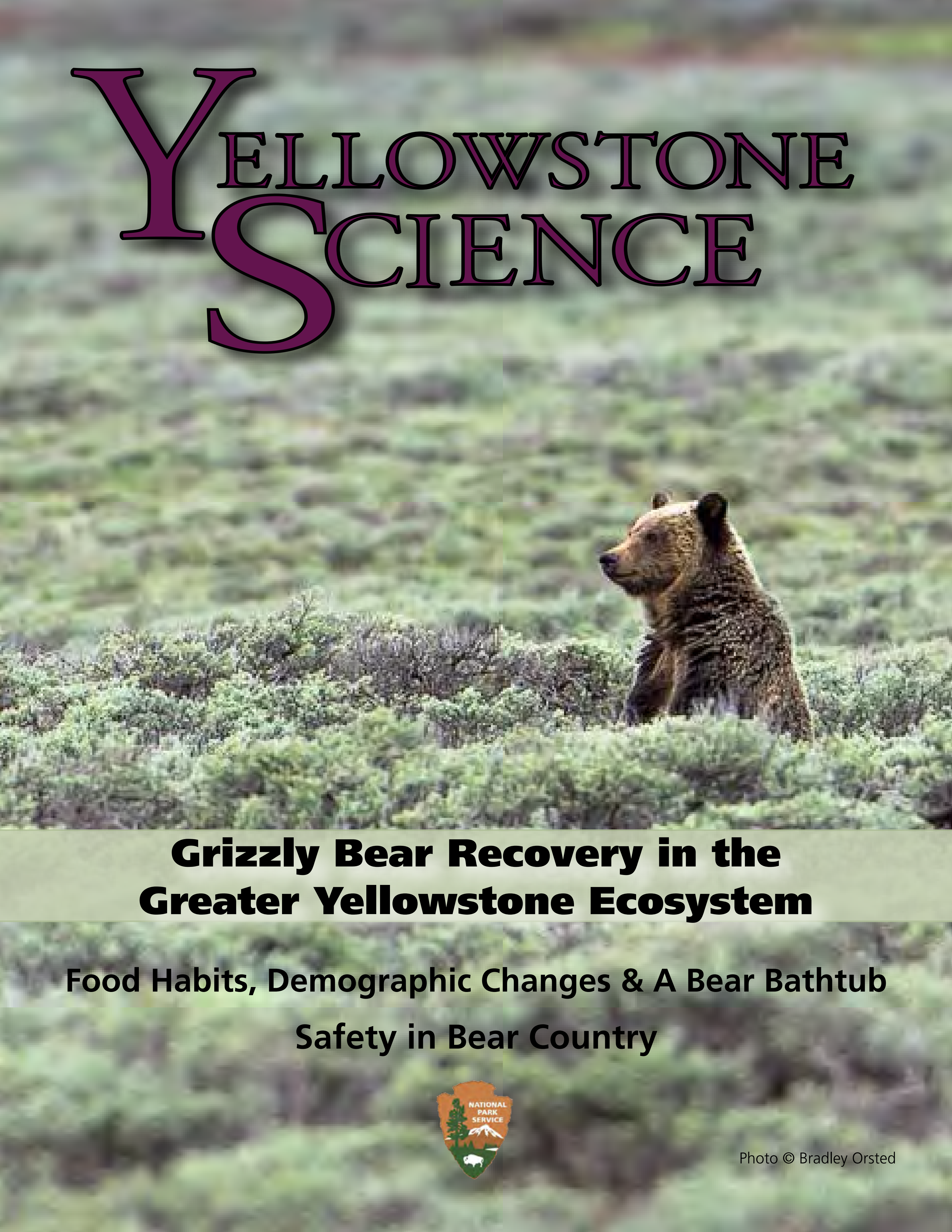
Yellowstone Science



Grizzly Bear Recovery in the Greater Yellowstone Ecosystem

Food Habits, Demographic Changes & A Bear Bathtub

Safety in Bear Country

Photo © Bradley Orsted

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A Celebration of Grizzly Bears

When I first began working in Yellowstone National Park in the early 1980s, it was fairly uncommon to see a bear, grizzly or black. If you saw a dozen bears in a summer, you considered it a good bear year. Today, you can easily see a dozen bears in one morning or even on one bison carcass. At present, if you're in a hurry when driving through the park, you must try to plan your travel route to avoid bear-caused traffic jams. Unlike the "bear jams" of the past, the bears causing traffic congestion today are not seeking human food handouts but are usually seen feeding on natural foods found in roadside meadows. Consequently, Yellowstone and Grand Teton national parks have become the premier bear viewing destinations in the lower 48 states. Bear viewing contributes significantly to the economies of park gateway communities, something I never imagined in the early 1980s. Although grizzly bears have increased significantly in numbers and range, their rate of increase is beginning to slow down in the Greater Yellowstone Ecosystem. This may be evidence they are approaching their carrying capacity, both biologically and socially.

In 2008, an entire issue of *Yellowstone Science* focusing on grizzly bears was published; it celebrated the removal of grizzly bears from threatened species status as one of the greatest conservation achievements in the history of the United States. That issue contained articles on the history of bear management and the controversial closing of garbage dumps in the ecosystem, the recovery and delisting of the species, and how grizzly bears would be managed and monitored after delisting. The issue also examined habituation, which was predicted to be the most significant bear management challenge moving into the future, as both park visitation and the bear population increased. About a year after the publication of that issue, grizzly bears were returned to threatened species status by court order, primarily due to uncertainty regarding the future of some bear foods because of climate change and other factors.

In this issue of *Yellowstone Science*, grizzly bears are once again the featured species. We present recent research on dietary preferences and the response of bears to changing food resources, demographics of the current greater Yellowstone bear population, and bear habituation to people in national parks. We also present information on grizzly range expansion, cub adoption, consumption of army cutworm moths at high elevation talus slopes, and the risk of a bear attack. In 2015, the U.S. Fish and Wildlife Service is once again considering removing grizzly bears from threatened species status. Whether you are in favor of or opposed to delisting, this issue of *Yellowstone Science* has something for you. We hope you find the articles interesting, engaging, and scientifically relevant. In contrast to the 2008 issue on bears, which was intended as a celebration of delisting, this issue is simply a celebration of bears as a wonderful, remarkable animal and an integral member of the Greater Yellowstone Ecosystem.

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YELLOWSTONE SCIENCE

a periodical devoted to natural and cultural resources

volume 23 • issue 2 • December 2015

FEATURES

DEPARTMENTS

Submissions to *Yellowstone Science* are welcomed from investigators conducting formal research in the Greater Yellowstone Area. Article acceptance is based on editorial board review for clarity, completeness, technical and scientific soundness, and relevance to NPS policy.

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Forty Years of Grizzly Bear Recovery in the Greater Yellowstone Ecosystem

Frank T. van Manen, Cecily M. Costello, Kerry A. Gunther, & Mark A. Haroldson

The fate and history of grizzly bear populations in North America are similar to that of other large mammals, and carnivores in particular. Indiscriminate killing and habitat loss took a severe toll on populations in the late 1800s and early 1900s. By the 1920s and 1930s, grizzly bears in the contiguous United States had been reduced to less than 2% of their historical range (Servheen 1999) and by the 1950s had been extirpated from most areas outside of Alaska and Canada (Cowan et al. 1974). In the lower 48 states, grizzly bears still persisted in Washington, Idaho, and Montana adjacent to the Canadian border, and in three small isolated populations further south (Cowan et al. 1974). These isolated populations included the mountains of Chihuahua, Mexico (the Sierra del Nido and possibly the Sierra Madre); the San Juan Mountains of southwestern Colorado; and the Yellowstone Plateau region of Wyoming, Montana, and Idaho, often referred to as the Greater Yellowstone Ecosystem (GYE).

Because of its large size, remoteness, and the protections afforded by national park, national forest, and national wildlife refuge lands over a large portion of the area, the GYE grizzly bear population was the only one of the three isolated populations that persisted in viable numbers after the 1960s (Cowan et al. 1974). During the following decade, biologists estimated as few as 600–800 grizzly bears remained in the lower 48 states. In 1975, grizzly bears in the lower 48 states, including the

GYE, were listed by the U.S. Fish and Wildlife Service (USFWS) as a threatened species under the Endangered Species Act. In 1983, the Interagency Grizzly Bear Committee was formed to help ensure grizzly bear recovery through interagency coordination of policy, planning, management, and research. The federal, state, and tribal members of this committee, as well as its Yellowstone Ecosystem Subcommittee, initiated various measures to protect vital habitat and reduce bear mortality in the GYE (see *Yellowstone Science*, 2008:16[2]). These measures were associated with higher survival, a steady increase in the bear population, expansion of bear range, and recolonization of previously occupied habitats.

By the end of the 20th century, the USFWS and these committees determined that the population had recovered and should be moved toward delisting. One of the tasks in the 1993 Recovery Plan (USFWS 1993) was the preparation of a Conservation Strategy, detailing management and monitoring plans for if and when the population was delisted. A final plan was released in 2007 (USFWS 2007a); and the USFWS submitted a final rule to delist the Yellowstone grizzly bear population in March 2007 (USFWS 2007b), effectively removing the population from the Endangered Species List. This delisting rule was challenged by a number of conservation organizations and the Federal District Court in Missoula, Montana issued an order vacating the delisting in September 2009.

Protections as a threatened population under the Endangered Species Act were reinstated in March 2010. The USFWS appealed the District Court decision on the primary grounds that: 1) regulatory mechanisms after delisting (i.e., the Conservation Strategy) were adequate to ensure the grizzly population would not decline; and 2) the potential loss of whitebark pine (*Pinus albicaulis*) as a food source would not threaten the GYE grizzly bear population. The 9th Circuit Court of Appeals rendered a decision in November 2011 and reversed the District Court decision regarding the adequacy of protections provided under the Conservation Strategy, but upheld the District Court decision that the USFWS had not sufficiently demonstrated the whitebark pine decline was not a threat to the Yellowstone grizzly bear population. In response to this court decision, the Interagency Grizzly Bear Committee and its Yellowstone Ecosystem Subcommittee tasked the Interagency Grizzly Bear Study Team with conducting a comprehensive assessment of the current state of knowledge regarding whitebark pine decline and responses of grizzly bears to changing food resources in the GYE. This research became particularly relevant given the increasing population trajectory documented at the time.

In this issue, we report on the results from several interesting grizzly bear research projects conducted in the GYE, including demographic changes, cub adoption among related mother bears, unique bear scent-marking behavior at a small remote pond, the numeric probability of being attacked by a grizzly bear when backpacking, results of a pilot project using new camera collar technology, and the challenges of managing habituated grizzly bears in the face of increasing visitation in national parks. In addition, we take a look back at some unusual attempts at modifying nuisance bear behavior during the early history of Yellowstone National Park.

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Acknowledgments

The federal, state, and tribal agencies that are members of the Interagency Grizzly Bear Study Team collectively spend a lot of time and effort to monitor and research grizzly bears in the GYE. With the expertise and enthusiasm of 30 to 40 agency personnel and thousands of hours of field effort each year dedicated to grizzly bear research and management, we have learned a great deal about the fascinating ecology of grizzly bears in the Greater Yellowstone Ecosystem. We are indebted to our partner agencies for their dedication and foresight to use science-based decision making as a guiding principle and for their continued support of the Study Team's research and monitoring efforts: U.S. Fish and

Wildlife Service; U.S. Geological Survey; National Park Service; U.S. Forest Service; Wyoming Game and Fish Department; Montana Fish, Wildlife and Parks; Idaho Fish and Game; and the Wind River Fish and Game Departments of the Shoshone and Arapaho Tribes.

Frank van Manen is a Supervisory Research Wildlife Biologist with the U.S. Geological Survey's Northern Rocky Mountain Science Center in Bozeman, Montana. He is the Team Leader of the Interagency Grizzly Bear Study Team, an interdisciplinary research team that addresses long-term research needs for management and conservation of the Greater Yellowstone grizzly bear population. Frank earned a M.Sc. degree in Biology from Wageningen University in the Netherlands in 1989 and Ph.D. in Ecology from the University of Tennessee in 1994. He joined the U.S. Geological Survey in 2000 and researched black bears, red wolves, Florida panthers, and other wildlife in the southeastern U.S. He has collaborated on international bear research projects with bear researchers in Ecuador, Sri Lanka, China, and Japan. He has served on the Council of the International Association for Bear Research and Management since 2001, and was elected President for two terms during 2007–2013. His current research emphasis is on the changing demographics and ecological adaptive capacity of Yellowstone grizzly bears.

Photo © Bradley Orsted

Grizzly Bears: Ultimate Omnivores of the Greater Yellowstone Ecosystem

Kerry A. Gunther, Rebecca R. Shoemaker, Kevin L. Frey, Mark A. Haroldson, Steven L. Cain, Frank T. van Manen, & Jennifer K. Fortin

Brown bears are widely distributed throughout Europe, Asia, and North America (Schwartz et al. 2003). In North America, grizzly bears once occupied diverse biomes from Northern Alaska south to Mexico and from the Great Plains west to the Pacific Coast. Although historic grizzly bear range is much reduced, grizzly bears continue to survive in vastly different landscapes including treeless arctic tundra, boreal and coastal forests, mountain forest/grasslands, shrub steppe, and prairie/riparian habitats. Their ability to use such a wide variety of habitats is attributed to their intelligence, adaptability, and opportunistic, omnivore generalist lifestyle (Schwartz et al. 2003).

Yellowstone grizzly bears occupy alpine, subalpine, montane, foothill, and even the edges of prairie vegetation zones encompassing the Yellowstone Plateau of the Central Rocky Mountains, referred to as the Greater Yellowstone Ecosystem (GYE). As is typical of mountain ecosystems, food resources for grizzly bears in the GYE are very dynamic, changing from season to season, year to year, and from location to location. In recent decades, there have been substantial changes in the distribution and availability of several high-calorie foods used by Yellowstone grizzly bears, such as cutthroat trout and whitebark pine seeds. With potential impacts from climate change and other human influences on the landscape, managers want to better understand how grizzly bears may respond to future changes in availability of food resources. To do so, one needs to know what foods are currently being consumed and how diverse their diet is under present-day environmental conditions. Research on grizzly bears in the GYE has been conducted continuously for over 50 years, likely making them the most studied bear population in the world; although no single study has compiled all data on foods consumed by GYE grizzly bears. Since no synthesis existed of all foods consumed by grizzly bears in the GYE, we conducted a review of 49 published papers, 17 books, 4 doctoral dissertations, 11 master's theses, and 97 state and federal agency administrative reports that have documented grizzly bear food habits in the GYE during the 124-year period from 1891 to 2014. From this literature we compiled a list of all the reported foods consumed by grizzly bears into one comprehensive document. Grizzly bears will consume almost any fresh, processed, frozen, canned, dried, boxed, or packaged foods sold for human consumption, including camp foods, groceries, beverages, grease, and garbage. We did not include the almost endless list of anthropogenic foods potentially available to GYE bears because, although these foods can provide nutrition for bears, their use most often leads to bears' lethal removal from the ecosystem.

Dietary Breadth of the Grizzly Bear

Our literature review indicated GYE grizzly bears eat an incredibly diverse array of foods, from those as large as bison and moose, to those as small as ants and midges. Grizzly bears of the GYE prey on fast and agile animals like elk, but also on slow and relatively immobile species such as earthworms. Some prey species fight back and are quite formidable to subdue, which we have observed when grizzly bears kill adult black bears or even other grizzly bears. Some insects, such as yellow jackets, put up a stinging defense but are not much of a threat to bears. Other species like ladybird beetles and cutthroat trout are relatively defenseless. In addition to prey species, grizzly bears eat many plants and mushrooms. Plants are consumed through grazing, digging, plucking, stripping, and peeling. Grasses, sedges, and clover are grazed; whereas, biscuitroot, yampa, and thistle roots are dug from the soil. Berries are plucked and stripped from branches and cambium is peeled from tree trunks. The foreclaws of grizzly bears are as long as 10 cm (4 inches) (Herrero 2002), and can be used to delicately dig up an individual yampa root or to 'rototill' acres of meadows to catch pocket gophers and dig up their food caches of plant roots. The average energy values of the ungulates (6.8 kcal/g), trout (6.1 kcal/g), and small mammals (4.5 kcal/g) eaten by grizzly bears were higher than those of the berries (3.2 kcal/g), forbs (2.9 kcal/g), and graminoids (2.5 kcal/g) they consumed (Craighead et al. 1995). At 7.9 kcal/g, army cutworm moths had the highest reported gross energy value of any food consumed (French et al. 1994). Some of the plant foods consumed, such as springbeauty, cow parsnip, and clover, are relatively high in protein. Other foods are rich in fats, like whitebark pine seeds and beargrass seed pods; whereas, others provide plenty of carbohydrates, such as oniongrass bulbs, yampa tubers, and roots of biscuitroot.

In all, we documented more than 266 species in 200 genera from four different kingdoms (Plantae, Animalia, Fungi, and Protista) consumed by GYE grizzly bears (Gunther et al. 2014; see a list of the scientific names of all food items mentioned in this article at: nps.gov/yellowstonescience). Grizzly bears consumed more than 162 different plant species (149 native and 13 non-native), including at least 85 forbs, 31 shrubs and berries, 25 grasses, 4 sedges, 2 rushes, 4 aquatic plants, and 4 different species of ferns and fern allies as well as cambium, catkins, and nuts from 7 tree species. The primary forbs eaten were clover, dandelion, thistle, horsetail, yampa, and biscuitroot. Frequently consumed berries included whortleberry, huckleberry, and strawberry. The most frequently consumed graminoids were Kentucky bluegrass, sedges, and brome grasses. Seven species of mushrooms were consumed, including false truffles, puffballs, and morels. We also documented bears feeding on at least 26 mammal, 4 fish, 3 bird, and 1 amphibian species. Additional animal species are undoubtedly consumed opportunistically, but have not been documented. The primary mammals consumed were bison, moose, elk, mule deer, pocket gophers, voles, and ground squirrels; but mountain goats, marmots, mice, and pikas were also eaten. Grizzly bears consumed at

Grizzly bears will often raid red squirrel middens—large caches of cones, rich with pine nuts, that the squirrels store for winter use.

least 36 species of invertebrates: primarily ants, army cutworm moths, yellow jackets, and earthworms. Twenty-four different species of ants were eaten including mound, ground, and log-dwelling species. It is easy to underestimate the importance of these insect species; however, ants are one of very few species that have been documented in every single grizzly bear scat-based diet study in the GYE from 1943 to 2009. Consumption of one algae (Knight et al. 1978) and one soil type (geothermal; Mattson et al. 1999) were also documented. Although the reason bears eat geothermal soil remains somewhat of a mystery, the soil may serve to restore mineral deficiencies because it contains high concentrations of potassium, magnesium, and sulfur (Mattson et al. 1999). Finally, grizzly bears consumed 26 species of domesticated plants and animals, including 13 species of cultivated agricultural, garden, and ornamental plants; 7 species of domestic livestock; and 4 species of domestic poultry, as well as domestic dogs and honey bees.

Foraging Strategy

Because of their need to accumulate large fat reserves for hibernation, grizzly bears are energy maximizers (Erlenbach et al. 2014). In grizzly bears, a diet of approximately 20% protein and 80% non-protein energy achieves maximum weight gain per unit of energy intake (Erlenbach et al. 2014, Coogin et al. 2014). To achieve this nutrient target and maximum weight gain, grizzly bears select mixed diets that maximize energy intake while optimizing macronutrient intake. This has been demonstrated in both wild and captive grizzly bears (Erlenbach et al. 2014, Coogin et al. 2014). The diverse diets of grizzly bears provides them the opportunity to eat appropriate proportions of nutritionally complementary foods during different seasons and in different geographic locations.

Whenever available, grizzly bears seek foods of high caloric value that are concentrated on the landscape and can be efficiently foraged (Schwartz et al. 2003). Accordingly, frequently used foods included ungulates (bison, elk, moose, mule deer), cutthroat trout, army cutworm moths, and whitebark pine seeds. Bears make seasonal movements within their home ranges to areas where these foods are abundant, such as ungulate winter ranges, elk calving areas, spawning streams, moth aggregation sites on remote talus slopes, and forest stands containing whitebark pine. Most of these foods are subject to seasonal, annual, and geographic variation in availability, and therefore are not abundant or available during all seasons, every year, or within every individual bear's home range. If some of these concentrated high-caloric foods are not readily available, grizzly bears can usually shift their diet to other items, which may have lower caloric value but are widely distributed across the landscape and readily available most years. These lower-calorie foods include a wide variety of plants (clover, spring beauty, yampa, biscuitroot, bistort, other forbs, horsetail, grasses, and sedges), colonial insects (ants), fungi (false truffles and mushrooms), berries (huckleberry, whortleberry, and gooseberry), and small mammals (voles, ground squirrels, and pocket gophers). Spatial and temporal abundance and annual predictability of these foods can compensate for their lower caloric value; and, consequently, these foods can comprise a large proportion of grizzly bear annual diets (Craighead et al. 1982).

Grizzly bears also supplement their diet with many foods consumed opportunistically. In fact, most foods we identified (including a variety of plants, fungi, vertebrates, and invertebrates) were consumed opportunistically with consumption varying annually based on availability and other factors. Opportunistic foods include a variety of species of plants, fungi, vertebrates, and invertebrates. Some opportunistic foods are consumed only during a short period each year (e.g., earthworms in wet meadows at the edge of the receding snowline during spring snow melt), while some are available only in small, localized areas (e.g., pondweed rhizomes from small ephemeral ponds within the Yellowstone caldera), and others are available only during sporadic periods of abundance (e.g., yellow jackets, grass hoppers, Mormon crickets, and midges). Many opportunistic foods are eaten primarily during periods with shortages of more preferred foods (e.g., yellow salsify and fernleaf licorice-root) or when randomly encountered while foraging for other species (e.g., mountain goats, grouse, boreal chorus frogs, and Utah suckers). Some foods of lower caloric value, such as grasses, sedges, and many forbs, may be consumed in areas between concentrations of higher-quality foods, thereby subsidizing travel and search costs (Mattson et al. 1984).

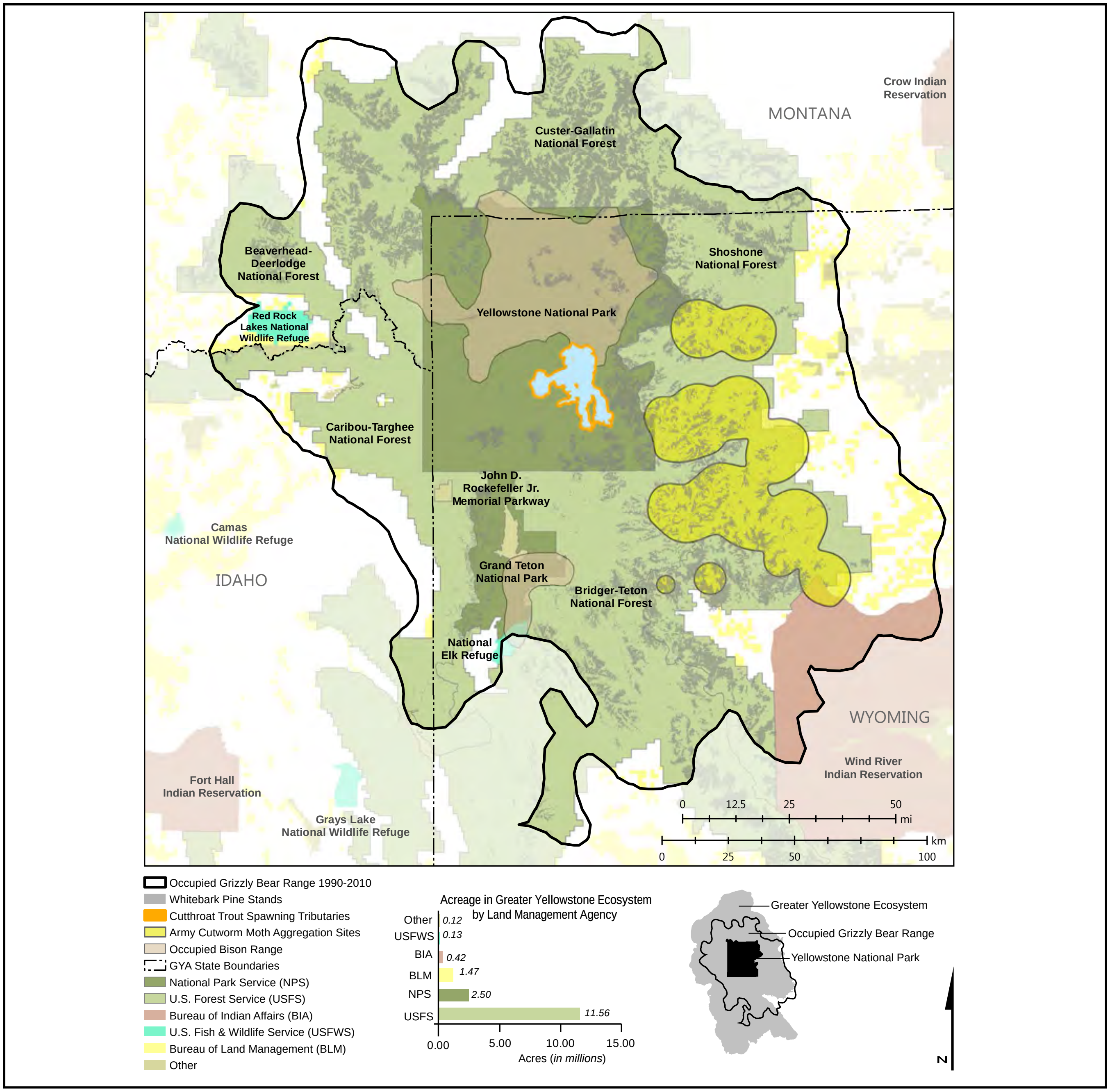
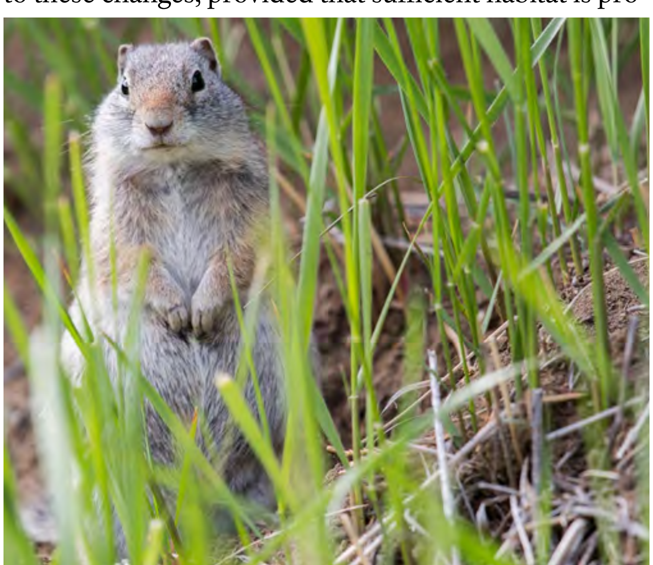


Figure 1. Distribution of four concentrated high-caloric grizzly bear foods (army cutworm moths, bison, cutthroat trout, and whitebark pine) within occupied grizzly bear range under different land management agency jurisdictions in the Greater Yellowstone Ecosystem (adapted from Gunther et al. 2014).

Benefits of a Flexible Diet

Grizzly bears in the GYE exhibit diet flexibility, consuming different foods depending on where their home ranges are located (figure 1). Some of the highest-quality foods are not found within all parts of the ecosystem and thus are likely not available to all GYE bears (figure 1). For example, army cutworm moths, bison, and cutthroat trout have limited distributions in the GYE, and even whitebark pine is only available to about two-thirds of all GYE grizzly bears (Costello et al. 2014). Because occupied grizzly bear habitat in the GYE is managed by many different state and federal agencies (figure 1), bears often cross jurisdictional boundaries to forage different food resources. Consequently, interagency cooperation is critical for successful, long-term conservation of grizzly bears and may be particularly important in the face of uncertainties such as climate change and expanding human occupation of the area. The diet flexibility demonstrated by Yellowstone grizzly bears greatly enhances their ability to occupy diverse habitats over a large geographic area. This diet flexibility likely also enhances their ability to cope with seasonal, annual, and longer-term perturbations in the abundance of high-calorie foods. Knowledge of the dietary breadth of grizzly bears helps managers of grizzly bears and their habitat document future changes in patterns of food consumption. This increased understanding provides managers with a strong foundation for making decisions about future grizzly bear management in the GYE.

Changing climate and introduced non-native species will probably change the species composition and distribution of the plants and animals consumed by GYE grizzly bears. However, the adaptability and omnivore generalist lifestyle characteristics that allow grizzly bears to occupy diverse habitats throughout the world give us optimism that grizzly bears are capable of adjusting to these changes, provided that sufficient habitat is protected to allow grizzly bears to adjust to the changes, and human-caused mortalities are kept at sustainable levels.



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How Important is Whitebark Pine to Grizzly Bears?

Cecily M. Costello, Frank T. van Manen, Mark A. Haroldson, Michael R. Ebinger, Steven L. Cain, Kerry A. Gunther, & Dan D. Bjornlie

In early summer, an industrious red squirrel climbs the trunk of a whitebark pine tree, scampers out to the end of a high limb, and snips off a cone that falls to the ground below. After dropping an ample collection of these cones, the squirrel carries them to a cool, moist place at the base of a large tree and buries them beneath the pile of discarded cone scales that have accumulated under a favorite feeding perch. Thus begins a routine that will occupy the squirrel for the weeks and months ahead as it stocks this and other larder-hoards, or middens, with foods it plans to subsist on during the long cold winter. However, not all of the squirrel's hard-won riches will last that long because in early fall, a grizzly bear may come sniffing about and usurp the calorie-rich stash of food. Ignoring the furious chatter coming from the branches above, the bear will dig up the midden's precious whitebark pine cones, carefully extract their seeds with dexterous claws, lips, and tongue, and consume the bulk of the cache in one sitting. Ah, the benefits of being a griz!

A relic from the ice age, whitebark pine in the Greater Yellowstone Ecosystem is now restricted to only the highest and coldest timbered zones, flourishing in extremes where other trees perish. In a stand of pure whitebark pine, far removed from roads and humans, a person might imagine they have stumbled into a fairy tale forest. Picture a canopy of curving, intertwined branches above large twisted trunks with rough flaky bark and the ground blanketed by the delicate, lime-green leaves of grouse whortleberry. As enchanting as such a forest might be, it is not the place where our narrative occurs. Red squirrels are largely absent from pure whitebark stands. A squirrel needs a variety of foods, so it would be unwise to place all its hopes on whitebark pine's unpredictable crops, not to mention their attractiveness to bears. No, the setting for our story is a mixed forest stand where whitebark pine intermingles with lodgepole pine, Engelmann spruce, and subalpine fir. The seeds of these other species may not have the calorie count of whitebark seeds, but they are more reliable.

The large seeds, or nuts, of whitebark pine are a high-energy food rich in fats, carbohydrates, and protein. This makes them a sought-after resource for bears fattening up in the fall before denning. But obtaining seeds is a challenge for ground dwellers; whitebark pine cones are indehiscent, which means they do not split open to scatter seeds when mature. Mature grizzly bears are poor tree climbers, so they must rely on red squirrels to harvest and concentrate the crop. In the end, these twists of nature help grizzly bears and make midden-raiding of whitebark pine seeds a worthwhile part of the grizzly diet.

The value of whitebark pine in bear diets has been recognized for many years, so the Interagency Grizzly Bear Study Team (IGBST) began documenting annual cone production in the GYE in 1980. Seed crops are quite variable, largely because of an adaptive tendency for trees to synchronize reproduction, referred to as a "masting" event. Producing occasional crops large enough to satiate seed consumers (e.g., squirrels, birds, bears) helps ensure that some seeds are left to germinate. In the GYE, large cone crops occur every 1 to 4 years, averaging every 2 years. Consumption by bears is correlated with this annual availability. During the 1970-1980s, seeds comprised 50–80% of fall scats when cone production was high, but were absent or scarce in scats when cone production was low (Mattson et al. 1991). Annual whitebark cone abundance has been linked with changes in grizzly bear survival, reproduction, movement, and frequency of management actions (Blanchard and Knight 1991, Mattson et al. 1992, Gunther et al. 2004, Schwartz et al. 2006). Abundant cone crops may influence nutrition, but they also affect bear foraging behaviors in ways that likely decrease vulnerability to human-caused mortality. When whitebark pine production is good, grizzly bears tend to use higher elevations, where the risk of bear-human conflict is lower and survival is higher (Schwartz et al. 2010).

Several emerging threats to whitebark pine have focused attention on the grizzly bear-whitebark relationship during the last decade. As a cold-adapted species, whitebark pine is vulnerable to climate change by a variety of agents. In the GYE, the most immediate threat has been the mountain pine beetle, a cambium-feeding insect that usually kills its pine host to reproduce. Historically limited by low winter temperatures at high elevations, recent beetle outbreaks, facilitated by warmer temperatures, have expanded into whitebark pine range and caused mortality within about 82% of the whitebark pine stands in the GYE (Macfarlane et al. 2013). Larger, mature trees are most affected by pine beetles; the progression of this impact was documented during recent IGBST cone production surveys. Between 2002 and 2010, there was a steady decline in the proportion of mature, cone-producing sample trees that remained alive (figure 1). By 2010, mortality levels reached 73%, but reduced mortality over the last few years indicates this beetle epidemic may be waning.

How did bears respond to this considerable change in whitebark pine availability? Just how important is this food? Is it an irreplaceable staple, or just one food among many? To answer these questions, we examined fall movements and use of whitebark pine habitats by grizzly bears over this decade of change. Beginning in 2000, the IGBST began deploying Global Positioning System telemetry collars on bears, allowing us to precisely pinpoint their locations throughout the day. By focusing on 72 individuals that were monitored during at least one fall season (August 15 through September 30) during 2000–2011, we were able to evaluate bear-whitebark pine relationships before, during, and after the peak of the recent beetle irruption. Using a map of whitebark pine in the GYE, we compared the proportion of time bears spent in this habitat to its pro-

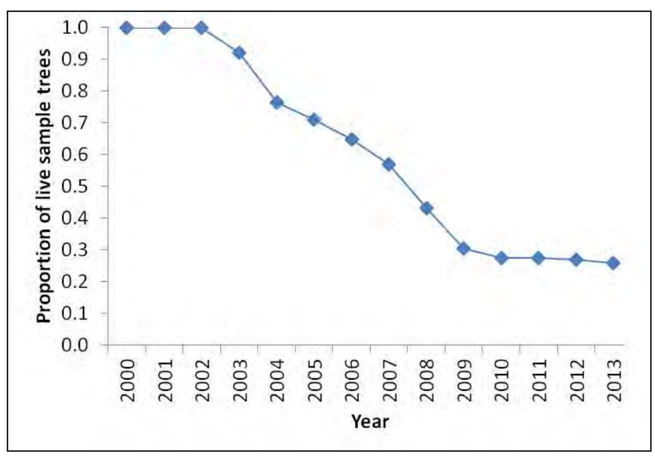

Figure 1. Beginning in about 2000, an outbreak of mountain pine beetles has caused considerable mortality among whitebark pine trees in the Greater Yellowstone Ecosystem. The proportion of mature, cone-bearing trees still alive on IGBST cone production transects steadily declined, especially during 2002–2010. Reduced mortality over the last few years indicates this beetle epidemic may be waning.

portion within their fall range. If use was higher than availability of whitebark pine, it indicated bears were selecting whitebark habitats, presumably to feed. If use was lower than availability, it suggested bears were spending their time feeding on other foods.

Surprisingly, we learned that one-third of these 72 bears had little or no whitebark forest in their fall range. This included bears observed in years before whitebark pine decline and in years of good cone production, indicating that a sizable proportion of the grizzly bear population might subsist on diets free of whitebark pine seeds, regardless of their abundance. However, given that whitebark forests make up only about 14% of the 50,000 square kilometers of occupied bear range in the GYE, perhaps it is not surprising to see this spatial variation in diet. In fact, in a study of diet specialization based on analyses of scats and feeding sign within Yellowstone National Park, Mealy (1980) identified three general foraging strategies employed by grizzly bears, only one of which included substantial amounts of whitebark pine seeds.

Nonetheless, the other two-thirds of our radio collared grizzly bears had whitebark pine in their fall range, and 72% of them appeared to select for this habitat during the fall season. Use varied among individuals, with observed days of use numbering as low as 1 and as high as 47 (all the days in our fall season). On average, bears used whitebark habitat for a total of 30 days but in bouts averaging 12 consecutive days at a time, indicating bears often left and returned to whitebark pine forests over the fall season. While it was clear whitebark pine was still important to grizzly bears, the average strength of selection declined over time, suggesting that as availability of seeds declined, bears sought them less (figure 2). In addition, during years of poor cone production, dates of early and peak use shifted 5–8 days later over the study period (with no change in late use), demonstrating that bears also reduced their duration of use over the years of the study.

We also examined whether grizzlies increased their fall movement rates, predicting that if seeds were a highly preferred food, the reduction in live whitebark pine would require bears to exploit more dispersed and distant stands over time. Increased movements, associated with low production, have been observed among several black bear populations where acorns are considered a fall staple. Among grizzly bears that had whitebark habitat in their fall range, we detected no change in movement rates over the study period. On average, bears did not roam over larger areas or search more within their fall range. We concluded that bears were consuming alternate foods within the area of their fall range. Thus, our results are more consistent with the idea that whitebark seeds are consumed opportunistically as part of a diverse diet, rather than a highly preferred fall staple.

Kerry Gunther counting whitebark pine cones as part of an ongoing survey.

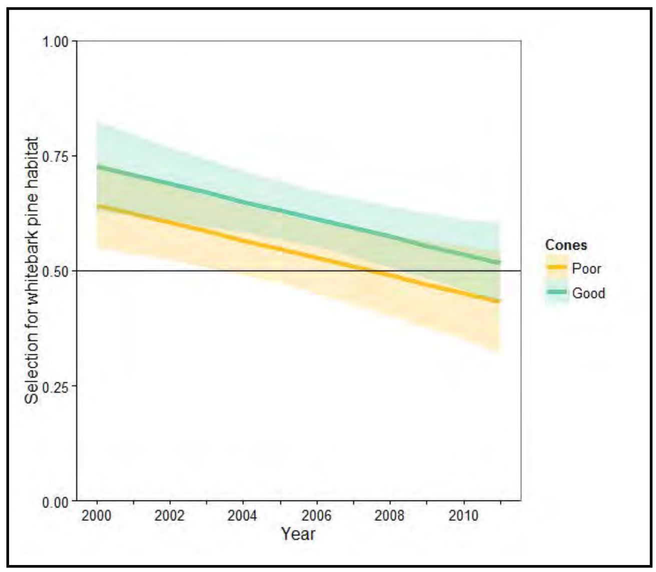

Figure 2. Estimated change in fall grizzly bear selection of whitebark pine habitats in the Greater Yellowstone Ecosystem during 2000–2011. Values above 0.5 indicate selection for whitebark habitat, while those below indicate selection against it. On average, grizzly bears continued to select for whitebark pine habitats throughout the study period, especially during years of good cone production; however, the strength of this selection decreased as availability of seeds declined.

Like most research, this leads to additional questions. If grizzly bears are swapping other foods for whitebark seeds, what are those foods? And are they as nutritious? Whitebark seeds are a near-perfect food, with a ratio of protein to energy shown to maximize mass gain in bears (Erlenbach et al. 2014). Among the hundreds of foods consumed by grizzly bears in the GYE (see "Grizzly Bears: Ultimate Omnivores of the GYE," this issue), it is mainly the animal foods that measure up to these tiny nuggets of nourishment. In fact, vertebrate meat represents the most concentrated and digestible energy available to bears. Yellowstone grizzly bears are highly carnivorous, even compared with other grizzly bear populations in the Rocky Mountains. Animal matter, largely from ungulates and insects, accounts for 40–50% of their annual diet. A recent study showed higher animal consumption during years of low whitebark cone production, suggesting that grizzly bears might compensate for low whitebark availability by consuming more meat (Schwartz et al. 2014). In another study, researchers found an increasing trend in use of large-biomass carcasses (e.g., bison and elk) during 2002–2011 (IGBST 2013), coinciding with the period of reduced selection of whitebark pine habitats. Perhaps most importantly, regardless of what alternative foods grizzly bears consume, trends in body mass and percent body fat suggest they have been able to maintain body condition (Schwartz et al. 2014) and reproductive rates (Interagency Grizzly Bear Study Team 2013).

Historically, use of remote, high-elevation whitebark stands was presumed to safeguard grizzly bears from some bear-human conflict and human-caused mortality, especially in years of good cone production. Therefore, we also examined grizzly bear selection of "secure" habitat (areas more than 500m from roads) during this period of whitebark pine decline. Data from the beginning of the study period support the historic relationship. Among those bears residing outside of the national parks (i.e., bears at most risk for human-caused mortality), selectivity of secure habitat was greater during years of good cone production compared to poor, but at the end of the study, the difference between years of good and poor cone production was not apparent (figure 3). Based on this finding, it seems possible the protective benefit of whitebark pine use could be diminishing. On average, though, most bears selected for secure habitat throughout the study. Among individuals, there was no correlation between selection of whitebark habitats and selection of secure habitats, so perhaps bears were not necessarily compelled to use riskier areas as a direct response to whitebark decline.

Yellowstone's grizzly bears attract a lot of public attention and have become the focus of many debates regarding whitebark pine and climate change. Many feared the decline of whitebark pine would affect the vigor of the grizzly bear population. However, our studies offer cautious optimism. As a rule, generalists typically respond well to environmental change. With the exception of their sensitivity to human development, grizzly bears are superb generalists, inhabiting a myriad of biomes worldwide. Occupying a much narrower range of conditions, it is the unique, cold-hardy whitebark pine that is the specialist, far more likely to be vulnerable to environmental change. Forecasts differ on its long-term persistence in the GYE, but scientists agree climate warming will have adverse impacts on whitebark pine (Keane et al. 2012). But, if we can do what it takes to curb global warming, combined with effective restoration practices, perhaps there is hope that whitebark pine can hold firm in the GYE. We then can look forward to a future where grizzly bears and whitebark pines continue to coexist in this spectacular ecosystem. And with any luck, the only complaints might come from the red squirrels.

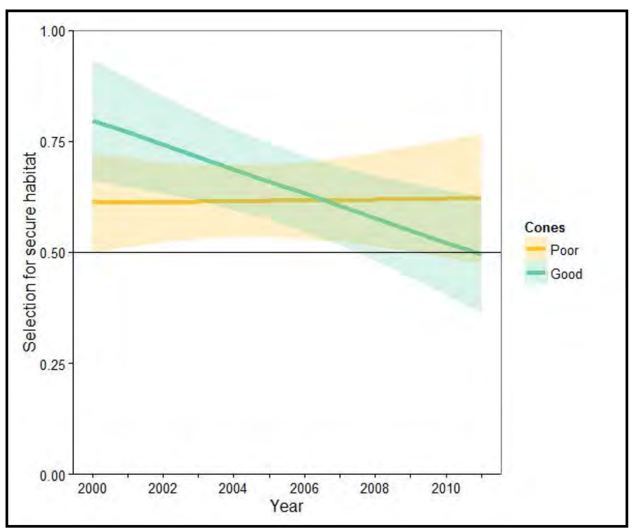

Figure 3. Estimated change in fall grizzly bear selection of secure habitats (areas more than 500m from roads) in the Greater Yellowstone Ecosystem during 2000–2011. Early in the study, grizzly selection for secure habitat was greater during years of good whitebark pine cone production compared to poor, likely due to the high elevation and remote nature of whitebark stands. By the end of the study, this difference was no longer apparent, suggesting the protective benefit of whitebark pine use may be diminishing. Nonetheless, most bears selected for secure habitat throughout the period, as indicated by values above 0.5.

LEADING THE WAY:
Women in Science

Cecily Costello has studied the ecology, management, behavior, and population dynamics of bears for more than 25 years. She has lived and worked in various regions including the Northeast, the Southwest, and the northern Rockies, but interestingly, her career has been bookended by work with Yellowstone grizzly bears. She got her first bear research experience as a volunteer for the Interagency Grizzly Bear Study Team in 1988. This brief, but memorable experience was highlighted by her first-ever handling of a bear – an adult female grizzly with two cubs. This was followed by her M.S. research on the habitat ecology of Adirondack black bears from the SUNY College of Environmental Science and Forestry, a state agency-sponsored study of black bear population dynamics and ecology in New Mexico, and her Ph.D. from Montana State University where she studied kinship, spatial relations, and male reproductive success of black bears. Since 2010, she has been a Research Associate with the College of Forestry and Conservation at the University of Montana, involved in various studies of black bears and grizzly bears in the Greater Yellowstone and Northern Continental Divide Ecosystems. She is an associate editor of the journal *Ursus*, and a former treasurer for the International Association for Bear Research and Management. Beginning in November 2015, Cecily begins a new position as a Research Wildlife Biologist with Montana Fish, Wildlife and Parks focused on grizzly bears.

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Demographic Changes in Yellowstone's Grizzly Bear Population

Frank T. van Manen, Mark A. Haroldson, Dan D. Bjornlie, Cecily M. Costello, & Michael R. Ebinger

Figure 1. A Study Team researcher fits a GPS radio collar on a female grizzly bear, Yellowstone National Park, 2013. A nasal catheter is used to provide supplemental oxygen to the bear during anesthesia. Straw is provided inside the bear trap to keep bears comfortable, the remains of which are visible on the bear in this photo.

One of the many benefits of studying grizzly bears in Yellowstone is they are a popular topic of conversation. The interest in Yellowstone grizzly bears is almost universal and for good reason, the Greater Yellowstone Ecosystem (GYE) invokes images of a wild, untamed landscape with grizzly bears as one of its most iconic species. In such conversations about bears, 9 out of 10 times the first question is "How many grizzly bears are there?" Many people expect a simple, straightforward answer. Although we usually have an answer, what's behind the answer is by no means simple. Like other elusive animals, grizzly bears are notoriously difficult to study. They occur in low densities, are active at times when observation is difficult (early morning and late evening), and use remote habitats and rough terrain. Only through a concerted, long-term research and monitoring effort have we begun to understand many fascinating aspects of grizzly bear population demographics (the statistical study of populations).

The Interagency Grizzly Bear Study Team (Study Team) started population studies in 1973 and have continued to-date, building one of the longest-running and most comprehensive biological datasets of any large carnivore in the world. To keep track of what the grizzly bear population is doing, the Study Team deploys a number of monitoring techniques ranging from observ-

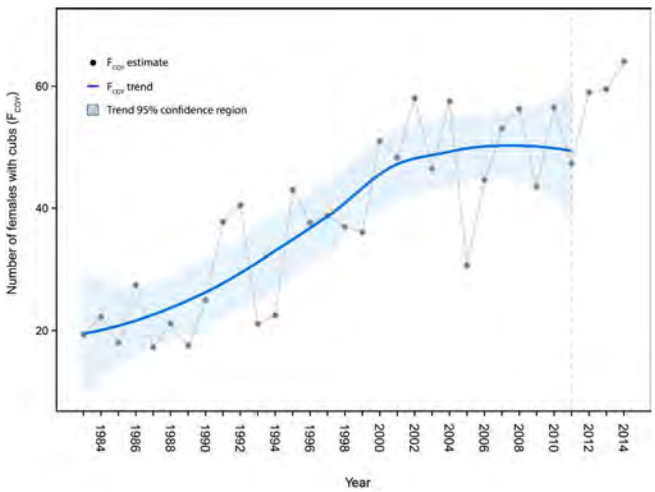

Figure 2. Estimated number (Chao2 estimator; Keating et al. 2002) and population trend (based on locally weighted scatter-plot smoothing) of unique females with cubs of the year (F_{COY}), Greater Yellowstone Ecosystem, 1983-2014.

ing bears in the field, to aerial observation and radio tracking from planes, to cutting-edge technologies, such as Global Positioning System (GPS) tracking with satellite transmitters. One of the primary jobs of the Study Team is to provide periodic assessments of the GYE grizzly bear population to assist managers with potential decision points in the management process. Managers often want to know the population size before deciding on appropriate actions. Additionally, monitoring information provided by the Study Team helps managers develop knowledge of how the population will likely respond to various types of environmental changes. In summary, one of our most important tasks is to count bears, which sounds easy, but doing so in practice and with scientific rigor is a very challenging task.

Monitoring Grizzly Bears

Early research efforts were dedicated to developing reliable population monitoring techniques that did not involve marking (e.g., numbered ear tags) or radio-collaring bears (figure 1), which was not permitted for several years after the Study Team was established. The first successful technique to be implemented involved counts of a specific segment of the population: females with cubs-of-the-year. This population segment was selected because females with cubs can be reliably distinguished from other bears (lone bears of either sex or females with yearling or two-year-old offspring), and they also represent the most crucial reproductive segment of the population. For some highly visible animals, such as elk (*Cervus elaphus*), a single aerial survey may provide a reliable estimate of an entire herd. However, bears are far less visible; therefore, sightings of females with cubs must be tallied over an entire spring and summer. Because observations occur over a long period, it was necessary to develop a rule set that assigns each observation to a particular "unique" female (Knight et al. 1995). Based on grizzly bear biology, the Study Team used information on the size of individuals' home ranges and size of family groups to assign an observation to either a previously observed or new female with cubs. For example, if a female with two cubs is observed only 5 kilometers from a previous observation of a female with two cubs, the observation is considered a resighting rather than a new unique female with cubs. It was recognized that these rules were not perfect; however, if errors occurred, the resulting count was conservative and was not designating multiple sightings as different females unless there was strong evidence. This reduced the risk of overestimating numbers of females with cubs and the overall population estimates derived from those counts, which was important for a population that did not show signs of growth until the mid-1980s. This method was adopted as part of the Grizzly Bear Recovery Plan in 1993. Further improvements to this technique occurred through the 1990s and early 2000s, which included a refinement to incorporate an estimate of females not observed, referred to as the "Chao2 estimator," named after the scientist who developed the technique (Keating et al. 2002, Cherry et al. 2007). Another enhancement was a statistical technique that would inform managers if a change in the trajectory of the population had occurred, essentially a "monitoring trigger" for the population (Harris et al. 2007). For example, a graph of a population growing at a constant rate each year will show a linear increase with each additional year of data. If this relationship changes from a linear, straight line to a nonlinear, curved line over time, it would signal a change in population trend. This monitoring trigger was implemented in 2007. In 2011 we detected that the growth rate of the Yellowstone grizzly bear population, which was linear during the 1980s and 1990s, had started to level off (figure 2). Further investigations showed this slowing of population growth likely started about a decade prior, around the early 2000s. For the Study Team, there was a very rewarding aspect to this result. Detecting a change in population growth meant the monitoring system set up by the Study Team

Table 1. Comparison of selected demographic vital rates for the Greater Yellowstone Ecosystem grizzly bear population for two study periods, 1983–2001 (Schwartz et al. 2006) and 2002–2011 (Interagency Grizzly Bear Study Team 2012).

	1983-2001		2002-2011	
Vital Rate	**Estimate**	**95% Confidence Interval**	**Estimate**	**95% Confidence Interval**
Cub survival	0.64	0.443–0.783	0.553	0.421–0.667
Yearling survival	0.817	0.489–0.944	0.539	0.346–0.698
Subadult (age 2–4) survival[a]	0.950[b]	0.926–0.965	0.948[c]	0.917–0.968
Adult (5+) female survival[a]	0.950[b]	0.926–0.965	0.948[c]	0.917–0.968
Adult (5+) male survival[a]	0.874	0.810–0.920	0.948[c]	0.917–0.968
Fecundity[d]	0.362		0.336	0.264–0.409

[a] Animals with unresolved fates were censored for analysis at last contact

[b] Rates were estimated using a combined subadult and adult age class

[c] No difference between age and sex classes

[d] Number of female cubs produced per breeding-age female per year

had worked and could provide important information for managers. One might even call this a "textbook" example of what we teach students in wildlife management curricula throughout the country: set up a population monitoring system, establish triggers that indicate when a change has occurred, study the details of that change, and adjust management accordingly. Of course, you may wonder why we got excited about detecting this change a decade after it started? The reality is that monitoring wildlife populations, grizzly bears in particular, is fraught with challenges. One important reason for this is that the reproductive rates of grizzly bears are very low: grizzly bear generation time is about 10.5 to 13.5 years, which means it takes that long for a female grizzly bear to replace herself in the population. Detecting changes in a grizzly bear population simply takes time. Data from the three years after 2011 show higher estimates (figure 2), but because of annual variation we do not yet consider that indicative of a new period of population growth. Indeed, a preliminary estimate for 2015 reinforces the notion that the population remains stable.

Changes in Vital Rates

Since population growth had changed, we initiated a comprehensive demographic review in the fall of 2011 to investigate in detail what caused the slowing of population growth. Using studies by Schwartz et al. (2006) for the period 1983–2001 as a basis for comparison, we reevaluated "vital rates" of GYE grizzly bears for the period 2002–2011. Vital rates refer to demographic measures of the population, such as survival of different age classes and reproductive output. Vital rates can also be combined to estimate annual population growth, symbolized by lambda (see page 22). For the period 1983–2001, Schwartz et al. (2006) observed a robust rate of annual population growth of 4.2-7.6%. However, our analysis of the 2002–2011 data indicated this annual growth had slowed to about 0.3-2.2% (Interagency Grizzly Bear Study Team [IGBST] 2012). The proximate causes of this slower growth were lower survival rates among the cub and yearling age classes and a slight decline in fecundity (measured as the number of female cubs produced per breeding-age female per year; table 1). Survival of independent females (2 years or older) did not change between the two time periods, but survival of adult males actually increased from the earlier to the later time period. Recent analysis, based on life histories of more than 1,200 grizzly bears collected since the 1970s, suggests the recruitment of younger individuals has decreased as the proportion of older bears in the population has increased. Of course, the real question is "What do all these new findings tell us about the population biology of Yellowstone grizzly bears and the ultimate cause of these changes?"

What are Potential Causes of Demographic Changes?

Recent data suggest there is a spatial component to these changing demographics. Previous observations based on data from 1983 to 2001 (Schwartz et al. 2006) indicated that Yellowstone, the core area for grizzly bears in the GYE, had already shown signs of stabilizing numbers. It also indicated the most vigorous population growth occurred in the zone outside Yellowstone but within the Grizzly Bear Recovery Zone (a zone designated by the U.S. Fish and Wildlife Service to implement recovery; figure 3). Areas outside the recovery zone were essentially "sink" areas, where the mortality rate exceeded the birth rate. Findings from our

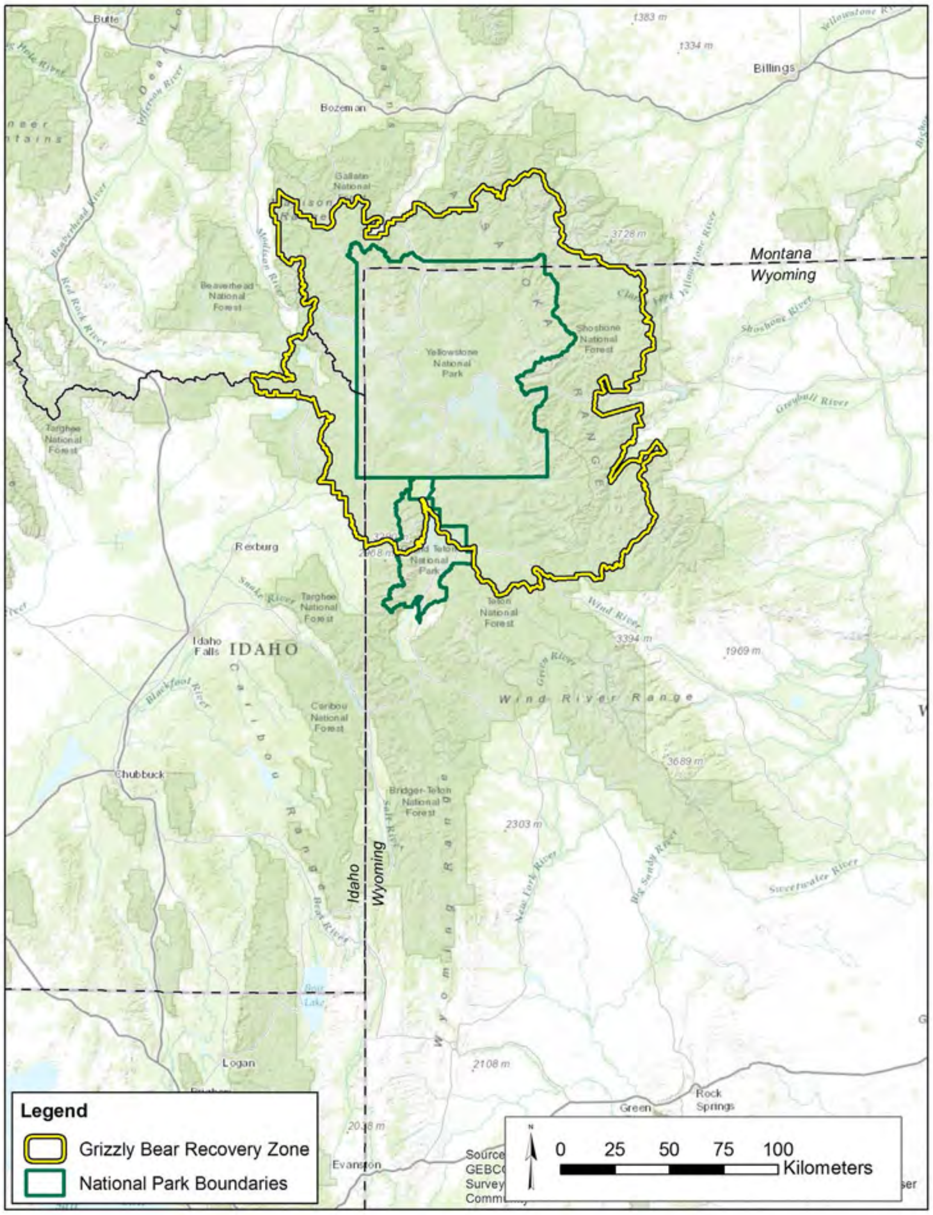

Figure 3. Grizzly Bear Recovery Zone and National Park boundaries for the Greater Yellowstone Ecosystem.

analyses of 2002–2011 data showed the process of population stabilization had expanded to the entire Grizzly Bear Recovery Zone (IGBST 2012) and areas outside the zone functioned less as population sinks. Throughout both periods of robust and slower population growth, grizzly bears expanded their distribution in the GYE, recolonizing some areas where grizzly bears have been absent for over a 100 years ("Shorts: Grizzly Bears and Army Cutworm Moths," this issue). By 2010, grizzly bears occupied around 50,280 km^2 (12.4 million acres) with few areas of prime habitat unoccupied (Bjornlie et al. 2014a). In other words, population growth rates have become more similar across the entire ecosystem as the population expanded, suggesting the population is reaching carrying capacity (a term used to define the long-term population size that can be sustained) given available space, food, and other resources in the environment.

Case closed, right? No, not quite. Whereas the data indicated the grizzly population may be reaching carrying capacity in many portions of the ecosystem, managers wanted to know what the ultimate cause of this may have been. Was it the "natural" process of a population simply reaching high numbers (also referred to as density-dependence), or could carrying capacity have been substantially reduced as a consequence of recent changes in availability of food resources? The most notable change in a grizzly bear food resource occurred with whitebark pine trees (*Pinus albicaulis*), the seeds of which are a high-calorie fall food for grizzly bears preparing for hibernation. High mortality of whitebark pine trees has occurred throughout the GYE since the early 2000s, primarily due to a native forest insect, the mountain pine beetle (*Dendroctonus ponderosae*; see "How Important is Whitebark Pine to Grizzly Bears?," this issue), which could have lowered carrying capacity. If the latter was the case, managers may be more inclined to take a more cautious approach than if the population had naturally reached a stable level at a higher carrying capacity. We set out to study this question by comparing the association of whitebark pine decline and grizzly bear density with survival and reproduction rates based on three decades of data (1983–2012; van Manen et al. 2015). It is very difficult to tease apart potential effects of food versus bear density, so we focused on developing ways to measure the degree of whitebark pine's impact and grizzly bear density experienced by each individual bear in our analyses, both of which varied immensely throughout the GYE and over time.

We detected no link between survival of independent bears and density or between their survival and whitebark pine decline. In fact, as we noted previously, survival of independent females (2 years or older) was high (95%) and has essentially not changed in 30 years. Survival of independent males increased during the decade of the 2000s from 87% to 95%. In contrast, survival of dependent bears (cubs and yearlings) declined and the drop in cub survival was most apparent among those bears that lived at high densities. There was no evidence of an association of cub and yearling survival with whitebark pine decline, but there was evidence for a link between reproduction and bear density. By concentrating our analysis on females with no offspring (i.e., those most likely to successfully breed), we found their probability of having cubs the next year declined slightly during the 1990s, prior to whitebark pine decline; and this decline was greater in areas with higher bear densities. Knowing that grizzly bear density may be a key factor, we next investigated potential drivers of how bear density may be affecting population growth. This is where things get really interesting.

Potential Drivers of Density Dependence

As a population approaches carrying capacity and factors start acting on the population as density increases, a predicted sequence of events for long-lived vertebrates is that juvenile mortality increases, females tend to initiate breeding later in life, reproductive output tends to decline, and, ultimately, adult mortality increases (Eberhardt 2002). We know from studies in Scandinavia and Alaska that cub survival is a potential density-dependent factor contributing to population regulation among bear populations (Swenson et al. 1997, 2001, Miller et al. 2003). Could it be that more older males in the population, because of their increased survival, are somehow related to lower survival of younger bears?

Intraspecific killing by males may function as a direct density-dependent effect on cub survival, but there has been vigorous debate as to what the potential biological drivers may be. Studies in Scandinavia support the notion of sexually-selected infanticide (male bears kill cubs they did not sire to create new mating opportunities; Swenson et al. 1997, 2001); whereas, North American studies indicate a greater vulnerability of cubs to various sources of mortality, including intraspecific killings, for populations nearing carrying capacity (Miller et al. 2003). Regardless of this debate, males are primarily responsible for intraspecific killing, and we hypothesize there is a connection with the increased survival of independent-aged males (table 1) and increased mortality of cubs since the early 2000s. We have field observations of males killing cubs, including several instances where the mother was killed as well, presumably while defending her cubs (e.g., in Lamar Valley and Hayden Valley). The frequency of these events seems to have increased in the last 10 years compared with previous decades. Although we have some evidence supporting this hypothesis, we always investigate potential alternative explanations as well.

Alternative Explanations

The first alternative explanation may be "interference competition," which refers to constraints on feeding efficiency of subordinate individuals (often juveniles or females with cubs) because of the presence of dominant individuals. Such competition can limit access to foods for subordinates, even when foods are plentiful. If conspecifics are potentially predatory, as in grizzly bears, increased vigilance may intensify this effect at higher population densities. Studies in Alaska (Nevin and Gilbert 2005) and Scandinavia (Steyaert et al. 2013) have demonstrated reduced energy intake among females with cubs as a consequence of avoidance of more dominant bears, especially large males. However, similar evidence of interference competition has not been observed in the GYE so far. Therefore, we cannot

Density-Dependent Population Regulation

The scientific discipline that most wildlife managers use to make informed decisions is population ecology: the study of how populations change over time and space, and interact with their environment. Ultimately, the goal of population ecology is to understand how and why populations change over time. Researchers do this by estimating the number of individuals or some segment of the population (e.g., counts of female grizzly bears with cubs-of-the-year) and if, or how, those estimates change over time. Population size or abundance is a well-known and easy to understand metric, but only provides information about a population at a single point in time. Although the concept of population size is easy to comprehend, accurately determining abundance can be challenging. Population trend is determined by numbers of births, deaths, and how many animals move into or out of the population (i.e., immigration and emigration) from year to year, typically expressed as the annual population growth rate, (represented by λ, the Greek symbol of "lambda"). A λ value of 1.03, for example, means the population size is increasing at 3% per year, whereas a λ value of 0.98 indicates population size is decreasing at 2% per year. A $\lambda = 1.0$ reflects a stable, unchanging population size. Estimates of λ for grizzly bear populations in North America range from 0.98 to 1.085 (Schwartz et al. 2003). Armed with the knowledge of population size and trend, and some notion as to the why, wildlife managers can make scientifically informed decisions regarding populations. The "why" question is often the most difficult for researchers to answer.

No population can grow forever because the resources it requires are finite. This understanding led ecologists to develop the concept of carrying capacity (expressed as "*K*"). This is the maximum number of individuals a particular environment can support based on the available resources (Krebs 2009). Classic studies of population growth occurred under controlled laboratory conditions where populations of a single organism, often an insect species or single-celled structure, were allowed to grow in a confined space with a given level of food supply. Under these conditions, *K* is a constant value that is approached in a predictable manner and can be described by a mathematical equation (figure 1A; Krebs 2009). However, few studies of wild populations have demonstrated the constant carrying capacity and population size suggested by this equation. Instead, many factors can cause variation in carrying capacity over time (e.g., food supply often varies from year to year). Also, populations may exhibit a delayed response to changes in carrying capacity, particularly for species with low reproductive potential. As a consequence, populations usually fluctuate above and below carrying capacity, resulting in relative population stability (figure 1B; Colinvaux 1986).

When a population is at or near carrying capacity, mechanisms that regulate or influence population size or the rate of change fall into two broad categories: density-dependent effects and density-

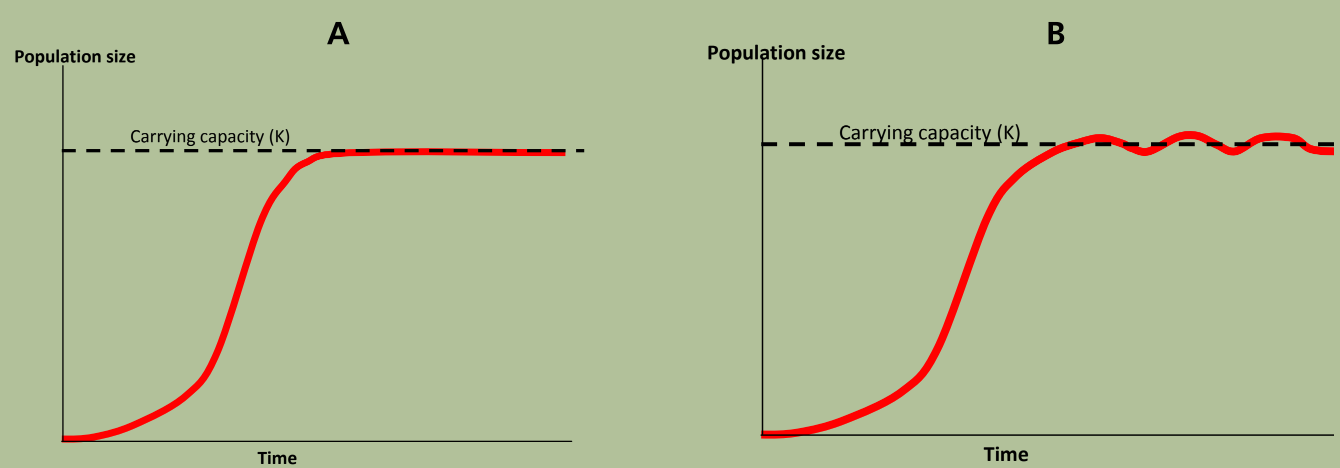

Figure 1. Typical population trend with respect to carrying capacity (K). A) Population ecologists call the initial growth phase and subsequent slowing a **logistic growth curve**, referring to slow growth when a population is small, with growth increasing more rapidly as the population reaches a larger size, and with growth slowing down as intrinsic and extrinsic factors start affecting vital rates such as survival and reproduction. B) Because carrying capacity varies, populations usually fluctuate above and below carrying capacity, resulting in relative population stability.

independent effects. Density-independent effects, or extrinsic factors, limit the number of individuals, regardless of how many individuals are in a population. These extrinsic factors may include limited food resources, weather, or human impacts. In contrast, factors that limit population growth as population size increases are density-dependent effects, or intrinsic factors, and are usually expressed through individual behaviors, physiology, or genetic potential (Taylor et al. 1994). Among bears, for example, a behavioral effect may occur in areas with higher densities, where dominant individuals may prevent subordinate bears from gaining full access to high-quality foods, which may affect the survival of subordinates. Population stability (i.e., fluctuation around carrying capacity) is often influenced by a combination of density-dependent and density-independent effects. Consequently, determining whether a population is affected more strongly by density-dependent or density-independent effects is a difficult undertaking, and this topic has not been extensively studied in large carnivore populations. In the Greater Yellowstone Ecosystem, researchers are fortunate to have a comprehensive, long-term dataset on grizzly bear demographics. Only with combined evidence from a number of studies and 30 years of demographic data have we started to gain important insights into these population dynamics.

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conclude whether or not it was a contributing factor to the slowing of population growth. Another alternative explanation of the decline in cub and yearling survival may be the reintroduction of gray wolves (*Canis lupus*) into Yellowstone National Park in 1995–1997. However, only four incidents of wolf predation on cubs or yearlings have been documented since 2001 (Gunther and Smith 2004, IGBST, unpublished data) so support for this explanation is not very strong.

Conclusions

Multiple lines of evidence (IGBST 2013) support our hypothesis that the slowing of population growth of Yellowstone grizzly bears is associated with increasing density of grizzly bears rather than the decline of a calorie-rich fall food resource, whitebark pine (van Manen et al. 2015). Nevertheless, population changes brought about by density effects may still be linked with food resources and carrying capacity of the environment. We considered the possibility that decline of whitebark pine and other resources (see "Response of Grizzly Bears to Changing Food Resources in the GYE," this issue) reduced carrying capacity, which could have reduced cub survival and reproductive transitions in a density-dependent fashion through direct competition for resources. This effect would be difficult to separate from that of interference competition as discussed previously. If this were the case, we would have expected home-range size and movements to increase (McLoughlin et al. 2000), bears to have relied on lower-energy food resources (McLellan 2011), and body condition to have declined as a consequence (Robbins et al. 2004). To date, there is little evidence for these conditions in the GYE; female home ranges have decreased in size where bear densities have increased (Bjornlie et al. 2014b), daily movements have not changed for females or males during fall hyperphagia (i.e., increased appetite before hibernation; Costello et al. 2014), bears continue to use high-quality foods (Fortin et al. 2013), body mass has not declined (Schwartz et al. 2014), and percent body fat among females in fall has not changed (IGBST 2013). Finally, current evidence suggests grizzly bears responded to declines in whitebark pine (Costello et al. 2014) and cutthroat trout (*Oncorhynchus clarkii*; Fortin et al. 2013) by shifting their diets, indicating this opportunistic omnivore was able to compensate for the loss of these particular foods.

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Frank van Manen *(see page 6)*

Mark Haroldson (pictured above) has had a passion for bears since he began working with them as an undergraduate in 1976. He has worked in bear research and management in several western states and provinces ever since. Since 1984 he has worked in various capacities for the Interagency Grizzly Bear Study Team in the Greater Yellowstone Ecosystem. He is currently a USGS Supervisory Wildlife Biologist for the study team and works out of the Northern Rocky Mountain Science Center, Bozeman, MT. He has authored and co-authored more than 45 peer-reviewed publications and three book chapters on a variety of topics related to grizzly bear ecology and demographics. Current research is focused on population trend and possible causes for the recent slowing of population growth in the Greater Yellowstone Ecosystem.

Response of Grizzly Bears to Changing Food Resources in the Greater Yellowstone Ecosystem

Frank T. van Manen, Cecily M. Costello, Mark A. Haroldson, Dan D. Bjornlie, Michael R. Ebinger, Kerry A. Gunther, Dan J. Thompson, Megan D. Higgs, Dan B. Tyers, Steven L. Cain, Kevin L. Frey, Bryan Aber, & Charles C. Schwartz

Female grizzly bear with cubs-of-the-year in mid-summer. Investigations by the Interagency Grizzly Bear Study Team so far do not indicate that reproduction has declined as the availability of various food resources within the Greater Yellowstone Ecosystem has changed.

"The only thing that is constant is change."

- Heraclitus

This simple idea put forward by a Greek philosopher about 2,500 years ago beautifully captures a key essence of nature, in which stability is often the exception rather than the norm. Indeed, how organisms respond to changes in biotic composition and structure–or ecosystem dynamics–is a central topic in ecology. As ecologists, when it comes to studying how animals respond to change, we often refer to "generalists" and "specialists." This division is based on how natural selection shapes a species' diet and habitat preference, and each has its own advantages.

Generalists are animals that tend to forage on a wide variety of food items or are able to live in a variety of habitats. Conversely, as their name implies, specialists are more selective in what they eat and the places they live. Although the specialists do not have as much flexibility in what they eat, they usually have less competition when obtaining foods; whereas, generalists must compete with other generalists in the environment. But being a generalist has its advantages too, most notably the ability to better cope with change in the availability of a particular food item or habitat type. Heraclitus' famous quote about change is particularly relevant to grizzly bears during the past few decades, as scientists began to observe notable changes in their food resources. These changes provided the Interagency Grizzly Bear Study Team with a unique opportunity to investigate how well one of nature's most iconic generalists fit ecological predictions: Did grizzly bears cope with these changes in their food base and, if so, how?

How Are Food Resources of Grizzly Bears Changing?

Grizzly bears are opportunistic omnivores and feed on a wide array of animals and plants. Although grizzly bears commonly consume herbaceous vegetation, larger bears have difficulty meeting their energy requirements unless they also consume high-calorie foods (Schwartz et al. 2003). Similarly, high-calorie foods also tend to play an important role during fall hyperphagia –a period prior to entering hibernation in which grizzly bears gain substantial weight, mostly in the form of body fat. Depending on where they live, bears in the Greater Yellowstone Ecosystem (GYE) typically have access to at least one of five high-calorie food items that have experienced various levels of change: bison (*Bison bison*), elk (*Cervus elaphus*), cutthroat trout (*Oncorhynchus clarkii*), whitebark pine (*Pinus albicaulis*), and army cutworm moths (*Euxoa auxiliaris*).

Yellowstone grizzly bears have been identified as one of the most carnivorous interior populations in North America (Jacoby et al. 1999, Mowat and Heard 2006). The GYE contains large populations of ungulates, and winter-killed elk and bison are important spring foods to bears (Green et al. 1997, Mattson 1997). Some ungulate populations in the GYE have experienced significant changes during the past decade; whereas, others have not. The Yellowstone bison population has fluctuated between 2,500 and 5,000 in recent decades, largely because of a removal program directed at limiting population growth and regulating numbers due to limited tolerance for bison in surrounding states (White et al. 2015). During 2014, numbers approached the record high count of 5,000 (White et al. 2015). Elk numbers on the northern range, in the Madison headwaters, and Gallatin Canyon have substantially declined; but elk numbers from some herds east of Yellowstone either remained constant or increased (Creel 2010, Cross et al. 2010). Competition for the ungulate resource likely has increased due to an approximate three-fold increase in grizzly numbers since the 1970s and growth of the reintroduced wolf population from 31 individuals in 1995 to a minimum of 463 in the GYE in 2012 (USFWS et al. 2013).

Prior to the 1990s, spawning cutthroat trout were a valuable food for grizzly bears residing near the tributary streams to Yellowstone Lake from mid-May through July (Reinhart and Mattson 1990), but this fish population has declined due to non-native lake trout (*Salvelinus namaycush*) predation, whirling disease (*Myxobolus cerebralis*), and prolonged droughts (Koel et al. 2003, 2005). The cutthroat trout population is estimated to be less than 10% of historical numbers (Koel et al. 2005), and biomass of cutthroat trout consumed by grizzly bears in this region declined by 70% between 1997 and 2007 (Fortin et al. 2013).

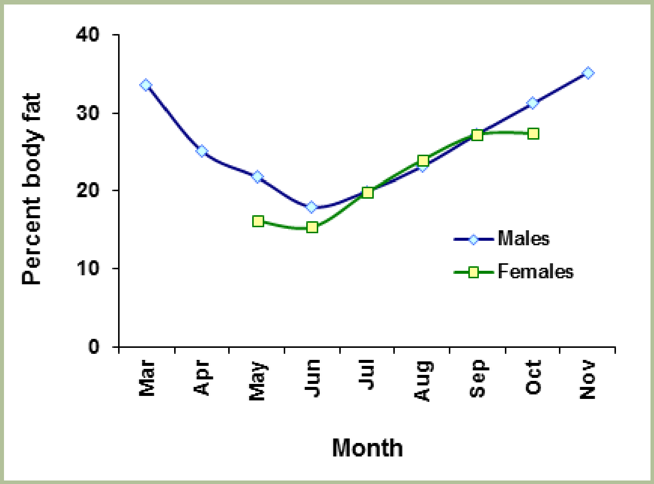
Seeds from whitebark pine are a frequent food for grizzly bears during mid-August through late September and, occasionally, in spring when seed production in the previous fall was high (Mattson et al. 1991). Grizzly bears typically consume whitebark pine seeds by raiding seed caches (middens) made by red squirrels (*Tamiasciurus hudsonicus*). Whitebark pine is a masting species; and grizzly bear consumption of seeds is associated with this natural cycle of good and poor years of cone production. Whitebark pine has experienced widespread tree mortality because of mountain pine beetle (*Dendroctonus ponderosae*), wildland fire, and white pine blister rust (*Cronartium ribicola*), with mountain pine beetle having caused the greatest mortality since the early 2000s (Gibson 2007; see "How Important is Whitebark Pine to Grizzly Bears?," this issue).

Finally, army cutworm moths provide the richest food source (8 kilocalories per gram) for grizzly bears in the GYE (French et al. 1994). Use of this food resource is unique, not only because bears can obtain substantial energy by consuming thousands of these tiny insects in a day, but also because this foraging occurs on very remote, high alpine talus slopes found mostly in the Absaroka Mountains east of Yellowstone (see "Shorts: Grizzly Bears and Army Cutworm Moths," this issue). We know relatively little about the variability of this food resource and whether the long-term availability of army cutworm moths is changing.

Bioimpedance—a tool to measure grizzly bear body composition

Grizzly bears and black bears in the GYE hibernate in dens anywhere from 3 to 6 months, starting in late fall. While in dens, they do not eat, drink, urinate, or defecate; they meet their metabolic needs by utilizing stored body fat. To accomplish this feat, bears must consume enough calories to build up sufficient fat reserves during the summer and fall months to sustain themselves through winter. Pregnant females give birth to newborn cubs during the denning period so their energetic demands are even greater than their male counterparts. Consequently, bears typically undergo an annual cycle of weight gain and loss. Much of the annual changes in weight are due to changes in the amount of body fat an individual bear possesses. Lowest weights are observed during early to mid-summer, before bears begin to accumulate their fat reserves; heaviest bear weights occur during late fall.

During the late 1990s, bear researchers developed a new method to estimate percent body fat of captured bears using electrical bioimpedance. Similar techniques had been available for human use since the mid-1980s. This non-invasive technique uses a device to measure the speed at which an electrical current travels through a bear. Fatty tissue has low water content and consequently is a poor conductor of electrical current; whereas, lean tissue contains more water and is a better conductor. Using this measure, together with the weight and length of the bear, we can derive an estimate of percent body fat. The Interagency Grizzly Bear Study Team began using this technique during 2000 and has acquired over 600 individual estimates of percent body fat to date. These data reveal seasonal changes in body composition, with lowest values in June and highest values just prior to the onset of denning. Although individual estimates can be quite variable, investigating trends for different sex or age classes of bears through time, or between differing availability of fall foods, can provide useful information. For example, our data indicate there is no evidence for a difference in fall estimate of percent body fat for bears captured during years with poor versus good whitebark pine cone production (Schwartz et al. 2014). Likewise, we have found no evidence for a decline in condition of grizzly bears in the fall, despite substantial mortality of mature whitebark pine trees (IGBST 2013). These results indicate bears continue to find the calories they need to support denning and reproduction and sustain a healthy population in the GYE.



Estimated mean percent body fat by month for male and female grizzly bears in the Greater Yellowstone Ecosystem, 2000-2014.

Measuring bioelectrical impedance on a captured and anesthetized grizzly bear in Yellowstone National Park to estimate percent body fat.

Grizzly Bear Responses to Changing Food Resources: Summary of Research Findings

The overall goal for this research project was to leave "no stone unturned," so multiple research questions were asked to determine if and how grizzly bears have responded to changes in food resources. If all investigations point to a similar interpretation, the overall findings would be more reliable. Eight research topics were explored to determine different types of responses to changing food resources, ranging from the individual to population level:

1. Diet diversity;
2. Grizzly bear selection of whitebark pine habitat;
3. Body condition;
4. Animal matter as alternative food sources;
5. Changes in movements and home ranges;
6. Changing mortality risk due to changing food resources;
7. Home-range size as an indicator of density versus resource effects; and
8. Relationship among changing vital rates, resource changes, and density dependence.

Yellowstone grizzly bears exhibit substantial variation in their diets. Based on a review of existing literature from 1891 to 2013, Gunther et al. (2014) documented that grizzly bears consumed 266 different food species (see "Grizzly Bears: Ultimate Omnivores of the Greater Yellowstone Ecosystem," this issue). These findings of a diverse diet are supported by numerous other studies that showed considerable adaptability in foraging strategies among bears in general (e.g., Stirling and Derocher 1990, Yeakel et al. 2013) and brown bears in particular (Van Daele et al. 2012). Diet flexibility is central to the evolutionary strategy of grizzly bears, which allows them to occupy a wide range of the world's biomes (Schwartz et al. 2013) and may partly explain why grizzly bears occupy the greatest diversity of habitats of the eight bear species in the world (Schwartz et al. 2003).

Results of this research indicate that grizzly bears in the GYE gradually shifted several major food items in their diets over a period of four decades as availability changed, while other food items were relatively constant (Gunther et al. 2014). For example, graminoids and ants were documented in all years for which bear scat data were available (37 years during 1943–2009). In response to the reduced availability of whitebark pine, Yellowstone grizzly bears exhibited reduced selection of whitebark pine habitat over the past decade in addition to a shorter and delayed duration of use during poor cone production years (Costello et al. 2014; see "How Important is Whitebark Pine to Grizzly Bears?," this issue). This response presumably reflects a reduction in midden excavation by grizzly bears, which was also documented after the extensive 1988 fires (Podruzny et al. 1999). As an alternative to whitebark pine consumption, grizzly bears seem to have increased consumption of animal matter and other foods. A new technique called stable isotope analysis can be used to determine the proportion of the diet that is assimilated from animal (isotopic nitrogen 15^{N}) versus plant resources (isotopic carbon 13^{C}). Stable isotope analysis is much more accurate than traditional techniques for diet analysis, which are typically based on food items found in bear scats. Also, it can be performed on various samples and reflect different time periods. For example, hair samples provide an estimate of assimilated diet over the previous year; whereas, a blood serum sample reflects the diet from the previous 10 to 14 days. Stable isotope analyses of samples collected during 2000–2010 (Schwartz et al. 2014) and analyses of carcass use (IGBST 2013) support an increase in consumption of animal matter coinciding with the period of reduced use and selection of whitebark pine habitat.

Interestingly, in the apparent transition of grizzly bears reducing use of whitebark pine seeds and shifting their diets to other foods, movements did not increase (Costello et al. 2014). We predicted home-range sizes would increase for those bears that lost most whitebark in their home range, but we found no such relationship. In fact, home-range size was more closely linked with bear density, showing much less variation where bear densities are higher. This finding suggests social pressures in those areas may be confining bears to smaller home ranges (Bjornlie et al. 2014b). Schwartz et al. (2014) and IGBST (2013) showed that foods available in the GYE appear adequate to maintain body condition (body mass, percent body fat) at levels prior to the whitebark pine decline. Schwartz et al. (2014) also demonstrated that body condition did not change during years of poor whitebark pine seed production, likely because grizzly bears compensated by consuming more animal matter in those years. Because body condition may influence reproduction (Robbins et al. 2012), we also investigated whether reproduction declined. However, analyses by the study team did not indicate this was the case (IGBST 2012). Thus, this body of new research conducted in the

GYE suggests grizzly bears continue to access sufficient food resources to maintain individual productivity.

At the population level, we addressed whether bears may become more vulnerable to mortality in less secure habitat areas due to whitebark pine decline. Based on observations by Schwartz et al. (2010) that grizzly bears move to lower elevations during poor whitebark pine years. Our analyses (IGBST 2013) indicate the benefits of good whitebark pine cone crops are still associated with reduced human-caused mortalities in fall for independent-aged (two years or older) grizzly bears. However, these findings also showed that mortalities inside the Grizzly Bear Recovery Zone did not increase much during the period of whitebark pine decline (2002–2011), which was confirmed by survival estimates of independent-aged bears. The annual survival rate for subadults (2–4 years old; both sexes) and adult females (more than 5 years old) was 0.95, showing no change for three decades. Also, adult male survival rates actually increased from 0.87 during 1983–2001 to 0.95 during 2002–2011 (Haroldson et al. 2006, IGBST 2012). We did observe an increase in mortality rate outside the Grizzly Bear Recovery Zone. We suspect these mortalities are more a function of expansion of occupied grizzly bear range (Bjornlie et al. 2014a) into locales where landscapes are less suitable for long-term occupancy and conflicts are more likely ("Shorts: Grizzly Bears and Army Cutworm Moths," this issue). Our final inquiry for this research project involved another population-level assessment, which is detailed elsewhere in this issue (see "Demographic Changes in Yellowstone's Grizzly Bear Population," this issue). Those analyses supported the notion that slowing of population growth that started in the early 2000s may potentially be associated with the population reaching carrying capacity rather than whitebark pine decline (van Manen et al. 2015).

Conclusions

Collectively, findings of these research projects do not suggest that changes in food resources have had profound negative effects on grizzly bears at the individual or population level. Grizzly bears obtained sufficient alternative foods through diet shifts and have maintained body mass and percent body fat over time. The picture that emerges is that grizzly bear diets are highly dynamic, changing daily, seasonally, annually, and even by decade, and vary by area within the GYE. Equally fascinating is to what degree diet specialization may be influenced by where a bear is raised and behaviors learned from the mother. With DNA techniques that allow us to determine parentage and new analytical approaches, we hope to address these new research questions.

Based on our extensive demographic analyses, we have not observed a decline in the Yellowstone grizzly bear population but only a slowing of population growth since the early 2000s (IGBST 2012, Higgs et al. 2013). Demographic analyses indicate increased bear density, rather than a decline in food resources, may be associated with this change in population trajectory, possibly indicating the population is nearing carrying capacity. These are key concepts in wildlife ecology that are often difficult to ascertain because most studies lack the long-term, detailed data needed to investigate them.

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Habituated Grizzly Bears: A Natural Response to Increasing Visitation in Yellowstone & Grand Teton National Parks

Kerry A. Gunther, Katharine R. Wilmot, Steven L. Cain, Travis Wyman, Eric G. Reinertson, & Amanda M. Bramblett

Bears, especially grizzly bears, have ferocious reputations that inspire fear and awe in many people. Grizzly bears' long claws and large canines–combined with their size, strength, speed, agility, and predatory nature–contribute to this reputation. Grizzly bears sometimes attack people during surprise encounters, and on rare occasions even prey on and consume humans (Herrero 1985). Therefore, some people believe grizzly bears are not suited for human-dominated landscapes. The iconic status of grizzly bears as symbols of remote wilderness lends further credence to their presumed incompatibility with humans. It is certainly true that grizzly bears survive best, and need the least amount of management attention, in large, remote wilderness areas. However, once the indiscriminate poisoning, trapping, and shooting of grizzly bears ceased during the early 1970s and modern predator management practices were implemented, grizzly bears have shown remarkable resilience and tolerance in the face of ever-increasing human presence.

In large national parks where development is minimized, food storage regulations are strongly enforced, and hunting is prohibited, grizzly bears flourish even among high human densities. This is especially apparent with the grizzly bear populations in Yellowstone and Grand Teton national parks (including John D. Rockefeller, Jr. Memorial Parkway) where millions of tourists visit each year and new record highs for visitation are set almost every decade. So how have grizzly bears managed to survive in national parks visited by millions of people each summer?

The ability of grizzly and black bears to survive in habitats with relatively high human densities can be attributed to their intelligence, behavioral plasticity, and opportunistic lifestyle, all of which contribute to remarkable adaptability. Habituation to human presence is the behavioral expression of that adaptability. The response of wildlife to humans is shaped by the predictability of human activities (Knight and Cole 1995). When animals experience a non-threatening human activity frequently enough that it becomes expected, they show little overt response (Knight and Cole 1995). Therefore, habituation is the waning of a bear's flight response to people (McCullough 1982, Jope 1985). Habituation is adaptive and conserves energy by reducing unnecessary behavior (McCullough 1982, Smith et al. 2005), such as fleeing from park visitors that are not a threat. Habituation allows bears to access and use habitat near areas with high levels of human activity, thereby increasing habitat effectiveness (Herrero et al. 2005). It is most commonly observed in national parks where exposure to humans is frequent, benign, predictable, and does not result in negative consequences for bears. In these circumstances, bears readily acclimate to predictable human activities (e.g., road traffic) and developments.

Habituation differs markedly from food conditioning, which is an entirely opposite learning process (Hopkins et al. 2010). Food-conditioned bears learn to seek humans and their developments for rewards (e.g., human, pet, and livestock foods; garbage), whereas habituated bears learn to ignore people after repeated, non-consequential encounters (Herrero et al. 2005). Human food conditioning invariably gets bears into trouble and ultimately reduces their survival (Gunther et al. 2004). National parks have been successful in decreasing the presence of food-conditioned bears because of strict food storage regulations, relatively high compliance with these regulations, and consistent regulation enforcement and education in developed areas. In contrast to the negative aspects associated with human food conditioning, under certain circumstances habituation can actually improve the fitness of bears by reducing energy expended in response to stimuli that have no consequences, and by giving bears access to additional natural food resources that are avoided by other human-wary bears (Herrero et al. 2005). Evidence suggests habituation is site specific. For example, a bear that displays highly habituated behavior along park roads may be more wary or intolerant of people in backcountry areas where it does not expect to encounter them.

Yellowstone (YNP) and Grand Teton (GTNP) national parks have populations of grizzly and black bears, and both parks have experienced significant visitation increases in recent years. Annual visitation to YNP and GTNP currently averages approximately 4 million and 2.7 million visits per year, respectively. Concurrently, both parks have experienced increasing levels of bear habituation in roadside habitats. This, in turn, has led to a growing number of "bear jams," a term used to describe the traffic congestion caused by visitors stopping to view and photograph habituated bears close to roads (Haroldson and Gunther 2013).

Yellowstone National Park

The year 1970 is considered the beginning of modern-day bear management in YNP. Prior to 1970, due to prevalent hand feeding by park visitors, most bears that frequented roadside habitats were food conditioned. In 1970, YNP implemented a new bear management plan, the foundation of which was to prevent bears from obtaining human foods, garbage, or other anthropogenic attractants (Meagher and Phillips 1983). Under this plan, bears that persisted in trying to obtain human foods and garbage were captured and removed (i.e., euthanized or sent to zoos). By 1979, most bears conditioned to human foods had been removed from the park. However, in the early 1980s a new bear management challenge emerged (Gunther and Wyman 2008). As park visitation and the grizzly and black bear populations increased, bears foraging for native foods that were habituated to people but not conditioned to human foods began to appear in roadside meadows (Haroldson and Gunther 2013). Initially, these roadside bears were not tolerated and were hazed, relocated, or removed by park officials out of concern they would eventually get fed by visitors, damage property, attack people, or get hit by cars. When these tactics failed to prevent habituation, YNP staff adopted an entirely different management strategy that was considered controversial at the time. Beginning in 1990, management efforts focused on humans instead of bears. Rather than trapping or hazing bears, park staff were routinely dispatched to bear jams to ensure visitors parked their vehicles safely, did not approach or feed bears, and behaved in a predictable manner.

This strategy has now been in place for 25 years (1990-2014), providing an opportunity to evaluate its efficacy. During this period, 4,587 grizzly bear and 7,618 black bear roadside-jams were documented. An additional 181 bear jams were recorded that did not identify the species of bear present. In total, 12,386 bear jams have been reported since 1990, with no bear attacks on the visitors that had stopped to view and photograph the habituated bears. The concern that tolerating habituated bears along roadways would lead to increases in bear-caused property damages, bear attacks, management removals of bears, and bear mortality from vehicle strikes was unfounded. In fact, humans and vehicles turned out to be more dangerous than roadside bears. Park staff recorded several minor vehicle accidents, and at least five people have sustained injuries when they were hit by vehicles at bear jams.

The number of bear-caused property damages, bear attacks, removals of problem bears, and bears being struck and killed by vehicles in the park have all remained low or even decreased under current management strategies (table 1). Human-bear conflicts have remained low despite increasing visitation (figure 1) and a growing number of bear jams (figure 2). However, this strategy does present new challenges for park managers because focusing management on people instead of habituated bears is labor intensive and expensive. Approximately 2,500 to 3,000 personnel hours are spent managing bear jams in YNP annually.

Nevertheless, YNP has demonstrated that given adequate staff, habituated bears can be managed along roads in a manner that is relatively safe for both park visitors and bears. Under the current management strategy, thousands of visitors are able to view, photograph, and appreciate bears while visiting the park each year. The opportunity to view bears not only provides a positive visitor experience (Taylor et al. 2014), it contributes millions of dollars to the local economies of gateway communities (Richardson et al. 2014). Positive bear viewing experiences also help build an important appreciation and conservation ethic for bears in people that visit national parks (Herrero et al. 2005).

Grand Teton National Park[1]

GTNP provides habitat for a stable population of black bears and, to date, an increasing number of grizzly bears as the population continues to expand in numbers and range. Prior to the early 2000s, grizzly bears were rarely observed outside the northern canyons of the park. However, as grizzly bears continued to expand their range, GTNP documented a steady increase in grizzly bear observations, beginning in the north and gradually progressing all the way to the south boundary near Jackson, Wyoming. Observations of habituated grizzly bears followed this trend: first in high visitor-use areas such as Jackson Lake Lodge, Oxbow Bend, Colter Bay, and eventually to the Moose developed area and the Moose-Wilson Road corridor.

The first documented observation of a habituated grizzly foraging naturally along roadside habitat in GTNP occurred in 2004. Recognizing the success of

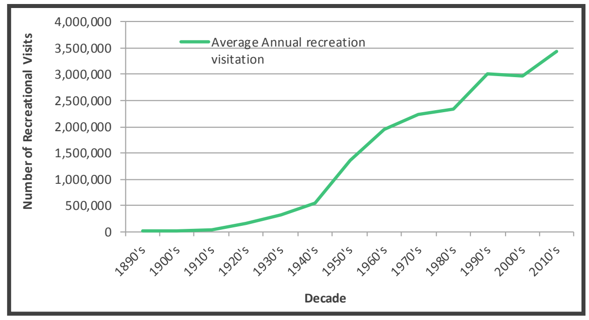

Figure 1. Average visitation by decade, Yellowstone National Park, 1890s–2010s.

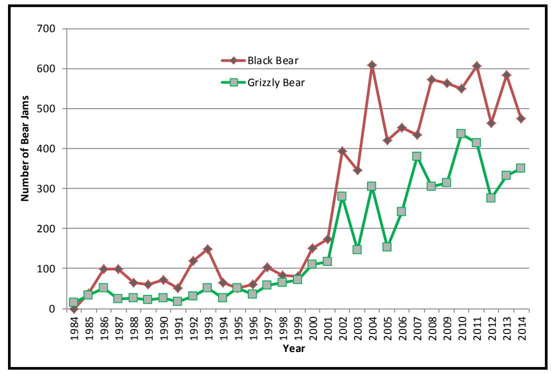

Figure 2. The number of grizzly and black bear jams in Yellowstone National Park, 1984-2014.

Table 1. Comparison of human-bear conflicts, bear attacks, bear removals, and vehicle strike mortalities of grizzly and black bears occurring during two different habituated bear management eras in Yellowstone National Park, 1979–2014.

Time Period	Management Strategy	Mean Annual Park Visitation	Number per One Million Visitors							
			Property Damages[a]		Bear Attacks		Bear Removals		Vehicle Strike Mortality	
			Grizzly	Black	Grizzly	Black	Grizzly	Black	Grizzly	Black
1979-1989	Prevent Habituation	2,303,894	3.9	2.5	0.6	0.1	0.4	0.1	0.1	0.4
1990-2014	Tolerate Habituation	3,079,479	1.6	1.4	0.3	<0.1	0.1	0.1	0.1	0.3

[a]includes incidents where bears damaged property or obtained anthropogenic foods

[1]data includes John D. Rockefeller, Jr. Memorial Parkway as well as Grand Teton National Park.

YNP's bear management program, GTNP adopted a similar strategy of managing humans at bear jams and tolerating habituated, but non-food-conditioned bears near roads. In 2007, as demands for managing bear jams rapidly escalated, GTNP created the Wildlife Brigade as a pilot program to manage visitors at the human-bear interfaces. The Wildlife Brigade was composed of both paid and volunteer staff. Prior to 2007, GTNP regularly managed periodic black bear jams; but the onset of grizzly bear jams required a reevaluation of GTNP's bear management program, out of which the Wildlife Brigade was born. At about the same time, GTNP transferred management of all frontcountry campgrounds to park concessionaires, and the Wildlife Brigade was designed to also provide food storage patrol and public education in the campgrounds.

Since 2008, the first year for which reliable bear jam statistics are available, GTNP has managed at least 1,032 black bear jams, 1,015 grizzly bear jams (figure 3), and 253 bear jams where the species of bear was not recorded. To date, habituated grizzly bear jams in GTNP have been dominated by family groups and sub-adults, the two classes of bears generally considered to be lowest in the bear hierarchy, lending to speculation these bears are using the roadside habitat in an effort to avoid more dominant adult males, which sometimes kill other bears. GTNP saw an almost 100% increase in grizzly bear jam activity from 2010 to 2011, which was attributed to the presence of two related adult females with cubs-of-the-year that foraged naturally along roadside habitats. Presently, it appears annual grizzly bear jam numbers in GTNP fluctuate based on the reproductive cycle and success of a small number of resident females. Not surprisingly, bear jam numbers for both species also seem to reflect the condition of natural foods in the park that occur near roads. The years when GTNP documented high numbers of black bear jams corresponded with years of excellent huckleberry, black hawthorn, or chokecherry crops along the Signal Mountain Summit and Moose-Wilson roads.

Although GTNP's experience with habituated bear management is still relatively limited, human-bear conflicts have remained very low (figure 4). There have been no bear-inflicted human injuries associated with bear jams, and no increase in vehicle-strike mortalities of habituated bears has been observed. However, at least 3 of 13 known cubs produced by habituated female grizzly bears have died as a result of circumstances possibly exacerbated by being habituated (table 2). Grizzly bear #615 was illegally killed when she was 3 years old by a hunter at close range on U.S. Forest Service lands just outside GTNP. Her comfort with close human proximity is thought to have contributed to her death. One of two grizzly bears weaned by female grizzly bear #399 as a yearling in 2012 was killed by a vehicle strike later that year. Grizzly bear #760, a habituated, non-food-conditioned male offspring of habituated female grizzly bear #610, was removed after a history of frequenting human developments outside the park. Grizzly bear #587, an offspring of #399 was removed as a 7-year-old

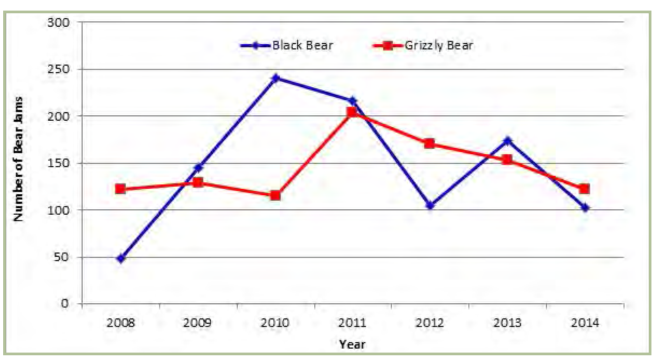

Figure 3. The number of grizzly and black bear jams in Grand Teton National Park and the John D. Rockefeller, Jr. Memorial Parkway, 2008-2014.

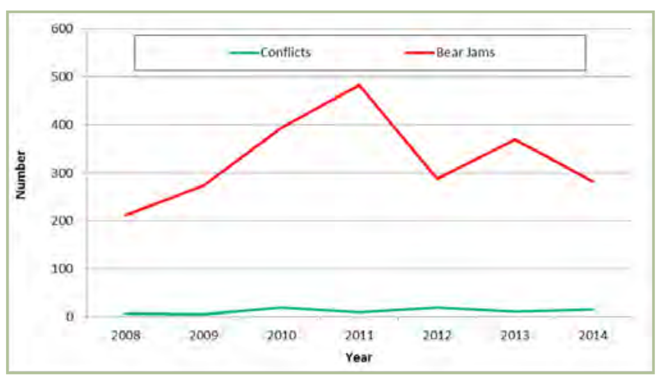

Figure 4. Number of bear jams and human-bear conflicts (human-food rewards, property damage, and human injury) in Grand Teton National Park and the John D. Rockefeller, Jr. Memorial Parkway, 2008- 2014.

Photo © B. Scates

Managing Habituation Depends on the Circumstances

Habituation is a form of learning in which an organism decreases or ceases to respond to a stimulus after repeated presentations. Depending on the situational context, this lack of response may or may not be beneficial to wildlife and/or people. Wildlife managers realize habituation occurs and use their knowledge of wild animal behavior in the context of a variety of situations in order to responsibly conserve and manage wildlife populations. In national parks, where humans are temporary visitors and their activities and infrastructures are highly controlled, habituated bears have been managed in a manner to reduce human-bear conflicts, allow for popular recreational bear viewing, and maximize the effectiveness of available habitat. However, in areas outside of national parks where human activities are less strictly regulated, habituation can greatly increase the chances of bears becoming conditioned to human foods or being involved in other types of human-bear conflicts that put both humans and bears at significant risk. Tolerance and management of bear habituation to people may work for some land management agencies under highly controlled and predictable situations, such as national parks, where habituation would typically not be an appropriate bear behavior under less controlled situations with completely different contexts. Habituated bears are still wild bears and should not be considered otherwise. It is important for the public to understand that habituation is sometimes unavoidable, and impacts both wildlife and people; and the way habituation is addressed by wildlife managers is extremely site and situation specific.

Table 2. Fate of cubs produced by habituated female grizzly bears in Grand Teton National Park.

Year (mother ID)	COY[1]	COY[1] ID / Fate as of 2014	Status 2014
2004 (399)	1	Unmarked / Unknown – lost during 2004	Dead
2006 (399)	1	#615 / illegal kill by hunter outside GTNP in 2009	Dead
	2	#610 / home range mostly in GTNP	Alive
	3	#587 / removed for repeated cattle depredation 2013	Dead
2011 (399)	1	Unmarked / roadkill as yearling in 2012, DNA confirmed	Dead
	2	Unmarked / unknown	Unknown
	3	Unmarked / unknown	Unknown
2011 (610)	1	#760 / removed for nuisance behavior associated with habituation	Dead
	2	Unmarked / unknown	Unknown
2013 (399)	1	Unmarked / unknown cause of mortality fall 2013	Dead
	2	Unmarked / still with mother	Alive
	3	Unmarked / still with mother	Alive
2014 (610)	1	Unmarked / unknown cause of mortality spring 2014	Dead

[1]Cub of the Year

for repeated cattle depredation, but as an adult he did not exhibit habituated behavior. In contrast to YNP, which is roughly seven times larger than GTNP and positioned in the center of the grizzly bear recovery area, GTNP's habituated bears may be more likely to leave the protected confines of the park and be susceptible to human-caused mortality associated with inadequate bear-attractant storage or attempts to use habitats in close proximity to people where bears are socially unacceptable.

Providing bear viewing opportunities to visitors in GTNP has proven to be very popular for both locals and visitors. Some GTNP bears have become so popular they even have their own Facebook pages. A program large enough to adequately manage the human-bear interface in GTNP using paid employees is cost prohibitive, so the Wildlife Brigade from its inception has been supported largely by volunteers. The 2014 Wildlife Brigade consisted of three paid seasonal park rangers, fifteen volunteers, and one intern which provided human-bear interface coverage seven days a week for over seven months of the year. While the Wildlife Brigade Program has been considered a success, maintaining this level of commitment now and into the future requires substantial financial support.

Future Considerations

Visitation in Yellowstone and Grand Teton national parks is expected to increase into the future. In national parks, habituation of bears to people is inevitable and may be necessary if bears are to survive in park units increasingly dominated by humans. Park managers should take this into consideration when planning future strategies for managing habituated bears. The safety of park visitors that view habituated bears along roadways and the safety of those bears is a legitimate concern for park managers (Herrero et al. 2005). However, to be successful, strategies need to consider not only human and bear safety, but also the energetic needs and nutritional state of habituated bears (Robbins et al. 2004, Haroldson and Gunther 2013), their contribution to bear population viability (Gunther et al. 2004), the aesthetic value of public bear viewing and the conservation awareness this brings (Herrero et al 2005), and the economic value of bear viewing to gateway communities (Richardson et al. 2014).

Although the ability of grizzly bears to adapt to increasing visitation undoubtedly has some limits, their behavioral flexibility allows them to exist in a broad continuum of human presence. As a general rule, when human activities in bear habitat increase, staff time and budgets dedicated toward human-bear management require a commensurate increase. Key components of a successful habituated bear management program include preventing bears from becoming conditioned to human foods and garbage, making human activities as predictable as possible, and setting certain boundaries for both bears and people. Appropriate boundaries for habituated bears include teaching them not to enter park developments and campsites or to approach people too closely. Appropriate boundaries for people include teaching them to store anthropogenic attractants in a bear-resistant manner, not to feed bears, and to maintain a minimum distance of at least 100 yards when viewing bears. Although signs, printed material, and website posts are the least expensive media for teaching bear safety and bear viewing etiquette to park visitors, retention of safety messages is highest when presented using face-to-face interactions with uniformed park staff (Taylor et al. 2014). The most formidable challenge for managing habituated bears in national parks is not managing the bears, but in sustaining and expanding the people management programs that have made habituated bear management a success in the parks to date. Habituation is a relatively new challenge faced by bear managers throughout the world, and many of these managers are viewing the Yellowstone and Grand Teton national parks models of habituated bear management with great interest while formulating their own strategies.

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Kerry Gunther, see page 2.

Katharine Wilmot (pictured at right) is the Bear Management Specialist for Grand Teton National Park, where among other duties she is responsible for supervising the park's Wildlife Brigade, a team dedicated to managing the human-bear interface, including bear jams and food storage compliance. Prior to coming to Grand Teton, Kate worked as a law enforcement park ranger with an emphasis on bear management in Glacier National Park and Katmai National Park and Preserve. She also worked as a biological science technician with the Glacier Bear DNA project and with the Glacier Wolverine Project. She received a B.A. in Environmental Science from the University of Colorado.

Photo © Matt Lundin

Special thanks to the **Yellowstone Park Foundation** & the **Grand Teton National Park Foundation** in recognition of their commitment to scientific research and management in Yellowstone and Grand Teton national parks, and who generously funded this project.

ROADSIDE BEAR VIEWING ETIQUETTE

In areas like Yellowstone and Grand Teton national parks, where millions of visitors recreate in bear habitat each year and bears are rarely injured or killed by people, bears learn people are not a threat and will tolerate people at close distances. This natural behavioral response is referred to as habituation. Habituation is observed in a wide variety of animals (including bears, bison, elk, bighorn sheep, wolves, and coyotes) and especially along high-quality roadside habitats. To ensure you do not put yourself or habituated wildlife at risk, please use the following guidelines when viewing or photographing roadside wildlife:

DO

- Park in established turnouts, and make sure your car is completely out of the lane of traffic.
- Make sure you put your vehicle into park and engage your parking brake.
- For your safety, view or photograph wildlife from your vehicle. If you exit your vehicle, stay near it so you can get inside if the bear or other wildlife approaches. There is no guarantee of your safety if you exit your vehicle.
- Maintain a safe distance of at least 100 yards or more from bears and wolves, and 25 yards or more from other wildlife.
- Watch other people in the area. If other visitors are putting you in danger, you should leave the area and report this behavior to the nearest ranger/visitor center.
- Always follow instructions provided by park rangers that are managing visitors and traffic at bear and wildlife jams.

DO NOT

- Do not stop your car in the roadway to view or photograph roadside wildlife.
- To avoid being struck by a moving vehicle, do not stand in the roadway while viewing or photographing wildlife.
- Do not set up camera tripods in the lane of traffic.
- Never surround, crowd, or approach roadside wildlife.
- Never follow wildlife as they leave the road corridor.
- Do not block an animal's path of travel.
- Do not run or make sudden movements, as this may cause predators to chase and attack you.
- Never feed wildlife!

Visitor Compliance with Bear Spray and Hiking Group Size in Yellowstone National Park

Kerry A. Gunther, Eric G. Reinertson, Travis Wyman, Dan Bergum, Nathaniel R. Bowersock, Amanda M. Bramblett, Eric Johnston, & Jeremy Nicholson

Large party sizes have been shown to reduce the risk of bear attack (Herrero 2002). In addition, bear deterrent spray has proven effective at reducing aggressive behavior by bears during surprise encounters (Herrero and Higgins 1998, Smith et al. 2008). To reduce the risk of bear attack in Yellowstone National Park (YNP), safety information distributed to visitors recommends all backcountry recreationalists traveling by foot maintain group sizes of at least three people and carry bear spray. YNP managers are interested in the level of visitor compliance with these recommendations. To evaluate compliance, we conduct annual surveys to determine the proportion of recreationalists that hike in groups of three or more people and the proportion that carry bear spray or other deterrents (e.g., bear bells, firearms). Although it is legal to carry firearms in Yellowstone National Park, it is illegal to discharge them in the park, so they are not considered a legal bear deterrent. While working on other bear research, monitoring, and management projects throughout YNP, we recorded how many recreationalists we encountered at trailheads and on trails and boardwalks carried bear spray or other deterrents. We also recorded information on the group size and the type of recreational activity. We grouped recreational activity into six broad categories: 1) day hikers, 2) overnight backpackers, 3) boardwalk trail users, 4) stock (horse or mule) day-riders, 5) stock overnight-riders, and 6) day-use bicyclist trail riders. Surveys were conducted visually. We recorded the presence of bear spray and other deterrents that were visible, and therefore quickly retrievable.

From 2011 to 2014, we surveyed 8,281 people in 2,908 groups on 64 different hiking trails and 5 boardwalk trails. Our surveys included 5,911 backcountry day hikers, 1,855 people walking on boardwalk trails, 355 overnight backpackers, 70 overnight stock-riders, 59 day stock-riders, and 31 day-use bicyclists.

Overnight backpacking parties had the highest level of compliance with YNP's bear spray recommendation. Fifty-two percent of backpackers carried bear spray. We believe the level of compliance by this type of recreationalist is due to the methods used to convey bear safety information to overnight backpackers. In YNP, permits are required for camping in the backcountry. During the permit process, backpackers are given face-to-face verbal information about bears and bear spray from the ranger issuing the permit. They are also required to watch a safety video containing information on hiking and camping in bear country and how to use bear spray. Backpackers are also given the "Beyond Road's End" safety booklet containing information on bear spray and hiking and camping in bear country. Social surveys indicate YNP visitors retain verbal information better than written information from signs or brochures (Taylor et al. 2014). In addition, we suspect many backpackers may have a high level of experience in bear country. Although the average group size for backpackers was 2.7 people per party, the most common party size was 2 people; indicating many backpackers did not follow YNP's recommended group size of 3 people for hiking in bear country.

Only 13% of day hikers carried bear spray. Permits are not required for day hiking, so day hikers may not receive the same level of bear safety information as backpackers. Since a permit is not required, day hikers may not receive verbal safety information from a park ranger, may not obtain published bear safety materials, and are not required to watch the safety video containing bear safety information. Visitor's day hiking in YNP can seek and obtain bear safety information from the YNP web page, park newspaper, day hike trip planners, safety brochures, and from rangers at visitor centers. However, the only bear safety information day hikers are exposed to if they don't seek it out themselves, is from the signs posted at trailheads. We also suspect many day hikers in YNP have a lower level of experience in bear country than backpackers. With an average group size of 2.9 people per party, day hikers were closer to the parks recommended group size; however, the most frequently observed group size was 2 people indicating many day hikers did not comply with the recommended group size of 3 for hiking in bear country.

The most common group size on boardwalk trails was less than the recommended 3 people per party and < 1% of boardwalk hikers carried bear spray. The low compliance with bear safety recommendations by this type of recreationalist may be due to the lower level of experience of visitors that use boardwalk trails, the methods that they receive bear safety information, and/or the assumption that bears are not found close to roads where boardwalk trails are located. Like day hikers, recreationalists on boardwalks are unlikely to receive face-to-face verbal bear safety information. In addition, although the chances of encountering bears may be lower on boardwalk trails than backcountry trails, the probability is not zero. It is not uncommon for grizzly bears to be observed on or near boardwalk trails, especially during spring when bears scavenge winter-killed ungulate carcasses which tend to be concentrated in thermal basins. Although rare, bears have attacked people on and near boardwalk trails. During the 45-year period from 1970 to 2014, 52 people were attacked by grizzly bears in YNP, 1 non-fatal attack occurred on and 1 fatal attack occurred near boardwalk trails. Although the risk of a bear attack on or near boardwalk trails is very low, only two incidents in 45 years, the risk could be further reduced by increasing the proportion of visitors that carry bear spray while walking boardwalk trails.

Overnight stock riders had an average group size of 5.0 people per party and 37% carried bear spray. The moderate level of compliance by this type of recreationalist is likely due to the face-to-face verbal bear safety information received by overnight stock riders and their high level of experience. Although bear spray may not be very useful while in the saddle, as deploying it from horseback may result in the rider being thrown from their horse, it is useful and encouraged for carry by stock groups during rest stops along the trail and while in camp. In general, people riding stock are less likely to be involved in surprise encounters and bear attacks. Horses usually sense a bear's presence before a person does (Herrero 2002), alerting the rider and reducing the chances of surprise encounters at close distances. The large size of horses is also more intimidating to bears. In addition, unlike humans, when charged by bears horses have enough speed and agility to outrun bears providing an added margin of safety as long as the rider can stay in the saddle.

Bicycle groups riding designated bike trails had a relatively low rate of compliance (13%) with YNP's bear spray recommendation and had an average group size (2.4 people per party) lower than recommended for bicycling in bear country. Bicyclists incur greater risk of surprise encounters because as a mode of transportation, bicycles are fast and relatively quiet, increasing the probability of surprise encounters.

Although some backcountry recreationalists in YNP carry firearms, and it is legal to do so, it is illegal to discharge them within the park or to take wildlife with them, so they are not considered a legal bear deterrent inside YNP. Firearms were openly carried by < 1% of the total recreationalists we observed. Day stock riders had the highest frequency of firearms carry (2%). Recreationalists riding horses often carry firearms for euthanizing injured stock. From our survey methods we could not determine if groups riding stock carried firearms for bear protection or for euthanizing injured stock.

Bear bells were used by only 1% of all recreationalists we observed. Backpackers (2%) and bicyclists (3%) had the highest frequency of bear bell use. Although bear bells may provide some benefit in alerting bears to the presence of approaching hikers (Jope 1982), they are generally not considered effective at preventing surprise encounters when hiking in strong winds, heavy rain, near rushing water, or in dense forest (Herrero 2002).

Knowledge of standard bear safety practices can significantly reduce the risks of bear-human confrontations and attacks. Although Yellowstone National Park provides bear safety information to visitors through many different media, the results of our survey indicate that many people are not following these recommendations. The reasons for the low rate of compliance are not known, but knowledge of these reasons would be useful to develop more effective bear safety messaging techniques. We suggest conducting a survey to determine why so few visitors carry bear spray. We also suggest using actual changes in visitor bear safety behavior to measure the success of any new messaging techniques implemented by the park.

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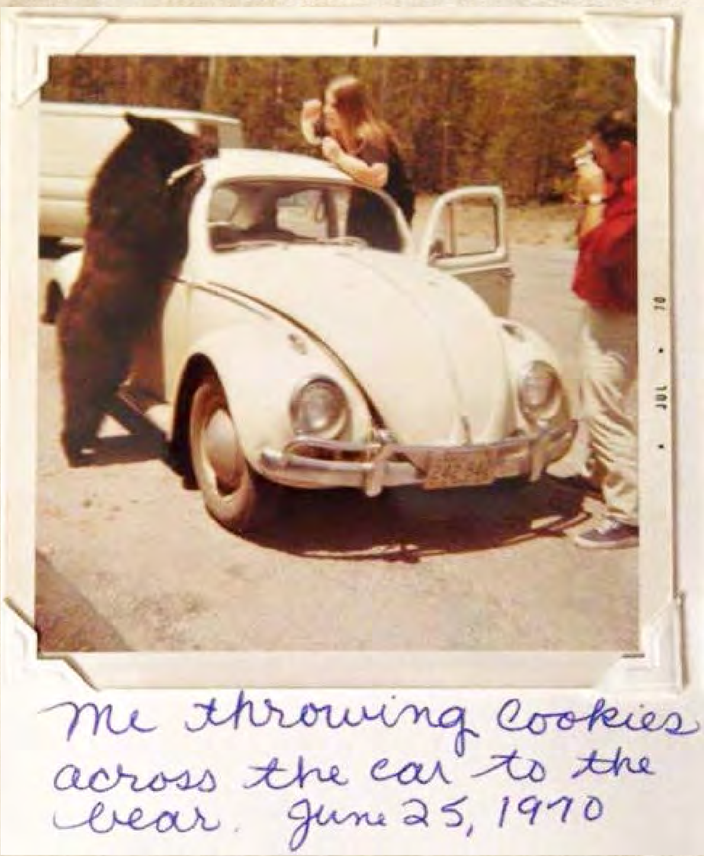
FROM THE ARCHIVES - 1970

Visitors & Bears



Cheryl Coble during a family visit to the park in 1970.
Photo © Wayne Coble

Bear Attacks - 1970

Number	Species
4	Grizzly Bear
6	Black Bear
2	Unidentified Species

The year 1970 was a period of transition for bears in Yellowstone National Park. In 1970, the Rabbit Creek Garbage Dump near Old Faithful was closed in an effort to wean bears off of human generated garbage. In addition, in an effort to reduce human-bear conflicts, park managers were converting all garbage cans in the park to a bear-proof design and were more strictly enforcing regulations that prohibited the recreational hand feeding of bears. In 1970, 4 people would be injured by grizzly bears and 6 by black bears. Two additional people injured by bears could not identify the species of the attacking bear. In response to these and other human-bear conflicts, 20 grizzly bears and 10 black bears would be captured and killed or sent to zoos in management actions.

YELLOWSTONE GR

KINGDOM: Animalia

PHYLUM: Chordata

CLASS: Mammalia

ORDER: Carnivora

FAMILY: Ursidae

SUBFAMILY: Ursinae

GENUS: *Ursus* (Latin word meaning "bear")

SPECIES: *arctos* (Greek word meaning "bear")

COMMON NAMES: grizzly bear, brown bear, silvertip

NAMES IN OTHER LANGUAGES: Spanish: Oso café/grande, French: Ours brun

GROUP OF BEARS: sleuth

LIFE SPAN: 20-30 years; oldest known in GYE 31 years

PELAGE: from black to brown to light blonde

LOCOMOTION: tetrapedal, plantigrade

SPEED: 35-40 mph

CLAW LENGTH: average 1.8 inches (45 mm), longest 5.9 inches (150 mm); claw length and shape allow efficient digging of foods from the ground but are less efficient for tree climbing than black bear claws

TREE CLIMBING ABILITY: cubs and younger, smaller bears are proficient tree climbers; however, adult male and female grizzly bears are also capable of climbing trees

TAIL LENGTH: 3-4.5 inches

BODY TEMPERATURE: 36.5-38.5°C (98-101°F) during active season; 34.4-35°C (94-95°F) during hibernation

RESPIRATION: 6-10 per minute; <1 per minute during hibernation

HEART RATE: 40-50 beats per minute; 8-19 beats per minute during hibernation

EYES: blue at birth, brown as adults, and greenish yellow in headlights in the dark

VISION: possibly equal to human vision; exhibits color vision and excellent night vision

GENETICS: 74 diploid chromosomes

NUMBER OF BONES: male = 225, female = 224 (not counting the metapodial sesamoid bones and hyoid bones)

NUMBER OF TEETH: 42

DENTAL FORMULAE: I 3/3, C 1/1, P 4/4, M 2/3 = 42 (upper [each side] = 3 incisors, 1 canine, 4 premolars, 2 molars; lower [each side] = 3 incisors, 1 canine, 4 premolars, 3 molars)

FEEDING HABITS: omnivorous carnivore; opportunistic generalist

CALORIC REQUIREMENTS: normal (May-Sept): 5,000-8,000 kcal/day; hyperphagia: 20,000 kcal/day; hibernation 4,000 kcal/day

AVERAGE BODY MASS: adult male = 413 lb (187 kg); adult female = 269 lb (122 kg)

HEAVIEST KNOWN WEIGHT IN GYE: adult male = 715 lb (324 kg); adult female = 436 lb (198 kg)

ESTIMATED NUMBER CURRENTLY LIVING IN THE GYE: 714

AREA OCCUPIED IN GYE: 58,000 km^2 (22,394 mi^2)

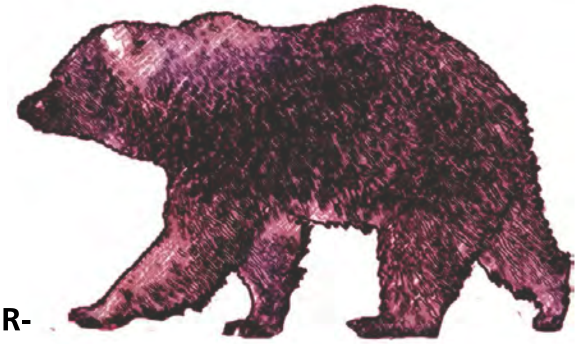
AVERAGE HOME RANGE SIZE IN GYE: males = 874 km^2; females = 281 km^2

SOCIAL BEHAVIOR: generally solitary except at concentrated food sources (ungulate carcasses, trout spawning streams, moth aggregation sites, etc.), during courtship, or when accompanied by young

ADULT SEX RATIO: 50:50 (M/F)

AGE COMPOSITION: 19% cubs, 13% yearlings, 25% subadults (2-4 yrs.), 43% adults

RIZZLY BEAR FACTS



PERIOD OF COURTSHIP: mid-May through mid-July

DELAYED IMPLANTATION: grizzly bears exhibit obligate delayed implantation or embryonic diapause

GESTATION: 235 days (implantation of embryo delayed until late November/early December)

BIRTH PERIOD: late January/early February

BIRTH LOCATION: in winter den

DEN ENTRY: pregnant females – 1st week November; other females – 2nd week November; males – 2nd week November

AVERAGE DENNING DURATION: females with cubs – 171 days; other females – 151 days; males – 131 days

DEN EMERGENCE: males – 4th week March; other females – 3rd week April; pregnant females – 4th week April

TYPICAL DEN TYPES: excavated (i.e., dug) = 91%; natural cavity = 6%; snow = 3%

TRUE HIBERNATORS?: yes, although bears are shallow hibernators and do not drop their body temperatures as low as many hibernators, they are considered to be true hibernators

WEIGHT LOSS DURING HIBERNATION: 15-30% of body weight

AVERAGE AGE OF FIRST REPRODUCTION (FEMALES): 5.8 years

LITTER SIZE: range 1-4 cubs per litter; average 2.04 cubs per litter

INTERBIRTH INTERVAL: average = 2.78 years

REPRODUCTIVE RATE: 0.336 female cubs/female/year

SURVIVAL RATE: cubs = 55%; yearlings = 54%; subadults = 95%; adult females = 95%; adult males = 95%

CAUSES OF MORTALITY (GYE): human causes = 85%; natural causes = 15%

PERIOD OF MATERNAL CARE: 18 to 42 months; average = 30 months

NURSING CHARACTERISTICS: females have three pairs of functional nipples

BEAR MILK: 30% fat, 15% protein

CUBS' EYES OPEN: at approximately 21 days

WEANING: nutritional dependence on mother's milk ends at approximately 24 weeks; offspring may continue to nurse occasionally until they separate from their mothers

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Photo © Fin Keleher

I AM NOT A SCIENTIST

What is anthropomorphism and what's wrong with it?

Charissa Reid

Anthropomorphism is defined as transferring human characteristics and feelings onto other species. In the Greater Yellowstone Ecosystem (GYE), this manifests itself in many different ways. It may cause a specific wolf or bull elk to be identifiable and be assigned a personality that includes a human name, a Twitter hashtag, or even a "I Saw Bear 399" bumper sticker. As National Park Service (NPS) Chief Wildlife Biologist Glenn Plumb puts it, "People name wild animals as a way of forming a relationship with something that is largely beyond their personal understanding."

In a world that is often very removed from nature and from the wild things in particular, any relationship that is forged may seem like a positive thing. A child who visits the GYE and sees grizzly bear "Molly" with her cub "Tickles" in a meadow near Fishing Bridge not only has a vocabulary that allows him to tell the story of that encounter, but also has food for the imagination. He may imagine the feelings of "Molly" as "Tickles" leaves her side or when winter covers the landscape. How will "Tickles" stay warm?

So, what's wrong with that?

As I spoke to wildlife biologists, several things led me to believe that this sort of personalization was, in the long run, a limiting and negative thing.

First of all, anthropomorphism limits our knowledge about other species. Time and again, science has shown us that many creatures are capable of hearing, seeing, tasting, and smelling things that are beyond our human capabilities. With so little known about the interaction of instinct and cognition that drive the bear, the wolf, or the cutworm moth, assigning human characteristics and motivations to their actions may make it more difficult to learn about the astounding reality scientific research can reveal.

Perhaps, most importantly, thinking of wild animals as individuals causes us to narrow our focus about what national parks are here to protect. P.J. White, Yellowstone's Chief Wildlife Biologist, stated the NPS should, "Discourage visitors from giving celebrity status to certain animals, which leads to their naming and anthropomorphism. Though some argue this helps connect people with nature, it also creates unrealistic expectations and issues for managers tasked with sustaining viable populations of wildlife rather than a zoo-like atmosphere where beloved animals are guaranteed protection."

Advertisement courtesy of 180 Amsterdam & Barber Amsterdam.

If we are tasked with preserving wild places for the future, we must think beyond our myopia of individual animals—named or unnamed, known or unknown—and think about preserving generations. Populations. Processes. Systems.

It is a wonderful thing to feel a connection with wildness. It is an even more wonderful thing to realize that this wildness is the keeper of many mysteries. I, for one, will be working hard at not limiting what those mysteries may be. And I'll be keeping my eyes on what I can do to protect the big picture.

Special thanks to the scientists who provided insights to this question: Dr. Glenn Plumb, Dr. P.J. White, Dr. Douglas Smith, and Kerry Gunther.

Charissa Reid is a member of the Science Communications Program team at the Yellowstone Center for Resources.


Photo © Bradley Orsted

SHORTS

Grizzly Bears and Army Cutworm Moths

Dan D. Bjornlie & Mark A. Haroldson

Grizzly bears in the Greater Yellowstone Ecosystem (GYE) have a very diverse menu, consisting of items many people would expect to see on their "dinner plate"—items like meat, fish, berries, and the occasional unsecured picnic basket. Moths are not likely one of those expected menu items. However, for more than 200 grizzly bears in the Absaroka Mountains of Wyoming, east of Yellowstone National Park, moths are a bountiful source of calories.

Although grizzly bear use of army cutworm moth (*Euxoa auxiliaris*) sites was documented in northwestern Montana in the mid-1950s, it was relatively unknown to scientists studying Yellowstone grizzly bears until the 1980s. There had been undocumented reports of grizzly bears eating "bugs," "insects," or "moths;" but it was not until 1986 that a radio-collared grizzly bear was observed feeding on moths in the GYE (French et al. 1994).

Army cutworm moths do not reside in the Absaroka Mountains year-round; in early summer, they migrate long distances to these alpine areas from the agricultural fields of the Great Plains. Once in the mountains, they feed on the nectar of alpine flowers by night and hide out in the interstitial spaces of the rocky talus slopes by day. These slopes are typically at or above 3,200 meters (10,500 feet) in elevation. It is on these high-elevation talus slopes that grizzly bears seek out army cutworm moths. By moving rocks and licking up the fast-moving moths before they can escape into another hole between rocks, bears can consume from 40,000 to 60,000 moths in a single day (White et al. 1999). At 8 kilocalories per gram, army cutworm moths are the richest documented food available to grizzly bears in the GYE (French et al. 1994). Remarkably, this level of moth consumption can supply a typical grizzly bear with approximately one-half of its annual caloric requirements in a 30-day period (White et al. 1999).

Multiple bears can be seen in the red circles, feeding on cutworm moths in late summer.

Rolling over rocks to expose the moths, the bears feed on a talus slope.

The abundance of moths, their high caloric value, and their ubiquitous dispersal within sites, make grizzly bears feeding at moth sites generally tolerant of other bears; they can be found feeding in groups of a dozen or more (French et al. 1994, Robison 2009). This is similar to bears feeding on the salmon streams of Alaska, where abundant food decreases the "personal space" requirements of bears (Smith et al. 2005). Because these talus slopes are generally remote from human development, foraging on moths keeps grizzly bears away from most human activities in summer, thereby reducing the potential for human-bear conflicts in these areas.

In agricultural areas in the Great Plains, army cutworm moths are considered an agricultural nuisance, and pesticides are used to control their numbers. Concerns have been raised about the potential for bioaccumulation of pesticides in bears feeding on moths. However, tests conducted on moths collected at moth aggregation sites where grizzly bears feed found little to no pesticide residue, likely due to moths amassing most of their summer body fat in the alpine tundra where pesticides are not used (Robison 2009).

Army cutworm moths can be found in talus slopes of the Rocky Mountains from New Mexico to Canada and in sites throughout the GYE, including the Teton Range, Wind River Mountains, and Gallatin Range. Why grizzly bears have only been documented feeding on army cutworm moths in the Absaroka Mountains east of Yellowstone Park remains unclear. Perhaps it is due to the juxtaposition of alpine flowers and talus slopes (used by moths) in close proximity to areas commonly used by grizzly bears. As the grizzly population has grown both in size (Schwartz et al. 2006, IGBST 2013) and distribution (Bjornlie et al. 2014), the number of moth sites used by bears and the number of bears observed on sites has increased considerably (Bjornlie and Haroldson 2014). During a flight over all moth sites in 2014, 220 unique grizzly bears were observed feeding on sites, including 14 different females with cubs. It is possible that as the grizzly bear population continues to expand, grizzly bears may discover and use moth sites in other portions of the GYE. If they do, the caloric wealth of army cutworm moths could provide grizzly bears in these new areas with yet another rich food source to maintain a healthy grizzly population.

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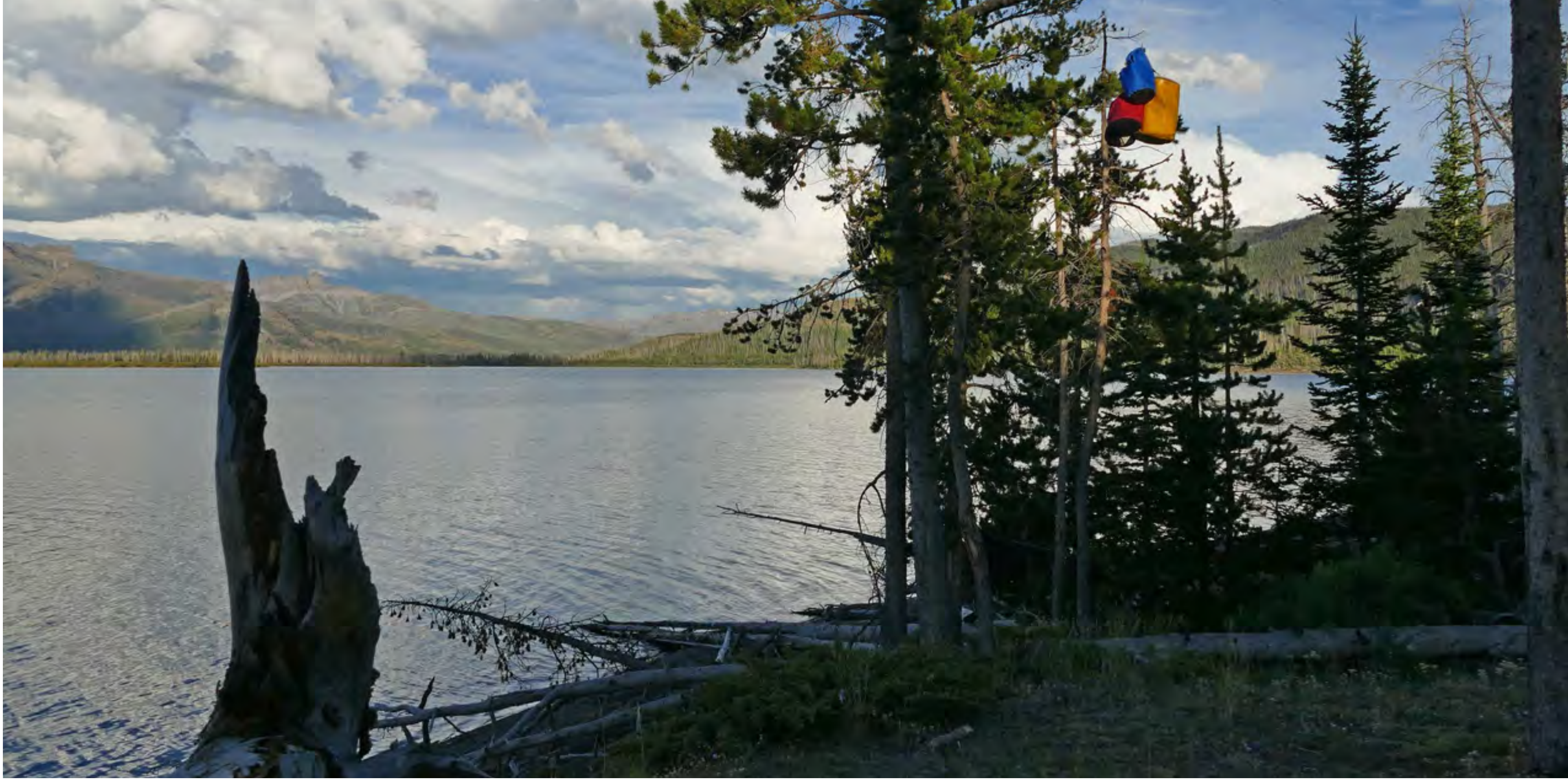
Response of Grizzly Bears to Overnight Backcountry Camping

Tyler H. Coleman, Charles C. Schwartz, Kerry A. Gunther, & Scott Creel

In Yellowstone National Park, visitors can hike and camp in backcountry areas that are considered critical habitat for the survival and recovery of grizzly bears (USFWS 1993), a species currently listed as threatened under the Endangered Species Act. Parkwide backcountry camping is a popular pastime, and camping numbers have continued to average 42,000 user nights per year over the last several decades (National Park Service 2012, I. Kowski pers. comm.). In 1973, Yellowstone developed new backcountry use procedures that included the establishment of designated backcountry campsites. The new system was designed to concentrate overnight use in distinct locations and to provide campers with bear-resistant, food storage solutions. In 1982, the park further restricted use of backcountry areas deemed critical for grizzly bear recovery by establishing Bear Management Areas (BMAs). The BMAs have restricted off-trail travel and/or seasonally restricted camping or hiking in defined areas. The objective of seasonally restricting human use in certain backcountry campsites was to help reduce human-caused bear disturbance and displacement, and to provide unhindered foraging opportunities for bears. However, since the development of the designated backcountry camping program and the BMA program, limited research had been done to determine if bear behavior or movement was altered by human occupancy in backcountry campsites.

Beginning in 2007, a study was designed to determine if Yellowstone's overnight backcountry human recreation activities were affecting grizzly bear movement and behavior patterns (Coleman et al. 2013). Concurrent with other research studies investigating grizzly bear diet and behavior (Fortin et al. 2013, Schwartz et al. 2014, Teisberg et al. 2013), the study investigated bear movements both inside and near BMAs surrounding Yellowstone Lake, between 2007 and 2009. The study used Global Positioning System (GPS) data collected from both bears and humans. Each GPS location was paired with a time to allow for analysis of discrete interactions between bears and people. Data was collected from 12 GPS radio-collared grizzly bears: nine males and three females. In addition, a unique approach was used to capture human location and movement data from 222 overnight backcountry camping groups (private, commercially-outfitted, and Yellowstone administrative users) occurring over 799 backcountry camp user nights. Hiking parties were randomly contacted at trailheads and asked to participate in the study by affixing a GPS unit to their backpack to track their movements. In almost every case, the individual(s) agreed to participate; and the study recovered 100% of the GPS units sent out with backcountry hikers. When combined with the Yellowstone backcountry reservation system, the human GPS data could identify when campsites were occupied and when they were vacant. This information was then paired with the locations of nearby collared bears. A parallel data analysis was also performed that ignored campsite occupancy. This approach helped to determine if the BMA backcountry restrictions were effective; it also underscored what could happen if researchers neglect the analysis of temporal data in human-wildlife disturbance studies.

Finally, the study helped identify specific distances where bears may be displaced from occupied backcountry campsites, which is helpful when creating buffers for future management decisions. Results indicated that grizzly bears strongly avoided areas within 400 meters of occupied backcountry campsites; however, beyond 400 meters their avoidance response lessened. The parallel analyses indicated bears were indeed avoiding the presence of people in backcountry campsites and not campsites themselves. When campsite occupancy was ignored, bears showed a strong attraction to backcountry campsites. This was a useful method to determine the response of the bear and confirm that backcountry campsite restrictions were effective. Campsite occupancy considered with a time-of-day variable may be an important factor; future studies could include a temporal variable for further investigation of this relationship. Results from this study also confirm previous investiga-



tions (Jope 1985, Gunther 1990, Kasworm and Manley 1990), where findings indicated bears avoided non-motorized recreational users in remote, backcountry locations. While the study was successful at concluding grizzly bears generally avoid backcountry areas occupied by people, the results could not be used to determine if variables such as habitat type, bear sex and age, recreational use type (e.g., hikers vs. horseback travel), and backcountry party size influenced bear avoidance behavior. Future studies, with a larger sample size, may be able to replicate the methods and evaluate more specific habitat characteristics.

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Expansion of Occupied Grizzly Bear Range

Dan D. Bjornlie, Mark A. Haroldson, Dan J. Thompson, Charles C. Schwartz, Kerry A. Gunther, Steven L. Cain, Dan B. Tyers, Kevin L. Frey, & Bryan Aber

When grizzly bears in the Greater Yellowstone Ecosystem (GYE) were first listed as threatened under the Endangered Species Act in 1975, the population consisted of only a few hundred bears. As the population increased, grizzly bears began to reoccupy portions of their former range, so estimating occupied range became an important task for biologists charged with monitoring the population. Beginning in 1973 and continuing through today, the Interagency Grizzly Bear Study Team has recorded confirmed locations of grizzly bears throughout the GYE. These locations have been used to create periodic estimates of occupied grizzly bear range since the early 1980s (Basile 1982, Blanchard 1992, Schwartz et al. 2002, Schwartz et al. 2006). More recently, new techniques were developed that blended elements from previous survey efforts into a more simplified approach that used all forms of confirmed grizzly bear locations (Bjornlie et al. 2014). Using this technique, reanalysis of past location data provided a fresh look at historic grizzly bear range for direct comparison with current results.

Analysis of grizzly bear locations from the early years of recovery in the late 1970s estimated the area of occupied grizzly bear range at approximately 16,000 square kilometers (6,178 square miles). At that time, the population was centered on Yellowstone National Park and a few adjacent areas of remote wilderness on national forests (figure 1). Through the 1980s, the population grew steadily, increasing its range mainly to the south and east in Wyoming, taking in an area of approximately 23,000 square kilometers (8,880 square miles) by 1989 (figure 1). However, in the 1990s expansion of the GYE grizzly bear population truly began to gather momentum as the population increased in numbers (IGBST 2012). Range expansion into the Owl Creek Mountains and the Upper Green River area of Wyoming, and to the northwest into the Madison and Gallatin mountains of Montana, increased the area of grizzly range to more than 33,000 square kilometers (12,741 square miles) by the end of that decade (figure 2). Another 10 years of expansion increased occupied range of grizzly bears in the GYE to over 50,000 square kilometers (19,305 square miles) by

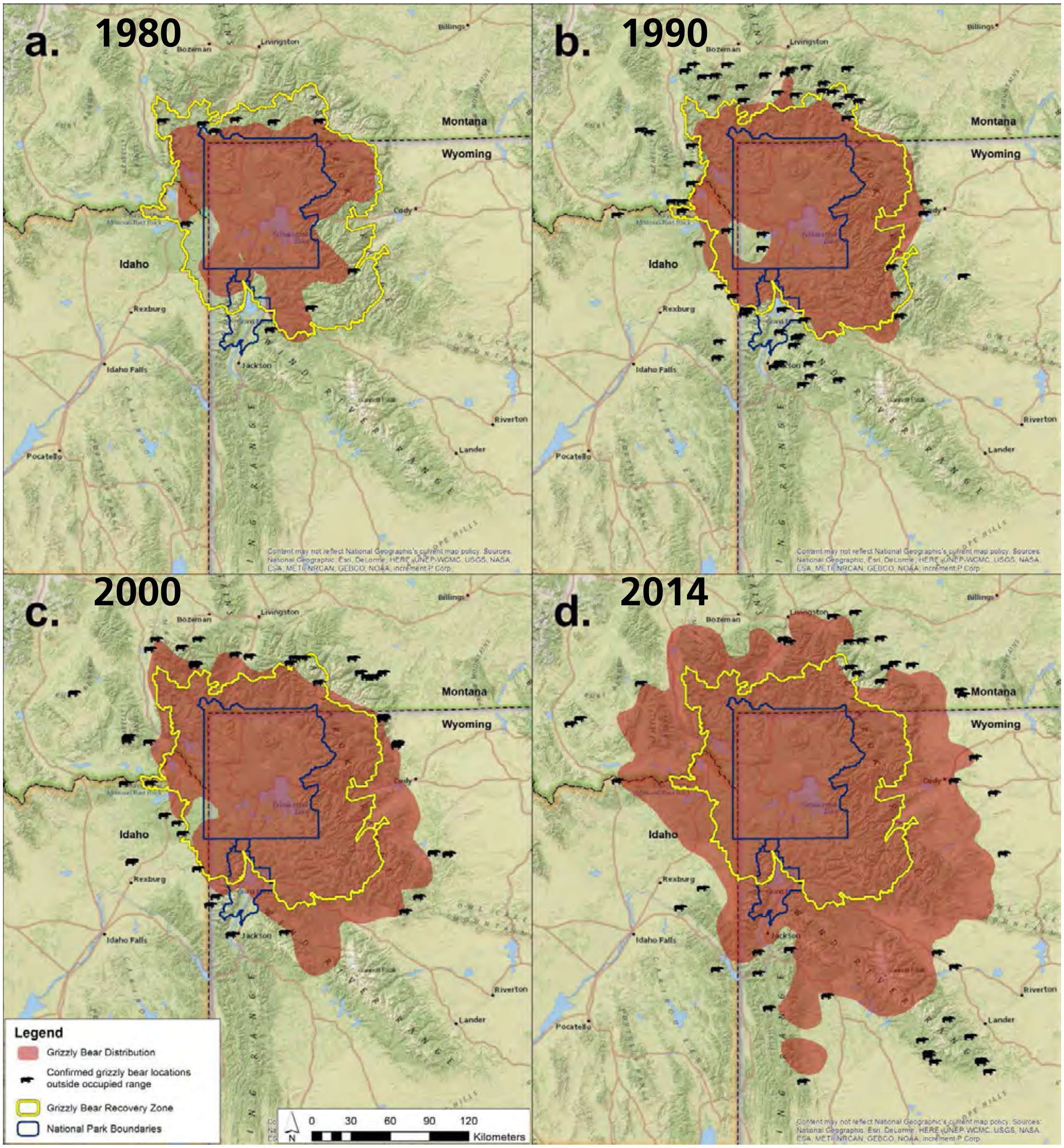

Figure 1. Grizzly bear distribution in the GYE from the 1980s through 2014.

2010 (Bjornlie et al. 2014), a 51% increase from the 1990s. The most recent estimate in 2014 increased the range to over 58,000 square kilometers (22,394 square miles; figure 1). Major areas of expansion in the 2000s occurred to the west in the Centennial Range on the Idaho-Montana border, the Pitchstone Plateau in the southwestern corner of Yellowstone, and across the Gravelly Range to the eastern slopes of the Snowcrest Range in Montana. In areas north of Yellowstone, expansion occurred to the edge of Interstate 90 at the northern reaches of the Absaroka Range and along the eastern extent of the Beartooth Mountains. To the south, grizzly bear range has expanded to the west and south into the northern portions of the Wyoming Range and the Wind River Mountains.

Changes in the availability of some grizzly bear resources (e.g., whitebark pine seeds) have raised questions regarding whether grizzly bears are simply leaving

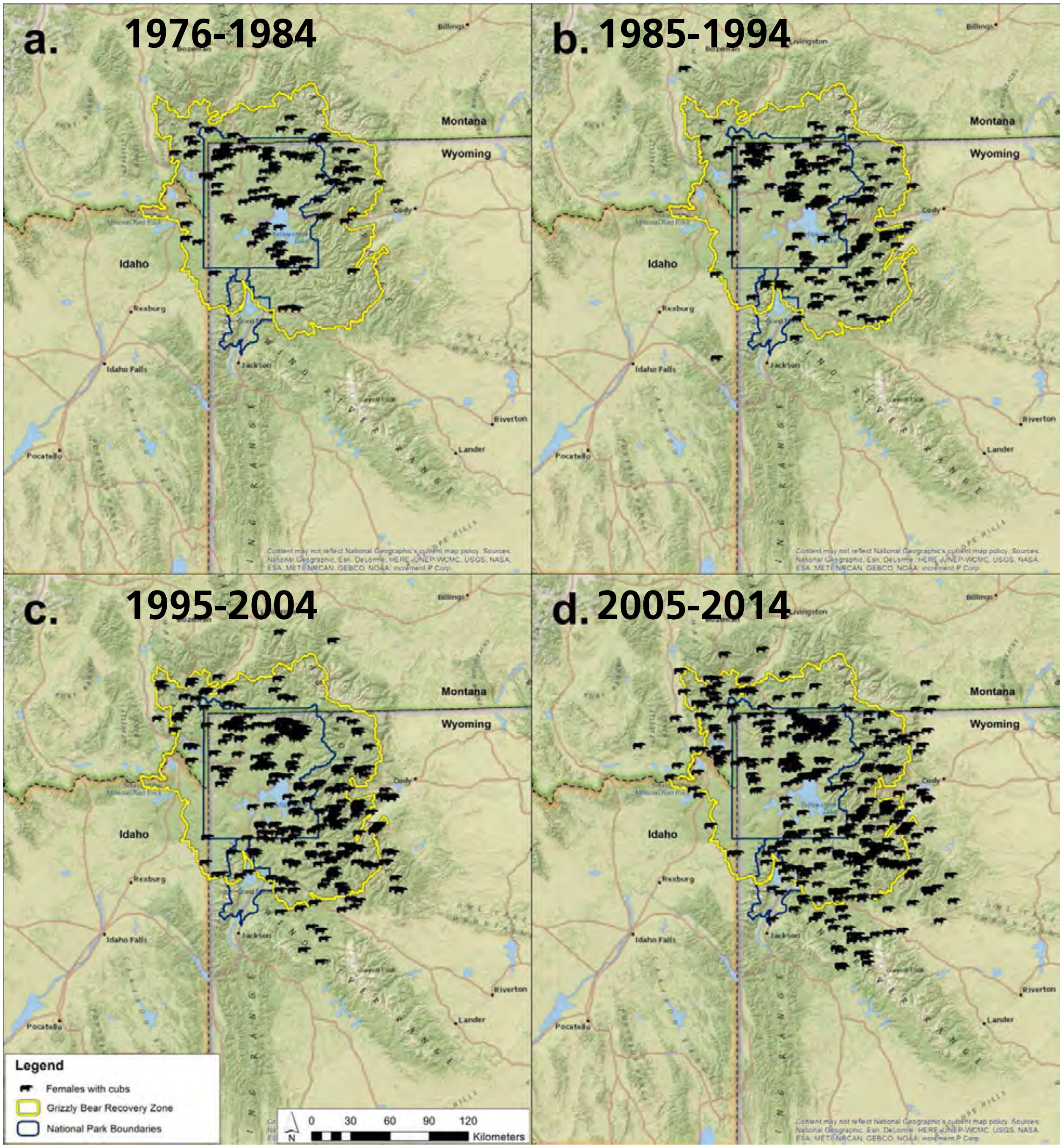

Figure 2. Distributions of initial sightings of unique females with cubs in the GYE from 1976 to 2014.

the core of the GYE in search of food. Female bears do not disperse widely like male bears, so female locations can be used to identify the core of a bear population. Sightings of female grizzly bears with cubs in the GYE have increased concurrently with the expansion of the main population, and show no evidence of a decline in the core of the distribution (figure 2).

Perhaps even more notable than the increase in area of grizzly bear range during recent decades are the many confirmed locations of grizzly bears well beyond the boundary of occupied range, some locations as much as 89 kilometers away (55 miles; figure 1). Many of these locations are in places that have not had documented grizzly bear presence in 100 years or more. In recent years, verified grizzly bear photos were taken by remote cameras at black bear bait sites at the southern extent of the Wind River Range south of Lander, Wyoming, and along the eastern front of the Wyoming Range west of

Big Piney, Wyoming (figure 1). The farthest southeast of these locations, near South Pass, are closer to the town of Boulder, Colorado, than they are to the most northwesterly confirmed grizzly bear location on the other side of the GYE. These outliers do not necessarily constitute occupied range, but reveal the leading edges of expansion as dispersing grizzly bears search for new areas to call home.

With the expansion of grizzly bears into long-unoccupied areas, there will be some inevitable growing pains. Some grizzly bears are moving into places that have greater human influence than the more remote core of the GYE. In the 1970s approximately 280 square kilometers (108 square miles) of occupied grizzly bear range encompassed private lands, less than 2% of the total area. Today the area of private land is over 9,000 square kilometers (3,475 square miles), over 16% of the total occupied range (figure 3). A consequence of range expansion is the potential for increases in human-bear conflicts and possibly human-caused bear mortality on private lands. Indeed, numbers of documented human-caused grizzly bear mortalities for independent age bears (≥2 years old) on private lands increased from 4 (12% of the annual total) during the decade of the 1970s, to 41 (26% of the annual total) during the 2000s (figure 4). Most (56%) of the private land mortalities since the 1980s have occurred outside the Grizzly Bear Recovery Zone (see figure 3 in "Demographic Changes in Yellowstone's Grizzly Bear Population," this issue).

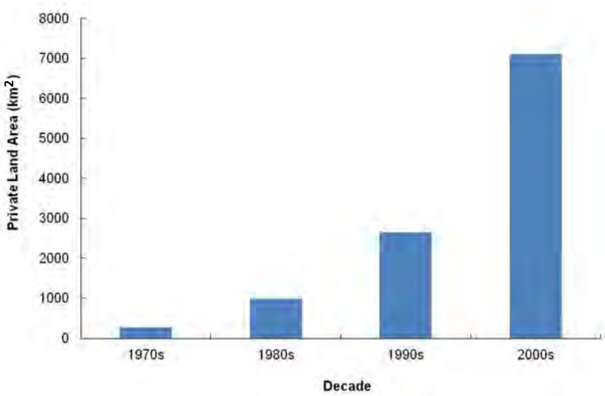

Figure 3. The area of private lands within grizzly bear distribution in the GYE by decade.

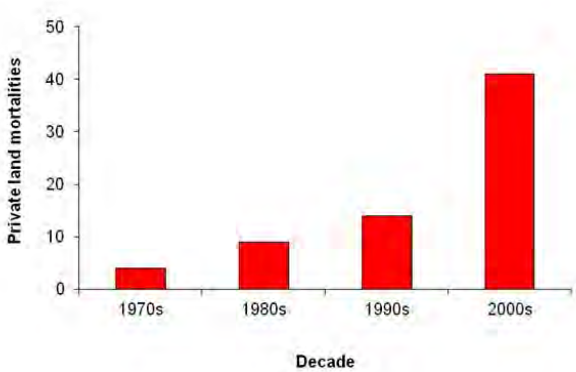

Figure 4. Numbers of documented human-caused mortalities of independent aged grizzly bears (≥2 years old) occurring on private lands in the GYE by decade.

People living, working, and recreating in these areas of expansion must now consider the presence of grizzly bears in various ways, whether it be in wildlife and land management practices, storage of attractants (e.g., food and scented items) for backcountry users and homeowners, or changes in techniques for hunting ungulates to avoid conflicts with grizzly bears. The arrival of grizzly bears in these areas will create new challenges for wildlife managers, and require new and innovative approaches. The recovery of the GYE grizzly bear population is one of the greatest success stories in wildlife management. As grizzly bears re-establish in places where they have long been absent, the dedicated management that has allowed the population to recover will continue to be important to maintain a place for one of the most iconic species of the American West.

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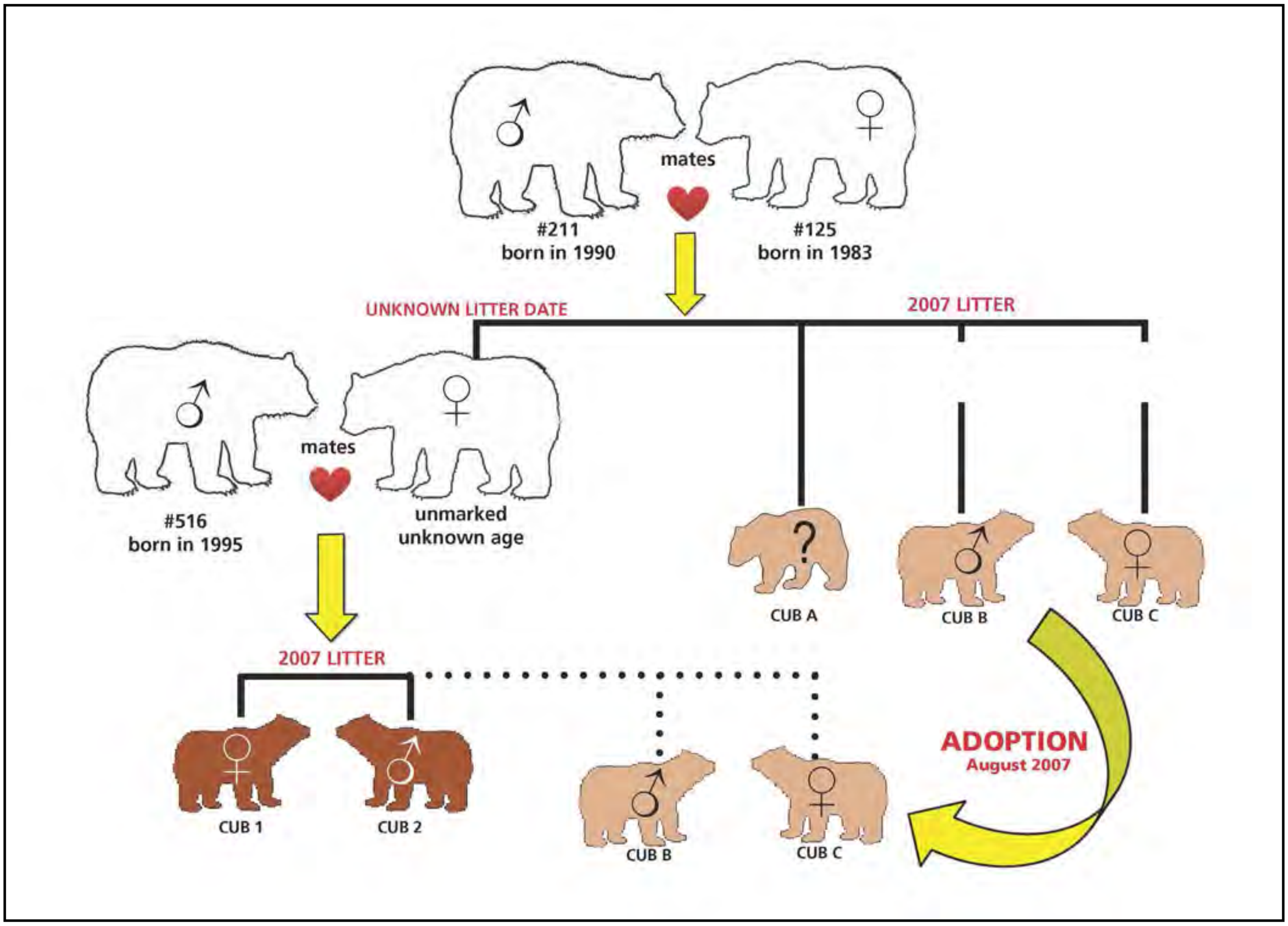
Grizzly Cub Adoptions Confirmed in Yellowstone & Grand Teton National Parks

Mark A. Haroldson, Kerry A. Gunther, Steven L. Cain, Katharine R. Wilmot, & Travis Wyman

The Interagency Grizzly Bear Study Team (IGBST) pays a great deal of attention to sightings of female grizzly bears with cubs (i.e., cubs in their first year of life) in the Greater Yellowstone Ecosystem (GYE). The team collects observations of females with cubs opportunistically from ground-based and aerial observers, and from systematic, twice-yearly observation flights covering over 45,000 km² in the GYE. The observations collected provide information regarding the distribution of reproductive females, as well as the basis for our population estimates and analyses of trends (Harris et al. 2007). Since team members closely scrutinize these sightings, which often accumulate on a daily basis, we tend to notice when something out of the ordinary happens. For instance, in the spring of 2006, aerial observations of a radio-marked female revealed she was accompanied by a mixed-aged litter of two cubs and one yearling offspring from the previous year (Swenson and Haroldson 2008). Mixed-age litters are rarely observed because females typically do not come into estrus and mate when they are raising cubs. However, if separation of a family occurs, it is possible for the mother to breed, re-associate with her lost offspring, and subsequently produce newborns during the denning period and emerge with a mixed-aged litter. Mixed-age litters might also occur through adoption. Cub adoption is another uncommon occurrence that we recently confirmed on two occasions in the GYE.

During August 2007, we observed an exchange of cubs by two females in the Dunraven Pass-Antelope Creek area of Yellowstone National Park (Haroldson et al. 2008). In this event, an older radio-marked female (#125), that had been observed on multiple occasions with three cubs, was observed with only one cub in mid-August. Shortly thereafter, an unmarked female with two cubs, that had been using roadside habitats in the same area, suddenly appeared with four cubs. Park staff deployed remote cameras and a hair collection site, and were successful in obtaining pictures and hair samples from the unmarked female and the four cubs accompanying her. By extracting DNA from the hair samples and comparing it to our extensive set of genotypes from captured bears, we confirmed that an exchange of cubs between the two mothers had occurred. But the story gets much more interesting. Our analysis also revealed the adult females were mother and daughter, and the father of the adoptive female was an old male grizzly bear (#211) that many park visitors refer to as "Scarface." In addition, this bear was also the father of the cubs that the radio-marked female (#125) lost. Thus, the younger adoptive female had gathered up and cared for her full siblings (one female and one male), as she had the same mother (#125) and father (#211) as the two cubs she took in. Her two cubs by birth were sired by a male (#516), whose home range also included the Antelope Creek area and was also in our genotype database. The young mother was last observed with four cubs during late August 2007. During the spring of 2008, we observed what we believed to be the adoptive female with one yearling on several occasions. Although we cannot be certain, she likely lost all but one of the four cubs.

In July 2011, we documented another exchange of cubs in Grand Teton National Park. Like the previous event, this one involved an adult daughter (#610) and her mother (#399). Both of these bears had been radio-marked in the past, but neither was being actively monitored during 2011. Bear #399 had cast her last radio-collar in August of 2006 when she was accompanied by three cubs, one of which was the future bear #610. Bear #399 was identifiable by her red ear-tag and distinctive scars on the left side of her nose. Her daughter (#610) was initially collared as a 3-year-old in 2009, was given yellow ear tags, and then shed her collar in 2010. DNA samples taken during the capture confirmed her relationship to #399. Both of these females were and continue to be highly visible along park roads and have quite a following among park visitors and wildlife photographers. Both bears were accompanied by cubs during the spring of 2011, #399 with three and #610 with two. Beginning in late July, visitors started reporting a female with yellow ear tags accompa-



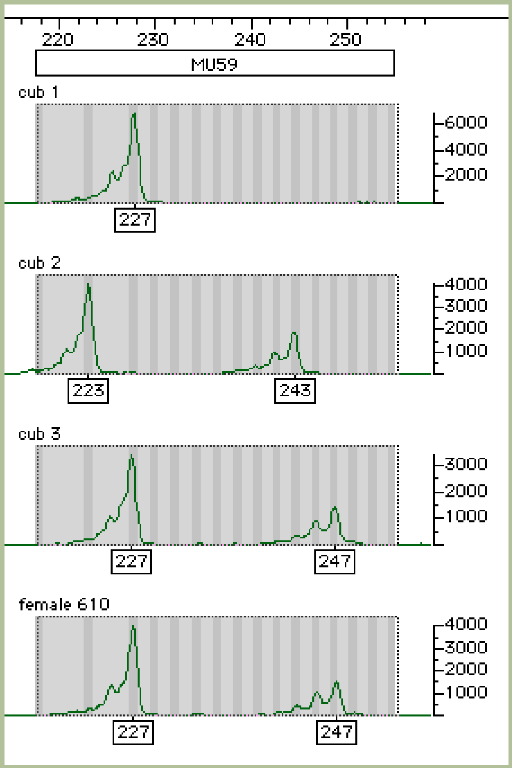
Unmarked female grizzly bear accompanied by four cubs-of-the-year on August 11, 2007, near Dunraven Pass in Yellowstone National Park. Two of the cubs are her own offspring; and two of the cubs were adopted from her mother, grizzly bear #125 (see heredity chart above).

Female grizzly bear #610 accompanied by three yearlings during the spring of 2012. One of the three offspring pictured was adopted during July of 2011 from #610's mother, bear #399.

DNA and Grizzly Bear Studies

Nowadays, wildlife studies that employ some type of DNA technique are commonplace, but probably few people are aware that a bacteria found in Yellowstone was responsible for critical advances in the field more than 30 years ago. The key breakthrough was due to a heat-stable enzyme (Taq polymerase) isolated from one of Yellowstone's thermophilic bacteria (*Thermus aquaticus*) and used in polymerase chain reaction (PCR; see Grogan 2010, "Yellowstone's Thermophiles" in *Yellowstone Science* 18:23-32). The PCR process involves the rapid replication of specific segments of DNA which allows scientists to obtain individual genotypes, even from tiny amounts of DNA such as those found in a hair follicle. With this capability, applied molecular biology advanced rapidly in the 1980s, and sophisticated statistical techniques soon followed. The basis for many DNA-based studies on grizzly bears involves genotyping material containing DNA, such as hair, blood, or tissue obtained from live captures, mortalities, or other non-invasive techniques (e.g., snagging a few strands of hair from rubbed trees or barbed-wire hair corrals) to achieve an individual identification. The process is popularly referred to as "DNA fingerprinting." Grizzly bear researchers in the Greater Yellowstone Ecosystem are conducting a variety of DNA-based studies. These include looking for recent evidence of immigration into the Yellowstone population from other grizzly populations to the north (Haroldson et al. 2010), though none has been detected to date. DNA-based studies have also been used to estimate changes in the number of grizzly bears visiting cutthroat trout (*Oncorhynchus clarkii*) spawning streams surrounding Yellowstone Lake (Haroldson et al. 2005, Teisberg et al. 2014) since this bear food source has declined primarily due to non-native lake trout (*Salvelinus namaycush*). Through DNA analysis of bear hair collected around the lake, biologists determined the number of grizzly bears visiting stream corridors declined from an estimated 73 bears during 1998–2000 to 27 bears during 2007–2009, concurrent with the decline in cutthroat trout. Currently, DNA-based studies are being used to estimate and track changes in the effective population size for Yellowstone grizzly bears (Kamath et al. 2015). Estimated from data on population genetic diversity and inter-relatedness, the 'effective population size' is an approximation of the number of individuals breeding and producing young. Parentage analysis, used to confirm the exchange of cubs, is another statistical technique that identifies probable mothers, fathers, and offspring from genotyped individuals.

A microsatellite is a fragment of repetitive DNA on a chromosome that tends to be highly variable in length among individuals. In the Greater Yellowstone grizzly bear population there are 7 alleles (or variants) identified at microsatellite site MU59. Shown (courtesy of Wildlife Genetics International, Nelson, British Columbia) is an electropherogram for microsatellite site MU59 and results from the grizzly bear #610. Offspring receive one allele from their mother, and one from their father. An offspring that inherits the same allele from both its mother and its father is said to be homozygous for that microsatellite site, resulting in a single peak on the electropherogram (Cub #1). An offspring with two peaks is said to be heterozygous, having inherited a different allele from its mother and its father (Cub #3). Cubs #1 and# 3 share a common allele (227) with their mother #610. Cub #2 does not share any alleles in common at this site with female #610, providing support that it is the adopted offspring.



nied by three cubs, and a female with a red ear tag with two. These changes in the numbers of cubs per mother caused quite a stir among a group of local photographers, who accused park staff of catching the females and changing their tags and/or mixing up the cubs. We do not know the circumstances surrounding the cub exchange, but park staff and bear researchers had nothing to do with it. None of the bears were captured that year. In October, park staff was successful in obtaining hair samples from the yellow-tagged female and the three cubs with her. Subsequent DNA analyses confirmed the familial relationships; somehow female #610 ended up with one of her mother's (#399) cubs. However, in this event, #610 adopted her half-brother, not a full sibling as in the Yellowstone event described previously; #610's father and the father of her mother's cub that she adopted were different individuals. Both fathers were known to us through our DNA database because they had been previously captured and genotyped. Bear #514 fathered #399's cub adopted by #610, and bear #679 was the father of #610's cubs. We also know female #610 successfully reared her own offspring and her mother's cub to the age of independence, with the break-up of this family occurring in spring of 2013. Bear #399's two remaining cubs stayed with their mother until their second spring, when the family separated a year earlier than is typical, a split that may have been caused by a male bear attempting to mate with #399.

Previous to the 2007 event, the last known cub adoption documented in Yellowstone National Park occurred when grizzly bears still congregated at the open-pit dumps during the late 1960s (Craighead et al. 1995). To our knowledge, the event we documented in Grand Teton was a first for that park. DNA genotyping, combined with sophisticated analytical techniques, allowed us to determine with near certainty the relationships among the individuals involved. In both instances, adult daughters adopted close kin, full-siblings in one event, and a half-sibling in the other. Having daughters living in close proximity to their mother is one aspect of the life history characteristics of grizzly bears that facilitated close kin being involved in the events we observed. While male offspring tend to disperse considerable distances away from their maternal ranges, female offspring tend to establish ranges adjacent to or near their mothers. We do not know for certain the circumstance or events that caused these "family shuffles." Conflicts with male bears looking for mating opportunities (Swenson and Haroldson 2008) or other carnivores can cause separations. Anecdotal reports suggested harassment by wolves may have led to cub separation in the Yellowstone event. We have no information regarding the cause of the Grand Teton event, but another possible scenario might be the inadvertent intermingling of cubs when two females interact. In any case, having adult daughters living in close proximity to their mothers was fortuitous for the young cubs.

In scientific parlance, group-living carnivores (such as wolves) are commonly referred to as "social" species capable of recognizing and choosing to cooperate with others of their kind based on kinship. In contrast, some scientists implicitly or explicitly argue that solitary species such as grizzly bears have little or no opportunity to discriminate kinship once independent from the family group, and individuals consequently compete with their neighbors. The family ties involved in the adoption events we observed dispute this point of view and suggest a much greater knowledge of kinship relations than previously thought. Although we are just beginning to develop an understanding of how grizzly bears communicate, we now have some evidence they likely have an intimate knowledge of their landscape and the other bears with whom they share it.

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Risk, Frequency, and Trends in Grizzly Bear Attacks in Yellowstone National Park

Kerry A. Gunther

Although grizzly bear attacks on people in Yellowstone National Park are rare, they draw world-wide media attention and can be quite traumatic for park visitors, staff, and the general public both locally and nation-wide when they happen. One of these rare attacks occurred in the park during the 2015 summer season, resulting in a human death, killing of the adult grizzly bear, and placement of two cubs in a zoo. This event was tragic, but also very unusual in the ecosystem, especially in light of the number of grizzlies and humans that could overlap in time and space.

Park managers strive to make the park as safe for visitors as possible, while still maintaining the park's wilderness character and protecting its resources. As part of these efforts, the park has an extensive Bear Safety Messaging Program that uses face-to-face interactions, social media, web pages, video, printed handouts, park newspaper articles and inserts, restaurant table tents, and roadside and trailhead signs to convey bear safety messages to park visitors. Documenting trends in bear attacks is one method managers use to gauge the efficacy of the park's Bear Safety Messaging Program. The following information includes statistics through the 2014 calendar year.

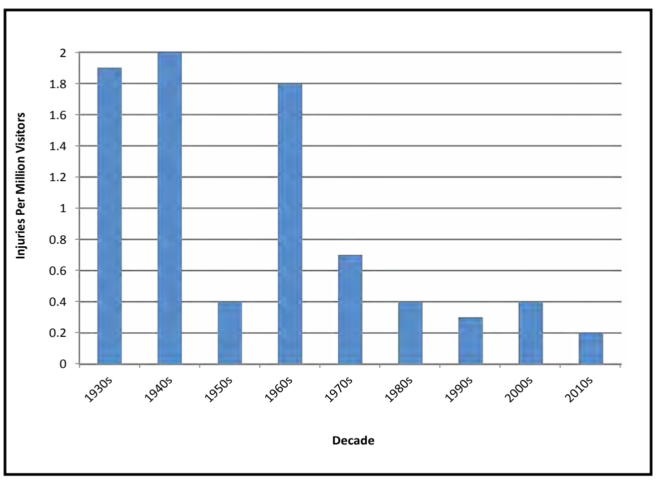

Figure 1. Number of people injured by grizzly bears per one million park visits by decade in Yellowstone National Park, 1931–2014 (data for the decade beginning in 2010 is from the 5-year period 2010-2014).

The number of grizzly bear-inflicted human injuries peaked in the 1940s at two injuries per one million park visits, but declined thereafter (figure 1, table 1). The number of bear-inflicted human injuries has averaged less than one injury per one million park visits each decade from 1970 to 2014. The year 1970 is considered the beginning of modern-day bear management in Yellowstone because previously most bears were conditioned to human foods and garbage. Food-conditioned bears are often involved in bear-human conflicts (Herrero 1985). In 1970, Yellowstone implemented a new bear management program. The foundation of the program was to prevent bears from obtaining human foods, garbage, or other anthropogenic (human) attractants to reduce bear-human conflicts (Meagher and Phillips 1983). By 1979, sources of anthropogenic attractants had been made bear-proof, most food-conditioned bears had been removed from the population (i.e., killed or sent to zoos), and bear-human conflicts declined significantly thereafter. This period in the late 1970s and early 1980s was most likely the low point for numbers of grizzly bears in the park and the ecosystem. From the mid-1980s through early-2000s, bear numbers increased at a fairly robust rate of 4-7% per year (Schwartz et al. 2006). Since the early 2000s, evidence suggests that the rate of increase for grizzly bear numbers in the park and the ecosystem has slowed, due primarily to density-dependent effects (IGBST 2013).

Grizzly Bear Attack History

Grizzly bear-inflicted injuries to humans in developed areas averaged approximately one per year during the 1930s through the 1950s, then increased to four per year during the 1960s. Grizzly bear-caused human injuries in developed areas decreased to one injury every two years (0.5 per year) during the 1970s. During the last 35 years (1980-2014), there have been only two (0.1 per year) grizzly bear-caused human injuries in developed areas (an average of approximately 1 every 18 years). The reduction in bear-inflicted human injuries within park developments during the period of increasing grizzly bear numbers is likely attributable to implementation of the new bear

Table 1. Number of park visits, number of people injured by grizzly bears, and number of injuries per one million visits by decade in Yellowstone National Park, 1930–2014.

Decade	Park Visits	Number of grizzly bear inflicted human injuries	Injuries per one million visits
1930-1939	3,232,417	6	1.9
1940-1949	5,524,563	11	2
1950-1959	13,553,771	6	0.4
1960-1969	19,520,600	36	1.8
1970-1979	22,397,176	15	0.7
1980-1989	23,449,930	12	0.4
1990-1999	30,126,032	9	0.3
2000-2009	29,677,184	12	0.4
2010-2014	17,183,756	4	0.2

Table 2. Risk of grizzly bear attack during different recreational activities in Yellowstone National Park, 1980–2014.

Type of recreational activity	Risk of grizzly bear attack
Remain in developments, roadsides, and boardwalks	1 in 25.1 million visits
Camp in roadside campground	1 in 22.8 million overnight stays
Multi-day backcountry trips	1 in 200 thousand overnight stays
All park activities combined	1 in 2.7 million visits

management program in 1970, which has been successful at preventing bears from obtaining human foods and garbage and keeping bears from becoming conditioned to anthropogenic attractants. From 1980 to 2014, one bear inflicted human injury occurred along a service road and one occurred on a boardwalk trail. Bear attacks along road corridors (3%) and boardwalk trails (3%) comprise very small proportions of total bear attacks.

During the 35-year period from 1980 to 2014, there were 33 human injuries caused by grizzly bears in backcountry areas of the park, an average of one per year. The vast majority of these were attributable to defensive aggression by bears during surprise encounters with hikers. Thirty-two of the 33 (97%) injuries occurred while people were traveling. Only 1 of the 33 (3%) backcountry bear attacks occurred in a backcountry campsite.

Risk of Grizzly Bear Attack

From 1980 to 2014, 37 people were injured by grizzly bears in Yellowstone (an average of 1.1 injuries per year). During that time period, the park recorded over 100 million visits. For all visitors combined, the chances of being attacked by a grizzly bear are approximately 1 in 2.7 million visits. The risk of grizzly bear attack is significantly lower for those visitors who do not leave park developments or roadsides, but significantly higher for those hiking in backcountry areas (table 2).

From 1980 to 2014, there were 100,436,902 visits recorded in Yellowstone. During that same time period, four people were injured in frontcountry areas of the park including developments (n = 1), roadside campgrounds (n = 1), roadside corridors (n = 1), and roadside boardwalk trails (n = 1). Therefore, the chances of being injured by a grizzly bear while in frontcountry areas of Yellowstone is approximately 1 in 25.1 million visits. Of the four people injured in frontcountry areas, one occurred in a roadside campground. From 1980 to 2014, there were 22,824,762 overnight stays in roadside campgrounds. Therefore, the chances of being injured by a grizzly bear while staying in a roadside campground in Yellowstone is approximately 1 in 22.8 million overnight stays.

Of the 33 people attacked in backcountry areas since 1980, 7 were on multi-day overnight trips and 26 were on day-trips. From 1980 to 2014, there were 1,396,299 multi-day overnight stays in the backcountry. Therefore, the chances of being injured by a grizzly bear while on a multi-day overnight trip in Yellowstone's backcountry is approximately 1 in 200,000 overnight stays. The park does not have statistics on how many park visitors day-hike in the backcountry, so the chances of being attacked by a

Table 3. Known human fatalities caused by grizzly bears in Yellowstone National Park, 1872-2014.

Date	Incident
September 16, 1916	A teamster sleeping under a wagon was killed by a grizzly bear at Ten Mile Spring near Turbid Lake at the southern end of Pelican Valley.
June 23, 1972	A man camping near Grand Geyser, in an illegal camp with improperly-stored food, was killed by an adult female grizzly bear when he returned to camp at night.
July 30, 1984	A woman camping was pulled from her tent and killed by a grizzly bear at a backcountry campsite at the southern end of White Lake, near Pelican Valley.
October 4, 1986	A man taking photographs was killed by an adult female grizzly bear near Otter Creek in Hayden Valley.
July 6, 2011	A man hiking with his wife on the Wapiti Lake Trail in Hayden Valley was killed by an adult female grizzly bear accompanied by two cubs.
August 25, 2011	A man hiking alone on the Mary Mountain Trail in Hayden Valley was killed by a grizzly bear.

grizzly bear while day-hiking in backcountry areas cannot be precisely calculated.

During the 143-year (1872-2014) history of Yellowstone National Park, 6 people are known to have been killed by grizzly bears inside the park (table 3), and one additional person was killed by a bear that was not identified to species (Whittlesey 2014). More people have died in the park from drowning (n = 119), falling (n = 36), suicide (n = 24), airplane crashes (n = 22), thermal burns (after falling into boiling thermal pools, n = 20), horse related accidents (n = 19), freezing (n = 10), and murder (n = 9) than have been killed by grizzly bears (n = 6). In fact, the frequency of people being killed by grizzly bears in the park (6 incidents in 143 years) is the same as being killed by a falling tree (n = 6) or in an avalanche (n = 6), and only slightly higher than the frequency of being struck and killed by lightning (n = 5) while visiting the park.

Challenges of Bear Safety Messaging

Bear safety messaging is especially challenging because, even though the consequences of bear attack can be quite severe (severe mauling and even death), the risk of attack for most park visitors is extremely small. This makes it difficult for visitors to understand the need for adhering to bear safety recommendations. The low rate of bear attack among frontcountry recreationalists suggests that bear management and safety messages for this type of recreationalist are effective, especially given the increases in grizzly bear numbers over the past several decades. Backcountry hikers have the highest risk of bear attack (approximately 1 in 200,000), but adherence to bear spray and hiking group size recommendations among this user group is low. In a 2011-2014 survey, only 13% of day hikers and 52% of backpackers carried bear spray (see "Visitor Compliance with Bear Spray and Hiking Group Size in Yellowstone National Park," this issue). The most common party size for both day-hikers and backpackers was two people per party, indicating that many day-hikers and backpackers did not follow the park's recommended group size of three people for hiking in bear country. Although backcountry hikers are probably more accepting of the inherent risks associated with recreating in bear country than other park visitors, new innovative messaging strategies may be needed to reduce the frequency of bear attacks on this recreational group.

There are no guarantees of safety when recreating in bear country. However, an awareness of the hazards can often mitigate the potential dangers. To learn more about safety in bear country, visit the park's web page at: go.nps.gov/yell/bearsafety

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SAFETY IN BEAR COUNTRY

Due to the behavioral differences between black bears and grizzly bears, most bear-inflicted human injuries that occur inside Yellowstone National Park are caused by grizzly bears. These injuries usually occur during unintentional surprise encounters between hikers and female grizzly bears with cubs in backcountry areas. Although the chances of being attacked by a grizzly bear are very low, you can further reduce the risks by taking certain precautions and understanding what to do should you have an encounter with a grizzly. When backcountry hiking, you can reduce the chances of being injured by a bear by: 1) hiking in groups of three or more people, 2) carrying bear spray, 3) staying alert for bears, 4) making noise in areas with poor visibility, 5) staying on established trails, and 6) not running once you see a bear. If you have a surprise encounter with a bear, slowly back away. If the bear charges, stand your ground and use your bear spray. If a charging bear makes contact during a surprise encounter (as evidenced by an immediate charge, head held low, ears laid back), you should play dead. If a curious or predatory bear (as evidenced by a direct focused approach with head up and ears erect) persistently stalks you, you should be aggressive and fight back. Fight back during any attack that occurs at night while you are sleeping.

The Bear Bath Tub

Kerry A. Gunther, Mark A. Haroldson, Michael Nichols, & Ronan Donovan

When radio tracking grizzly bears, they sometimes lead you to very unique and interesting places; remote hidden gems in Yellowstone's vast wilderness. Places you would never look at a map and say, "I'm hiking to that spot to see what's there." Over a decade ago, while retrieving a radio-collar that had come off of a female grizzly bear, we discovered one of those little gems. We called it the "bear bathtub." A female grizzly bear that had worn a collar was radio-monitored to track her survival and reproductive success as part of the Interagency Grizzly Bear Study Team's (Study Team) ecosystem-wide population monitoring effort. She had been recaptured without her radio collar the previous week, so we knew there was a dropped collar on the landscape that needed to be retrieved. A Study Team pilot tracked the telemetry signal of the missing collar to its location. The coordinates provided by the pilot were used to get us in the general area, and then we used a hand-held telemetry antenna and receiver to follow the collar's signal to its exact location. After tracking the signal up and down ridges and climbing over what seemed an endless amount of deadfall, we finally emerged out of a narrow gully. As we exited the gully, the radio signal changed from its high pitched beep to a deep booming click indicating the collar was very near. We were in a small opening surrounded by forested hills, near a small pool of water. The radio signal led us straight to the pool and became significantly louder when we pointed the antennae into the pool. We circled the pool to confirm our suspicion that the collar lay on the bottom of the pool. It did. However, as we peered into the murky depths of the pool, we could not see any sign of the collar. Dividing the pool into a grid, we used the telemetry receiver as one would use an avalanche beacon receiver, to determine the portion of the pool containing the radio collar. We reached down about shoulder deep into the icy, cold pool to where the collar should have been, but could not reach the bottom of the pool. We then used a hiking pole to slide along the muddy bottom of the pond to locate the collar. Each radio collar has an activity monitor, so when the radio signal changed to a faster, active pulse rate, we knew we had moved it. We used the hiking pole to pull the radio collar along the muck at the bottom of the pool and partially up the side where it could be retrieved from the pond. Written in our notes, the pond containing the radio collar was a *"bathtub size pool of water, 2-3 feet deep and approximately 3-4 feet wide by 8-10 feet long. Four, well-worn game trails, all with numerous bear tracks led in to and out of the pool of water. It appeared that the radio-collared bear and other bears had been using the pool of water as a bathing hole all summer."*

Years later, while working with the National Geographic Society to document the wildlife and ecological processes of the park, we had the opportunity to deploy some of the sophisticated high-tech, high-resolution remote cameras designed by National Geographic at the pond to find out more about how bears used it. These "camera traps" allowed us to document bear activity at the pool without disturbing the bears. The photos and video provided us with interesting insights into bears' visits to the bear bathtub. Photo and video documentation indicated it was used by multiple individuals of both black and grizzly bears. Bears came to the pool, soaked, bathed, and cooled off. Females brought their cubs to play at the pool. Even adult bears were observed playing with sticks pulled up from the bottom of the pool. Interestingly, bears also scent-marked along the edge of the pool, rubbing their necks and cheeks on the ground and lush grasses surrounding the pool. We hope to learn more about the scent-marking behavior observed at the pool. Regardless, it appears that bears enjoy a nice cold soak on a hot summer's day as much as humans do.

Since discovering the bear bathtub, several other collars have been retrieved from small, cold ponds. The park likely has many such places visited by bears to bathe, soak, play, and scent mark. The bear bathtub is just one of the many special places in Yellowstone National Park that grizzly bears have helped us discover.

YS

Bear bathtub photos taken by camera trap.

Camera Collars: The Evolution of Tracking Bears through Yellowstone

Nathaniel R. Bowersock, Kerry A. Gunther, Travis Wyman, Chad Dickinson, Dan Bergum, Frank T. van Manen, & Mark Haroldson

In the early 1960s, pioneering biologists Frank and John Craighead developed some of the first radio-telemetry technology ever used in wildlife studies, testing early radio collars on a few grizzly bears in Yellowstone National Park (Craighead et al. 1963). Radio-collaring bears enabled the Craighead brothers to estimate home range size, movement patterns, food habits, and social dynamics of the grizzly bears they collared (Craighead 1976). Since the Craighead's early efforts, telemetry technology has improved significantly. Collars have become smaller and lighter, and battery life has increased. Programmable electronic release mechanisms have been added to allow for predictable date and time collars drop, and the addition of mortality switches helps determine when the collars have stopped moving. Over the last two decades, tracking technology has also advanced to include Global Positioning System (GPS) packages that provide near real-time, highly accurate animal movement data via satellite links. More recently, video cameras have been added to GPS collars which can be used to determine the animal's activities and behavior at specific times and locations. This increases the ability of researchers to collect new types of data from the animals they study.

As part of a pilot study in 2014, the Yellowstone Bear Management Office and the Interagency Grizzly Bear Study Team deployed GPS camera collars on two male grizzly bears and one male black bear. The intent of this study was to field-test these collars and document the accuracy of feeding site investigations as a method for determining bear habitat use and food habits. These newly developed camera collars were designed to record videos from the bear's point of view; recording 20 seconds of video every 20 minutes during daylight hours, while simultaneously recording GPS coordinates of the bears' locations.

Two of the camera collars (black bear #22517 and grizzly bear #228) deployed in the summer of 2014 were retrieved that fall. From these two collars, more than 2,600 videos were recorded; and at least 15 different foods eaten by the bears were identified. Black bear #22517 was mostly active during the day; whereas grizzly bear #228 was mostly active at dawn, dusk, and at night. The third collar (grizzly bear #394M) was dropped in a remote area of the park and was recovered in June 2015, but the video download has yet to be received.

After being collared, black bear #22517 spent only a week in Yellowstone National Park. He then traveled south from Mammoth Hot Springs up over Little Quadrant Mountain and Antler Mountain, along the northwest side of Yellowstone, to an area around West Yellowstone, Montana (figure 1). Black bear #22517 consumed a greater variety of foods than grizzly #228. The videos captured on his collar show him feeding on the seeds of whitebark pine on Antler Mountain before heading on to the West Yellowstone area. He then scavenged an elk carcass just south of West Yellowstone for several days. Subsequent videos documented #22517 killing and feeding on what appeared to be an old female black bear, after she approached too closely when he was feeding on the elk carcass. One of the more intriguing observations was how quickly #22517 moved while foraging on small plants and mushrooms, with little difference in speed compared with his typical traveling mode.

Field crews found the presence of bear sign (tracks, scat, hair, etc.) at 52.5% of a sampled subset of GPS locations recorded for black bear #22517 which is similar to results from other studies (Hunter et al. 2004, Podruzny and Schwartz 2002, Fortin et al. 2013). However, when comparing the bear sign found at GPS locations to the video recorded at the same time and location, field crews correctly classified the bears' activities or foods being fed on at only 7.1% of the locations searched. At many of the GPS locations, field crews found evidence of bears ripping open logs to forage ants (figure 1), but the

Photo of Grizzly Bear #228. Taken from camera trap set near apple trees.

videos associated with those bear locations showed that he foraged on other food items such as Oregon grape and service berry, rather than ants at these locations. Because the camera collars record videos only every 20 minutes, certain behaviors that occurred between video recordings were likely missed. Additionally, it is difficult to detect evidence of bears grazing on small plants and berries compared with obvious and long-term persistence of sign left at logs that have been torn apart by bears.

Grizzly bear #228 was mostly active at night, and the majority of the videos recorded by his collar were of him sleeping in day beds. The videos indicated he often slept at the base of pine trees or under thick brush near rivers and creeks. Field crews documented more carcass feeding by grizzly bear #228 than black bear #22517, including elk, bison, and deer carcasses. One of the more interesting video segments from #228's collar was the distant lights of the town of Gardiner, Montana, while he fed in apple orchards at night along the Yellowstone River within the Gardiner Basin.

Field crews were more successful at finding bear sign (71.8%) at grizzly bear #228's locations compared to black bear #22517 (52.5%). Additionally field crews were more accurate at identifying the foods and behaviors of #228 at the locations searched compared to the video recordings, possibly due to the disturbances he created in making day beds and foraging on plants and trees. Also, he was a larger bear and spent more time at carcasses, which persist longer and are easier to detect in field surveys. Compared with #228, the misclassification of foraging and behavior was greater for black bear #22517. One contributing factor may have been differences in the food items selected by the two bears. For example, when both bears were foraging for fruit, #22517 meticulously consumed single berries without disturbing the rest of the plant, whereas #228 ripped branches off of apple trees to feed.

Although the 2014 pilot study is only a small data set, it provided useful insights into the potential advantages and disadvantages of this new camera collar technology. Because of the simultaneous collection of video data and

Figure 1. Map of GPS point locations recorded by black bear (#22517) with photos of prevelant food cosumption observed from recorded videos.

The lead author with Grizzly Bear #394, whose collar was retrieved in the spring of 2015. The bear weighed 576 pounds at capture.

GPS locations, camera collars have great potential to increase our knowledge of bear activities, movements, food habits, and interactions with other bears. Application of this technology will likely provide many new insights into the interesting lives of bears.

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Nate Bowersock (pictured above) is a wildlife biological technician who has worked in Yellowstone National Park for the last eight years. He has worked with river otters, wolves, and birds in the past and has worked for the Bear Management Office for the last four years. He enjoys learning about the many wildlife species that live in YNP and hopes to continue to learn more about how these fascinating animals interact with one another and the landscapes where they are found.

Special thanks to the Expeditions Council of National Geographic Society for their grant that made this project possible.

Bear Art: A Vanishing World Treasure

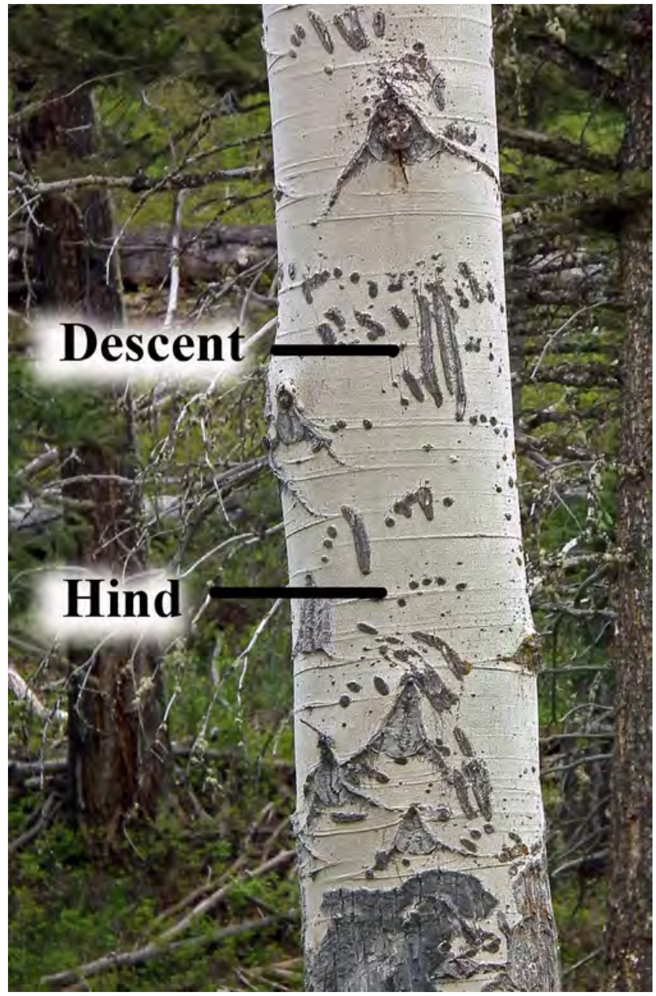
James Halfpenny & Jim Garry

They "etch-a-sketch" their wanderings across the landscape, recording on their favorite blackboard—the aspen. These markings on aspen are the art of salient, thinking beings. Bears.

Art, by nature, is in the mind of the beholder, but most would recognize the works of Thomas Moran as critical to the Greater Yellowstone Ecosystem (GYE) and the history of Yellowstone National Park. Yet, to the naturalist and visitor, trees can record an art form much older than the park, but equally as important in telling the story of Yellowstone. We first heard bear biologist Charles Jonkel refer to the stories written in the bark as bear art. Now countless visitors can "feel" bear presence through these markings.

Some consider the etchings on trees to be unconscious records of the movement of a bear through a landscape, opportunist markings of passage. As art conveys a message or meaning from the artist, so too may the bear's scribbling. To the trained eye, markings tell stories and convey messages. Scratches, bites, and rubs convey behavioral and ecological history. Marks may tell the story of a mother protecting her young, mating strategies, or claims of home range. Perhaps they say "I am looking for a female" or "I am the biggest bear —Move on!" To the bear art connoisseur—the trained naturalist—the markings show the trail up and down a tree, giving clues of physical and behavioral features such as the height of a bear, loss of fur following hibernation, gripping a tree while climbing, checking for insects, and more.

In Yellowstone, trees with bear markings may be isolated or congregated in what we call "throne rooms." These areas consist of clusters of aspen well used by bears. Due to the soft, smooth, light-colored nature of aspen bark, bear claw marks on this tree species are especially visible. Here hang bear Picassos, extending skyward. In the room are a few main thrones which show exquisite detail of climbing, perhaps even multiple trips up and down. There are other minor chairs of bear royalty, trees showing more escapades. Throne rooms are special places where one can stand in awe knowing that a bear passed here, leaving its message. We share throne rooms with those who approach with reverence, as if they were walking among the decorated spires of Notre Dame de Paris.



Reading the story on a bear art tree. Vertical scratch marks were made during descent. The arc of five scars was made by the jab of a hind foot directly into the trunk during ascent.

Trees with markings made by bears may also be thought of as "bear dendroglyphs," a phrase coined by Rawdon O'Connor, as we studied bear signs in Yellowstone. These bear dendroglyphs, like carvings in trees created by humans, record the heritage of our ecosystem; but these transient features are endangered. Alongside the late Dr. Elaine Anderson, we started recording bear trees in 1990 as part of our Yellowstone Association Institute class, "Bears: Bones, Signs, and Stories." In the class, we photographed and recorded locations of bear dendroglyphs; however, some of the trees we have mapped and aged have since gone through the process of senescence and died. The photographs are the only remaining record.

The aspen tree is an iconic image found throughout the American West. Mature aspen overstory is in a state of decline, and there has been little aspen recruitment since the 1920s (Larsen and Ripple 2003). Aspen is a clonal organism, meaning the trees within an aspen stand are genetically identical stems growing out of the same root system. Most aspen trees live about 100-150 years, and the Yellowstone aspen population is in that age class (Painter et al. 2014). Aspen stands are often small and widely distributed. Seed establishment is rare due to the need for specific growing conditions (i.e., light, temperature, precipitation) and disturbances such as fire (Romme et al. 2005, Brown et al. 2006). Drier, warmer climate conditions can cause drought stress on roots, resulting in a loss of root connectivity within the stand (Anderegg et al. 2012). Overgrazing by ungulates is another reason seedlings and root sprouts are not replacing older trees (Painter et al. 2014).

The future of aspen throughout the West looks bleak (Anderegg et al. 2013). Today, infrequent fire occurence, drought, slow growth, conifer competition, and changing climatic conditions are taking their toll (Romme et al. 2005, Kulakowski et al. 2013). Even with successful new growth, it will be decades before trees are large enough for bears to climb and mark. Bear natural history is being lost. The future forebodes several decades during which visitors may not readily witness bear art on aspen trees. The loss of aspen tree bear art appears beyond the grasp of human control, although for those who look closely, bear claw marks will still be visible among the pine tree species in the park. Therefore, our charge is to learn from the bears, record their art in photographs, map the locations with GPS devices, and share with others.

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Orphaned Cub Survives to Produce Family of Its Own

Kerry A. Gunther, Travis Wyman, Craig Whitman, & Stacey M. Sigler

Female black bear #33, as a fall cub on November 27, 2007, shortly after being captured at Old Faithful where she had been attempting to break into dumpsters.

In late November, 2007, an orphaned female cinnamon black bear cub-of-the-year was observed in the Old Faithful developed area attempting to break into bear-proof dumpsters. The orphaned cub was very small, in poor condition, and appeared to have too little body fat to hibernate. On November 25, Bear Management Office and Interagency Grizzly Bear Study Team staff captured the cub with a catch pole, put her into an aluminum bear trap, and transported her to an isolated spot on an old service road in the Stephens Creek drainage. The bear trap would serve as an artificial den for the remainder of the winter. The cub was given a thick bed of hay, and additional bales of hay were stacked around the outside of the trap to provide further insulation. Human activity at the artificial den site was kept to a minimum to reduce the likelihood of habituating the cub to humans. Each day all scats were raked from the trap, and the cub was given a fresh bucket of water and an ample supply of apples and road-killed elk and mule deer. As each apple was placed into the trap, the cub would take a bite out of it as if to claim it, then carry the apple to the far end of the trap to save for later. Due to cold winter temperatures, a layer of ice formed on the bucket of water each night; the next day when the water was changed, there was always a round hole in the ice where the cub had punched her nose through to get at the water.

At one of the feeding sessions, a dead elk was found next to the bear trap, along with a bald eagle and a pack of wolves. From tracks at the scene, it looked like a small group of cow elk had come to the site to eat the hay being used to insulate the outside of the artificial den. A pack of wolves had then killed and consumed one of the elk. A bald eagle was also scavenging the elk. It's interesting to imagine what the cub had thought of all the commotion outside of her artificial den as the pack of wolves killed an elk within feet of her winter home. The stories that bear cub could tell! To prevent further ungulate feeding on the hay, a temporary barbed wire fence was strung around the artificial den.

In early January, 2008, the cub had gained considerable weight and looked quite plump; it was decided to cease feeding the now-fat cub, which would send her physiology into hibernation for the rest of the winter. The amount of food provided was gradually reduced and then cut off completely. Within a few days, the cub was curled into a tight ball and hibernating soundly. She was checked on periodically throughout the winter and always found in a deep sleep.

In March, the cub was immobilized with a dose of Telazol; and her right ear was fixed with a green ear-tag (#33). Then, she was placed in a small wooden den box that was carried further up the Stephens Creek drainage to a secluded spot. The den box was covered with a teepee of sticks, and the cub was left to emerge on her own. Several weeks later, the cub had emerged from the den box and was gone.

Over the next seven years, there was a lot of speculation about what had happened to the cub and fear she may have died that first spring or summer living on her own. The Bear Management Office staff never saw the green ear-tagged bear, and no other park staff or visitors reported seeing her. Then, on June 7, 2015, an adult cinnamon black bear with a green ear-tag in her right ear, accompanied by one cub was observed approximately one mile south of the old Buffalo Picnic Area on the Dunraven Pass road. A visitor photographing the bear with a large lens was able to zoom in on and read the ear-tag number. It was black bear #33, the Old Faithful orphan from 2007. Now eight years old, she had not only survived but appeared to be in great shape! The extra efforts in capturing and feeding the orphaned cub had paid off. She was now raising a cub of her own and had not been involved in any conflicts with people since attempting to break into dumpsters eight years earlier.

Photo of 8-year-old adult, female black bear #33, taken on June 7, 2015, along the road between Tower Junction and Dunraven Pass.

Vu par un bénévole...
(Through a Volunteer's Eyes)

Raphael & Daniel Sitbon-Taylor

Daniel & Raphael Sitbon-Taylor are high school students from southern France who came to Yellowstone to learn about how bears are managed in the ecosystem. Over 760 volunteers donated 99,812 hours to Yellowstone National Park in 2014 and, like Daniel and Raphael, provide a valuable service to the park and come away with a new appreciation for the park's resources.

Raphael: During the summer of 2014, I had the chance to wake up every morning at 6:00 AM, dress quickly in my volunteer clothing and head up the hill at the North Entrance of Yellowstone to meet up with my co-workers from the Bear Management Office in Mammoth.

There, the morning would start by siphoning through dozens of bear and rare animal sighting reports in order to get a better understanding on the location of these dominant mammals. When the paperwork was cleared, the work day varied as a function of different circumstances. It could range from setting a bear trap, to conducting a wildlife survey to working countless hours directing traffic at a bear jam.

In 2014, National Geographic was creating a special piece on Yellowstone for the National Park Service's 100th anniversary. This meant that they wanted never-seen before footage of wildlife in the park and were willing to invest in state-of-the-art camera collars that would video the world from the bears' point of view. The collar takes a 20-second video every 20 minutes during the day and emits a GPS signal a few times an hour, allowing the bear's movements to be tracked. The camera is preprogrammed for approximately 60 days and once it reaches its battery life, it falls off the bear's scruffy neck. Collaring a bear is actually quite a selective process and size matters. The Yellowstone study was set up on black bears and the neck of the black bear has to be big enough so that the collar won't slip off when he/she goes for a swim or scratches his/her neck on a tree. The bear also can't have cubs as capturing a mother, even if only for the short time that it takes to insert a collar, might put the cubs' lives in jeopardy. The Bear Team had extensive information on the habitats of the park's black bears so we had the advantage of knowing where bears that might be suitable for the project would be roaming. It is in these areas that we installed our metal bear trap boxes.

Daniel (age 16) and Raphael Sitbon-Taylor (age 17) in their volunteer uniforms.

The most important step in attracting a bear is preparing bait that appeals to the type of bear that you are trying to lure. For example, deer meat is more like-

Working at bear jams were a regular part of the boys' daily duties.

ly to attract a black bear than a grizzly while bison or elk meat is more likely to attract a grizzly and even repulse a black bear. This situation occurs because grizzly bears are stronger and more aggressive than black bears and will chase the latter from the bigger bison/elk carcasses that provide more meat and emit a strong stench. In order to find deer meat, we would head out to collect road-killed animals. Once we recovered a carcass, we would start cutting it up and prepare it to be used for bait. We would then bring it back to the storage room where the last step occurred: preparing an extremely nauseating mixture consisting of deer parts, blood, anise, blueberry and cantaloupe extract, and worst of all, a completely nose-dropping mixture of expired fish puree.

Once the bait was prepared, we would perform what is called "a drag" which consists of "dragging" the stomach-turning bait around the trap and then creating a figurative line towards the entrance of the trap with the bait. We would then put the bait in a big bag and hang it high around a branch where the wind could carry the stench far enough so that bears, with an extraordinary sense of smell, would pick it up. A large part of the deer was hung at the very end of the trap on a string so that when the bear pulled down the meat it triggered the trap door to close. Bears are usually extremely wary of these traps but their desire for food overcomes their initial fear of the big metal box. We often had to wait for hours and hours just to find a bear and it was thus disappointing when a bear who was finally attracted to the trap wasn't always large enough to be fitted with the collar. However, playing even a small part in harnessing this non-invasive technology, and gaining a glimpse into a bear's life, was an incredible experience.

Daniel: The next summer, after having heard of the great moments my brother Raphael experienced working for Kerry Gunther and his bear management team, I was more than excited to embark on my own Yellowstone internship. Although I went during the same time of year and volunteered in the same program, the circumstances of the bears themselves resulted in unpredictable experiences and unique opportunities.

One difficulty that came up for our team was a "problem bear," a bear who was no longer scared of

Daniel drags a carcass along a designated route to attract a black bear to an area for trapping.

humans was roaming through campsites in search of food and was causing problems at the Grant Village campground. While we managed to catch a bear by the campground, we did not euthanize it because a second bear, whom we were unable to distinguish from the "problem bear," was also seen in the vicinity of Grant. This type of problem can usually be avoided by keeping bears away from human food and storing trash inside bear-proof containers. While volunteering for the bear management team, we all invested a lot of effort into delivering bear boxes to campsites throughout the park. Bear boxes might be the single most important item protecting campers from bears and vice versa ("a fed bear is a dead bear"). Bears are naturally scared of humans and want nothing to do with them; that being said, bears will always think "food first" (with the exception of mother bears who will do anything to protect their cubs). This is where the bear boxes come into place; there is one bear box per campsite and campers can store all their food inside them. If all visitors respect this easy rule, bears will not feel the need to roam around the campsite and get themselves into unnecessary trouble. Delivering these bear boxes might not have been the most thrilling part of my summer, but it was definitely an essential task.

During my stay at Yellowstone, a bison carcass in Hayden Valley (less than 100 feet from the road) was attracting grizzly bears. At one point, no fewer than 8 grizzly bears gathered in the area! This was, as one would expect, attracting many tourists (300+), resulting in a situation that was not just damaging to the roadside vegetation but also potentially dangerous for these visitors. We were therefore charged with removing the carcass, an assignment that involved dragging the carcass onto a truck and transporting it to a carcass dump. This was quite scary as there was a female grizzly with her two cubs just a few hundred yards away from us. While this may have angered the tourists (we did take away a big bear attraction), it was necessary for the safety of all concerned.

Another part of working for Bear Management involved directing bear jams. Bear jams are, as the name implies, traffic jams caused by bear sightings. These can range from very difficult to very easy to manage. While at a bear jam, we always had to make sure that cars weren't blocking traffic and were parked behind the "white line." This can be hard because cars will always stop for a second or two to take pictures. But working at a bear jam only gets tricky if the bear decides to move and get closer than 100 yards from the road; the first step is to get all the tourists onto the road (tourists are allowed off the road if the distance between them and the bear is more than 100 yards, making for better photographs) and at a reasonable distance from the bear. If the bear then decided to cross the road, our job was to make noise and scare the bear, but only during the time that he/she was on the road. We did this to let the bear know that the road is human territory and is not an area where he/she should feel comfortable.

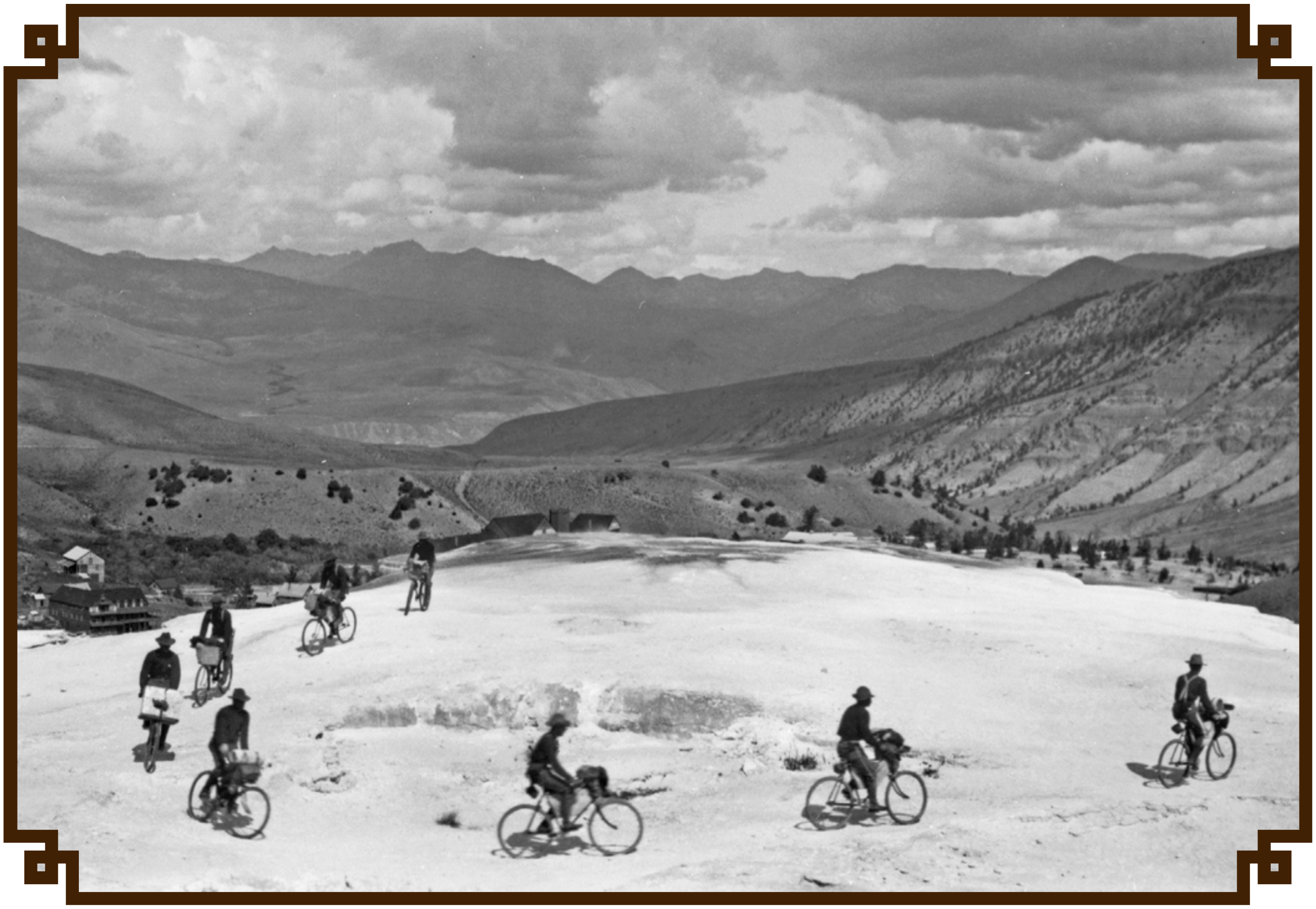
Conducting wildlife surveys was another bear-related part of the job. Once a week, three of us went down to Trout Lake, south of Cooke City, to count the number of native cutthroat trout in the stream. Cutthroat trout are one of the most important energy sources for grizzly bears during the spring and summer. While carrying out this survey, we would also note how many groups of people had bear spray or bear bells. Ideally, everyone should carry bear spray and hike in a group of three or more people. Another survey consisted of counting the number of pine cones per pine tree. We would count cones on approximately twenty trees and then calculate the average. Pine nuts are an important food source for both grizzly and black bears so this study helps to determine the extent of the bears' food supply. This information directly impacts tourists because if the bears don't have a lot of food, it is more likely that they will get in trouble with human food and garbage. I also participated in a visibility survey. For this survey, we had a plywood cutout of an average sized bear in the park. We would go to the middle of random campsites, and I would set off with the bear in all four cardinal directions. When my co-worker couldn't see the "bear" anymore, because his view was blocked by natural or man-made items such as campers or tents, he would measure the distance and mark it down. This study was quite fun as we were questioned every 2 minutes about why we were walking around with a plywood bear!

We are incredibly lucky to have had the opportunity to discover Yellowstone from the inside, even if we realize that we experienced only a fraction of what the park has to offer. Working with the Bear Management Team made our respective summers the best of our lives. It was truly a life-changing experience.

Soldiers on the Terraces

The Story of the Twenty-fifth Infantry Bicycle Corps & its Visit to Yellowstone Park, August 1896

Wes Hardin



The Bicycle Corps riding around the top of an inactive portion of Minerva Terrace.This photo is believed to have been taken on August 30 or 31, 1896. F. Jay Haynes, photographer, Haynes Foundation Collection, MHS Photograph Archives, Helena, H-3616.

For many visitors to Yellowstone National Park, and especially those at Mammoth Hot Springs, the photograph of soldiers in old-fashioned uniforms standing with their heavily loaded bicycles on the white travertine formations of Minerva Terrace has become an iconic image. This photograph can be found on the walls of restaurants and general stores throughout the park, and gracing the pages of several publications on bookstore shelves. Given the fact that the U.S. Army administered Yellowstone National Park for 32 years and constructed Fort Yellowstone at Mammoth Hot Springs to serve as its base of operations, it would be logical to assume the cyclists in the photograph were soldiers stationed at the fort. One could also conclude the photo proves the army routinely used bicycles to patrol the park during the 1890s. However, both conclusions would be incorrect. The cyclists in the photograph were indeed soldiers, but not from Fort Yellowstone. They were members of the Twenty-fifth Infantry Bicycle Corps and they rode their bicycles nearly 300 miles from their home base in Missoula, Montana, to get to the park. These military cyclists had not come to Yellowstone merely to enjoy the scenery and marvel at geysers and hot springs; the primary purpose of the trip was to test the effectiveness of bicycles for transporting men and equipment over mountainous terrain (Dollar 1985, Moss 1896). Yellowstone Park seemed a perfect location for this challenge.

The Bicycle Corps that visited Yellowstone was the brainchild of Second Lieutenant James A. Moss. A native of Louisiana, Moss had graduated from West Point in 1894 and was assigned to the Twenty-fifth Infantry Regiment, an all-black unit with white officers, based at Fort Missoula, Montana. Within a month of Moss' arrival at Fort Missoula in 1895, he received permission from army headquarters to establish the first unit of its kind to test the bicycle as a means of transportation (Dollar 1985). Between July 20 and August 6, 1896, Moss had selected eight men for his Corps and put them through a rigorous training program consisting of 15 to 40-mile bike rides a day. "It would have been hardly possible," Moss observed, "to find a better spot [for the thorough testing of the bicycle for military purposes] than in this . . . region of western Montana where nature places so many obstacles in the way of the cyclist" (Moss 1896, Moss 1897a).

The Trip to Fort Yellowstone

After making a three-day, 60-some-mile practice ride to Lake McDonald near St. Ignatius, Montana, Lieutenant Moss and the eight other members of the Bicycle Corps set out for Yellowstone on August 15, 1896. Moss planned to ride first to Fort Harrison near Helena, Montana, where supplies would be replenished, and then on to Fort Yellowstone at the north end of the park. Often the roads were so rutted and dusty that the only solution was to find the nearest railroad tracks, dismount, and push the bicycles on top of the wooden ties (Moss 1896). To understand just what conditions the soldiers faced, one has only to read a sample entry from Moss's official report:

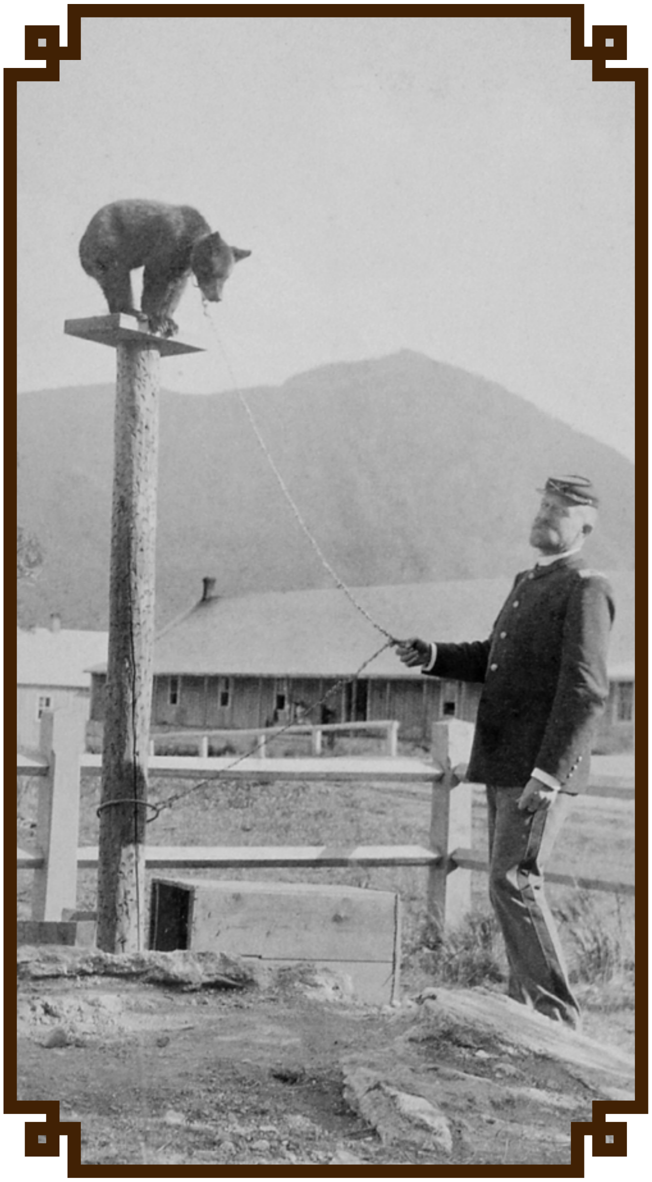
"Left camp 6:18 A.M., Struck a mountain ¾ mi. from camp. Grade quite steep. At 7 o'clock delayed 30 mins. fixing Sgt. Green's gun and knapsack. Reached Avon 9 a.m. At 10 a.m. delayed 5 mins. fixing puncture. 10:10 Forman broke his seat spring. Delayed 10 minutes. 10:55 a.m. delayed 25 mins. fixing puncture. Reached Elliston 11:30 a.m. Stopped here until 1 o'clock, when we left for Helena.

The grade was so steep that we could not ride down—had to roll our wheels the whole way down—had to use brakes until we had cramps in our fingers, to prevent wheels from getting away from us—was, without doubt, hardest work so far on the trip.

At 5:15 stopped 10 mins. to fix puncture. A few minutes later, delayed from 6:30 to 7 p.m. fixing three punctures. Reached Fort Harrison 7:30 p.m. Distance travelled, 44 miles (Moss 1896)."

After eight days contending with stiff headwinds, blazing heat, drenching rains, steep grades, terrible roads, and numerous mechanical breakdowns—as well as a harrowing ride at night over the old wagon road through Yankee Jim Canyon—Moss and his men reached Fort Yellowstone on Sunday, August 23. Moss and his men spent the next two days resting, drawing supplies from the quartermaster, and installing eight new pairs of "puncture-proof" tires on their bicycles. On the morning of August 25, the men began their tour of the park, leaving Mammoth Hot Springs and cycling past Liberty Cap. Moss planned his journey through the park so each day would end at a soldier station—small cabins located at most major junctions along the Grand Loop Road—where there was adequate space for the cyclists to pitch their tents and prepare meals. The first evening was spent in the Lower Geyser Basin at Captain Scott's Camp, a large tent encampment established near the Fountain Hotel and Great Fountain Geyser, that enabled the army to better patrol the park during the summer months (Haines 1997, Moss 1896, Moss 1897a, Schullery 1979).

The Bicycle Corps remained in the Lower Geyser Basin all day on August 26. Early the next morning, they set out for the Upper Geyser Basin where they experienced the thrill of seeing "the Giantess, the Castle and Old Faithful [geysers] all playing at the same time" (Moss 1897a). After departing West Thumb for the Grand Canyon of the Yellowstone on August 28, the cyclists spent their fourth night near the Upper Falls of the Yellowstone. The next morning, Moss led his men along the north rim of the Grand Canyon of the Yellowstone, stopping at Lookout Point, Grand View, Inspiration Point, and other points of interest, including the Lower Falls. Lieutenant Moss made few comments about the return trip to Mammoth Hot Springs, on August 29 except to conclude ultimately the ride through the park had a positive effect on the men: *"The soldiers were delighted with the trip . . . [were] treated royally everywhere . . . thought the sights grand . . . and seemed to be in the best of spirits the whole time. I think the moral effect of the seething water, the roaring of the geysers and the sulphuric [sic] fumes was more conducive to good order and military discipline than a dozen general courts"* (Moss 1896, Moss 1897a).



Captain George Anderson with a black bear cub, circa 1895, Mammoth (Bunsen Peak can be observed in the background). Anderson served in the dual role of Post Commander of Fort Yellowstone and Acting Superintendent from February 1891 to June 1896. While he was extremely dedicated to the principle of preserving Yellowstone National Park and preventing its exploitation, he and other soldiers had no problem with the idea of keeping bear cubs as pets. Courtesy of YNP Archives.

Moss and his men spent August 30-31 resting up after their tour of the park. Although Moss made no mention of any photo session in his report, it seems most likely the famous photographs of the Twenty-fifth Infantry Bicycle Corps posing at various locations on the terraces of Mammoth Hot Springs were taken on one of those two days (Moss 1896). For his superiors, Moss prepared a cursory summary of the Bicycle Corps' overall performance in Yellowstone: "The entire trip through the park, 132 miles, was made in nineteen hours of actual traveling, averaging about 7 miles per hour. Poorest time in the park: 18 miles in 4 hours of actual traveling (between Upper Basin and West Thumb). Best time in the park: 20 miles in 2 hours, riding the first 10 miles in 55 minutes (between Norris Geyser Basin and Fort Yellowstone)." The Bicycle Corps rode out of Fort Yellowstone on September 1, 1896, and began the trek back to Fort Missoula by way of Fort Harrison in Helena, Montana. During the next three days, the cyclists faced stiff winds, muddy roads, and brutal rain. Moss and his men wheeled back into Fort Missoula at 8:00 p.m. on September 8, 1896, having completed a journey of nearly 800 miles (Moss 1896).

The following year, Lieutenant Moss departed from Fort Missoula with an expanded Bicycle Corps of 22 men mounted on improved Spalding bicycles and set out on a trip to St. Louis, Missouri, a journey of 1,900 miles. Moss and his men followed the Northern Pacific Railroad as they made their way east; and while they stopped briefly in Livingston, Montana, they did not return to Yellowstone Park (Moss 1897b). After returning to Fort Missoula by train, Moss made plans to have the Corps ride from Missoula to San Francisco, California, in the spring of 1898 to demonstrate how fast soldiers on bicycles could travel on good roads (Moss 1898). That trip never took place. With the outbreak of the Spanish-American War, Army Headquarters cancelled all further experiments with bicycles. The men of the Twenty-fifth Infantry Regiment marched out of Missoula and were shipped to the Philippine Islands until 1902. Once the conflict ended, soldiers of the Twenty-fifth Infantry did not return to Fort Missoula, but were redeployed to posts in Nebraska and Oklahoma Territory (Nankivell 1973).

Lieutenant Moss did not accompany the Twenty-fifth Infantry to the Philippines; instead he fought in Cuba, having been transferred to the Twenty-fourth Infantry at the outbreak of hostilities with Spain. Moss was awarded the Silver Star for gallantry in action and was later promoted to Captain. During World War I, Moss, by then a colonel, commanded the 376th Infantry Regiment, nicknamed "the Buffaloes" [sic] because it, like the Twenty-fifth Infantry, was made up of black soldiers. Many of the soldiers who cycled with Moss through Yellowstone Park made the U.S. Army their career. They were paid less than their white counterparts and often suffered from the effects of segregation and racial inequality. Even so, the black soldiers earned high praise wherever they served.

For example, after helping prevent violence during a railroad strike in 1894, a Montana newspaper editor described the men of the Twenty-fifth Infantry as follows: "The prejudice against the colored soldiers seems to be without foundation for if the 25th Infantry is an example of the colored regiments there is no exaggeration in the statement that there are no better troops in the service" (The Evening Star 1941, Nankivell 1973).

In 1918, the U.S. Army pulled its troops out of Yellowstone, and the National Park Service, newly established two years earlier, assumed responsibility for controlling and protecting the park. As gasoline-powered vehicles became the dominant form of transportation on park roads, fewer and fewer visitors were seen venturing into Yellowstone on bicycles (Haines 1997). However, the accomplishments of the Twenty-fifth Infantry Bicycle Corps and its amazing ride through the park during the summer of 1896 have continued to capture the public's imagination to this day.

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Wes Hardin spent 30 years managing several historical museums across the country. He received a B.A. from Idaho State University, an M.Ed. from Utah State University, and an M.A. from Wayne State University. He currently teaches history courses at community colleges in Michigan during the winter and works as a park ranger in Yellowstone during the summer. His interest in early cycling in Yellowstone and the 25th Infantry Bicycle Corps grew out of research conducted for exhibits and programs while serving as director of the Historical Museum at Fort Missoula. An article, "Wheeling Through Yellowstone: A History of Early Bicycling in America's First National Park" appeared in the Spring 2014 issue of *Montana: The Magazine of Western History*. Photo by Shauna Bittle, courtesy of The Evergreen State College.

From the Archives

The high-wheel bicycle W. O. Owen used to make the first bicycle ride through Yellowstone Park in September, 1883.

While the Twenty-fifth Infantry Bicycle Corps may be the most famous group of cyclists to wheel through the park, they were not the first to do so. In September, 1883, William O. Owen, C. S. Greenbaum, and W. K. Sinclair became the first men to ride bicycles in Yellowstone Park. The three men hired a wagon and team to haul the party's food, camping gear, and three high-wheel bicycles. Owen and his companions entered the park by the Henry's Fork of the Snake River; and when road conditions permitted, the three took short rides, taking in the sights as they wheeled by (Owen 1891, Dollar 1985). Fifty years later, Owen returned to Yellowstone and donated his nickel-plated Columbia high-wheel bike (left) to park officials.

A LOOK BACK

Early Attempts at Modifying Bear Behavior in Yellowstone National Park

Kerry A. Gunther & Mark A. Haroldson with written descriptions by C.J. Buffalo Jones (undated manuscript) and Olaus Murie (1944)

Portrait of C.J. Buffalo Jones, Yellowstone National Park Game Warden, 1902-1905.

Yellowstone bears spend up to six months hibernating in winter dens without eating or drinking. Because of the long period of fasting and the need to accumulate large fat reserves for hibernation, bears are a very food motivated species for the 3-4 months prior to den entrance. This food motivation combined with their intelligence, adaptability, and omnivore generalist lifestyle, allows bears to quickly learn to exploit new food resources, especially high-calorie anthropogenic foods. Shortly after the establishment of Yellowstone National Park, grizzly bears and black bears learned that people and their camps, developments, and garbage piles provided easy sources of concentrated, energy-rich foods. In addition, many bears became bold enough to break into tents, buildings, and vehicles to obtain anthropogenic foods, often causing considerable property damage and sometimes injuring people in the process. Although lethal removal of food-conditioned bears provided a short-term solution to the problem, many park visitors, staff, and managers were opposed to this strategy and instead sought non-lethal methods to change bear behavior. Aversive conditioning is one method of attempting to modify undesirable behavior in wildlife. In the context of bears in Yellowstone, aversive conditioning is defined as the use of negative stimuli in an attempt to permanently alter a bear's behavior, with the goal to reduce human-bear conflicts. Attempts at aversive conditioning of bears date back to the early history of the park.

During the park's infancy, and prior to implementation of formal bear management programs, there was some informal bear management being practiced (Schullery 1992). Bears that entered permanent camp facilities, where visitors could rent tent-cabins by the night, were sometimes fed meat with broken glass in it or sponges fried in grease (Schullery 1992). These efforts may have been intended to kill the problem bears, or to make them miserable enough (a form of taste aversion) to teach them to stay out of the tent-camps.

One of the earliest formal attempts at aversive conditioning of bears in the park was conducted by Park Game Warden C.J. "Buffalo" Jones. Buffalo Jones was a colorful, old frontier character appointed as Game Warden of the park by the Secretary of the Interior in 1902 (Schullery 1992). Jones' flowery and sometimes biblical descriptions of his duties as Game Warden provide us with interesting

Yellowstone National Park Game Warden Buffalo Jones aversive conditioning a black bear using a willow switch.

insights into his early attempts at modifying undesirable bear behavior. In Buffalo Jones' own words:

When I arrived at the Park, it did not take long to find that the bears were making life miserable for the people who were trying to camp through Wonderland. In fact, they were molesting the hotels and road camps, where the men were stationed to build new roads through the park. Even the old veteran road builder, Mr. Kelly, who had in charge, a hundred or more men, told me in a tremulous voice "either me or the bars has got to git out of the park", and Capt. Waters, who with his family lived at the lake, and had the transportation of passengers across that delightful and picturesque body of water, was tired of his ruffian neighbors of the forest. But the men who suffered the most, at least in feelings, were the men who had charge of the dairies at the various hotels. The bears must have surely migrated from Canaan, where flowed the milk and honey, for their fondness for the one, is only exceeded by their greed for the other, and just as sure as a pail of milk was out of the hands of a milkman, a bear would have his snout in the pail, and if the man dared to interrupt and pressed him to hard, he would seize the rim of the bucket, and scamper off to the woods, and that was the last of the pail, to say nothing of the milk.

Buffalo Jones went on to say…..

The situation was just this: either the bears must be killed, made wild again or the Park must be closed to traffic and pleasure parties. To be sure the last proposition was not to be considered, so either they must be killed or made wild. It would require drastic measures to accomplish this latter measure, for so much affection had been lavished upon them by the maids, they had become very gentle. When it was passed around that I intended to punish the creatures to make them afraid of their friends, I had the whole park up in arms against me. The managers of the hotels said it would interfere with their custom, for the tame bears were one of the chief attractions, and the girls nearly went into hysterics when my plans were known.

Mr. Jones further stated….

I saw that something desperate would have to be done, and I tried pelting the intruding animals with fine mustard shot, thinking to sting them good, and make them shy. This helped a little, but did not prove altogether satisfactory. I then arranged a block and tackle, with ropes over a large limb of a tree, dropped a noose on the garbage heap where the bears came to feed, and when a bear stepped into it, pulled the rope until it was securely about the foot, then with the aid of a soldier or tourists, drew him up until they stood *on two feet and with a smart willow switch, I gave it a severe chastisement. This new method of treatment rather caught the bears unawares and appeared to break their spirit for to be detained against their will is a disgrace to wild creatures and they remember their punishment all their lives and teach their offspring to beware, being sure that every men's hand contains a willow switch and a rope.*

However, by 1905 park management had ordered Buffalo Jones to quit the practice, and he resigned his position as Game Warden shortly thereafter (Schullery 1992).

In the 1940s, bears were still causing considerable property damage and still inflicting injuries on many park visitors; therefore, park managers continued experiments with aversive conditioning to keep bears out of developments. In 1943, wildlife biologist Olaus Murie was assigned the task of studying the life history of the park's bears to provide information to managers that could be used to solve the park's bear problems. In his 1943 progress report on the "Yellowstone Bear Study," Murie (1944) stated:

The bear situation in the Yellowstone is by no means unique. The bear problem is not confined to national parks, but is national in scope. Wherever man enters the bear habitat for any length of time, bear-man relationships are bound to become complex. It is true, however, that this relationship has become most acute in the Yellowstone because of man's long residence there, the great concentration of people, the protection of bears, and the attitude toward the bears assumed by park visitors. But speaking more generally, bears are likely to make themselves familiar whenever they find camps in their domain and are given encouragement by the presence of garbage or unprotected food. The bear problem has appeared in several national parks. Bears also become familiar around lumber camps, or any construction camp in the woods where garbage becomes available.

I have seen published accounts to the effect that many bears became pets at the construction camps along the Alaskan Highway. Thus we have a broad picture of bear reactions, on the basis of nation-wide experience. The outstanding feature, as I see it, is the tendency for bears to become tame and to lose the fear of man when they come in contact with him frequently. Animals in general have this tendency, of course, but some respond more readily than others. The bears seem to lose all fear and reach the point where they are not unduly alarmed when hit with sticks or stones to drive them away, or when shot at, or otherwise harassed by irate campers who have suffered bear depredations. The bear retreats far enough to get out of the way, then goes the rounds seeking new advantages. Tourists have this in common too: They seem to lose all fear of bears. Perhaps there are two reasons for this. Familiarity with bears poking along the highway like bums seeking a hand-out, or coming to the doors in camps eternally seeking garbage, tends to dispel any previous impressions of a heroic or dangerous animal of the forest.

Murie (1944) described an experiment where he used an electronic cattle prod attached to a long pole to administer aversive conditioning to black bears in an effort to get them to stay out of the Fishing Bridge Campground. Murie (1944) stated:

I am convinced that the electric prod held in the hand, or any similar device, is not effective. In fact, any punishment inflicted personally, in such a manner that it is obvious to the bear that a person is involved, is not likely to work. Experience has shown that the bear learns to recognize the particular person or car that administers the shock or other punishment, and he simply avoids that person or car in the future, but does not fear other persons or cars."

Murie concluded it was very difficult to drive bears off once they had acquired the habit of seeking garbage near human dwellings. After studying the food habits of grizzly bears and black bears in the park, Murie (1944) concluded:

There is ample natural forage for bears and that garbage is not required to support the bear population. It is further concluded that although the bear is largely a vegetarian, it has a strong desire for meat and foods included in garbage and that its actions are unquestionably influenced by the presence of such food resources. It is pointed out that the bear is a shrewd, unusually resourceful animal, easily adaptable to many situations, easily tamed in the presence of men, and that therein lies our problem. Another fact enters the problem—misconceptions in the minds of tourists, their assumption that the park bear is a harmless or semi-domesticated animal. Driving bears away, inflicting punishment on them personally, are no permanent help. Electronic devices have proven fairly successful, when operated automatically and dissociated from the presence of man. It is planned to continue food habits studies, with special attention to spring and early summer, and the relationship with elk in the calving season. It is also planned to experiment with electric devices on garbage cans and car windows as deterrents in special cases, to cure certain individual bears of their raiding habits. It is recommended specifically to produce a bear-proof garbage container as the first step, and obtain full cooperation of the concessionaire, prior to any intensive program of enforcing regulations on tourists.

By the mid-1970s, the park had successfully solved most of its bear problems associated with bears conditioned to human foods, and aversive conditioning was no longer necessary. However, by the early 1980s a new management challenge had surfaced. Bears that were habituated to people but not conditioned to human foods, began foraging on natural foods in roadside meadows in close proximity to park visitors (see "Habituated Grizzly Bears: A Natural Response to Increasing Visitation in Yellowstone and Grand Teton National Park," this issue). Some bears even became habituated enough to feed on natural foods within park developments. With this new challenge and in an effort to prevent bear-jams and associated traffic congestion, aversive conditioning resurfaced as a potential method to keep bears from foraging in roadside meadows during daylight hours. In addition, aversive conditioning was used to teach bears, even those not seeking human foods, to stay out of developed areas.

In the 1980s, the park began deploying what was referred to as the "Bear Thumper Gun." The Bear Thumper Gun had a 32 mm bore and used a black-powder charge to fire 1 1/4 x 3 inch plastic bottles filled with 30 cc of water, making a 602 grain projectile. The load traveled about 144 meters per second with 300 foot pounds of energy. The bottles had a wide surface area and collapsed upon impact. The theory was to inflict pain on bears without risk of penetration, injury, or death. The Bear Thumper Gun was used in combination with a portable public address (PA) system that played taped calls of California quail (*Callipepla californicus*, a species not found in Yellowstone). The idea being that bears would associate the quail call with the pain inflicted by the Bear Thumper Gun, so they could eventually be made to leave the roadside or development simply by playing the quail call. Driving through the Bridge Bay Campground, with the call of the California quail blaring over the PA system, most visitors went about their normal business of setting up tents, grilling burgers, etc., without taking any notice of the quail call at all. Of course, most visitors probably did not know that California quail were not found in Yellowstone, so the quail call probably sounded perfectly wild and natural to them.

Using black powder in the Bear Thumper Gun required that the reloadable shell casings and barrel be cleaned frequently to maintain accuracy. Unfortunately, even with a clean barrel the Bear Thumper Gun was only accurate out to about 20-25 yards. If lucky, one might hit a bear at 30 yards—beyond that range you could not expect to hit much. In addition, the black powder left such a large cloud of smoke it was difficult to tell whether a bear had been hit at all. Regardless, when feeding on natural foods along roadsides, bears learned to move just out of range (35-40 yards) anytime the Bear Thumper Gun was pulled from the truck. Bears seemed to recognize park vehicles, uniformed park staff, and the distance at which the Bear Thumper Gun could be effectively fired. Bears also appeared to have a much greater pain threshold and tolerance to hazing than the park had staff and budget to counteract (hazing must be consistently implemented during teachable moments to be effective). Bears had beaten yet one more attempt to modify their behavior.

At the present time, a combination of 12-gauge shotgun-fired cracker shells, bean bag rounds, and rubber bullets are used to haze bears out of park developments. With consistent application, the park has had some success at teaching individual bears to skirt around developments rather than walking through them. The success is likely attributable to several factors, including: 1) providing bear-proof food and garbage storage in park developments, therefore eliminating anthropogenic attractants that lure bears into developmented areas; 2) trained personnel are usually present and able to quickly respond to haze bears out of developments, allowing the consistent application of hazing that is critical to modifying bear behavior; 3) developments have somewhat distinct geographical boundaries (pavement) identifiable to bears and staff, allowing for hazing to be consistently applied; and 4) developments are areas of concentrated human activity with associated noise and odor, therefore reducing the attractiveness of these areas to bears. Bears are no longer routinely hazed from roadsides because teaching bears to avoid miles of roadside habitat containing abundant natural foods cannot be implemented on a consistent basis and is cost prohibitive. In addition, because the food reward cannot be eliminated, hazing has not been effective at teaching bears to avoid roadside habitat.

Aversive conditioning is not a solution to habituation or food conditioning in bears. It is simply another tool, secondary to visitor education, food storage, and enforcement of regulations for food storage and wildlife approach distances. The dilemma for park managers is how to balance the needs of bears with the expectations of park visitors while providing for the safety of both, and at the same time remaining within fiscal constraints. The next challenge for park managers is to find innovative, cost-effective ways to manage the large numbers of visitors who want to view, photograph, and experience bears, or to develop cost-effective methods to prevent habituation in the face of ever increasing park visitation. In the meantime, highly intelligent and remarkably adaptable grizzly and black bears are habituating and learning to coexist in close proximity to people, so they can survive in a landscape that is increasingly dominated by humans.

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Grave Digger Bear

Kerry A. Gunther, Travis Wyman, & Susan Chin

On August 20, 2002, the Bear Management Office received a call that a black bear was digging up graves at the old Mammoth Cemetery near the Xanterra Horse Corrals. It was reported that the bear was pulling something out of the graves, possibly bones. Bear Management Office personnel responded to the cemetery and observed a large black bear digging into the grave mounds. Closer inspection revealed that red squirrels had cached limber pine cones in small cavities in the grave mounds, and the black bear was digging up the squirrels' middens to consume the cones that had been stored inside. When the graves had originally been dug, the extra dirt that had been displaced by the coffins had been placed on top of the graves creating a mound of dirt over the caskets. It appeared that the coffins now had rotted away causing some of the dirt in the mounds to cave-in, creating small cavities that red squirrels were now using to cache cones. The black bear was digging out these small cavities in an effort to eat the cones stored inside.

Fortunately for Frank Welch, red squirrels had not cached any cones in his grave, saving him the indignity of being both killed, and later dug up, by bears. Frank Welch was a wagon teamster who had the unenviable distinction of being the first person in YNP to have been killed by a grizzly bear. After being killed by the bear along the East Entrance Road in 1916, he was buried in the Mammoth Cemetery. His grave was just a short distance from the graves that were being dug up by the black bear.

Although this year's crop of whitebark pine was a near total failure, there was an abundant crop of limber pine cones. Both whitebark pine and limber pine are present in YNP. Both whitebark pine and limber pine are five-needle pines that produce cones containing large seeds that are eaten by birds and mammals. Due to its abundance and wide distribution throughout YNP, whitebark pine is an important food for some wildlife, especially grizzly and black bears. In contrast, limber pine is not very abundant in YNP and has a fairly limited distribution. Limber pine is most abundant in the area within and surrounding the Mammoth developed area. Limber pine has also been planted as an ornamental in the Mammoth developed area and campground. In years when limber pine produce an abundant cone crop, it is not unusual to have bears coming into the Mammoth developed area and campground to feed on the cones. Although limber pine seeds benefit bears nutritionally, they also attract bears into the Mammoth developed area and campground resulting in bear-human conflicts and subsequent management actions.

NOTE: This story originally appeared in *The Buffalo Chip*, an in-park newspaper that is no longer published, in October 2002.

A DAY IN THE FIELD

An Underdog's Story

Sarah Haas

There is little to compare with spending a day in Yellowstone's backcountry. By departing the busy roadways and parking lots and entering into the wildness of open space, the true personality of Yellowstone can come to life. That's how I spent a perfect day in June—roaming the sagebrush of the northern range with the NPS Greater Yellowstone Network Inventory and Monitoring crew. Our goal was to locate a cluster of wetlands and small pockets of habitat that support elusive, highly camouflaged creatures beneath the shadows of Quadrant Mountain.

Yellowstone, though famous for hydrothermal features that shoot water into the air, is not known for its wetlands or amphibians. There is a reason for that. Both are quite rare in the park; and if you're not looking, you can easily miss them. Representing less than 3% of the total land area within the park, wetlands (including ponds, wet meadows, and marshes bordering lakes and rivers) are uncommon. For amphibians, life in a limited, widely dispersed resource can be tough.

There are five native amphibian species documented in the park: Columbia spotted frog (*Rana luteiventris*), boreal chorus frog (*Pseudacris maculata*), western tiger salamander (*Ambystoma mavortium*), boreal toad (*Anaxyrus boreas*) and, most recently, a single sighting of a spadefoot toad (*Spea bombifrons*) added one more to the species list. The boreal chorus frog appears to be the most common and widespread throughout the park, but likely remains undetected by almost all visitors except in the spring when the chorusing of these tiny frogs can be heard near wetlands. Dependent on wetlands for completing a successful life cycle, the chorus frog and all of the park's amphibians are linked to the fate of a resource in decline; and population monitoring is revealing this correlation in troubling trends.

Wetland and amphibian monitoring has been conducted annually in the park for nearly 15 years through collaborative efforts by the NPS, U.S. Geological Survey, university, and non-governmental cooperators. Monitoring results indicate amphibian populations are vulnerable to

regionally detected climate trends of increasing temperatures that contribute to declines in annual snowpacks and runoff. This combination of hotter, drier conditions leads to the drying of wetlands and ponds. If continuous drought conditions are added to the mix, the result may be the loss of wetlands and displacement or local extirpation of the multitude of species that rely on them for survival.

Add disease agents such as ranavirus and chytrid fungus to the equation (both detected within the park) which can also affect survival and reproduction, and it becomes clear that amphibians are a vulnerable species on many levels. Amphibians have been identified as a native species "vital sign" for monitoring, due to their role as indicators of ecosystem health from threats such as pollution, habitat loss, and climate change. Keeping a close eye on wetlands and their amphibian populations may assist park managers with answering multiple questions about the status of the Yellowstone environment, and offer insight on the trends of habitats and species that are vulnerable to even subtle environmental change.

A committed fan of the underdog, I was happy to participate in searching for a class of animals that have so many factors weighing against them. The method of detection is fairly simple, yet requires a trained eye and attention to detail. Dr. Andrew Ray was the organizer of my day in the field. As an aquatic ecologist with the NPS Greater Yellowstone Inventory and Monitoring team, Dr. Ray is the program lead who coordinates with collaborators and monitoring crews every season to monitor Yellowstone and Grand Teton national parks' wetlands and amphibian populations. Measurements on the size, depth, and water temperatures of each surveyed wetland are gathered along with a description of the vegetation composition of each survey area. A team of at least two surveyors independently circle the water body and regularly sweep pond water using a net. Contents of the net are then examined for signs of amphibian life: egg, larvae, and metamorphic forms of frogs, toads, and salamanders. Adults are also documented, but move away from wetlands after breeding and are therefore more difficult to detect than their early life stages.

We were fortunate that field day in June. We found all the species in the remote wetland sites that were previously detected, marking another season where the "present" box could be checked on the data forms. The future is not so certain though, and existing populations can quickly turn to "previously occupied" within a matter of one or two years. Keeping track of what we have on our public lands can be a double-edged sword. We are often in the business of monitoring loss, rather than the preservation of ecosystem integrity. Underdogs, however, should never be written off; even if they don't win the race, they can teach us valuable lessons. This is a race worth watching.

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For more information on amphibians in Yellowstone and monitoring efforts in the Greater Yellowstone Ecosystem:

go.nps.gov/yellowstoneamphibians
go.nps.gov/amphibians

Sarah Haas is the Science Program Coordinator at the Yellowstone Center for Resources. She attempts to maintain field skills by tracking salamanders, frogs, and other wildlife in Yellowstone. She consistently roots for the underdog, so is a good person to engage in a friendly wager.

NEWS & NOTES

Farewell to a Friend

On April 22, 2015, Dr. Lester Lee Eberhardt passed away at the age of 91. Dr. Eberhardt co-authored numerous peer-reviewed papers while working with former Interagency Grizzly Bear Study Team leader Dr. Richard Knight on grizzly bear demographics in the Greater Yellowstone Ecosystem. He also worked closely with National Park Service biologists on predator-prey dynamics and the effects of wolf restoration to the ecosystem. Dr. Eberhardt was world-renowned for his pioneering work on the demographics and population dynamics of grizzly bears, marine mammals, ungulates, wolves, and other long-lived vertebrates. Like grizzly bears, he was a survivor of large-scale change, including the Dust Bowl, the Great Depression, World War II, and political battles over grizzly bear conservation and habitat protection. Dr. Eberhardt was a mentor to many biologists working in the Yellowstone area, and he will be sincerely missed by all his friends and colleagues in the world of ecology and wildlife management.

Dr. Lee Eberhardt, husband, father, grandfather, outdoorsman, scientist, and friend, born October 15, 1923, died April 22, 2015.

Two Grizzly Bear Patriarchs With Long Study History Pass on in 2014

Mark A. Haroldson & Frank T. van Manen

The grizzly bear research conducted in Yellowstone National Park and the surrounding ecosystem is one of the longest ongoing studies of a large carnivore in the world. The study team began capturing and radio-collaring individual bears in 1975, and the effort has continued annually through the present. As a result of the long duration of the study, researchers have developed extensive histories for numerous individual bears. These histories document when and where individuals were captured and the circumstances surrounding those events, when females had offspring and how long the young stayed with their mothers, and ultimately when bears died and the circumstance of their deaths.

This past year (2014), the study team documented the death of two male bears with long and fascinating histories. Their passing is of note because both were originally transported into the park after management captures for sheep depredations.

Bear #155 was transported to the Blacktail Deer Plateau from the Caribou-Targhee National Forest as a 3-year-old bear in September 1989. He continued to reside in the park after his release and was radio-monitored in 10 of the next 26 years, during which he traveled in the northern or center portions of the park. During the fall of 2014, at the old age of 28, he was captured and euthanized after breaking into an out-building and obtaining food rewards at a residence north of the park. The age of this bear was close to the oldest recorded age in the Greater Yellowstone Ecosystem, which was a 31-year-old male.

Bear #281 was transported to Yellowstone National Park after being captured for killing sheep near Pinedale, Wyoming, in 1996 at the age of four. Like bear #155, #281 continued to reside within the center portion of the park and was radio-monitored during 11 of the next 18 years. During early June 2014, bear #281 was observed in poor condition near Mud Volcano. Park staff and visitors watched the 22-year-old male bed down under a tree on June 3. On the morning of June 4, he was found dead in the same bed. Upon examination, park staff observed several deep wounds on his shoulders and back near the spine that were likely caused by a fight with another bear. These wounds likely contributed to his poor condition and death.

Both bears came to the park under similar circumstances, and both had a long life without much in the way of additional conflicts with humans. There are few places left in the world where large carnivores do that, but Yellowstone National Park is one of those places.

Grizzly Bear #155, when captured on 10/01/04, weighed 641 pounds and had 41% body fat.

Grizzly bear #281, in his daybed in Hayden Valley where he succumbed to complications of old age and wounds likely inflicted by another bear.

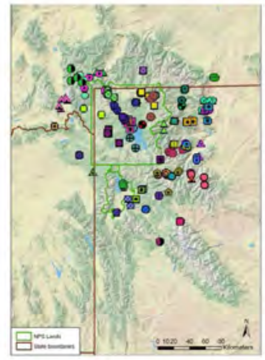
Photo © Jennifer Morey

Leucistic Elk Observed in Yellowstone

Sarah Haas

In May 2015, hikers in Yellowstone's northern range encountered a rare sighting. A cow elk with a white coat was observed in a small herd foraging along a hillside. The cow elk, full grown and apparently healthy, was likely leucistic—a form of coat irregularity caused by a lack of melanin production due to a rare recessive genetic trait. Unlike a true albino, where a complete lack of melanin pigment exists, leucism results in a washed-out appearance but does allow for some coat coloration. It is rare to encounter wildlife with either leucism or albinism, as those individuals are generally removed from the population—they are usually easy prey for predators. However, some populations of leucistic animals can survive quite well when afforded conservation protection, passing on their recessive trait to multiple generations, such as the famous white lions of Timbavati in South Africa.

The rare sighting of this leucistic cow elk in Yellowstone demonstrates genetic mutation can and does occur world-wide, even in protected areas like a national park. The hikers who watched this unique individual reported that the leucistic elk seemed to be more vigilant than the rest of the herd, apparently noticing the hikers before the other elk in the group. She also tended to stay in the center of the herd, a behavior possibly learned over time to protect herself from predators due to her more obvious appearance. These sightings are of value to park managers and can be early alerts to the health of park wildlife. Please inform a park ranger if you notice odd behavior or appearance of any wildlife in the park—citizen science is a valuable tool for a 2.2 million acre management area!



Females with cubs observed in 2013

Record High Number of Female Grizzly Bears with Cubs in 2013

Mark A. Haroldson & Frank T. van Manen

The Interagency Grizzly Bear Study Team, composed of grizzly bear managers and researchers from both state and federal agencies within the Greater Yellowstone Ecosystem, is responsible for monitoring grizzly bear population trend. One method used by the study team to monitor trend is to track numbers of unique females with cubs-of-the-year (i.e., cubs) observed annually. Females with cubs represent the important reproductive segment of the population. Females produce cubs on average about every three years, so a three-year sum approximates the number of breeding or reproductive females in the population. To accomplish the count, team members compile sightings of females with cubs from annual survey flights and ground-based observations. Next, a "rule set," based primarily on distances between sighting and numbers of cubs in the family, is applied to produce a conservative estimate for the number of unique females with cubs observed. Results vary annually, but there has been a positive trend for the ecosystem since the mid-1980s, with a general leveling off starting in the early 2000s. However, results for 2013 were the highest count to-date, with an estimate of 58 unique females with cubs. For comparison, 49 unique females were identified in 2012 and 50 unique females observed in 2014. The three-year sum from 2012 to 2014 resulted in a total of 157 adult female grizzly bears living in the GYE. The record number of female grizzly bear sightings and the unique families derived from them were well-distributed throughout the ecosystem in 2013, with 15 females with cubs observed within Yellowstone National Park. The long-term average for females with cubs for Yellowstone National Park is 11, with high counts occurring in 1986 (n = 20), 2000 (n = 20), 2004 (n = 22), and 2010 (n = 20).

Some Bears Emerge from Dens Early in 2015

Kerry A.Gunther

Data from radio-collared bears indicate a small proportion of Yellowstone bears emerge from their dens in early February (figure 1). However, the first observed bear activity of the year is typically not reported until the first week of March, after many adult male bears have emerged from dens to feed on winter-killed ungulate carcasses and succulent emerging spring vegetation. This past winter some bears were observed out of their dens several weeks earlier than what is typical. The winter of 2014-2015 was unseasonably warm with above average temperatures and below average snowfall at elevations under 8,700 feet. At elevations under 7,350 feet, spring snowpack was well below average, due to extremely warm temperatures from mid-March through April. On January 25, a black bear was observed in the Bridger Mountains north of Yellowstone National Park; and on January 27th, grizzly bear tracks were observed near Pahaska Teepee, Wyoming, east of the park. On February 1st, a bear track was observed in the Beattie Gulch drainage, just north of the park boundary at Reese Creek. The first bear activity observed in Yellowstone National Park was a grizzly bear scavenging a bison carcass near Mud Volcano on February 9th. Over the next several days, this bear was observed by park visitors traveling by snowmobile and snow-coach through the park. Although a few bears emerged from dens earlier than typical (possibly because of warm temperatures, melting snow, or availability of food), many bears remained in their dens and emerged at dates more typical for their species, sex, and age class.

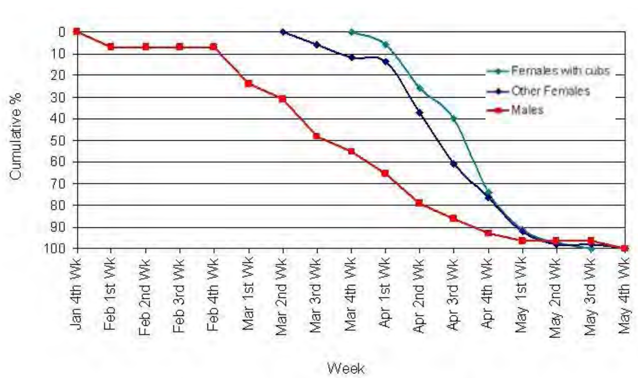


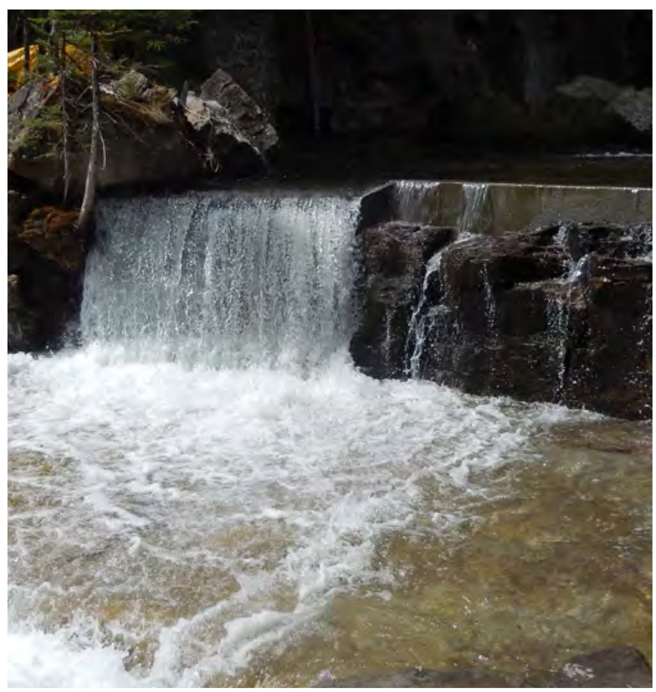
Figure 1. Cumulative percent of radio-collared bears emerged from dens by week, in the Greater Yellowstone Ecosystem, during 1975-1999 (from Haroldson et al., 2002, see page 45).

Westslope Cutthroat Trout and Artic Grayling Restored to Grayling Creek – Part I

Erik Öberg

With the tip of a bucket, eight years of planning and preparation delivered hundreds of native trout to their new home. In April, 2015, staff from Yellowstone Center for Resources and Montana State University worked together to capture, transport, and release 680 westslope cutthroat trout (WCT; *Oncorhynchus clarkii lewisi*) from Geode Creek on Yellowstone's Blacktail Plateau to Grayling Creek near West Yellowstone.

Initiated in 2007, this project required many elements to result in a successful outcome. Genetics Labs, Inc. in Idaho and Montana helped Yellowstone fisheries biologists identify a 100% genetically pure population of WCT in Geode Creek. Grayling Creek, with over 30 miles of connected tributaries was ideal habitat, had predatory, non-native brown trout (*Salmo trutta*) and hybridizing rainbow trout (*Oncorhynchus mykiss*) that needed to be removed for successful WCT reintroduction. Drainages were mapped, an environmental assessment was approved, non-native trout were removed with piscicides, and a fish barrier waterfall was modified to prevent the return of unwanted species.



Special thanks to the **Yellowstone Park Foundation** in recognition of their commitment to scientific research in Yellowstone National Park, and who generously funded this project.

Moving fish is not easy. A team of biologists combed through pools and pocket water of Geode Creek, using backpack mounted electro-shockers to net all 680 fish, one or two fish at a time. Steep terrain and the need to keep fish cool and oxygenated required many arduous trips to transport fish in coolers fitted with aerators to downstream holding cages. Once the target number was captured and counted, the fish were ready for the trip to Grayling Creek. The WCT were placed in a large transport tank and driven to six release sites along Grayling Creek. Snow was added to the tank to keep the water temperature as low as possible to reduce stress on the fish.

With less than 4% mortality and rapid dispersal upon release, the WCT appear to be off to an excellent start in their new habitat. Now begins the work of monitoring to determine if long-term success of the project can be achieved. WCT and Artic grayling (*Thymallus arcticus*) eggs were brought to the Grayling Creek drainage later in the summer of 2015 to restore its namesake fish. Especially for graylings, eggs incubated on-site imprint and acclimate more successfully than fish released from lakes or hatcheries. If the project succeeds, this will be the only fluvial (or river) grayling population in Yellowstone and one of only a handful in the lower 48 states. The first phase of this restoration project is now complete.

Review of **"Large Carnivore Conservation: Integrating Science and Policy in the North American West"**

Editors: Clark, S.G., and M. Rutherford. 2014. Large Carnivore Conservation: Integrating Science and Policy in the North American West. University of Chicgo Press, Chicago, IL, USA.

Reviewed by: Nathaniel R. Bowersock

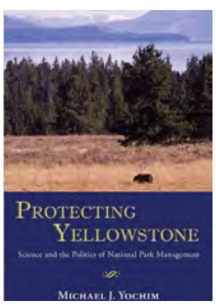
"Creating a sustainable future depends on changing or adjusting currently unsustainable perspectives and damaging practices to be more realistic and adaptive. This is one function of sound decision making."

One of the biggest struggles a wildlife biologist faces is trying to communicate with the public about the scientific research conducted to inform sound management decisions. However, understanding the values of local people when formulating these decisions plays an even bigger role in whether or not these decisions are supported once implemented. In Large Carnivores Conservation: Integrating Science and Policy in the North American West, six case studies are presented that discuss the successes and failures of wildlife biologists trying to conserve large carnivores in North America while balancing the needs of the local communities. As stated in the book, "good science is important for wildlife management, [but] the best science cannot resolve value-based disputes."

Not only can wildlife be unpredictable and challenging to manage, but incorporating the human dimension component into conservation efforts can result in obstacles toward success. Some of the case studies presented in the book highlight the challenges of being an effective wildlife manager today. In the case of trying to rehabilitate mountain lions in the American Southwest, local politics were used to undermine the management set forth by wildlife biologists. Biologists tried to use science to prove why their management decisions were positive for both mountain lions and the public; but local fears and concerns outweighed science-based information, and poor mountain lion management was implemented. In another case, biologists trying to manage grizzly bears in the Yukon of Canada found the bear population was in a decline and that new management actions were necessary. However, local people did not like the way biologists were conducting their research because the local people felt the methods were disrespectful to their values. This led to a lack of local support of the research findings and management choices being promoted.

On the other hand, in the cases of managing wolves in southern Alberta and grizzly bears in central Montana, wildlife biologists were more successful in communicating their ideas and assessing the values of the local people, which resulted in positive management of large carnivores. Both communities in these cases relied on livestock for a living and were concerned about the expansion of large carnivores into their communities. In both cases, the biologists reached out and involved the local ranchers in the management decisions from the beginning. Both projects also established goals that reduced carnivore-livestock interactions and had flexible management plans that could be adjusted due to dynamic circumstances. These two stories highlighted the importance of how integrating the values of the local community with sound management decisions can provide the public with regulations that most people can accept in order for carnivore populations to prosper.

This book is a great resource for wildlife biologists working to conserve large carnivores or any other species of conservation concern. Science is an important tool that should be used to make sound management decisions; but without the consideration of local views or values of wildlife, proper management generally is not successful. The case studies presented in this book provide helpful insight into the many factors biologists need to consider when making management decisions. Additionally, this book is a wonderful way for the public to understand how and why wildlife biologists make daily decisions in their various fields working with a wide spectrum of species. The book's main message is that the management of carnivores will vary with local community values; but with proper communication, an understanding about management choices can be achieved that will allow people and wildlife to coexist.



Review of **"Protecting Yellowstone - Science and the Politics of National Park Management"**

Yochim, M.J. 2013. Protecting Yellowstone - Science and the Politics of National Park Management. University of New Mexico Press, Albuquerque, NM, USA.

Reviewed by: Sarah Haas

For national parks such as Yellowstone, with a complex history, large size, and public popularity, the spotlight on decision making and resource management actions can often be intense. There have been several large-scale and long-lasting debates throughout the park's history that have resulted in not only internal policy making, but had ripple effects throughout the National Park Service.

In his book, *Protecting Yellowstone - Science and the Politics of National Park Management*, Michael Yochim takes a closer look at several of the park's major controversies since the 1980s. The issues range from conflicts over development planning to predator reintroduction. The author selected six major topics to illustrate that even in the same park, during the same era of NPS policy, the outcomes of management decision making can be framed, constrained, and shaped by public values, stakeholder interests, politics, and a variety of pressures on park managers that sometimes have a limited connection with the actual problem being addressed.

The book admirably synthesizes six controversies into abbreviated summaries of key events, turning points, and outcomes. Within the confines of 184 pages, the book cannot present an in-depth analysis or the full spectrum of each controversy. However, the author effectively uses interviews with park staff and extensive reviews of park historical documents to frame issues and present his analyses on why the outcomes of these controversies varied widely and which forces were most influential. In the end, the author suggests that the success, or failure, of the park's ability to implement desired management actions hinges on two determinants: politics and the scientific research backing the decision making. Central to this is the ability of park managers to form supportive coalitions with external stakeholders.

Yellowstone will continue to face challenges in natural and cultural resource protection, public visitation and safety, budgetary constraints, among other issues. The park is still wrestling with some of the issues presented in *Protecting Yellowstone*, with bison management the most notable continuing challenge. The author recommends three main strategies for successful policy-making: commitment to scientific research, allowing for sufficient time to build coalitions and resolve differences, and advancing strong visions toward preservation. Park leaders have undoubtedly utilized these, and other, strategies over the years, at times more successfully than others. Yochim's book shines a light on a few of the key challenges faced in the park's recent past with a message to learn from history in order to continue the mission of protecting Yellowstone.

SNEAK PEEK
Coming Up in *Yellowstone Science*

Douglas W. Smith

Bringing Wildness Back: Reflections on the Reintroduction of Wolves in Yellowstone

Like grizzly bears, wolves lived across huge swaths of North America, as well as Europe, Asia, and the Middle East, making them one the most widely distributed mammals. In a matter of a few centuries, humans reduced the majority of this extensive world-wide range and population. An obligate carnivore, humans initially respected the wolf as a hunter, sometimes patterning our ways after them, and occasionally respecting them with religious awe. For some cultures this is still the case.

About the time of the agricultural revolution 10,000 years ago, things changed. With the domestication of some wildlife into livestock, their natural defenses against predators were bred out of them to ease coexistence with humans—animal husbandry—and wolves took advantage of it. Livestock was easy prey, and the truce between wolves and humans ended. Wolves were killed. The killing was limited until the advent of steel for making traps and recipes for poisoning took hold in the mid-1800s. With this technology wolves were wiped out from large areas across Asia and virtually all of Europe and the continental United States, except for a thin sliver of northern Minnesota. The only thing that protected them was remoteness. As Teddy Roosevelt, an early Yellowstone advocate, said, "They were the beast of waste and desolation." Early park policy in Yellowstone was to kill them, and superintendents regularly reported on the annual kill count. The last wolf was killed in the park in 1926.

This enthusiasm to exterminate has rarely been equaled. Wolves were thought to directly oppose civilization and the manifest destiny mindset of the time. They were killed with near religious fervor—sometimes tortured or captured and released without a lower jaw. It is a wonder there is any place they survived. Once the airplane came along, it too was used to penetrate any protection remoteness offered.

The 1950s probably saw the low ebb of wolf numbers world-wide. Around this time some of the zeal to kill abated, and too, imperceptibly, human attitudes softened. Some bounties survived into the 1960s, but wolves had been eliminated from most populated areas by this time so it escaped our attention.

With a break from the elimination pressure, wolves crept back. First quietly populating the remote regions, and with poison mostly banned, they had a chance. Some people even spoke out in their favor, but this was not more than a very few until the 1960s. Around this time the vast depopulation of a species was acknowledged, and some wondered about its impacts. Virtually nothing was known about this animal, and it was gone before we knew what it did. Some early visionaries, in both the U.S. and Canada, pondered this and initiated studies in the late 1950s. Set in parks, there was an appreciation that predators may have served a purpose. Concerns also began to surface about burgeoning numbers of ungulates and their impact on the environment. Adolph Murie, a researcher in Yellowstone and Denali national parks, documented Isle Royale National Park without wolves—too many moose and the forest declined. This was dire enough that park officials attempted a reintroduction in 1952. This effort failed, but unbeknownst to park officials wolves came back themselves across Lake Superior ice in the late 1940s. Durward Allen saw the opportunity and started a study in 1958 that runs to this day—the longest of its kind. Much of the work is landmark due to its length and has led to difficult-to-acquire insights about how nature works with wolves. A sister study in another park in Ontario, Canada, began in 1959 with Douglas Pimlott. It too has run almost continuously to this day.

Together these studies improved our understanding of wolves and spawned other studies—many other studies. But with stacks of studies, the struggle remained on how to live with them. Knowledge led to some understanding and appreciation, but not in the hearts and minds of many. Some still felt wolves should be relegated to the unpeopled lands. It is with this backdrop that Yellowstone steps in during the mid-1990s even though Yellowstone is not unpeopled. We sit in the middle of the lower-48 with millions of people coming to the park each year.

With rare public profile, wolves returning to the world's first national park got a lot of attention. The questions "What good are they?" and "Should we do this?" became more significant than ever. Yellowstone was a ground zero. Powered by the Endangered Species Act (ESA) and National Park Service policy, but also because many people supported it, reintroduction was approved to move forward.

The question remained "How do we do this?" – natural immigration like what happened near Glacier National Park or reintroduction? Yellowstone is more isolated than Glacier. Although large with the surrounding public land, it's essentially not ecologically connected to anything. Some feared the overt action of reintroduction sponsored by the federal government would be equated to "cramming wolves down our throat." They were right. But the reintroduction in Yellowstone was able to relax some of the stringent regulations of the ESA, like livestock protection, which was a key provision.

So wolf reintroduction won out and played out with the world watching. In the winter of 1995, with much fanfare, 14 wolves were reintroduced to Yellowstone and 20 to central Idaho from a source population in Canada. What happens next stops here and begins in the next issue of *Yellowstone Science*!

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SPECIAL THANKS

to the talented photographers who donated their work for this issue: Bradley Orsted, Michael "Nick" Nichols, Fin Keleher, Ronan Donovan, MacNeil Lyons, B. Scates, Matt Lundin, Josh Westerhold, P. Potter, Jeff Bittner, and Connie Moisson.

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Support for *Yellowstone Science* is provided, in part, by the Yellowstone Association and the Yellowstone Park Foundation.

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Bear watching en route to the chapel in Grand Teton National Park.

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