Chapter 4

Understanding Grizzlies: Science of the Interagency Grizzly Bear Study Team

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Chuck Schwartz is a very lucky man. Over the course of three decades he has worked with grizzly bears in Alaska, Russia, Pakistan, and Japan and he has never had a serious accident. Good technique helps. Chuck is the leader of the USGS Northern Rocky Mountain Science Center Interagency Grizzly Bear Study team based in Bozeman, Montana. His group conducts the long-term research and monitoring of grizzly bears in the Greater Yellowstone Ecosystem. Before coming to Montana, he worked for the Alaska Department of Fish and Game for more than 20 years conducting research and providing management recommendations on moose, brown, and black bears. As a member of the IGBST, Mark Haroldson has studied the bears of Yellowstone for over 30 years; probably no one knows the population as well as he does. Kerry Gunther is Yellowstone's bear management biologist. When human-bear conflicts occur, Kerry is the guy who deals with it. He has worked in the park for over 25 years.

The history of the region is bound up with the grizzly. Frank and John Craighead began a long-term research program of the bear in 1959 and developed techniques to capture and track large animals. They pioneered the use of radio telemetry and early satellite imagery data.

Between 400 and 600 grizzlies are spread across the Greater Yellowstone Ecosystem. Their range and low density makes them a particularly difficult animal to study. Grizzly bear demographics, particularly the role of human caused mortality, is central to the mission of the IGBST. The most important demographic group is females with cubs; they add to the stock of bears and therefore are critical to the recovery and sustainably of the population. The passion Chuck holds for the bears is obvious in his writing and in a career dedicated to knowing "the Great Bear".

J. Johnson



Yellowstone Grizzly Bear (Steve Hinch)

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The grizzly bear** (ursus arctos horribilis) **inspires fear, awe, and respect in humans to a degree unmatched by any other North American wild mammal. Along with other bear species, it has the capability to inflict serious injury and death to humans and sometimes does.

In the Greater Yellowstone Ecosystem, some grizzly bears live in areas visited by crowds of people or near human settlements. Here, the presence of the grizzly remains a physical and emotional reality. A hike in the wilderness that includes grizzly bears is different from a stroll in a forest from which grizzly bears have been purged; nighttime conversations around the campfire and dreams in the tent reflect the presence of the great bear. Contributing to the aura of the grizzly bear is the mixture of myth and reality about their ferocity, unpredictable dispositions, large size, strength, huge canines, long claws, keen senses, swiftness, and playfulness. Bears share characteristics with humans. They have a generalist life history strategy like extended periods of maternal care and, and omnivorous diets. They are highly intelligent, learn quickly, and have long memories.

The dominance of the grizzly in human imagination played a significant role in the demise of the species. Conquest of the western wilderness seemed synonymous with destruction of the great bear. Prior to European settlement of North America, grizzly bears could be found from northern Alaska south through Canada and the western United States and into northern Mexico. In the contiguous United States, habitat was altered or destroyed and important bear foods like salmon, elk, and bison were greatly reduced by dam building, market hunting, and competition with livestock. Primarily during the 1920s and 1930s, the grizzlies' historical range decreased nearly 98%. Of the 37 grizzly bear populations known to exist in 1922, 31 were gone by 1975. In the West, grizzly bears were poisoned, shot, and trapped to reduce depredation on domestic cattle, sheep, and poultry. A stockman captured the prevailing attitude in the 1920s: "The destruction of these grizzlies is absolutely necessary before the stock business...could be maintained on a profitable basis.".

Yellowstone National Park (YNP) was established in 1872 to protect the area's geysers, thermal features, and scenic wonders. However, due to its remoteness and the protections afforded by national park status, it also became one of the last refuges for grizzlies in lower forty-eight states. Grizzly and black bears became one of the parks most popular attractions. By the 1880s park visitors enjoyed watching bears that gathered to feed on garbage dumped behind the hotels. As early as 1907, park staff were killing some black and grizzly bears because of conflicts with people. By 1910, black bears had learned to panhandle for food from tourists traveling in horse-pulled wagons. The first recorded bear-caused fatality occurred in 1916, when a grizzly bear killed a wagon teamster in a roadside camp.

When cars replaced horses and wagons, the number of park visitors and the amount of garbage they left behind increased. More garbage attracted more bears and park managers even encouraged bear viewing at some dumps by providing log bleachers and interpretive rangers. Unfortunately, this mix of people interacting with food-conditioned bears created problems. From 1931 through 1969, bears caused an annual average of 48 human injuries and 138 incidents of property damage. After a bear killed a woman in the Old Faithful Campground in 1942, Congress criticized park managers for failing to solve the bear problems.

In 1963, an Advisory Committee to the National Park Service issued a report titled "Wildlife Management in the National Parks" that recommended maintaining park biotic communities in as near a primitive state as practical. It recommended and nearly complete removal of human influence on wildlife populations to allow natural processes to work. The Leopold Report, in combination with the fatal mauling of two women by grizzly bears in separate incidents in Glacier National Park, the frequency of bear-caused injuries and property damages in YNP, and new environmental regulations

for open-pit garbage dumps, led to the implementation of an intensive Bear Management Program in YNP in 1970. In addition to strict enforcement of regulations prohibiting the feeding of bears, the new program called for bear-proof garbage cans and dumpsters and the closure of all the park's garbage dumps.

In 1970, the decision to close the park's last two garbage dumps was highly controversial. Brothers John and Frank Craighead, pioneers of grizzly bear research, agreed that the dumps were inconsistent with National Park Service management philosophy, but believed they played a crucial role in reducing human-caused bear mortality. They opposed a rapid phase-out of the dumps, especially the Trout Creek Dump. They believed an immediate closure of all dumps would increase conflicts, management removals, and mortality both inside and outside the park. The Park Service believed a gradual phasing out of dumps would result in several more generations of bears becoming dependent on human foods, leading to more bear-conflicts over time. After obtaining the advice of the National Sciences Advisory Committee, park authorities chose to close the park's remaining two dumps quickly in 1970 and 1971. The state of Montana closed the three dumps in the park gateway communities of West Yellowstone, Gardiner, and Cooke City in 1970, 1978, and 1979, respectively.

Within twelve years (1968–1979), all municipal dumps in the GYE that had aggregations of grizzly bears were closed, and many bears that previously ate garbage dispersed in search of alternative foods. Many of the bears that came into conflict with people at developed sites, campgrounds, private homes, and on cattle and sheep allotments were removed by the National Park Service or the state fish and game agencies from Wyoming, Montana, and Idaho, or were killed by private citizens. At least 140 grizzly bear deaths were attributed to human causes during 1968–71. Due to the growing disagreement between the Craighead brothers and the park over the dump closures, and restrictions placed on their research and publications that the brothers did not accept, their research permit in Yellowstone was not renewed after 1971.



▲ PHOTO 4.1 The grizzly bear is one of the most adaptable large mammals in North America. Extremely resourceful, the bear will feed on almost any source of calories including carrion, insects, vegetation or, human garbage. This bear is likely digging for ground squirrels in the Lamar Valley. (NPS, Yellowstone National Park)

Due, in part, to uncertainty about the status of Yellowstone bears and declines in other grizzly bear populations, the U.S. Fish and Wildlife Service listed grizzly bears in the lower forty-eight states as a threatened species under the Endangered Species Act in 1975. Once a species is listed under the ESA, the U.S. Fish and Wildlife Service is required to prepare a recovery plan and lay out a framework for recovery. The foundation of this framework is built on a scientific understanding of the species, its habitat requirements, limiting factors, and population trend.

Creation of the Interagency Grizzly Bear Study Team

The need for better information was motivation for the creation of the Interagency Grizzly Bear Study Team (IGBST) in 1973. The Study Team initially had representatives from the National Park Service, the Forest Service, and the U.S. Fish and Wildlife Service; representatives from the states of Wyoming, Montana, and Idaho were added later. Dr. Richard Knight was named the Study Team leader by Assistant Secretary of the Interior Nathaniel Reed. The primary objectives of the team are to determine the status and trend of the grizzly



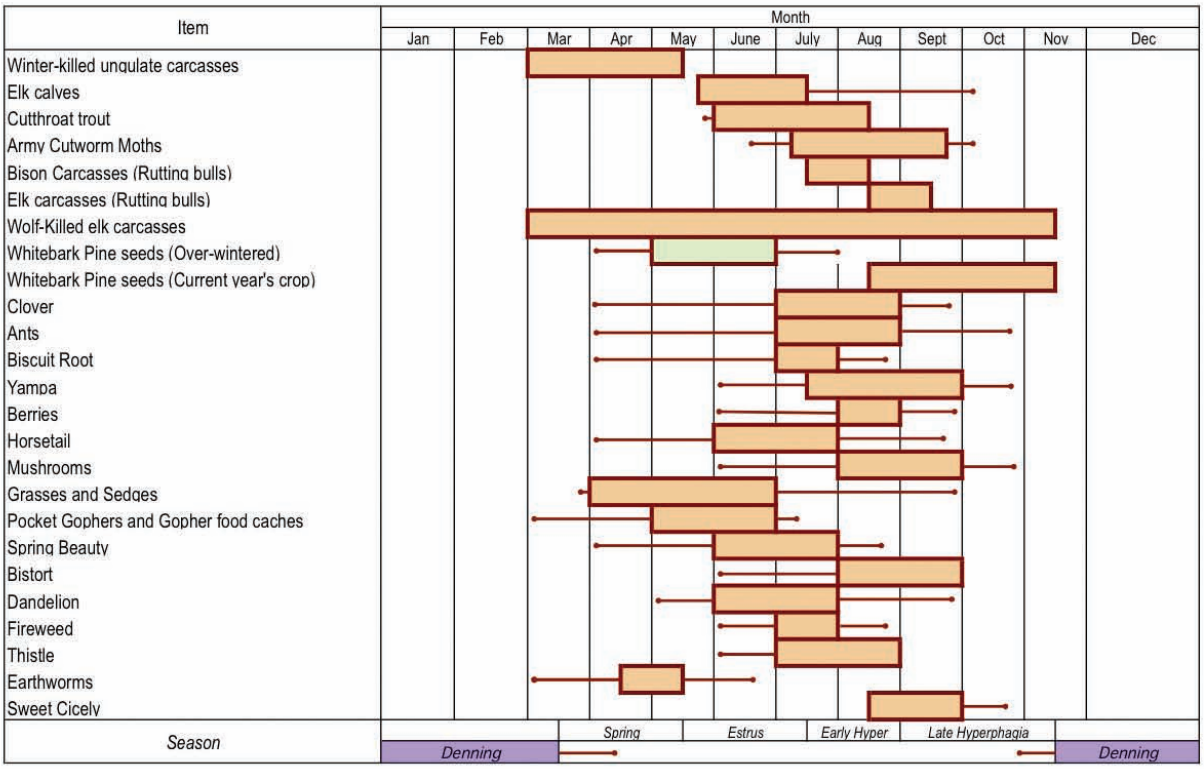
▲ PHOTO 4.2 Bears eating garbage at Trout Creek, Yellowstone National Park, ca 1960s. Early in the Park's history, feeding garbage to bears was common. This practice was stopped in the late 1960s. (NPS, Yellowstone National Park)

bear population, the use of habitats by bears, and the relationship of land management activities to the welfare of the bear population.

For more than 30 years, members of the Interagency Grizzly Bear Study Team have been investigating grizzly bear biology in the Greater Yellowstone Ecosystem. Much of the early work was gleaned by tracking radio-collared bears, examining scats and foraging sites, and observing bears in general. In recent years, the Study Team has used the newest research techniques and cooperated with outside specialists in chemistry, genetics, and nutrition to further advance the understanding of grizzly bear ecology. The new research techniques used by the Study Team include highly-accurate Global Positioning Satellite (GPS) collars that pinpoint a bear's location many times a day; hair snares fashioned of barbed-wire that collect small samples of hair when bears rub against them. DNA and nutritional analyses that determine the sex, identity, and the diet of each can be preformed on very small samples, such as bone flakes, a drop of dried blood, or a few hairs from the hair trap.

Biology of the Yellowstone Grizzly

Grizzly bears are a difficult animal to study. They have often been relegated to remote rugged terrain, occur at low densities, are wide ranging, and elusive. Grizzly bears have one of the slowest rates of reproduction of any large terrestrial mammal in North America. In the GYE, female bear typically do not reach sexual maturity until 4–7 (5.8 years) years of age, and produce a litter of 1-3 cubs once every 3 years. They are long lived with reproductive senescence occurring around 28 years of age. Young bears dependent upon their mothers care have low survival rates with only 57% reaching age two. Cause of death for most dependent young is often unknown, but most probably die from starvation or are preyed upon by other, often male, bears. About 85% of adult bear mortality in the region is human caused. Agency removal of bears that have come into conflict with people either by euthanasia or relocating to zoos is the major cause of mortality (54.2%). Other causes include self-defense kills



▲ FIGURE 4.1 Seasonal availability of grizzly bear foods in the Greater Yellowstone Ecosystem. Yellowstone grizzly bears spend 5–6 months in a winter den. When not denning, bears spend much of their time foraging on a large number of different foods. Bears make use of these foods when they are available. (IGBC, USGS)

by big game hunters (17.0%), mistaken identity kills by black bear hunters, (8.5%), malicious killing or poaching (18.6%), and road kills (1.7%).

Grizzly bears are truly seasonal animals. They have evolved life history strategies that included denning and associated physiology in response to adverse environment conditions, primarily seasonal lack of food and unfavorable weather. In Yellowstone they spend 5–6 months each year in winter dens; they typically entering dens in late fall and do not emerge until early spring. During hibernation, they do not eat, drink, urinate or defecate. They subsist entirely on fat stores from the previous autumn. Pregnant females are the first to enter dens, typically during the last week of October or the first week of November. Females with young (cubs or yearlings) enter dens in early November, and male bears den about a week later. In spring, males are the first to emerge, typically during the last week of March, although it is not uncommon for some males to emerge as early as February. Females with older cubs in the den emerge around the third week of April, whereas females with newly born cubs typically do not leave their den until the last week of April, and some remain in their dens through April.

Grizzly bears are opportunistic omnivores. They deviate from most other meat-eating carnivores by the volume and variety of vegetative foods in their diet. Yellowstone grizzly bears commonly consume herbaceous vegetation during spring and early summer. In early spring, bears seek out carcasses of both bison and elk that die of starvation during the long winter. Ungulate carcasses are a highly valuable food for bears in the spring. As the season progresses bears take advantage of other high quality foods as they become available. Yellowstone grizzly bear actively prey on newly born elk in late May through June. They also consume other animals when available. Ground squirrels, pocket gophers, and ants are relatively common items in the diet. During summer, their diet is a mix of plant and animal matter.

In late summer, grizzly bears enter the hyperphagic period - from the Greek for “excessive eating”. Because bears spend nearly half of the year hibernating, they must store large quantities of fat to sustain physiological

functions during denning. Females that give birth to cubs in the den require additional fat for milk production. In years when fall foods are abundant, it is not unusual for bears to enter their dens with 35-40% of their body mass as stored fat. To build their fat stores, Yellowstone grizzlies need to eat large quantities of high quality foods: these include seeds of whitebark pine, army cutworm moths, and ungulates.

Research priorities under the ESA are driven by the mandate to recover and sustain the population of bears in the region. Since listing in 1975, the emergent agenda includes monitoring the bear population, tracking and understanding their health, the nature of their food supply, breeding and genetic issues, and tracking individual bears in order to better understand their behavior and habitat use. Research scientists have devised a number of techniques to track and study grizzlies. Techniques range from simple observations, to sophisticated use of radio telemetry, visual analysis of bear scats for food habits to more complicated chemical processes. Here we describe just a few.



▲ PHOTO 4.3 Adult females with cubs add to the stock of grizzly bears in the region and are the focus of much of the research of the Interagency Grizzly Bear Study Team. The number of cubs a female produces varies based on the availability of food and other environmental conditions. (NPS, Yellowstone National Park)

Females with Cubs

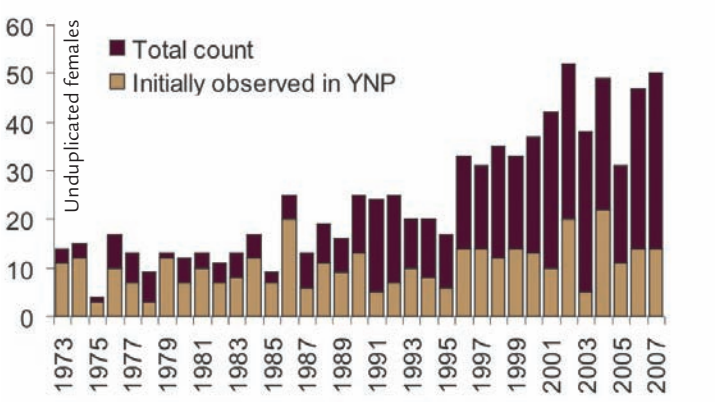
When the Yellowstone grizzly was listed as a threatened species, biologist recognized that to recover the population, human caused mortality had to be minimized. At the time, reducing adult female mortality by one or two bears per year would likely have been enough to stabilize the population. But managing mortality within sustainable levels required knowledge of how many bears resided within the ecosystem. However, estimating bear numbers in not an easy task.

For the first two years after its formation, the IGBST was not permitted to capture and/or mark bears in YNP. This early prohibition against marking individuals eventually led the Study Team to develop a method for estimating population size that the team continues to use today. Dr. Knight and the Study Team observed that adult females with cubs were easy to see and that the number of cubs provided clues for distinguishing family groups. Summing the count of unique females over three successive years provided a conservative estimate of how many reproductive (i.e., adult) females were in the population. Counts were added over three years because, on average, adult female grizzlies produce a litter every three years. This produces the best available abundance data in the GYE.

To distinguish unique females from repeated sightings of the same female, the Study Team developed a rule set for observations. It was recognized that these rules were not perfect and if errors occurred, two different females were more likely called the same female as opposed to calling two sightings of the same female two different families. Thus, it was felt that employing the rule set returned conservative (or low) estimates for the number of females. This method was adopted as part of the Grizzly Bear Recovery Plan in 1993. A running three year average of females with cubs was used to establish a minimum population number and set allowable mortality limits. However, using counts of unique females with cubs was criticized by some scientists because the rules to differentiate families had not been verified, the technique did not account for variation in observer effort (number

of people looking for females) or the sightability of bears with area and time (bears tend to be more easily seen in dry years), and the estimate was a minimum count not an estimate of the total population.

During the late 1990s, the Study Team and numerous collaborators began investigating methods to address these concerns. An evaluation of the rule set used to differentiate families confirmed that the method resulted in increasingly conservative estimates as population size increased. Methods to estimate total numbers of females with cubs and account for variation in sightability of bears and observer efforts were also investigated. Employing the best of these methods indicates an estimated 5% increase in grizzly females with cubs during 1983–2006. The Study Team working with other professionals also devised method to take estimates of females with cubs and derive an estimate of total population size. These estimates are now used to set mortality limits for cubs and yearlings (dependent bears), and independent females and males.



▲ FIGURE 4.2 Changes in numbers of females with cubs-of-the-year in the Greater Yellowstone Ecosystem (total count) and within Yellowstone National Park, 1973–2007. Changes in counts of females with cubs-of-the-year reflect the general increase in the Yellowstone grizzly bear population for about 1983 forward. The light colored portion of the bars indicates a stable population of bears in YNP. The darker portion indicates and expansion of the population to the Greater Yellowstone region. (IGBC, USGS)

Estimating Vital Rates from Radio-Marked Bears

Probably the most widely employed technique to study wildlife is radio telemetry. In 1959, brothers John and Frank Craighead and their dedicated team developed many of the earlier methods used to safely capture, immobilize, age, and mark grizzly bears. Nearly 50 years ago, they developed the first radio-transmitter collar and directional receiver and tracked two grizzlies to their winter dens.

Biologists use telemetry systems to track animals. Telemetry, derived from the roots *tele* = remote, and *metron* = to measure, is composed of three parts: the radio transmitter, an antenna, and radio receiver. The transmitter is attached to the animal with a collar and transmits a signal at a very high frequency (VHF). Each collar has its own frequency similar to different channels on a conventional radio. By tuning the receiver to the specific channel, the signal transmitted from the collar can be heard. With the use of a directional antenna, instrumented animals can be located either from the ground or with the aid of an aircraft. Once an animal is found, many variables can be recorded. These include, the number of cubs or older offspring seen with a collared female (this allows us to estimate reproductive rates and cub and yearling survival), the habitat type the animal is using, and the current status of the individual (i.e., alive or dead). Our radio collars are built with a mortality mode. This mode allows the researcher to determine if the animal is alive or possibly dead. The system is simple. If the animal moves the collar at least once every four hours, the transmitter returns a signal (beat) every second. If however, the animal is dead or has lost its collar, the beat rate declines to once every two seconds. Tracking to the collar allows us to determine if the bear is dead or if it has shed its transmitter. Collars typically transmit for about 3 years, but many are shed before the battery powering the transmitter fails. We intentionally incorporate a cotton spacer in all the collars. This cotton spacer typically rots through in about two to three years and the collar falls off. This allows us to recover the collar and have it refurbished so it can be used multiple times. It also means the bear does not wear the collar for the rest of its life.

The Study Team began capturing and radio-collaring grizzly bears in 1975. Early efforts were limited because

of the time and expense required to capture, instrument, and monitor the bears. Aircraft were required to locate and monitor the status (i.e., alive or dead) of collared bears and to obtain observations of females for estimates of reproductive performance. In 1986 the Study Team began collaring bears specifically for the purpose of monitoring population trend. The initial target was to monitor 10 adult females that were well-distributed throughout the ecosystem. However, because of their larger home ranges, male bears were captured about four times as often as females, providing additional information on topics including habitat use, movements, and cause of mortality. But it is female bears that drive the demographic vigor of the population.

In the mid-1990s, the target was raised to 25 monitored females to allow more precise estimates and increase confidence in the results. By then, estimates of adult female survival and population trend suggested that the population had stabilized but disagreement persisted over whether the population was likely increasing. An analysis published in 1999 that used reproductive data and survival rates obtained from 1975–1995 suggested the population had changed little to none during that period. Subsequent work published by the Study Team and collaborators clearly demonstrates that GYE grizzly bear numbers increased at an average annual rate of about 4–7% during 1983–2001. This increase is likely a result of increased female survival and is similar to trend estimates derived from counts of females with cubs. The agreement between these two methods that used independent approaches provides confidence that the increase in the population was real.

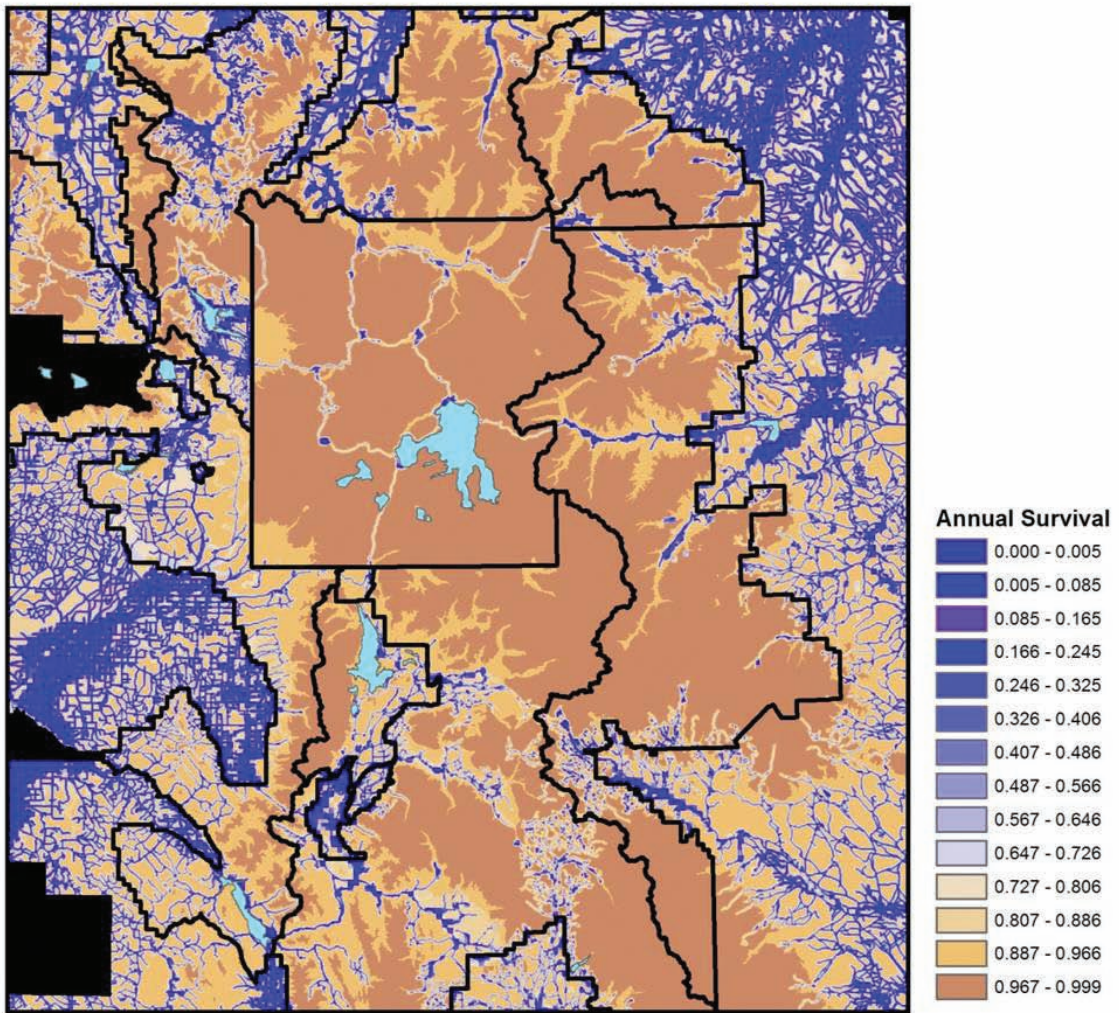
Determining What Is Hazardous to Bears

By following radio-instrumented bears the Study Team has been able to understand what influences bear survival. Location, it turns out, is very important to bear survival. We have constructed survival models that reveal bears living inside Yellowstone National Park have very high rates of survival, whereas bears living near human developments have lower rates of survival. But why? By looking at variations in bear survival and linking this to measures of habitat quality and disturbances within each bears home range, we are able to show that bear mortality is more influenced by human disturbances on the landscape. Thus as the number of roads, recreational developments, and homes within a bears home range increase, their chances of mortality also increase. By combining this hazard surface with our estimates of reproduction and survival, we created what biologists refer to as a source-sink surface. This surface considers the rate of survival necessary to maintain a healthy population. Source habitats are where lambda ≥ 1, whereas sink habitats are those where lambda <1. These models allow managers to evaluate and sometimes mitigate impacts of changes to bear habitat for the overall health of the bear population.

GPS Telemetry — Knowing Where Your Bear Is at Midnight

Nearly 50 years ago, Frank and John Craighead used the very first radio-transmitter collar and directional receiver to track two Yellowstone National Park grizzly bears to their winter dens. Since that time, we have witnessed numerous improvements, innovations, and technological advancements in animal tracking systems. Scientists realized early on that since it was possible to determine a satellite's orbit from earth, it was quite feasible to reverse the process to determine an exact location on Earth. This concept spawned the creation of a satellite-based navigation and positioning system. The Global Positioning System (GPS) technology offers positional accuracy better than 30 meters.

In 1995, the first GPS collars were deployed on Alaskan brown bears. GPS collars were deployed on Yellowstone grizzly bears two years later. GPS telemetry has revolutionized grizzly bear research, improving our ability to collect abundant, accurate, fine-scaled spatial data. VHF telemetry required a person to physically locate the bear, so most locations were collected during the day when conditions were suitable for aircraft flights. This meant that most bears wearing VHF collars were located between the hours of 6:00 AM and 2:00 PM. We knew very little about their nighttime activity and habitat use patterns. GPS technology is capable of collecting a position fix at any time and thus allowed for data



▲ FIGURE 4.3 The survival of a grizzly bear is directly related to where it lives in the Greater Yellowstone Ecosystem. Using data from radio-collared bears, the Study Team was able to determine what factors influence survival. Bears living in areas with human development (roads, homes, campgrounds, lodges etc) and in areas open to autumn ungulate hunting have lower rates of survival when compared to bears living in more secure habitats (wilderness areas and national parks). This figure shows predicted rates of survival for an adult female in the GYE. Warmer colors show areas of high predicted survival, whereas cooler colors show areas where bear survival is compromised by human development. (IGBC, USGS)

collection 24 hours a day, 7 days a week. This wealth of information has revealed some interesting behavioral patterns in the Yellowstone grizzly. For example, using GPS technology and incorporating an activity switch in the collar, the Study Team has been able to reconstruct the daily activity patterns of individual bears. These patterns show that grizzly bears are most active at sunrise and sunset, but are also active during mid-day and at night. Interestingly, male bears tend to be more night active. Activity patterns are also linked to daily air temperatures. Grizzly bears appear to be heat sensitive and reduce their daytime activity patterns when air temperatures exceed about 20°C.

DNA Fingerprinting and Mercury Analysis

Cutthroat trout were previously an important food for grizzly bears living around Yellowstone Lake, but cutthroat numbers have declined precipitously since the illegal introduction of lake trout there. Counts of spawning cutthroat trout at Clear Creek declined from

Estimating the Population Trend

Scientists estimate population change with some fairly complicated mathematical equations. Our sample of radio-collared bears allows us to estimate vital (estimates of reproduction and survival) rates. These rates include an estimate of reproduction success for female bears (fecundity). We derive this estimate by observing and tracking the fate of cubs born to collared females. Collared bears also provide estimates of annual survival. From the sample of marked individuals and the application of survival models, it is possible to determine the average survival rate for different classes of bears. We typically estimate survival for males and females, and compare these rates for adult and subadult bears. Once we have estimates of vital rates, these are combined in mathematical models such as a Leslie Matrix or Lotka equation to estimate population trend.

A simple analogy may make this more understandable. We can think about the grizzly bear population in Yellowstone as a bank account. The population represents the amount of money in this account. Reproduction in the population is the same as interest paid on the principal. New money deposited increases and withdrawals reduce the size of the account. Estimating population change is simply tracking new bears entering the population (reproduction) and bears leaving (mortality). The best expression of trend for a population is Lambda (λ) or "finite rate of change". Estimates of λ tell us whether, on average, numbers of births and recruitments for a population are greater than deaths or visa versa. Thus, $\lambda > 1$ indicates an increasing population, $\lambda = 1$ stable, and $\lambda < 1$ a decreasing population. A population that remains stable (neither grows nor declines), has a trajectory of 1.0. This would be equivalent to a bank account where withdrawals equal the interest paid to the account. A declining population has a trajectory of less than 1.0. A population with an estimated trajectory of 0.9 is declining at 10% per year; we've withdrawn the interest paid to the account plus 10% of the principal. However, population change is much more sensitive to the loss of an adult female than the loss of a cub. Adult females produce cubs and thereby add to the "capital stock" of bears, whereas a cub must remain in the population for at least five years before it can begin to produce offspring. If we put this into dollar terms, the loss of an adult female is equivalent to withdrawing 73¢ whereas the loss of a cub is only about 13¢, or the loss of one adult female has the same potential impact on the population as the loss of five cubs. It's like getting interest paid on the account each year or waiting five years before any is paid. Obviously, the account with annual interest grows faster. Biologists estimate reproductive and mortality rates from radio-collared animals and can determine population trajectory, just like you do when you check your bank account statements.

more than 70,000 in 1978 to around 500 in 2007. Studies of fish use by bears in the late 1980s relied on detecting fish parts or determining the presence of fish remains in bear scats. In the late 1990s, the Study Team discovered that mercury in the effluent from thermal vents in Yellowstone Lake could be used as an indicator of fish consumption by bears. When a bear eats a fish that has eaten plankton containing mercury, the mercury is deposited in its hair. By working with scientists from the Washington State University Bear Research, Education, and Conservation Program in Pullman, WA we were able to determine that measuring the concentration of mercury in bear hair provides a direct measure of the number of fish consumed by that bear. Coupling mercury concentrations in bear hair with DNA analyses has allowed biologists to estimate how many



▲ PHOTO 4.4 Researchers work quickly and according to strict standards of care when their research requires them to drug and handle a bear. They often administer oxygen and IV fluids. Here, scientists monitor oxygen saturation, heart rate, and temperature as they carry out isotope and bioelectrical impedence tests on a young bear. (IGBC, USGS)

bears consume fish, how many fish each bear eats, and the sex of the bears that eat fish. Results showed that in the late 1990s most fish were eaten by male bears. A three-year study, started in 2007, is documenting the extent to which bears have shifted away from fish to other foods. Preliminary results confirm that very few bears still eat fish, and that most of the bears that previously ate fish are now focused on preying on elk calves adjacent to the lake. Elk are now calving in the post-fire blow-down resulting from the 1988 fires and tracking studies suggest that the bears have shifted accordingly.

Stable Isotopes and Bioelectrical Impedence

For years, biologist learned about the food habits of the Yellowstone grizzly bear by examining scat and visiting telemetry locations of bears in an attempt to determine what they were eating. Within the past decade, new methods are now available to supplement this information. This work took on greater importance with the effects of climate change on regional vegetation and the discovery of lake trout in Yellowstone Lake in the early 1990's.

The new technique we use to quantify diets of both living and dead bears is called "stable isotope analyses." Isotopes are different forms of the same element, for example ^{14}N and ^{15}N. Both are nitrogen but the far rarer form, ^{15}N, has one extra neutron, is non-radioactive, and occurs naturally. When an animal eats plant material that contains small amounts of ^{15}N and digest it, the body preferentially retains ^{15}N relative to ^{14}N. Thus, bears that have eaten only plants will have ^{15}N in their hair or bones similar to levels found in deer and elk. However, when a bear eats meat (e.g. elk), it is consuming a food with higher levels of ^{15}N because the herbivore flesh contains a higher concentration of ^{15}N when compared to plants. Consequently, bears that eat meat have ^{15}N levels elevated above those found in herbivores. It is this ^{14}N to ^{15}N ratio that allows us to quantify the proportion of plant and animal matter that a bear ate during the past few weeks, months, or lifetime. By feeding the captive bears at Washington State University various diets that included deer, trout, clover, grass and other foods and analyzing the isotope ratios of both food and bear, we were able to calibrate this technique specifically for grizzly bears.

The Bear Research, Education, and Conservation Program at Washington State investigated the historical diets of Yellowstone grizzly bears. The oldest grizzly bear bones they analyzed came from a 1,000-year-old packrat midden excavated from the Lamar Cave. Due to the efforts of this hard-working packrat that had a fetish for bones, they showed that meat (everything from ants to trout and elk) provided 32% of the nourishment for those grizzly bears and 68% came from plants.

From 1914 to 1918 when many hotels were feeding kitchen scraps to attract grizzly bears for tourist entertainment and towns had open-pit garbage dumps, nourishment of the Park's grizzly bears switched almost entirely to meat (85% meat: 15% plants). After all such feeding was stopped by the early 1970's and bears were forced to return to natural foods, the diets of young bears of both sexes and adult females returned to the levels observed 1000 years ago (~40% meat: 60% plants), although adult males have continued a more carnivorous life (~80% meat: 20% plants). Large males can more efficiently prey on the Park's elk and bison or can claim the carcasses of animals that died from other causes. Bears that have been killed for preying on livestock

Using DNA to Estimate Bear Numbers

We are all aware of the powers of DNA fingerprinting. The O.J. Simpson case is a good example. Biologists also use DNA to identify individual bears and their sex. We use barbed wire hair snares to collect samples. The method is quite simple. Bears are attracted to a specific site with bait, usually cattle blood. The blood, referred to as a "call lure" is suspended above the ground in a plastic milk jug from a tree several feet above the ground. It is placed high enough so that a bear cannot obtain a food reward, but is attracted to the site by the smell of the blood carried on the wind. Surrounding the call lure, a corral is built with a single strand of barbed wire set about 2 feet off the ground. When the bear crosses under or over the wire, a small amount of hair is snagged on the barb. Hair with follicles contains bear DNA. Using genetic techniques, it's possible to identify individual bears and determine their sex. Using capture-mark-recapture models (these models estimate the number of bears not captured based on the frequency of bears that are captured), we can estimate the number of bears using an area.

outside the Park had diets that were 85% meat:15% plants. These levels of meat consumption are in contrast to the grizzly bears in Montana's Glacier National Park or Alaska's Denali National Park where plant matter provides 97% of their nourishment. Thus, for grizzly bears, the opportunity to consume meat differentiates the Yellowstone ecosystem from many other interior ecosystems where bears must feed primarily on plants.

One of the most important plant foods eaten by grizzly bears in the Greater Yellowstone are the high-fat, energy rich nuts of the Whitebark pine. In years following a good crop of seeds of this high elevation conifer, grizzly



▲ PHOTO 4.5 The hair corral trap is an extraordinarily simple method for collecting DNA from large predators. A barbed wire fence encircles a lure of blood. When the bear investigates the potential food, he leaves a few clumps of hair as he ducks under the wire. The hair is collected and returned to the lab for analysis. The bear is unharmed and avoids the danger of being trapped, drugged and handled. (Justin Teisberg)

bear females tend to produce more three-cub litters than one-cub litters. The opposite is true following poor seed crops. In poor seed years, bears in YNP shift their diets, and their survival rate remains high because the park is a secure environment. However, in years of poor seed production outside the park, particularly on the edge of the ecosystem, more bear conflicts occur as they expand their feeding range closer to humans, and mortality rates tend to increase. In a separate study, we wanted to actually quantify the nutritional value of pine nuts to grizzly bears. Like the other studies, we needed to find some element that occurred in pine nuts that did not occur in the bears' other foods, was absorbed when nuts were consumed, and ultimately was deposited in the bears' hair in proportion to amount of nuts consumed. Fortunately, whitebark pines concentrate a rare sulfur isotope (^{34}S) that occurs in the nuts' protein and therefore is absorbed by the bears and is deposited in their hair. Using isotope analysis similar to what we employ with ^{15}N we were able to demonstrate that ^{34}S was a good biomarker for quantifying pine nut consumption rates in grizzly bears. This study showed that during the year when cone production was high (average 39 cone/tree) pine nuts provided 97% of the annual nourishment for the Park's grizzly bears. The breakpoint for good versus poor years was about 20 cones/tree. We also showed that when nuts were scarce, grizzly bears ate more meat.

Whitebark pine is currently under attack by native mountain pine beetles, previous outbreaks of which have resulted in high mortality rates in trees across the West. The Study Team, in cooperation with the National Park Service's Inventory and Monitoring Program, is tracking both mortality rates in the GYE due to pine beetles and blister rust infection, an exotic fungus that has killed many whitebark pine trees in the Pacific Northwest since it arrived in North America in the late 1920s. It has been less lethal in Yellowstone, but continues to spread and surveys suggest that about 20% of the whitebark trees in the GYE are infected with rust. We do not yet have statistically rigorous estimates for whitebark pine mortality rates from either blister rust or mountain pine beetles or for the extent of their impacts on whitebark communities for the entire GYE. However, the impact on some whitebark stands from pine beetles appears to be considerable in portions of the GYE. How the changes in whitebark abundance will affect grizzly bear numbers is not entirely known.

In an effort to understand how the decline in whitebark might affect grizzly bears we employ a method called bioelectrical impedance analysis (BIA). BIA is a common method used to estimate body composition. Electrical impedance or opposition to the flow of an electrical current can be used to estimate the amount of water within the bear. We know from other research that there is an inverse relationship between body water and body fat. Using simple equations, we can estimate the amount of fat in a bear. We are interested in knowing how fat a bear is because in the GYE they can spend up to 6 months in a winter den, living entirely off stored body fat. Bears must gain sufficient weight to survive this long denning period, and for females that produce cubs, fat also provides the energy necessary to produce milk during lactation. Our early results suggest that the bears are able to attain adequate fat levels for denning in both good and poor seed years.

Conclusion

In April 2007, the U.S. Fish and Wildlife Service officially removed the grizzly bear in the GYE from the Endangered Species list. As expected, several lawsuits were filed challenging this decision. Proponents for delisting point to the successes that have occurred since 1975, including the increase in bear numbers, the recolonization of previously occupied habitats, high rates of female survival, and the current health of the population. Those opposed to delisting express concerns about the possible effects of climate change and declines in whitebark pine, and whether delisting the Yellowstone population separately from the other U.S. populations was appropriate. The agencies involved in the process prepared numerous documents detailing how the bears will be managed, including monitoring protocols, mortality limits, and habitat management programs. The courts will now determine if all these efforts meet the requirements of the ESA. Regardless of that decision, the IGBST will continue to monitor grizzly bears in an effort to understand how the species adapts in a dynamic ecosystem in the face of natural and man-made change. The long-term survival of grizzlies in Yellowstone is intimately linked with humans, how we impact the ecosystem and how much space we leave for bears. The challenge of the 21st Century is attempting to avoid and subsequently attempting to correct the errors of the 19th and 20th Centuries. If we are not up to the task, there will be no true wilderness to inspire the thoughts and dreams of the children in the next century, only forests.



▲ PHOTO 4.6 The recovery of the grizzly bear is one of the great success stories of conservation. The bear is a living symbol of wilderness and our national commitment to the preservation of our last wild places. (IGBC, USGS)