most probable mode of transportation across watersheds for most aquatic nuisance species. Non-native species may be found attached to boat hulls and trailers and in bilge water. When retrieved in October, the settling plates had been colonized by many native invertebrates including snails (*Physa* sp.), fingernail clams (*Sphaerium* sp.), scuds (*Gammarus* sp.), leeches (*Glossiphonia* and *Erpobdella* spp.), and caddisflies (*Phryganea* and *Agraylea* spp.), but no zebra mussels were found.

#### **Long-term Water Quality Monitoring**

During 2006 we collected monthly physical and chemical water quality data at 12 sites on major rivers year-round and at seven sites on Yellowstone Lake during the ice-free period from May to October. A multiparameter probe was used to collect water temperature, dissolved oxygen, pH, specific conductance, and turbidity. Water samples were also collected for total suspended solid and volatile suspended solid analysis. In June we began a more comprehensive water quality monitoring effort as part of the Greater Yellowstone Network's Inventory and Monitoring Program. This sampling regime includes anions (sulfate, chloride, bicarbonate, and carbonate), cations (calcium, magnesium, sodium, and potassium) and nutrients (nitrate-N, nitrite-N, ammonia, total phosphorus, and ortho-phosphate). Dissolved and total metals (arsenic, copper, iron, and selenium) in the water and sediments are measured twice during high and low flow periods in Soda Butte Creek at the park boundary.



Fisheries volunteer Derek Rupert demonstrates electrofishing techniques to students in a Yellowstone Association Institute class.

# **Geology**

Protection and monitoring of YNP's geothermal features is a focal point of the park's geology program. In 2006, the park's geologists provided assistance to law enforcement (describing and reporting on natural features taken by visitors), interpretation (seasonal, permanent, and winter guide training), and business management (fuel spill remediation efforts near the Snow Lodge at Old Faithful) staff. They also secured permission from maintenance staff to begin removal of a boardwalk near Palette Springs at Mammoth, and responded to requests for information from the media, general public, and other Yellowstone staff.

#### **Montana Water Rights Compact**

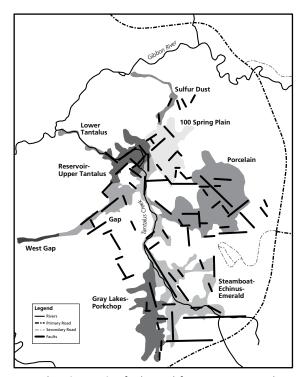
The Montana Water Rights Compact, established in 1994 between the state of Montana and Yellowstone National Park, protects geothermal features in the park by limiting groundwater withdrawal in a designated area north of the park. This Controlled Groundwater Area was to be monitored by the state of Montana with funding provided by the federal government. In 2005, YNP received a base increase from Congress to implement a comprehensive geothermal monitoring plan for the park, including \$141,000 that was to be paid annually to the Montana Bureau of Mines for monitoring the Controlled Groundwater Area and \$255,000 for geothermal monitoring in the park. In 2005 and 2006, \$145,000 from the latter sum was paid to the University of Montana, Utah State University, and Montana State University for collaborative efforts to monitor the park's geothermal features using remote sensing techniques. In 2006, an additional \$43,000 (\$22,000 from Yellowstone National Park funds and \$21,000 from the NPS Water Resources Division) was paid to the Montana Bureau of Mines and Geology to begin an assessment of plugging a geothermal well drilled by the Church Universal and Triumphant near LaDuke Hot Springs in 1986.

#### **Geothermal Monitoring Program**

Protecting the park's unique geothermal features is primary to its enabling legislation. The Geothermal Steam Act of 1970, as amended in 1988, also requires that the park's geothermal features be protected and monitored. In March 2003, park

staff and partner scientists prepared a geothermal monitoring proposal to initiate a comprehensive, scientifically-based geothermal monitoring program within Yellowstone. The proposal included groundwater and surface water monitoring, remote sensing of thermal features, chloride flux monitoring, and geochemical monitoring. The park's Technical Oversight Committee and the Yellowstone Volcano Observatory (YVO) have peer reviewed and support the proposed program as a critical component of monitoring the Controlled Groundwater Area, monitoring volcanic and seismic hazards, and protecting the park's irreplaceable geothermal features. The work is estimated to cost \$989,000 per year.

In 2006, geothermal monitoring in the park continued with the acquisition of airborne remotely sensed, thermal infrared images obtained over the Old Faithful, Norris, Mud Volcano, and Mammoth areas, and the Sour Creek resurgent dome. Additional effort was expended to improve the chloride flux component of the geothermal monitoring program. A \$100,000 study funded by the Water Resources Division was begun that will improve our understanding of shallow groundwater movement in the Norris area.



Map showing major faults and fractures among the hydrothermal sub-basins within Norris Geyser Basin, determined by examination of airborne remotely sensed, thermal infrared images.

#### **Yellowstone Volcano Observatory**

The Yellowstone Volcano Observatory (a partnership set up by the park with the U.S. Geological Survey and the University of Utah) monitors volcano and earthquake hazards within the park using a network of 26 seismic and 13 GPS leveling stations. There were 1,202 earthquakes in Yellowstone in 2006, with rapid uplift continuing along the axis of the Yellowstone caldera. Near White Lake in the upper Pelican Valley area, the ground has risen about 16 cm in the last two years. In 2006, YVO published a 10-year monitoring plan for the Yellowstone Volcano and is in the process of finishing a report on volcanic hazards in Yellowstone.

# **Vegetation**

The vegetation found in Yellowstone reflects the physical environment—climate, geology, soils, elevation, and aspect—as influenced by natural disturbances and human activities. Preserving native vegetation communities and associated processes while minimizing human influences has great value for wildlife habitat, wilderness, cultural landscapes, and scientific research. However, in some situations, such as with hazard trees or fire, park visitors and staff must be protected from risks associated with the natural processes operating on vegetation communities.

YCR's vegetation staff has diverse responsibilities and functions related to the perpetuation or restoration of vegetation communities, management of threatened or endangered species, safety and enjoyment of the public, mitigation of human-induced effects, assessing threats from external sources, and general management and compliance needs.

#### **Plant Inventories**

The park's vascular plant list includes more than 1,375 taxa. Yellowstone has met the goal of the servicewide inventory and monitoring initiative that requires documenting at least 90% of the vascular plant species in each park and incorporating the information into the NPSpecies biodiversity database.

*Native Species*. Two native species were found during summer 2006 for the first time in the park:

 A very small population of common oakleaf fern (Gymnocarpium dryopteris) was located in



Common oakleaf fern (Gymnocarpium dryopteris).

a rock crevice during rare plant inventories in the Norris area for the Fire Cache's wildland-urban interface project. Common oak fern occurs across the boreal north and reaches south at scattered locations in the Rocky Mountains and Black Hills. It is considered a plant species of concern in Wyoming due to its rarity in the state.

• Jointed rush (*Juncus articulatus*) was located during the wetland delineation at Old Faithful, where it is part of the extensive wetland along Zipper Creek near the Old Faithful Ranger Station. Although widespread across the northern portion of the United States, the species is relatively uncommon in Wyoming and has been identified in only two counties, Teton and Platte.

*Non-native Species.* Two additional non-native species were documented for the first time in 2006:

- Several years ago an odd-looking Potentilla was collected in the Midway Geyser Basin area. Barbara Ertter, the North American expert on the genus Potentilla who examined the specimen last fall, identified it as ashy cinquefoil (*Potentilla inclinata*), a European species which had not previously been reported in the Rocky Mountains.
- During the rare plant inventory in the Old Faithful development, a single plant of bird's-foot trefoil (*Lotus corniculatus*) was found. The plant, which had both blooms and mature fruits, was destroyed. This species has become well-established in the Bozeman area.



Bird's-foot trefoil (Lotus corniculatus).

Rare Plant Surveys. To prevent inadvertent negative impacts to rare plant populations in the park, surveys are conducted prior to construction projects, trail re-routes, and other disturbance activities. One benefit of these required compliance activities is the data gathered: the summer field season resulted in documenting 257 additional sites for the GIS layer of "species of special concern" or rare plants in the park. Summer fieldwork for Federal Highway projects took place primarily in the Old Faithful area, a fascinating amalgam of various plant communities where "species of special concern" occupy thermally warm sites and wetlands as well as barren black obsidian sand. Other frontcountry construction sites that were investigated for wetlands or rare plants include the route for the powerline burial near the Lake housing area, the Norris and Madison developed areas for the wildland-urban interface project, and the road realignment near the new fire dorm by the YACC camp. Surveys were also initiated for ground-disturbing activities resulting from the re-routing of the West Thumb Overlook trail and of trails near Outlet Lake and Fairy Falls, the construction of the proposed fish barrier on Specimen Creek, and the Shoshone/Bannock repatriation site.

#### Yellowstone Herbarium

The Yellowstone National Park Herbarium houses approximately 9,000 specimens that have been curated and entered into a database. The specimens are used by NPS personnel and outside researchers to identify vascular plant taxa as well as the bryophytes, fungi, and lichens that occur in the park, and to document the presence, variation, and distribution of native species, and the arrival and spread of exotic species. With the new herbarium facility at the HRC, staff are finally making significant inroads on the backlog of specimens to be added to the ANCS+ database. Several hundred specimens are in the process of labeling, mounting, and cataloging.

During the 2006 field season, 77 vascular plant specimens were collected and will eventually be mounted and catalogued into the herbarium. These new specimens were needed to document the native flora in under-collected portions of Yellowstone, and the arrival and spread of exotic species.

#### **Bryophyte Survey**

Bryophytes (mosses, liverworts, and hornworts)

represent an under-sampled and relatively poorly understood component of the park's ecosystem. Judy Harpel was funded by Canon U.S.A. through the Yellowstone Park Foundation to gather information on the bryophytes present in the park in 2006. This extensive survey, to be conducted over two field seasons, will culminate in a comprehensive bryophyte species list for the park.

The dry sagebrush steppe and dry grasslands were surveyed during the spring, when the small cryptic mosses and liverworts are visible, although some species are so inconspicuous that they look like little black dots on the soil surface. During the summer, the surveys focused on various forest types, alpine meadows and tundra, talus slopes, forested wetlands, peatlands, and riverine systems. The decrease in visitation in the fall allowed for surveys in geothermal areas, especially Norris Geyser Basin and the White Creek area.

One western North American endemic species found during the summer field season, Roell's moss (Roellia roellii [Röll] Crum), was the first record of this large, distinct moss in the park. When first found in a fishing area along the Madison River it was thought to have been introduced, but two additional locations were subsequently found in very different areas of the park. These additional locations suggest that this species may have previously had a broader distribution within the park. It occurs in higher elevations in the cool-climate forests of British Columbia, northern California, Idaho, Oregon, and Washington, reaches the eastern edge of its range in Colorado, Montana, and Wyoming, and is rare in Alaska, Nevada, and Utah. Because of its large size and distinct characteristics, it is surprising that it went unnoticed by previous bryophyte collectors.

#### Woody Vegetation on the Northern Range

The continuing controversies surrounding the status of woody vegetation (aspen, willow, and cottonwood) as it has been affected by historical and current elk population levels and wolf reintroduction, support many diverse research opportunities. The Vegetation Management Specialist supervised one seasonal employee, one Fulbright Scholar (J. Rubio, employed with the Ministry of the Environment, Spain), and two part-time volunteers. The primary emphasis of their work was the

resampling of 113 aspen transects that have been established throughout the northern range, 14 long-term established willow transects, and LANDSAT imaging of stream channel morphology and change. Sampling protocols called for measurement of current annual growth, proportion of browsed stems, pellet counts as an index of ungulate use, and tree/shrub mortality.

The Vegetation Management Specialist also oversaw woody vegetation research projects undertaken by visiting scientists during 2006:

- Drs. Tom Hobbs and David Cooper of Colorado State University and Drs. Linda Zeigenfuss and Robert Stottlemyer of the USGS-BRD in Fort Collins in the 4<sup>th</sup> year of a study of the effects of herbivory and hydrology on willow ecology;
- Dr. Andrew Hansen of Montana State University in the second of a three-year study of bird species diversity in willow communities of varying structure and size;
- Dr. Don Despain of the USGS-BRD at Montana State University and Dr. Rex Cates of Brigham Young University in the first of a two-year study of temperature influences on willow growth and phenolic production; and
- Initiation of a study with Dr. Stottlemyer to investigate the spatial and seasonal changes in soil and sediment microbial functional groups in natural and artificial beaver dams.

#### **Alpine Vegetation**

Ken Aho, from Montana State University, completed his dissertation entitled "Alpine and Cliff Ecosystems in the North-Central Rocky Mountains," the first alpine vegetation study of any volcanic mountains in the central or northern Rocky Mountains. In addition to quantitatively describing alpine plant communities on 10 peaks in and near Yellowstone's northeast boundary, Aho established permanent transects as a baseline from which we can monitor impacts from the non-native mountain goats that are increasingly moving into and using the area. Alpine plant diversity and cover have declined in Olympic National Park as a result of non-native mountain goats. While the net effects of global warming on terrestrial vegetation communities are difficult to gauge, alpine communities are likely to be particularly altered. In Greater Yellowstone, treelines are expected to move up in elevation,

reducing the extent of alpine areas and alpine diversity. A three-year project beginning in FY08 will enable us to resample and expand upon Aho's transects and begin monitoring the abundance, distribution, and demographics of mountain goats so that we can evaluate management alternatives and develop an adaptive management plan to protect the alpine ecosystem.

#### **Forest Insect Infestations**

A partial aerial survey of the park conducted during 2006 by the U.S. Forest Service confirmed continuation of the insect-caused mortality of overstory trees that erupted early in the decade. The park had about 30,000 acres of whitebark pine mortality and 1,200 acres of lodgepole pine mortality, both caused by the mountain pine beetle. Other beetle species are causing mortality of subalpine fir (western balsam bark beetle), Douglas-fir (Douglas-fir beetle), and Engelmann spruce (Engelmann spruce beetle). Pockets of red needled trees resulting from these host-specific insects are evident throughout the different elevation and forested vegetation zones of the park.

Most of the insects responsible for the mortality are small (1/8" long) native bark beetles in the Scolytidae family. They are often referred to as "primary" beetles because through sheer numbers their feeding activity can girdle a tree and be directly responsible for its death. A tree attacked during the summer will have a red crown the following summer, and the red needles usually drop within the next year, leaving a bare, standing dead tree. Secondary beetles, like the native wood-boring and longhorn beetles, are larger (3/4" or more) and attack trees that are already dying or dead.

Another native defoliating insect, the spruce budworm, is also irrupting throughout the lower elevations of the Lamar and Yellowstone River valleys. Host trees are primarily Douglas-fir and secondarily Engelmann spruce. During the budworm's caterpillar life stage, the developing larva feed on the new needles of the year as they emerge, leaving behind a brown cast or "halo" on the outer portion of the tree crown as a result of dead, partially consumed needles. The spruce budworm usually does not feed on old growth needles or kill mature overstory trees except in severe outbreaks, but at high densities it can cause local pockets of mortality among under-

story seedlings and saplings. About 14,000 acres of spruce budworm activity is evident in the park with some seedling/sapling mortality; the most conspicuous defoliation is visible along Reese Creek, the Mammoth Terraces, Lava Creek, and near the Hellroaring trailhead.

Landscape-scale drought and the availability of suitable host trees are the primary forces in the initiation and persistence of insect outbreaks. Healthy trees can successfully defend themselves from beetle attack by "pitching out" adult females as they try to bore their way into the tree. Climate can also be a driving force in diminishing insect outbreaks, as when extreme winter temperatures kill off overwintering broods, or wet summer weather impedes the insects from invading additional trees. Insect activity also decreases as the older, more preferred, and susceptible trees are killed off. All of these insects remain active in local areas between outbreaks, but the resulting tree mortality is negligible.

Park staff have collaborated with scientists from Harvard University (Dr. Paul Moorecroft, Dr. Heather Lynch) and the non-profit Yellowstone Ecological Research Center (Dr. Robert Crabtree) to compile and analyze forest insect effects and trends since the 1960s. An important finding of this research, the results of which have been published in a scientific journal (see Appendix 2), is that mountain pine beetle outbreaks some 15 years previous to the 1988 Yellowstone fires acted to increase the odds of burning by 11%, primarily through the indirect height release of understory trees that flourished after beetles killed off the overstory canopy. More recent beetle activity did not influence fire risk.

An additional research effort was initiated in 2006 with the awarding of a Joint Fire Sciences proposal to investigate reciprocal interactions between forest fires and insect outbreaks, historical and recent. Rocky Mountain and Great Lakes Cooperative Ecosystem Studies Units agreements were established between Yellowstone National Park and three academic researchers: Dr. Dan Tinker at the University of Wyoming, Dr. Monica Turner at the University of Wisconsin–Madison, and Dr. William Romme at Colorado State University. The research team was provided with digital maps and datasets of historical and recent forest fires and insect activity to facilitate field research activities.

#### **Vegetation Management**

Fire Management. Daily tasks of the Vegetation Management Specialist during the 2006 fire season on the Magpie (>3,500 acres) and Stinky (>1,000 acres) fires included briefing management staff and field crews on expected fire behavior, making long-term fire behavior risk projections, and aerial reconnaissance/mapping of the fires. The Vegetation Management Specialist also served on Yellowstone's Fire Management Strategy Team and the Gallatin National Forest/Yellowstone National Park Fire Program Analysis Team that addressed fire program operational structure, fire management operations, prescribed burning issues, and logistics and implementation of hazard fuels reductions in the wildlandurban interface, and represented Yellowstone on an interagency team that is developing disturbance and succession regimes for various vegetation communities in the northern Rocky Mountains as part of the national LANDFIRE fire condition class assessment under the lead of The Nature Conservancy. Lead authorship was assumed in "Vegetation Dynamics Development Tool (VDDT)" model development for the aspen forest type.

Hazard Tree Management. To protect people and property, it is necessary to identify and remove potentially hazardous trees in areas of high visitor and employee use. In 2006, implementation of the newly approved Hazard Tree Management Plan was undertaken by staff from all park divisions. As part of this plan, the Vegetation Management Specialist trains resource management sawyer crews in hazard tree identification, assists with hazard tree assessments when called upon, and provides a centralized repository for records of hazard tree removal efforts throughout the park. During 2006, 1,063 hazardous trees were removed parkwide, including five that were identified within the Mammoth Historic District.

#### Vegetation Education

In addition to identifying plant species upon request for other park staff, outside researchers, and the public, the vegetation staff participated in more formal education efforts during 2006, including:

 weed identification for the Northern Rocky Mountain Exotic Plant Management Team, Yellowstone resource management personnel, Montana Conservation Corp, and Gallatin National Forest;

- 14 field seminars for various university, international, and media groups on topics including northern range/woody vegetation issues, fire ecology, forest insect activity, and disturbed lands restoration;
- rare plant and vegetation overviews for the Division of Interpretation, the Montana Native Plant Society, and the Bozeman chapter of American Association of Retired People (AARP); and
- a course on Yellowstone wildflowers was taught through the Yellowstone Association Institute.

#### Wildlife

In YCR wildlife programs, staff with expertise in wildlife biology work individually and in small groups to apply National Park Service policy in the management, research, and monitoring of individual species and groups of species and their encounters with people.

#### **Road-Killed Wildlife**

Bear Management Office staff maintain a database of large (>30 lbs.) and mid-size (badger, Taxidea taxus; porcupine, Erethizon dorsatum; red fox, Vulpes vulpes; and pine marten, Martes americana) mammals killed on park roads each year. A total of 99 large and mid-size mammals were hit and killed by vehicles on park roads in 2006. Elk (Cervus elaphus, 31) and mule deer (Odocoileus hemionus, 31) were the species most often killed in collisions with vehicles. Other species hit and killed by vehicles on park roads included bison (Bison bison, 12), coyote (Canis latrans, 8), red fox (5), pronghorn (Antilocapra americana, 3), moose (Alces alces, 2), pine martin (2), bighorn sheep (Ovis canadensis, 1), grizzly bear (Ursus arctos, 1), black bear (Ursus americanus, 1), river otter (Lontra canadensis, 1), and badger (1). The average rate of vehicle strike mortality for all park roads combined was 0.2 large and mid-size mammal road-kills per mile of park road. The highest road-kill rate was on U.S. Highway 191 (1.9 road-kills per mile of road). U.S. Highway 191 is the only park road with a 55 mph posted speed limit: all other roads in YNP are posted at 45 mph or lower. Highway 191 comprises approximately 7% of the primary roads in YNP, but accounted for 39% of road-killed mammals in the park in 2006. Annual

numbers of road-killed wildlife are variable from year to year and are related to wildlife population numbers, park visitation, weather conditions, and other factors.

#### **Integrated Pest Management**

As the park's Integrated Pest Management (IPM) Coordinator, the Vegetation Management Specialist maintains Commercial Pesticide Applicator certification, submits Pesticide Use Requests (27 in 2006) to the NPS Washington Office for approval to use specific pesticides in the park, and completes Pesticide Use Logs (22 from 2005) that detail the amount of pesticides used each year. During 2006, he responded to 29 different pest complaints involving insects (11), small mammals (12), spiders (5), and fungi (1) by working with park employee and concessions staff to determine the source of each problem and ways to minimize or eliminate it according to IPM protocols. He also worked with the park's fisheries biologists to secure permission from the Washington and Intermountain Regional Offices to use piscicides as part of the restoration plan for westslope cutthroat trout in the High Lake drainage.

#### **Bears**

#### **Grizzly Bear Recovery Status**

The grizzly bear was listed as a threatened species under the Endangered Species Act (ESA) in 1975 due to a high incidence of human-caused mortality that had caused a significant population decline. Since 1975, the Greater Yellowstone Ecosystem (GYE) grizzly bear population has increased from an estimated 136 bears to 549 bears in 2006. In recent years, the population has been increasing at 4–7% per year. GYE grizzly bears have expanded their range by more than 48% in the last two decades.

On November 17, 2005, the U.S. Fish and Wildlife Service (USFWS) published a proposal in the Federal Register to remove the distinct population segment of grizzly bears in the GYE from the list of species protected under the ESA (50 CFR, part 17). The USFWS held meetings for public comment on the proposal in Bozeman, Montana; Cody and Jackson, Wyoming; and Idaho Falls, Idaho, in January and February 2006, and accepted written and e-mail comments through February 15, 2006. More than 200,000 comments

were received. The USFWS is expected to publish its record of decision on the proposal in March 2007.

If GYE grizzly bears are removed from threatened species status, they will be monitored and managed under the guidance of the Conservation Strategy for the Grizzly Bear in the Greater Yellowstone (www.r6.fws.gov/species/mammals/grizzly/yellowstone.htm). The Conservation Strategy was written by all the agencies that manage grizzly bears and their habitat in the GYE. In YNP, grizzly bear management will not change drastically after delisting. The park will continue to protect bear habitat and emphasize prevention of bear-caused property damages, bear-inflicted human injuries, and human-caused bear mortalities through public education, sanitation, storage of human foods and garbage in a bear-proof manner, and enforcement of bear management food and garbage storage regulations.

#### **Population Monitoring**

*Reproduction.* At least 15 distinct females with home ranges either wholly or partially within YNP produced at least 29 cubs in 2006 (Figure 1). Average litter size was 1.9 cubs per litter. Five one-cub litters, 6 two-cub litters, and 4 three-cub litters were observed. The annual number of females producing cubs in YNP has remained relatively stable in recent years, suggesting that the park may be at or near carrying capacity for grizzly bears.

*Mortality*. Due to the grizzly bear's low reproductive rate and vulnerability to human-caused mortality, it is important for bear conservation to

keep mortalities at a sustainable level. In 2006, there was one known grizzly bear mortality in YNP. On May 25, the carcass of a 192-lb. adult female grizzly bear estimated to be 10 years old (from tooth wear) was found floating in Yellowstone Lake between Storm Point and the mouth of Pelican Creek. Necropsy of the carcass indicated that the bear had died from severe blunt trauma, most likely caused by a collision with a vehicle.

#### **Bear Foods Monitoring**

Elk, bison, cutthroat trout (*Onchorynchus clarkii*), and whitebark pine (*Pinus albicaulis*) seeds are four of the highest sources of energy available to grizzly bears in YNP. Due to the importance of these foods to bears, YNP staff monitor their annual availability within the park.

Winter-killed Ungulate Carcasses. Twenty-nine routes in ungulate winter range were surveyed to monitor the relative abundance of winter-killed ungulate carcasses available for bears to scavenge after den emergence in spring. A total of 75 elk, 1 pronghorn, and 39 bison carcasses were documented along the 285.4 km of survey routes, for an average of 0.4 carcasses/km surveyed. Twenty-five (33%) of the elk carcasses and 15 (38%) of the bison carcasses had conclusive evidence of scavenging by bears. Grizzly bears or their tracks were observed on 18 (62%) of the 29 survey routes.

*Spawning Cutthroat Trout.* Five spawning streams on the north shore and four spawning streams in the West Thumb of Yellowstone Lake

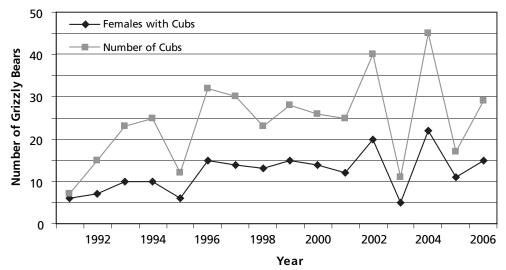


Figure 1. Female grizzly bears with cubs and total cubs counted in Yellowstone National Park, 1991–2006.

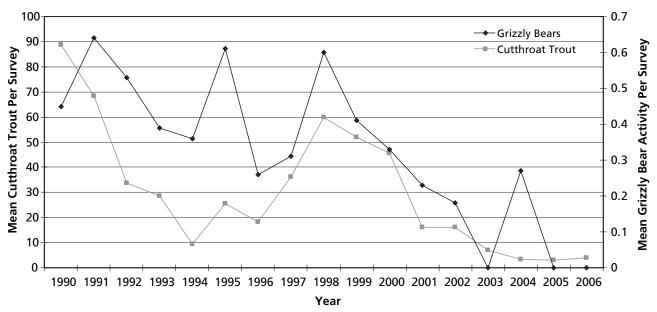


Figure 2. Mean number of spawning cutthroat trout and activity by grizzly bears observed during weekly surveys of nine streams tributary to Yellowstone Lake, 1989–2006.

were surveyed to document the presence and abundance of spawning cutthroat trout and predation of trout by bears (Figure 2). Only four of the nine streams contained spawning cutthroat trout. A total of only 27 spawning cutthroat trout were counted in these four streams. No evidence of grizzly bears fishing on any of these nine streams was observed.

Whitebark Pine Seeds. Whitebark pine surveys were conducted on 10 transects in YNP. The cone counts at these 10 transects averaged 42.4 (SD = 49.7) cones per tree in 2006, approximately three times more than the long-term (1987–2005) average of 14.4 (SD = 32.0) cones per tree, per year, for all transects located in YNP.

#### **Bear Confrontations and Conflicts**

*Bear-Human Confrontations*. We define confrontations as incidents where bears approach or

follow people, charge or otherwise act aggressively toward people (posture, slap ground, pop jaws, etc.) enter frontcountry developments, or enter occupied backcountry campsites without inflicting human injury. Incidents where bears enter developments or occupied backcountry campsites are listed as confrontations, even if the bears involved did not behave aggressively, due to the potential threat to human safety. Incidents where bears injure or kill people are listed in the *Bear–Human Conflicts* section below.

In 2006, there were 174 reported incidents of bear–human confrontations (Table 1). Grizzly bears were involved in 120 of the confrontations and black bears in 49. The species of bear involved could not be determined for five confrontations.

*Bear–Human Conflicts*. We define bear–human conflicts as incidents where bears damage property,

	Type of confrontation						
Species	Bear in development <sup>a</sup>	Bear in occupied backcountry campsite	Bear approached or followed people	Charge or aggressive behavior	Total		
Grizzly bear	89	8	9	14	120		
Black bear	31	7	8	3	49		
Unidentified bear species	1	2	2	0	5		
Total	121	17	19	17	174		

<sup>&</sup>lt;sup>a</sup>Listed as a confrontation due to the potential threat posed to human safety, even if the bears involved did not behave aggressively.

Table 1. Number of incidents of bear-human confrontations reported in Yellowstone National Park, 2006.

	Type of conflict					
Species	Property damage No food reward	Anthropogenic foods	Human injury	Total conflicts		
Grizzly bear	8	2	0	10		
Black bear	3	4	0	7		
Unidentified bear species	2	0	0	2		
Total	13	6	0	19		

Table 2. Number of incidents of bear-human conflict reported in Yellowstone National Park, 2006.

obtain anthropogenic foods, or injure people. In most incidents where bears damage property, they are attempting to obtain human foods, garbage, or other attractants. In most incidents where bears obtain anthropogenic foods they damage property in the process. In 2006, there were 19 bear–human conflicts reported (Table 2). Ten of these incidents involved grizzly bears and seven involved black bears. The species of bear involved could not be identified in two incidents.

#### **Bear Management Actions**

In 2006, there were 816 bear-related incidents where management action was taken (Table 3), including:

- 706 incidents where park personnel responded to roadside bear-jams to provide traffic control, answer visitors' questions, and ensure that visitors did not approach or throw food to bears;
- 78 incidents where bears were hazed out of developments or away from roadsides due to concern for visitor safety;
- 18 incidents where trails, campsites, or other areas were closed to the public due to safety concerns related to bear activity;
- 12 incidents where bear warnings were posted at trails, campsites, or other areas due to bear activity;
- 1 incident where a grizzly bear that damaged property in the Lake Village employee trailer

- court was captured and relocated in an effort to prevent further conflicts; and
- 1 incident where a black bear that charged people, damaged property, and obtained anthropogenic foods at the Canyon campground was captured and euthanized.

#### Grizzly Bear Captures/Relocations/Removals.

One grizzly bear was captured and relocated in a management action in 2006. On August 29, Bear Management Office staff trapped a two-year-old female grizzly bear that had been involved in five incidents of property damage in the Lake Village employee trailer court. The bear had also entered the Lake Village development on numerous occasions to forage for natural food. Park rangers and Bear Management Office staff had attempted to haze the bear out of the Lake Village area on numerous occasions by yelling and using horns, sirens, cracker shells, and bean-bag rounds. Hazing was successful only on a short-term basis; the bear kept returning to the Lake Village area throughout the summer. After being captured, the bear was ear-tagged and radio collared, given identification number 539, then relocated by boat to Charcoal Bay at the South Arm of Yellowstone Lake. The relocation was unsuccessful. Bear #539 returned to the Lake Village area three days after being released at Charcoal Bay. After returning to the Lake Village

Species	Bear warnings posted	Temporary area closures	Bear-jam Management	Management hazing	Attempt to trap, unsuccessful	Capture, mark and release on site	Capture and relocate	Capture and remove
Grizzly bear	8	8	242	48	0	0	1	0
Black bear	2	6	452	30	0	0	0	1
Unidentified bear species	2	4	12	0	0	0	0	0
Total	12	18	706	78	0	0	1	1

Table 3. Number of bear management actions taken in Yellowstone National Park, 2006.



Bear #539's transport on Warwood to Charcoal Bay.

area, park staff closely monitored #539's movements and hazed it out of the Lake Village development 15 times between September 1 and October 17. Bear #539 denned for the winter within a few miles of Lake Village and is expected to return to the development in spring 2007.

Black Bear Captures/Relocations/Removals. No black bears were captured and relocated in 2006. One black bear was captured and euthanized. On June 17, at approximately 9:00 a.m., an adult, 144-lb. black bear entered the Canyon campground and began chasing people out of their campsites and eating whatever food was left behind. The bear also caused multiple property damages while attempting to break into vehicles and campers. Hazing and bear spray were not successful in getting the bear to leave the campground. Due to the bear's very aggressive behavior and the fact that it had obtained multiple food rewards, Bear Management Office staff trapped the bear and euthanized it.

Bear-Human Conflict Prevention. An important component of the park's Bear Management Program is to prevent bears from obtaining anthropogenic foods. By preventing bears from obtaining human foods, the likelihood of bears damaging property or injuring people as well as the need to remove bears in management actions is reduced. As part of this program, the Bear Management Office purchased and installed three, 30-cubic-foot, bearproof food storage boxes in the park in 2006. Two food storage boxes were installed at Indian Creek campground and one at Norris campground.

#### **Public Education and Outreach**

The long-term survival of bears in the Yellowstone ecosystem depends on park visitors and surround-

ing communities having an understanding of bears and bear management practices. As part of this goal, the Bear Management Office presented 38 bear-related educational talks, field trips, and slide shows to state and federal employees, and elementary school, high school, college, and university groups, and at teacher training seminars and Yellowstone Association Institute classes in 2006. Presentations covered topics including safety in bear country, history of bear management in YNP, grizzly bear food habits, grizzly bear conservation, and grizzly bear recovery.

#### **Birds**

Two species were added to the Field Checklist of Birds of Yellowstone National Park in 2006. A rusty blackbird (*Euphagus carolinus*) was observed in the Mud Volcano area by James Hancock and



Rusty blackbird (Euphagus carolinus).

many others on January 14; and three least tern (*Sterna antillarum*) were seen on the north shore of Yellowstone Lake on May 20–21 by visitors and a park wildlife biologist. This brings the total number of bird species documented in the park to 323. An updated Field Checklist, available on the park website at www.nps.gov/yell, is scheduled to be available in spring 2007.

#### **Species of Special Interest**

Bald Eagle. The U.S Fish and Wildlife Service downlisted the bald eagle from endangered to threatened in 1995 as a result of significant population gains made over the last three decades. Although certain populations are not completely recovered due to heavy metal contamination problems in the Great Lakes region, and habitat encroachment and development problems associated with riparian zones in the desert southwest, the bald eagle is expected to be delisted in 2007.

In Yellowstone, 33 active nests in 2006 produced only 10 fledglings (Figure 1), the lowest since the early 1990s. The large number of nest failures were primarily due to the weather—wet snows, rain, and strong winds.

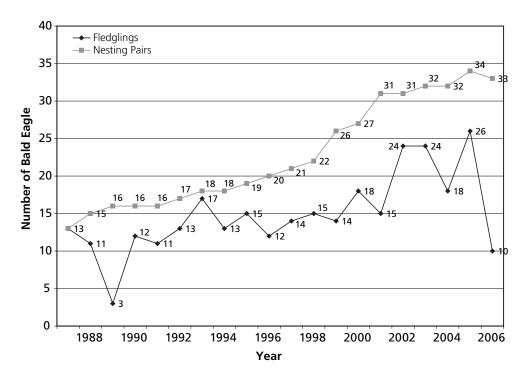


Figure 1. Bald eagle productivity in Yellowstone National Park, 1987–2006.

For the fifth consecutive year, a pair of bald eagles occupied a nest in a large tree located about 150 feet off the Madison-to-West Yellowstone road from mid-February through early July. To allow the eagles to obtain nest material and food without human disturbance, park staff again set up a temporary closure in the immediate vicinity of the nest where visitors were not allowed to stop. As in 2005, two eaglets fledged from the nest.

Peregine Falcon. The peregrine falcon was removed from the federal list of threatened and endangered species in 1999 and is now managed as a species of special concern. Yellowstone National Park continues to be a stronghold for peregrines in the northern Rockies. One new eyrie was found in 2006, bringing the total number of peregrine eyries in YNP to 31, from which 50 peregrines fledged, the largest number ever recorded in Yellowstone (Figure 2).

Trumpeter Swan. The park's resident trumpeter swan count declined to 14 in 2006, the lowest since the 1930s. Recruitment from outside the park, especially Montana's Centennial Valley, has traditionally been a critical factor in maintaining the park's population, but swan numbers west of the park have declined substantially in the last two decades. Recruitment was observed on the west side of the

park in 2006 for the third consecutive year, but these gains have been offset by predation.

Documented trumpeter swan nest attempts have ranged from 2 to 10 per year since 1986, but have averaged only three per year since 2001. In 2006, the three nest attempts resulted in four cygnets hatching from one brood, but no fledglings. As in 2005, one of the newly hatched cygnets was seen being preyed upon by an adult bald eagle, and egg clutches from two swan territories were destroyed by grizzly bears. During January and February, a bobcat was observed hunting along the banks of the Madison River, where he preyed upon a juvenile or cygnet trumpeter swan as well as a mallard duck and two Canada geese. In April, two trumpeter swans were preyed upon by three wolves in the Gibbon Meadow area; the birds were forced into soft snow where they were easily killed. In May, a lone wolf came upon a pair of adult swans sleeping in the Gibbon Meadow area, and killed one of them in the water.

Molly Islands Colonial Nesting Birds. Aerial and boat surveys were used to census birds at the two Molly Islands in mid-May, early June, early August, and mid-September 2006. This was an average year for colonial nesting bird production, with fledglings from the nests of American white pelicans, double-



crested cormorants, and California gulls, but no Caspian tern nests.

Osprey. The park's osprey population has been on a downward trend for the last six years. Only 23 young fledged from 41 nests in 2006, compared to 96 fledglings from 64 nests in 2000, most of them on Yellowstone Lake. On 600-acre Frank Island, which had as many as 25 nesting pairs in 1994, a wildfire burned nearly all of the trees in 2003 and a severe windstorm blew down most of the remaining potential nest sites in 2005. Another possible factor in the osprey decline on Yellowstone Lake could be the decrease in young cutthroat trout, a major food source for ospreys.

*Harlequin Duck.* The park's harlequin duck population fluctuates slightly from year to year, with

generally 22–26 pairs residing in the park. More precise information is not known because the remoteness of many of the areas in which the ducks are found makes monitoring the ducks time-consuming and difficult.

Common Loon. The count of adult common loons in the park was 39 in 2006, within the range of between 34 and 51 during the last 18 years. Of the nine nest attempts in 2006, only six loonlets fledged.

#### **Other Population Monitoring**

North American Bird Migration Count. Yellowstone National Park participated in the North American Bird Migration Count for the 14<sup>th</sup> consecutive year in 2006. Traditionally scheduled on the second Saturday in May, this year the count was done on May 13. Four observers recorded a total of 89 bird species and 2,446 individual birds between Yellowstone Lake and Shields Valley, Montana, 70 miles north of the park. These results were above average due to the wet spring conditions. Sixty-eight of the bird species were observed within the park.

Breeding Bird Surveys. Three Breeding Bird Surveys were conducted in the park in 2006. This data, which is sent to the Patuxent Wildlife Research Center in Laurel, Maryland, is used to develop population trends for North American songbirds and is available online at www.mp2-pwrc.usgs.gov/bbs.

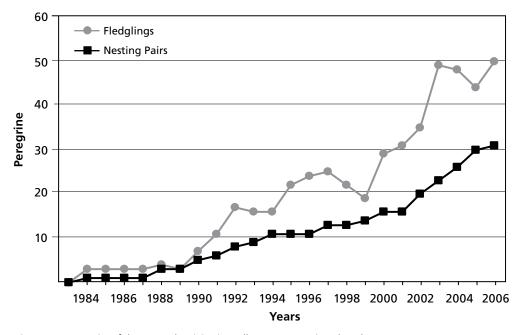


Figure 2. Peregrine falcon productivity in Yellowstone National Park, 1983–2006.

Christmas Bird Count. The six participants in the annual Yellowstone Christmas Bird Count observed a total of 35 bird species and 1,602 individual birds on December 17. These results were slightly above the long-term averages. The weather was somewhat mild by Yellowstone standards, with clear skies and temperatures ranging from -6 to 19° F, and 0–5 inches of snow on the ground depending on the elevation. New abundance records were set for northern pygmy-owls (2), northern flickers (12), and cedar waxwings (72).

Red-tailed Hawks and Swainson's Hawks. Although the staff ornithologist has collected incidental data about red-tailed hawks and Swainson's hawks nesting in the park via ground reconnaissance and aerial surveys over the last 20 years, a more thorough effort to map nesting territories was made during 2003–2006. The results indicate that 126–139 red-tailed hawk pairs nest in the park each year and their territories remain fairly constant. Many of the nesting sites have been occupied for at least two decades.

Swainson's hawks are much fewer in number. Incidental field data collected via ground reconnaissance and aerial surveys indicate they ranged in abundance from 28–36 nesting pairs during 2003–2006. The park ornithologist attributes the slight reduction in numbers he has observed over the past two decades primarily to drought-like conditions or a shift toward a drier weather cycle.

Black-billed Magpies and Common Ravens. An estimated 73–120 pairs of black-billed magpies nest in the park each year. Magpie nesting habitat in the park appears to be slowly declining as a result of reduced, dying, or decadent substrates as a result of drought-like conditions or changes toward a drier weather cycle. Information collected by the park ornithologist during the last 20 years suggests the abundance of common raven nesting pairs (100-150) has not changed significantly, and most nest sites are traditional and have been occupied for decades. Since ravens are long-lived birds, there are also a large number of non-breeders in the population. The summer population in the park is estimated to vary between 300-500. The large whitebark pinenut production in 2005 and 2006 brought above-average numbers of common ravens as well as Clark's nutcrackers to the Mount Washburn area in the fall.



#### **Bison**

Bison are among the most intensively managed wildlife species occupying habitats in and around Yellowstone National Park. During the past 100 years, the population has grown from a few dozen animals to nearly 4,000. Some of these bison are infected with the bacterial disease brucellosis, and some of them migrate to low elevation winter ranges along and beyond the park boundary.

In 2000, as part of an interagency partnership, the National Park Service completed a lengthy planning process to develop a management strategy for the Yellowstone bison population. Their expansion in range necessitates cooperative management to ensure conservation across multiple jurisdictions. The Bison Ecology and Management Office (BEMO) continues to conduct a monitoring program to track vital rates of the population and understand the dynamic nature of how brucellosis infection affects bison.

#### **Boundary Control**

Boundary control operations were much more extensive along the north boundary than the west boundary during the winter of 2005–06. The large population size at the beginning of the winter and the slightly above-average snow pack conditions led to an earlier start on hazing and capture operations than in most years. A total of 1,308 bison were captured, nearly all of them at the north boundary,

where 304 were held at the Stephens Creek corral for approximately one month to mitigate brucellosis risk management needs. A total of 1,002 bison were culled from the population through management actions, including 87 calves that were consigned to Montana Department of Fish, Wildlife and Parks for the quarantine feasibility research program. An additional 46 bison were harvested on winter ranges adjacent to the park through hunting programs managed by Montana Fish, Wildlife and Parks and the Nez Perce tribe.

#### **Population Monitoring**

Three aerial counts were conducted in July and August of 2006. Population counting conditions were generally good except that the third flight experienced extensive early morning fog in the Hayden Valley and Canyon area. The population estimate based on these flight results is 3,905 (95% range 3,247–4,563). The daily counts varied less this year than in many past years. During the third flight, 491 calves were counted.

From 2000 to 2006, the annual rate of population growth has been 16% in the Northern Range subpopulation and 1% for the Central Interior subpopulation (Figure 1). The difference in growth rates appears to be the result of management actions that have had more impact on the Central Interior subpopulation during this period.

Classification of the population is done to assess the population status and demographic trends relative to boundary control operations and ecological processes occurring in the system.

The calf-to-adult cow ratios observed in both areas in mid-summer 2006 indicated good productivity (45 calves per 100 females on the northern range; 40 calves per 100 females in Hayden Valley). The ratio of yearlings in the population, which is an index of recruitment, was higher than during the past few years, and the trend is slightly greater in yearling females than in yearling males.

Eighteen female bison were captured during the fall and early winter to deploy or remove radio transmitting devices that are used to maintain a marked sample of individual animals. Of the 14 adult bison, 10 were pregnant, and 1 of 4 two-year-old bison was pregnant. This is consistent with previous monitoring results. All of the pregnant bison that survived the winter carried their pregnancies to full term and produced a surviving calf.

The primary mode of brucellosis transmission between bison is thought to be through oral ingestion of bacteria when susceptible bison investigate the reproductive tissues expelled during a parturition event (abortion or birth). In most of 11 observed parturition events in 2006, one to four bison from the same group came to investigate the newborn and/or the birth materials. Samples of birthing tissues were collected at 15 parturition sites and samples from two of the sites cultured positive for brucellosis.

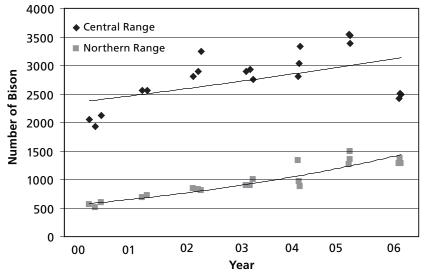


Figure 1. Annual bison counts during summer by breeding area, 2000–2006.



Mike O'Brien (University of Montana) collects bison fecal sample for genetics study.

# Non-invasive Sampling to Detect Genetic Diversity

In 2005, the BEMO program initiated a pilot study to determine the feasibility of sampling bison fecal material for extracting DNA. Cells from the lining of the intestinal tract are sloughed off as pellets pass along the digestive track and are excreted with the pellets. By collecting the mucus substance found on the surface of the buffalo chip when it is very fresh, the DNA can be fixed in the field and prevented from deteriorating. This technique has been very successful in carnivore research and recently validated in research on elephants in Asia and India. The preliminary results show that this technique can be successful in bison as well. More than 40 microsatellite loci have been screened and a subset of 14 loci were determined to provide good to excellent amplification of DNA. Preliminary results showed amplification of mtDNA fragments of 100 to more than 800 base pairs long. Approximately 400 samples have been collected from throughout the summer and winter range distribution of Yellowstone bison. The project is also collecting samples from the Jackson bison population in the southern GYA. After many months of refining the extraction methods, we have found the appropriate quantity and type of template for use in maximizing the extraction of DNA. Early results show that proportions of known haplotypes differ between the two subpopulations.

## **Elk and Other Ungulates**

Yellowstone National Park supports one of the most diverse complexes of migratory ungulates in North America, including bighorn sheep (*Ovis canadensis*), bison (*Bison bison*), elk (*Cervus elaphus*), moose (*Alces alces*), mule deer (*Odocoileus hemionus*), pronghorn (*Antilocapra americana*), and white-tailed deer (*Odocoileus virginianus*). The park has also been colonized by descendents of mountain goats (*Oreamnos americanus*) that were introduced in Montana in the 1940s and 1950s.

#### Elk

We continued monitoring key vital rates and limiting factors of Yellowstone elk to evaluate the relative effects of disease, harvests, land use, predation, and environmental factors on elk demographics and population trends. We collaborated with the U.S. Geological Survey Northern Prairie Wildlife Research Center and University of Minnesota to estimate annual survival rates for 85 adult female elk radio-collared on the northern range during March 2000–February 2004. Annual survival rates averaged 0.83 for females 1–15 years old, with most deaths occurring from December through March. Eleven of 33 documented deaths were attributed to hunter harvest, 14 to predation (10 wolf, 2 unknown, 1 cougar, and 1 bear), 6 to unknown causes, and 2 to winter-kill. Wolf-killed elk were typically older (median = 12 years) than hunter-killed elk (median = 9 years), but elk known to winter outside the park, where they were exposed to hunting, were also younger (median = 7 years) than elk not observed outside the park (median = 9 years). Consequently, differences in ages of elk killed by wolves and hunters may reflect characteristics of elk exposed to various causes of mortality as well as differences in susceptibility.

We also collaborated with Dr. L. Lee Eberhardt to evaluate trends in annual counts and removals of northern Yellowstone elk. The population decreased during 1976–2004 in response to: 1) liberal harvests of antler-less elk outside the park; 2) substantial winterkill and reduced calf survival during 1989 and 1997; and 3) the rapid numerical response of wolves and their predation on elk following restoration in 1995–1996. No influential effects of snow pack or summer precipitation were

detected on the growth rate of the population. Estimated wolf kill of elk exceeded hunter harvest during 2003–2005, but wolves likely had a smaller effect on elk dynamics because they concentrated on calves and older females with lower reproductive value. Antler-less harvests were reduced 96% by Montana Fish, Wildlife and Parks during 2000–2006 to decrease removals of prime-aged animals with high reproductive value and increase adult female survival. Conservative harvests of females may be necessary for many years to avoid destabilizing elk dynamics given the abundant complex of predators.

We continued surveillance for chronic wasting disease (CWD), a contagious, fatal disease of deer, elk, and moose for which there is no vaccine or known treatment. It is transmitted by direct animal-to-animal contact or, indirectly, through the environment. Deer, elk, and moose of Yellowstone National Park are at near-term risk for infection by CWD because known infected cervids are approximately 130 miles from the park, the disease has recently spread across Wyoming toward the park, and large populations of deer and elk utilize park habitats. The staff has developed plans to implement management actions to reduce or stabilize the prevalence of the disease if it is detected in or near the park.

#### **Pronghorn**

Staff continued monitoring abundance and key vital rates for pronghorn. They collaborated with the Yellowstone Ecological Research Center, the University of Idaho, the Bernice Barbour Foundation, and the Yellowstone Park Foundation to continue a three-year study of differential recruitment among pronghorn fawning areas in relation to



wolf and coyote densities and use areas. In addition, staff collaborated with Montana State University to analyze pronghorn counts during 1918–2006. Concerns about sagebrush (Artemisia spp.) degradation led to removals of more than 1,100 pronghorn during 1947-1966; counts decreased from approximately 700 to 150. Contrary to expectations, the population did not exhibit enhanced demographic vigor after the termination of the harvest program; counts remained between 100-190 during 1967–1981. However, the population irrupted to a peak abundance of approximately 600 during 1982–1991, with a slowing in growth rate as counts exceeded 500. Numbers crashed to 235 pronghorn during 1992–1995, perhaps because important food resources (e.g., sagebrush) on the winter range were severely diminished by high densities of browsing elk, mule deer, and pronghorn. Pronghorn numbers remained relatively constant during 1996-2006, at approximately 196–235.

Staff also collaborated with MSU to evaluate habitat use and diet composition by 37 radio-collared, adult females from December 1999 through March 2005. Attributes of vegetation type, elevation, solar radiation, and slope associated with 1,446 different groups containing radio-collared pronghorn were compared to 9,891 randomly selected points from the winter range. Pronghorn selected intermediate elevations and slopes, preferred greasewood (Sarcobatus vermiculatus), and avoided sagebrush in comparison to the grassland cover type. The avoidance of sagebrush, which is highly important to other wintering pronghorn populations, may stem from a substantial decrease in this plant type on the winter range by the 1960s due to intense browsing by congregated ungulates. The percent composition of sagebrush in the winter diets of pronghorn decreased from 67% during 1985-1988 to less than 10% during 2000–2001, while rabbitbrush (*Chrysothamnus* sp.) increased from 5% to 60%.

#### **Bighorn Sheep**

Staff collaborated with the Northern Yellowstone Cooperative Wildlife Working Group to evaluate if bighorn sheep numbers had decreased following wolf reintroduction because of lower survival and recruitment. Counts of bighorn sheep decreased following the severe winter of 1997, but then increased 7% annually during 1998–2005. Recruitment

followed a similar temporal pattern, decreasing to 7–11 lambs per 100 ewes during the severe winter of 1997 and the following winter, but then increasing to 21–34 lambs per 100 ewes during 1998–2005. Annual estimates of survival for 14 adult females and 4 males 1–3 years old were high (0.94) and indicative of an increasing or constant population. Thus, the presence of wolves did not prevent the bighorn sheep population from increasing slowly during the decade following reintroduction. However, sheep counts remain low compared to the 487 sheep observed before an outbreak of keratoconjunctivitis caused 60% mortality during 1982, which suggests that other factors have limited the recovery of this relatively isolated, high-elevation, native sheep population.

#### Wildlife Responses to Winter Recreation

Staff continued to monitor the behavioral responses of bald eagles (Haliaeetus leucocephalus), bison, elk, and trumpeter swans (Olor buccinator) to snowmobiles and coaches by repeatedly surveying groomed road segments from December 2005 through March 2006. They also collaborated with MSU to analyze 5,688 interactions between these species and groups of snowmobiles or coaches during 2003–2006. Bison responded less frequently (20%) to snowmobiles and coaches than swans (43%), elk (52%), or bald eagles (83%) due to fewer vigilance responses. However, the frequency of higher-intensity movement responses was similar among species (8–10%). The likelihood of vigilance and movement responses by these species increased significantly if animals were on or near roads, animal groups were smaller, humans approached animals on foot, interaction time increased, or the numbers of snowmobiles and coaches in a group increased. Human disturbance did not appear to be a primary factor influencing the distribution and movements of any of these species, nor was there evidence that snowmobile use during the past 35 years has significantly affected their demography or population dynamics.

Staff also collaborated with MSU to quantify temporal trends in the amount of bison road and off-road travel during 1997–2005 in the upper Madison River drainage. Bison were observed on the road less often from December to April when the roads are groomed than during the rest of the year, and there was no evidence that bison preferentially

used groomed roads during winter. Bison travel on and off roads was positively correlated with snow pack, bison density, and the springtime melt period. Travel was only a small percentage (11%) of all bison activity, with foraging comprising 67% of observations. Also, only 7% of traveling bison and 30% of foraging bison were displacing snow. Thus, foraging rather than traveling appeared to be the major energetic cost to bison in winter. Bison generally used their own trail networks, connecting foraging areas with stream corridors, geothermal pathways, and self-groomed travel routes. These data indicate that changes in bison spatial dynamics during the past three decades have likely been the result of the natural phenomenon of density-dependent range expansion rather than caused by the anthropogenic influence of road grooming.

In addition, staff collaborated with MSU and California State University-Monterey Bay to evaluate 121,380 locations from 14 female bison with GPS collars in central Yellowstone. The probability of bison travel and spatial distribution of travel locations were affected by slope, landscape roughness, habitat type, elevation, and distances to streams, foraging areas, forested habitats, and roads. Streams were the most influential natural landscape feature affecting bison travel and their travel network was spatially defined by the presence of streams that connected foraging areas. Also, the probability of bison travel was higher in regions of variable topography that constrained movements, such as in canyons. Roads may facilitate bison travel in certain areas, but many road segments used as travel corridors appear to be overlaid upon natural travel pathways because road segments receiving high amounts of bison travel had similar landscape features as natural travel corridors.

### **Mid-sized Carnivores**

Yellowstone supports a broad variety of midsized carnivores, including the American marten, river otter, and red fox, as well as two uncommon species, the wolverine (*Gulo gulo*) and the Canada lynx (*Lynx canadensis*). Although little is known about their presence in the park, mid-sized carnivores undoubtedly play an important ecological role as predators and scavengers of small and medium-sized prey. The Canada lynx and wolverine are rarely seen because of their small numbers and affinity for boreal forests and alpine habitats, but they carry strong aesthetic and existence values for the public. The Canada lynx is federally protected as a threatened species. In 2007 and early 2008 the U.S. Fish and Wildlife Service (USFWS) will conduct a status review that may result in a decision to list the wolverine as endangered under the Endangered Species Act. Two previous petitions to list the wolverine were denied due to a dearth of information about the wolverine's life history and ecological requirements.

The mission of the mid-sized carnivore program in Yellowstone is to improve the information available to resource management, planning, and interpretation staff in the park. The program also provides data that supports the park's responsibility to consult with the USFWS concerning the effect of park management activities on endangered species.

#### 2006 Highlights

In 2006, the mid-sized carnivore program completed its first winter field season for collaring wolverines to monitor their movements, and finalized the 2001–2004 Yellowstone lynx survey by publishing the findings in *Northwest Science* (vol. 80:199–206). Staff also provided administrative assistance to Wildlife Conservation Society biologists who are conducting a wolverine study in the western GYE, including some areas adjacent to the park's north and west boundary.

#### Absaroka-Beartooth Wolverine Study

The wolverine, the largest member of the weasel family, has recently emerged as a species of primary concern for federal land managers in the Rocky Mountains because of its low population density, infrequent reproduction, genetic fragmentation, and possible sensitivity to human disturbance. The goal of the Absaroka-Beartooth Wolverine Study is to collect basic ecological and mission-critical information on wolverines during a five-year study in the Absaroka and Beartooth Ranges, and to encourage wolverine conservation by building public knowledge and appreciation through education. Project cooperators with Yellowstone National Park include the Yellowstone Park Foundation (primary fund raiser), the U.S. Forest Service, the Rocky Mountain Research Station of the U.S. Department

of Agriculture, Montana Fish, Wildlife and Parks, Wyoming Game and Fish, and the Rocky Mountains Cooperative Ecosystem Studies Unit.

Beginning in mid-January, project staff baited and maintained 29 live traps clustered in four trap lines in east Yellowstone (East Entrance Road, 8 traps; Northeast Entrance Road, 6 traps) and the Gallatin and Shoshone national forests. The total trapping effort through early April exceeded 1,800 trap nights. Two healthy, mature male wolverines, each weighing more than 25 pounds, were captured in March, including one along the East Entrance Road. Both were instrumented with GPS collars and VHF transmitters. The sizes of their annual home ranges were approximately 156 mi<sup>2</sup> and 155 mi<sup>2</sup>, and mean elevations were 9,100 and 10,400 feet. One male moved 280 air miles over a 26-day period at an average rate of 1.4 kilometers/hour. During one particular two-hour period, he traveled more than nine kilometers. Project staff made several forays into the backcountry to monitor the two wolverines and document their food habits. Several new traps were built during the summer and fall, including one near Dunraven Pass.

Assisted by wolverine project staff, the Division of Interpretation taught five "wolverine" field camps during 2006 in gateway communities surrounding the park to expose grade-school children to wolverine life history, research techniques, and the social, ecological, and aesthetic values of the species. Project staff also taught two Yellowstone Association Institute courses on wolverines, gave nine public and professional presentations, and distributed an annual newsletter and several updates to private and governmental cooperators. The project is expected to continue through 2009.



Cooperators Dan Tyers and Jeff Copeland (USFS) with a wolverine.

#### Wolves

#### **Population Monitoring**

Population Status. At the end of 2006, at least 136 wolves in 13 packs occupied Yellowstone National Park (Figure 1). This represents a 15% rebound in wolf numbers after the population decline in 2005 (Figure 2). In 2006, there was no evidence of a disease outbreak, which was the cause of the population drop in 2005; adult and pup survival was very good. Unlike previous years, there was very little turnover in packs; of the 13 packs present in 2005, 12 were still together at the end of 2006, along with one new pack, the Oxbow Creek pack. Pack size ranged from 4 (Cougar Creek) to 19 (Leopold) and averaged 10.5 wolves.

Wolf distribution across the park has remained the same for several years, indicating that all available wolf habitat is settled. Pack turnover, when it occurs, is always within the occupied wolf range and new areas of settlement have not been recorded.

Although it includes only about 11% (1,000 km²) of the park area, the northern range continues to support most of the park's wolves because of greater year-round prey density. The seven packs using the northern range had a total of 75 members; the six packs in the rest of the park, 61 members. However, recent analyses indicate that social strife (wolf–wolf

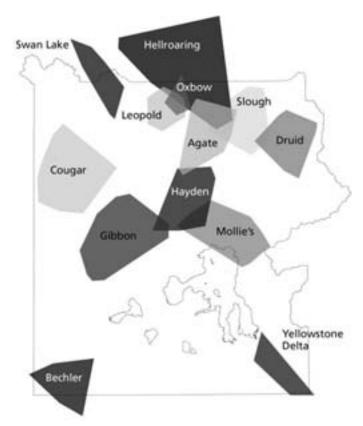


Figure 1. Territories occupied by the 13 wolf packs residing primarily in YNP.

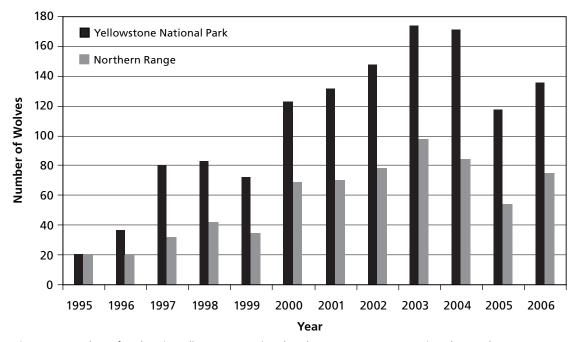


Figure 2. Number of wolves in Yellowstone National Park, 1995–2006, comparing the northern range to the total park population.

killing and territorial clashes) and probably disease were limiting wolf numbers on the northen range. Based on these observations, we expect wolf numbers to decline over the next several years despite the recent one-year increase in wolf numbers.

Reproduction. After a poor year in 2005, there seemed to be some compensatory survival in 2006; of the 77 pups counted in the park, 60 (78%) survived compared to only 32% in 2005. The average number of pups in the 11 packs that had counted pups was 6.8. The average number of pups born to each breeding female was 5.4 because in three packs, two females bred. These multiple litters, like those previously documented in the park, occurred on the northern range.

The Slough Creek pack had a litter, but none of the pups survived, probably due to competitive interactions with another pack. The reason for the absence of pups in the Cougar Creek pack is not known, but could be the result of reproductive failure by the breeding female, who was eight years old.

Mortalities. Nine collared wolves, seven males and two females, died in 2006: four as a result of intraspecific strife, one from natural causes, one from a control action, one killed illegally outside the park, and two from unknown causes. The mortality rate among collared wolves in 2006 was 18%, compared to the 11-year average of 20%.

#### **Wolf Predation**

Including definite, probable, and possible kills, project staff detected a total of 218 wolf kills in 2006: 219 elk (80%), 30 bison (14%), 6 coyotes, 5 wolves, 3 deer, 2 bighorn sheep, 2 moose, 1 beaver, 1 golden eagle, and 12 unknown prey (4%). The composition of elk kills was 32% calves (0−12 months), 16% cows (1−9 years old), 14% old cows (≥10 years old), 31% bulls, and 7% elk of unknown sex and/or age. Bison kills included 12 calves, 11 cows, 3 bulls, and 2 of unknown sex and age.

Winter Studies. The kill rate per wolf was higher during the 2005–2006 winter than the preceding winter, probably because of deeper and more crusted snow that made elk and bison more vulnerable to wolf predation. However, the total number of elk killed declined because the wolf population was smaller (Figure 3). This was the first winter since 1996–1997 that the Wolf Project documented significant winter-kill of elk and bison.

Summer Studies. Project staff continued efforts to document the wolves' summer predation patterns using GPS telemetry and by collecting scats at dens and rendezvous sites. They also collected data on invertebrate diversity and abundance at summer carcasses in collaboration with Dr. Chris Wilmers (University of California–Davis). Members of the order Coleoptera (including beetles) dominated the

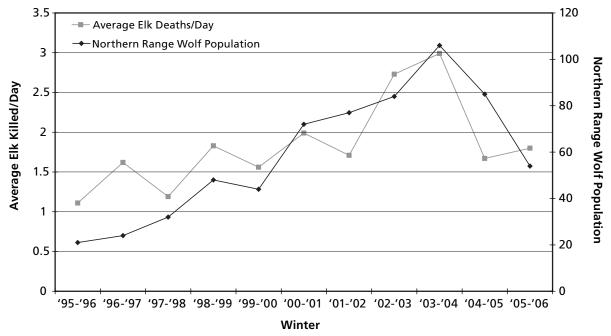


Figure 3. Average number of elk killed by wolves (November–March) and northern range wolf population (1995–2006).

sampling, particularly those in the family Silphidae (carrion beetles).

#### Other Wolf Management and Research

Wolf Capture and Collaring. Staff captured and handled 26 wolves from 12 packs in 2006. At year's end, 37 (27%) of the 136 known wolves were collared. In addition to deploying standard VHF and GPS collars, three ARGOS collars, which track wolves via satellites and are capable of emailing the locations to the wolf office, were used on the more remote packs (Delta, Bechler, and Mollie's) in 2006.

Population Genetics. A collaborative effort with the University of California–Los Angeles that began in 2005 continued to use genetic techniques to construct a population pedigree for all handled Yellowstone wolves and understand the gene flow among the three Rocky Mountain wolf recovery areas. In 2006, project staff made considerable efforts to get DNA samples from key breeders in the population that will allow for greater understanding of pack lineages, parentage, and relatedness among packs.

*Disease.* Serum from 222 wolves was sent to Cornell University and tested for exposure to three common canine diseases: infectious canine hepatitis, canine parvovirus, and canine distemper virus. All three were found to be present in Yellowstone wolves. Presence of sarcoptic mange, a disease

detectable through the physical examination of a wolf (e.g., hair loss), is also being monitored.

*Visitor Management.* Area closures for wolves are minimized except in the case of denning wolves. Small areas around dens were temporarily closed at Slough Creek and Hayden Valley in 2006.

This was the seventh year that private funds were used to manage wolf viewing by park visitors. Project staff worked closely with the Division of Resource and Visitor Protection and the Division of Interpretation in wolf viewing areas in Slough Creek, Round Prairie, Antelope Creek, and Hayden Valley to ensure that objectives for wolf and human safety, education, and research were met. It is estimated that more than 13,000 visitors viewed wolves during the summer of 2006.

#### **Public Involvement and Outreach**

Nineteen volunteer field technicians worked a total of 6,200 hours in 2006. Wolf Project staff gave more than 100 talks at scientific conferences and to the general public. Douglas Smith was interviewed 60 times by media sources about park wolves. For the sixth straight year, Smith accompanied U.S. Forest Service personnel on horseback into outfitter camps adjacent to the park to discuss wolf issues. This year, three camps on the north boundary in Gallatin National Forest were visited with YCR Chief Tom Olliff.



Wolf Project staff weighing and processing.