Bears Remain Top Summer Predators

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Yellowstone Elk Calf Mortality Following Wolf Restoration

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CHRIS CROWE

A vulnerable newborn elk calf is dependent on its mother for food and protection from predators.

Background

In the ten years since wolves (*Canis lupus*) were restored to Yellowstone National Park (YNP), elk (*Cervus elaphus*) numbers have substantially decreased. The northern range elk herd is the largest elk herd in Yellowstone, and constitutes the majority of the park's elk population. During 1994–2005, early winter counts of northern Yellowstone elk decreased from 19,045 to 9,545. Also, during winters 2000–2004, calf:cow ratios declined from 29:100 to 12:100, and were among the lowest recorded during the past several decades. Though many factors (e.g., predation, hunting, and drought) likely contributed to this decreasing abundance and low recruitment, several state and federal legislators continue to speculate that wolves are the primary reason for the recent decrease in elk recruitment rates, and have called for the immediate delisting and liberal control of the abundance and distribution of wolves. Because both wolves and elk are culturally, economically, and ecologically important in the Yellowstone area, it is vital to determine the basis for the decline in the elk population. To help this effort, we initiated a three-year study of northern Yellowstone elk calf mortality in May 2003. Our study was designed to follow up on Dr. Francis Singer et al.'s baseline pre–wolf restoration elk calf mortality study (1987–1990).

The primary objectives of our study were:

- to determine relative causes and timing of elk calf deaths;
- to evaluate survival rates and recruitment of elk calves into the adult population;
- to determine nutritional condition and disease status of calves killed by wolves and other predators; and
- to evaluate the temporal and spatial variation in the proportion of calves killed by predators.

When the final results of this study are complete, they will provide managers and researchers with post–wolf restoration data and an assessment of the extent to which wolf predation is additive or compensatory to other sources of elk calf mortality. In other words, wolves could be killing enough calves to greatly reduce the herd (additive mortality), wolf predation could be merely substituting for other mortality sources such as starvation or deaths caused by other predators (compensatory mortality), or some of each type of mortality could be occurring. A report by the National Research Council (Orians et al. 1997) indicated that information regarding the extent to which wolf predation is additive to historical patterns of mortality (e.g., winter-kill, other predators) is critical for the effective management of this ecosystem in the future. Prior to the first year of our study, no information was available regarding wolf predation on Yellowstone's elk calves <5 months of age, when they are smallest and most vulnerable.

Our preliminary analysis of this study indicates that grizzly and black bears, rather than wolves, are having a greater impact on neonatal elk calf mortality than any other predator.

This article presents some of the study results. The final results of the project will be summarized in a Ph.D. dissertation expected to be completed by December 2006, and one or more publications in peer-reviewed scientific journals. In anticipation of those final results, however, and with delisting of both gray wolves and Yellowstone-area grizzly bears (*Ursus arctos*) on the political horizon, we feel it is important to share somewhat surprising information: our preliminary analysis of this study indicates that grizzly and black bears (*Ursus americanus*), rather than wolves, are having a greater impact on neonatal elk calf mortality than any other predator.

Bears and Elk Calves

That bears prey on Yellowstone elk calves has long been well known. For example, in 1920, park naturalist M.P. Skinner and visitor A.B. Howell saw a black bear catch an elk calf after apparently deliberately hunting through sage (Howell 1921). In his *Bears in the Yellowstone,* Skinner wrote, "as it is only two or three weeks before the little fellows [elk calves] are strong and expert enough to escape, the damage done [through bear predation] to the elk herds is not very great" (Skinner 1925). Thomas Thompson watched a grizzly sow and her three yearlings take two elk calves near Gibbon Meadows in May 1942 (Thompson 1942). In his field notes for 1942–1943, Olaus Murie recorded six elk calf mortality events, including park ranger Lee Coleman's observation of a grizzly consecutively killing and eating two elk calves near Dragons Mouth Spring, with the event lasting more than an hour (Murie 1943–1944). In *The Elk of North America,* Murie wrote, "No systematic study of bear food habits was made, but field examinations of bear droppings in the Yellowstone Park–Jackson Hole area over a period of years did not reveal an excessive percentage of elk calf remains, and the elk herds in these areas continue to increase" (Murie 1951).

Believed to be attracted by elk calves, grizzly bears were seen gathering in the Swan Lake Flat area, where approximately 1,000 elk resided, as early as 1947 (Grimm 1947). Park ranger H.B. Reynolds witnessed an elk herd attempting to defend several calves from grizzly bears in Lamar Valley in the spring of 1950. Three calves fell behind the herd of about 60 elk while being chased by three mature grizzly bears. The herd circled around and rejoined the elk calves several times, but the calves soon fell behind again. Each time the herd circled back to retrieve the calves, the grizzly bears drew closer. Finally, one of the calves darted past the herd instead of running into it with the other calves. It was soon captured and eaten (Reynolds 1950). A 1951 study, focused on the Gallatin elk herd ranging in part through northwestern YNP, tagged 132 elk calves to examine the biology of Rocky Mountain elk calves and investigate mortality sources (Johnson 1951). That study also documented bear predation of elk calves.

In anticipation of the congressionally-mandated wolf restoration in the mid 1990s, YNP implemented an elk calf mortality study throughout the park's northern range, led by Dr. Francis Singer from 1987 to 1990. That study documented survival rates as well as the timing and causes of elk calf mortalities in the absence of wolf predation. Singer et al. found that prior to wolf restoration, summer survival rates for northern Yellowstone elk calves were 50–85%, and 72% of all calf deaths during summer were due to predators (i.e., bears and coyotes, *Canis latrans*). Bear predation accounted for 23% of all calf mortality (Singer et al. 1997).

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It has long been known that bears prey on Yellowstone elk calves. These grizzlies were seen in Lamar Valley in May 2005.

Design and Methodology

Capture

To investigate current causes of elk calf mortality, we are replicating, to the extent feasible, the methodology and experimental design for capture and monitoring of elk neonates used during 1987–1990 (Singer et al. 1997). That study was less extensive and comprehensive, but provides a baseline for comparison upon which to examine the impact of wolves on the YNP ecosystem and on elk calves in particular.

Each year, we captured a sample of 44–56 calves ≤6 days old, spatially and temporally distributed across Yellowstone's northern range. Spatially, we captured calves from four general areas (Mammoth/Stephens Creek, Swan Lake/Gardners Hole, Blacktail Deer Plateau/Tower, and Lamar Valley) to test for differential survival. Does a calf born in Lamar have a different survival probability than a calf born in Mammoth? Such differences, if found, may result from a variety of factors, including varying predator presence, quantity of preferred vegetation, or weather patterns.

A young elk calf often remains still following capture and processing. At less than four days old, most elk calves tend to hide motionless versus run when they perceive danger.

To test survival differences based on temporal birth distribution, we captured calves born in the early (May 17–26), middle (May 27–June 5), and late (June 6–15) portions of the calving season. For example, a calf born early may "sneak by" before the predator's search image of an elk calf has fully developed or before predators concentrate on calving grounds. A calf born in the middle (peak) of the calving season may escape predation by the dilution effect: because elk are fairly synchronous breeders, many calves are born during the peak and any individual calf may have an increased probability of evading predators. A calf born in the late period may have a better chance of surviving if the majority of bears have already left the calving grounds for higher elevations, where they feed on army cutworm moths and whitebark pine nuts.

We conducted intensive helicopter and ground searches of the sampling areas from May 15 through June 15 to locate elk neonates. Because most cow elk separate from the larger herd when they are ready to give birth, we searched for lone cows. Ground captures were attempted on calves observed opportunistically during May 15–June 15. Ground searches for calves were conducted from vehicles or by using spotting scopes to survey areas where calves were suspected based on maternal behavior or information from park visitors or staff. We conducted aerial searches during three 2- or 3-day periods in the early, middle, and late portions of the calving season (i.e., a total of 6–9 days during each calving season). When a calf was spotted, the pilot landed in the vicinity and two biologists manually captured the calf. We did not attempt to capture calves if predators were observed nearby.

During captures, we collected age, sex, and weight measurements, general body condition data, and blood samples. To minimize our impact on the cow–calf bond during capture, we wore fresh latex gloves for each capture, dressed in clothing that had been washed in "descenting" detergent, used a fresh side of a blanket washed in "descenting" detergent for each capture, minimized ground contact, and completed most captures in less than 10 minutes. We aged calves by examining their wobbly stance, incisor eruption, attached umbilicus, and status of hooves and dew claws (Johnson 1951).

We fit calves with 23-gm ear-tag transmitters designed to emit a radio signal for approximately one year, and to change pulse rate if motionless for more than four hours. This change

A radio-tagged elk calf is released in the Swan Lake area following capture. Note the wide wobbly stance, indicating that the calf is less than two days old.

in pulse rate (i.e., "mortality mode/signal") alerts us to a probable calf mortality and enables us to examine the carcass soon after death. In short, the transmitters allow us to quickly and conveniently monitor daily survival via aerial and ground telemetry without observing each animal.

Monitoring

From approximately mid-May through mid-July, when the risk of mortality to calves was relatively high, signals of radio-tagged calves were monitored via airplane for mortality each day at dawn. As calves became older and less prone to mortality, aerial monitoring was reduced to three times per week during mid-to-late July, twice per week during August–September, and bi-monthly throughout the first year of each calf's life (approximately June 1). The pilot obtained locations for all dead calves using a Global Positioning System (GPS) unit. He also searched around carcasses for predators to reduce the risk that ground crews might walk in on a carcass with large predators nearby.

In addition to aerial monitoring, ground crews monitored transmitter frequencies three-to-four times per day until approximately July 15 and once per day from July 15 to approximately September 30. Telemetry was used to triangulate approximate daily locations of calves.

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Using telemetry, Yellowstone interpretive ranger John Meyer is attempting to locate an elk calf transmitter on mortality mode along the north side of Mt. Everts. The calf was determined to be killed by a black bear.

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Elk calves that have not yet joined a nursery herd with other calves and cows will often hide under sage brush or near downed timber.

Mortality Site Investigations

Throughout the study, ground crews investigated mortality sites and conducted necropsies of dead calves to evaluate causes of death based on evidence such as predator tracks, consumption patterns, canine puncture measurements, and caching behavior. Bear kills were typically identified by the presence of a "banana-peeled" elk calf hide. Interestingly, we found that coyotes often buried elk calf heads. Wolves tended to consume the entire carcass, leaving little behind for examination. In such cases, predator tracks and DNA from predator scat and hair are used to identify the predator species.

For calf condition analyses, crews also collected the midsections of elk calf femurs, as well as metatarsuses. Marrow fat content from the femur midsection can potentially tell us if the calf was fat-depleted because nutritionally compromised animals will use fat stored in the marrow. However, marrow deposition in calves is not as well understood as it is in adults,

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Elk calf study volunteer Daniel Ravenel collects bear hair from branches near an elk calf mortality site for DNA analysis to determine bear species.

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Top: Elk calves killed by bears typically result in a "banana peel" appearance. Bottom left: Cougars typically cache their prey with light forest floor debris. Bottom right: Coyotes bury elk calf remains with packed dirt.

Processing of Biological Samples

Marrow content and metatarsus-length analyses are conducted during winters in conjunction with the Yellowstone Wolf Project's analyses of their wolf-killed elk marrow and metatarsus samples to ensure consistent methodology between studies and allow for comparisons. Additionally, blood samples collected during captures are being screened to test for diseases and other factors that might indicate predisposition to mortality (Kunkel and Mech 1994, Sams et al. 1996; Cook et al. 2001; Ditchkoff et al. 2001). Blood values such as blood urea nitrogen, thyroxine, cytokines, and serological values will be compared between surviving elk calves and those killed by predators. If blood values indicate that wolves, for instance, are primarily killing calves in poorer condition than those surviving, then wolf predation could be improving the overall condition of the elk herd even while reducing its numbers.

Bears accounted for approximately 55–60% of all deaths (including both predation and non-predation) for tagged elk calves during their first 30 days of life, while coyotes and wolves each accounted for approximately 10–15% of tagged calf deaths.

so interpretation of marrow fat content is questionable. Additionally, testing marrow fat content is only a one-way test. In other words, we can determine if the animal *was not* healthy, but we cannot confirm the animal *was* healthy, because the animal may have had an ailment not directly related to fat use, such as poor hearing. We collected the metatarsus because it is the last elk calf bone formed while in the womb. Therefore, a calf with a shorter metatarsus compared to those of other calves of the same age may have been born a runt, and therefore been more likely to die from predation.

Results

Capture

One hundred fifty-one elk calves ≤6 days old were captured and processed during the summers of 2003–2005. Table 1 indicates the number of calves captured, methods employed, and temporal and spatial distributions.

Estimated ages of elk calves at capture ranged from <0.5 days to 6 days, and were similar for females and males across years. Estimated birth dates of captured calves ranged between

Captures	**Summer 2003**	**Summer 2004**	**Summer 2005**	**Total 2003–2005**
Total captured	**51**	**44**	**56**	**151**
Ground captures	6	4	1	**11**
Aerial captures	45	40	55	**140**
Capture periods				
Early season	14	11	26	**51**
Mid season	17	20	18	**55**
Late season	20	13	12	**45**
Capture area				
Mammoth/Stephens Creek	14	12	13	**39**
Gardners Hole/Swan Lake	11	14	14	**39**
Blacktail Deer Plateau/Tower	10	10	11	**31**
Lamar Valley	16	8	18	**42**

Table 1. Comparisons of capture methods, timing, and locations for 2003, 2004, and 2005 radio-tagged elk calves on the northern range of Yellowstone National Park.

May 16 and June 10 during 2003–2005, with most calves born around June 1 each year. Calf capture and birth weights were similar across years, averaging approximately 17–18 kg and 14–15 kg respectively, with males tending to be heavier. Birth weights of calves were estimated from capture weights using linear regression of estimated age versus capture weight. The estimated daily growth rate for each sex was applied to each calf's estimated age at capture to back-calculate estimated birth weights.

Mortality Causes

We will calculate final mortality and survival rates after all of our data are collected. What follows are not mortality rates, but rather the proportions of the calves' deaths that were caused by various factors.

In our study, predators have caused more than 90% of northern range elk calf mortality. In 2003 and 2004, more than 70% of this predation occurred within the first 15 days of life. Bears accounted for approximately 55–60% of all deaths (including both predation and non-predation) for tagged elk calves during their first 30 days of life, while coyotes and wolves each accounted for approximately 10–15% of tagged calf deaths. Causes of death for northern Yellowstone elk calves during summers 2003–2005 were generally similar.

Some of the rarer elk calf mortalities we recorded included one probable drowning, one calf likely killed by a golden eagle (*Aquila chrysaetos*), one low-birthweight calf, one calf likely dying from complications associated with pneumonia, one hunter-killed calf, and one calf probably dying from exposure to cold. Interestingly, the calf presumed to have died from exposure to cold was found intact, with fresh bear and wolf tracks in the snow less than 10 m from the carcass. To date, we have only recorded one elk calf killed by a cougar (*Puma concolor*). There was also one yearling (tagged as a calf in 2003) that likely died from infection after being scalded in a hot spring near West Thumb.

Conclusions

The bear predation results of the 1987–1990 elk calf study were not surprising, considering the absence of wolves and that bear predation of neonatal ungulates has been noted in various studies covering different geographic areas and diverse ungulates (Kunkel and Mech 1994; Zager et al. 2002; Festa-Bianchet et al. 1994; Ballard et al. 1991). However, the ratio of predators to prey on the northern range has increased since that study. Wolves were restored to YNP during 1995 and 1996, and rapidly increased in abundance and distribution. Approximately 171 wolves resided in YNP during 2004 (USFWS et al. 2005). At the end of 2004, the highest density of Yellowstone wolves within the park occurred on the northern range, where 84 wolves resided in seven packs (USFWS et al. 2005). Elk calves accounted for 15% of documented Yellowstone wolf kills during 2004 (USFWS et al. 2005). Thus, wolves might be expected to be a significant limiting factor for recruitment in Yellowstone elk if much of their predation is additive to other mortality sources.

Wolves might be expected to be a significant limiting factor for recruitment in Yellowstone elk if much of their predation is additive to other mortality sources.

We had anticipated that bear predation would likely be a relatively higher source of early calf mortality, but that wolf predation would increase during autumn and winter,

PHOTOS SHANNON BARBER

Left: Heavy rains the night before likely caused this elk calf to drown in an otherwise shallow creek in northern Lamar Valley. Right: This elk calf was likely killed by a golden eagle near Blacktail Deer Creek. The previous study (1987–1990) also recorded one eagle-killed calf.

VINCE GREEN

This elk calf likely died of exposure following late spring snow and freezing rain. Fresh bear and wolf tracks were found in the snow less than 10 m from the intact carcass.

due in part to their different hunting styles. Grizzly and black bears appear to concentrate in elk calving areas on the northern range during May and June, searching in grid-like patterns for hiding neonate calves (Gunther and Renkin 1990), whereas wolves tend to select vulnerable prey while testing groups of elk (Smith et al. 2003). Thus, wolves may be more likely to kill calves within groups of elk during autumn and winter.[1] Studies of caribou calf mortality in Denali National Park, Alaska, found that bear predation was

> One explanation may lie in bear numbers, and in the success of grizzly bear recovery in the Greater Yellowstone Area (GYA).

predominant early in the calving season, but declined with calf age, while wolf predation peaked later in the season (Adams et al. 1995). Also, bears obviously are not a factor in calf mortality while in their winter torpor.

It is surprising, however, that wolves are apparently having less impact on elk neonate survival than bears. One explanation may lie in the numbers, and in the success of grizzly bear recovery in the Greater Yellowstone Area (GYA). Surveys suggest that the abundance of GYA grizzly bears has increased since the 1987–1990 study. The minimum population estimate for GYA grizzly bears increased from 150 in 1987 (Haroldson et al. 1998) to 431 in 2004 (Haroldson and Frey 2005) which translates to approximately 70–92 grizzly bears on the northern range during summer

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Dan Krapf, along with Wendy Hafer and Mike Wagner of the Yellowstone Fire Cache, assisted in three years of helicopter captures of elk calves.

(K. Gunther, YNP, personal communication). Black bears occur in unknown numbers, but are also seasonally abundant on the northern range during autumn and summer (K. Gunther, YNP, personal communication).

The results of this study have immediate relevance to the Montana Department of Fish, Wildlife and Parks in setting harvest quotas for local elk hunts, and to the U.S. Fish and Wildlife Service regarding the delisting of wolves. For example, the Montana Department of Fish, Wildlife and Parks has already proposed a reduction of antlerless elk permits from 1,100 to 100 for the Gardiner Late Hunt based on evidence of continued low recruitment of elk calves into the adult elk population. Furthermore, information regarding the effects of wolves on ungulate population dynamics and, in turn, other interactions (such as elk–vegetation) has implications for areas throughout the U.S. and abroad, where wolves and other large predators (e.g., black bears) are recolonizing and increasing in density. Ultimately, this study will contribute to basic scientific knowledge about wolf–prey interactions and factors that predispose neonates to mortality.

We will continue to monitor radio-tagged calves through spring 2006. These data will enable us to compare trends in survival rates and cause-specific mortality among years, and evaluate factors that may predispose calves to death.

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Footnote

[1] Due to high summer mortality in our study, our results to date are necessarily biased toward early calf mortality and may not correctly depict mortality sources during winter. Also, the majority of calves in our study that survived the summer wintered in the Mammoth/Stephens Creek study area, so our winter sample is not as well distributed as our summer sample.

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Tom Lemke of Montana Fish, Wildlife and Parks (MTFWP) assisted with the necropsy field crew and aerial captures. Neil Anderson (MTFWP, Bozeman, Montana) performed necropsies of intact elk calf carcasses and tissue samples were analyzed by the State of Montana Department of Livestock Diagnostic Laboratory Division (Bozeman, Montana). Lisette Waits and Cort Anderson of the University of Idaho (Moscow, Idaho) performed DNA analyses of predator hair and scat samples. Kristy Pilgrim of Carnivore Conservation Genetics Laboratory (Missoula, Montana) also performed DNA analyses on one hair and scat sample. Dr. James Halfpenny trained our 2005 crew on predator hair identification. Rick McIntyre and the Yellowstone Wolf Project shared their information on elk calf natality and mortality. Also, the Yellowstone Wolf Project graciously provided us the use of a vehicle each summer. Yellowstone's Bear Management Office shared information regarding bear feeding behavior, and Dr. Francis Singer provided helpful consultation during both the design and analysis stages of the project.

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Dr. P.J. White and Shannon Barber capture and process an elk calf after spotting it from the helicopter.

Shannon Barber is a Ph.D. candidate in the Wildlife Conservation Program at the University of Minnesota. She recently completed research on photopollution impacts on the nocturnal behavior of the marsupial sugar glider. **Dr. L. David Mech** is a senior scientist for the Northern Prairie Wildlife Research Center, U.S. Geological Survey and an adjunct professor at the University of Minnesota. He has studied wolves and their prey since 1958. **Dr. P.J. White** is a wildlife biologist for Yellowstone National Park. His work primarily focuses on ungulates and winter-use issues.

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