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Case Study

Lessons learned from a 20-year collaborative study on American black bears

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Abstract: In the 1980s, black bears (*Ursus americanus*) began expanding into historic habitats in northwestern Nevada, USA. Over a period of >30 years, black bears recolonized areas where human populations have also increased. Our research represents one of, if not the longest-running and earliest comparative studies of a black bear population at wildland–urban interface and wildland areas in North America. As the population increased, we observed: 1) increasing human–bear conflicts in areas where several generations of people had lived in almost total absence of bears (70–80+ years); 2) changes in attitudes by the public toward bears and in the social realm regarding garbage management; and 3) changes in the demographics, behavior, and ecology of this bear population, due to an increasing human footprint on the landscape. Herein, we discuss a few of the lessons learned from this long-term study and the value of a collaborative approach between a state agency, a university, and an international conservation organization. Our collaborative approach allowed us to better understand the ecological, demographic, and behavioral changes in a large, recolonizing carnivore that is a functional omnivore, often residing at the wildland-urban interface, and to use these data to impact conservation and management. Throughout the study, our data were used extensively by various media, emphasizing public education about human–bear conflicts. This media platform proved important because of the impact it had on wildlife conservation. For example, partly in response to media coverage of our data-based education efforts, 3 Nevada counties enacted garbage management ordinances, and the Nevada legislature passed a state law prohibiting the feeding of large game mammals. Further, several million dollars in bear-resistant garbage containers are now used in the region by the public and government entities. The end result of these conservation measures has been a recolonization of the Great Basin Desert by bears from the Lake Tahoe Basin and Sierra-Nevada Range into portions of Nevada where bears have been absent for >80 years.

Key words: black bears, collaborative, conservation, human–wildlife conflicts, Lake Tahoe, Nevada, urban bears, *Ursus americanus*

In many regions across the globe, recovery of extirpated populations of large carnivores is extremely difficult and rarely accomplished due to a variety of factors, one of which is the large-scale space that carnivores must coexist on a landscape now also occupied by humans. This is particularly true for apex predators, such as bears (*Ursus* spp.) that have large home ranges and occur at low densities, especially in arid landscapes (Beckmann and Berger 2003*a*). Thus, being able to successfully recover large carnivore populations requires: 1) identifying threats to their existence across the landscape at large scales; 2) mitigating those threats; and 3) monitoring population responses over space and time in response to management and conservation efforts (Lackey et al. 2013, Wynn-Grant et al. 2018).

Historical records indicate viable populations of both black bears (*U. americanus*) and grizzly bears (*U. arctos*) were extirpated from Nevada, USA by the early 1900s due to several anthropogenic factors, including direct removal of bears due to conflicts with people and alterations of forested habitat during the mining booms at the end of the nineteenth century (Lackey et al. 2013)—specifically, the Comstock Lode era beginning in the 1860s where massive swaths of forests were cut in the eastern Sierra Nevada for use by pioneers and in the underground mines (DeQuille 1947, Nevada Forest Industries Committee 1963). Habitat regeneration due to changes in forestry practices and a post-1920s decline in the reliance on wood as a source of fuel was one possible reason the bear population in western Nevada

initially began to increase and recolonize historic habitat. This recolonization was enhanced by management and conservation efforts over the past 30 years by the Nevada Department of Wildlife (NDOW), the University of Nevada, Reno (UNR), and the Wildlife Conservation Society (WCS; Beckmann and Lackey 2008, Lackey et al. 2013). Yet, even in the early 1980s, black bear sightings, management issues, and bear deaths from vehicles were considered rare events in Nevada (Goodrich and Berger 1994). In 1979, the director of NDOW stated at the first Western Black Bear Workshop: "Nevada has no bear, except for an occasional one that strays in along the Sierras adjacent to Lake Tahoe in California. Therefore, we have no management responsibilities" (LeCount 1979). By the late 1980s, black bears were once again present enough in western Nevada that UNR began preliminary studies of bear demographics (Goodrich 1990). At this time, it was believed that Nevada's black bears existed in 2 separate populations: 1 population in the Sierra Nevada near Lake Tahoe (~30 bears) and the other in the Sweetwater Mountains (no population estimate available) bordering California, USA, approximately 129 km (80 miles) to the south of Lake Tahoe (Goodrich 1990; Figure 1). We now know that these 2 populations were a single population both genetically and demographically, operating as part of a western Nevada metapopulation (see Malaney et al. 2018). However, human–bear conflicts were rare during the time period of this first study, and Goodrich (1990) reported no conflict bears in his dataset.

By the mid-1990s, conflicts between humans and black bears began to rise sharply in the Lake Tahoe Basin and the western portion of the Great Basin Desert in Nevada (Beckmann and Berger 2003*a*, Lackey 2004). A 10-fold increase in the annual number of complaints and a 17-fold increase in bear mortalities due to collisions with vehicles were reported between the early 1990s and early 2000s (Beckmann and Berger 2003*a, b*). Motivated by these increasing human–bear conflicts, but without knowing the relative importance of factors driving the increase, we initiated a new effort in 1997 to understand black bear ecology in the region.

We began a cooperative investigation between NDOW and UNR to look at the causes for the increase in conflicts, and specifically to determine if it was due to an increasing bear population, an increasing human population, both, shifts in use of the landscape by bears, or factors unknown at that time. Understanding the drivers behind the increase in conflicts would provide the context in which NDOW could make decisions regarding the management of bears. However, given the lack of recent history of bears in the state, NDOW had no funding for bear research and had only a small amount of funds and a relatively loose set of protocols for dealing with human–bear conflicts.

We recognized that an opportunity existed to study and understand the mechanisms leading to the increasing level of conflicts. Initial project proposals by Carl Lackey internal to NDOW failed, presumably due to fiscal concerns. However, in 1997, outside funding sources were raised by Jon Beckmann while attending UNR as a Ph.D. student. These funds provided an initial 5 years of finances to engage NDOW in a long-term research effort on black bears in Nevada. The collaboration was enhanced further when the WCS joined the partnership in the early 2000s, and this trifecta of partners continues to date.

The collaboration between a state agency, a university and a nongovernmental organization (NGO), all with different perspectives and mandates, allowed us the opportunity for a unified approach to use science for informing management and policymakers making important conservation decisions. Here we discuss outcomes resulting from these efforts.

Study area

Our study area encompassed approximately 12,000 km^2 in western Nevada and included the area from Reno, Nevada south to Topaz Lake, including the eastern Lake Tahoe basin (Nevada side), the Carson Range of the Sierra Nevada, several Great Basin Desert mountain ranges (e.g., the Pinenut and Virginia mountains), and valleys dominated by human settlements within this area (Beckmann and Berger 2003*a, b*; Figure 1). These mountain ranges are characterized by steep topography with high granite peaks and deep canyons and are separated by desert basins ranging from 15–64 km wide that include expanses of sagebrush (*Artemesia* spp.), which bears use infrequently (Beckmann and Berger

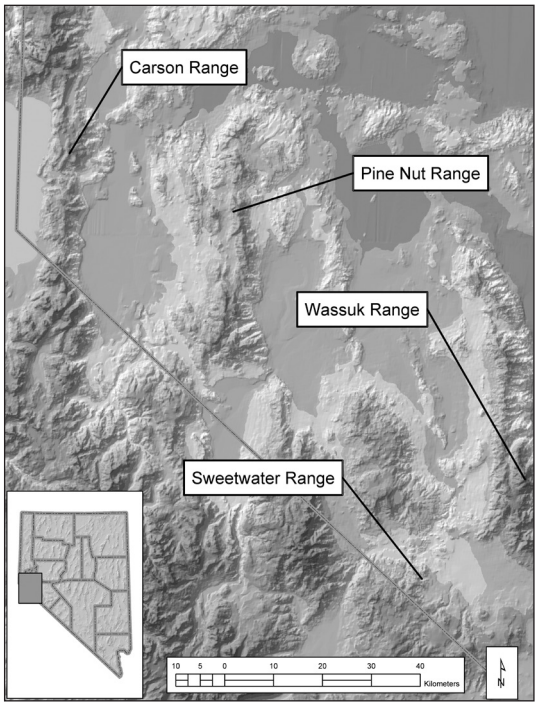

Figure 1. Western Nevada, USA study area of black bears (*Ursus americanus*) at the wildland–urban interface and in backcountry regions. Bears have been expanding from the Carson Range (part of the Sierra Nevada Mountains) and re-colonizing areas of the Great Basin since the 1980s.

2003*a, b*). The area is arid with hot summers and cold winters. Average annual high and low temperatures are 20° C and 4° C on valley floors (Reno, Nevada) with cooler temperatures in the mountains. The majority of precipitation falls as snow in the winter with an average of 56 cm snowfall and 19 cm rainfall on the valley floors and 130 cm average snowfall and 32 cm average rainfall in the mountains (Virginia City, https://usclimatedata.com).

Methods

Field research

We captured bears from 1997 to 2018 both in response to human–bear conflicts and in backcountry areas, using methods previously described in Beckmann and Berger (2003*a, b*) and Lackey et al. (2013; Figure 2). We captured bears using culvert traps (Teton Welding, Choteau, Montana, USA), modified Aldrich foot snares and free-range techniques (i.e., tranquilizing unconfined animals). Our sample consists of >1,500 captures and recaptures of 956 individual bears (585 males, 371 females), and we have deployed almost 200 collars (approximately 80 very high frequency [VHF] and 120 global positioning system [GPS] transmitters). Bears were captured and handled according to NDOW protocols and safe handling protocols described by the American Society of Mammalogists (Sikes et al. 2016).

As part of our research, in 1997 we began using nonlethal management techniques such as on-site releases combined with aversive conditioning (AC). Our use of AC tools such as less-lethal ammunition and bear spray evolved over the course of the study and depended upon availability, product improvements, and quality of the results. However, for the majority of our study we used: less-lethal rubber slugs and rubber buckshot (Lightfield Ammunition, Adelphia, New Jersey, USA); Pepperball® capsaicin projectiles (United Tactical Systems, LLC, Lake Forest, Illinois, USA); and Counter Assault® bear deterrent spray (Counter Assault, Kalispell, Montana, USA). We began using private houndsmen and hound dogs for AC in the early stages of the study but switched to Karelian Bear Dogs (KBDs) in 2001 (Beckmann et al. 2004).

The first KBD was purchased as a puppy and came from a litter owned by a grizzly bear biologist in Montana. This dog, as with all our dogs subsequently brought into the program, was trained by NDOW handlers. We used only 1 dog from 2001 to 2004 but have used ≥2 dogs since that time. In addition to aversive conditioning of black bears, our KBDs are used for educational presentations at schools and community gatherings. The NDOW's KBD program is funded entirely by the handlers and through public donations. The 2 K9 handlers currently have 8 KBDs in the program.

The cumulative results from our studies on deterrent techniques (Beckmann et al. 2004) and effectiveness of translocating bears in the western Great Basin (Beckmann and Lackey 2004) helped shape bear management policy in the state.

Media engagement

Local, national, and international media displayed interest in the various aspects of our research, management, and conservation efforts. In western Nevada, increasing black bear populations and the associated conflicts

Figure 2. Researchers placing a global positioning system collar on a black bear (*Ursus americanus*) in western Nevada, USA (A). Two Karelian Bear Dogs on a release of a black bear in Nevada as part of the aversive conditioning research and program (B).

posed new challenges for home owners. Allowing media access to our research and results on a consistent basis was important to increase public tolerance for bears and support for their conservation. We worked with communication specialists to develop NDOW's first public education program on reducing human–bear conflicts (*I'm Bear Aware—Are You?*), which was later renamed *Bear Logic*. We subsequently used newly collected data over the years to facilitate changes to this program; new data and information were included in printed brochures, videos, and given at public presentations.

Results and discussion

During the early phase of recolonization of western Nevada by black bears, adult males (>5 years of age) dominated our sample. We documented that some bears were being pulled out of backcountry areas into urban areas with attendant elevated mortality rates, resulting in urban areas being attractive population sinks (see Beckmann and Berger 2003*a, b*; Beckmann and Lackey 2008). Over time we also observed that female bears began to increase their use of garbage and other anthropogenic resources in the wildland–urban interface. Females in urban regions demonstrated high reproductive outputs in terms of cubs produced and lower age at first reproduction, but never realized this putative gain in fitness compared to wildland counterparts due to elevated mortality of cubs (mainly from collisions with vehicles; Beckmann and Berger 2003*a, b*; Beckmann and Lackey 2008). Although these urban sink areas only represent 7% of the western Nevada landscape, they were limiting the recolonization process.

Successes of the collaboration

With this new knowledge in hand, we began a multifaceted education campaign where we engaged the public and policymakers (e.g., county advisory boards) with 2 goals: 1) to reduce the number of human–bear conflicts by enacting effective garbage storage regulations and through improved bear-resistant infrastructure; and 2) to increase the number of bears in backcountry areas in western Nevada by having them redistribute themselves across the landscape in response to lower anthropogenic food availability at the wildland–urban interface.

Since its inception, NDOW has committed >$60,000 USD to their human–bear conflict education program, almost all of which has been educational materials handed out to the public. Our data were partly responsible for 3 Nevada counties enacting garbage management ordinances, beginning with Douglas County in 2001. Similarly, the intensive media coverage we employed helped raise awareness and tolerance for bears. During the first year of our study, bears and our bear research were highlighted in various print, radio, and television media a total of 41 times (J. Beckmann, unpublished data). There are now >$3 million of bear-resistant containers (BRCs) in the Lake Tahoe Basin and western Nevada that were not present 20 years ago (J. Beckmann,

unpublished data). Further, the state of Nevada enacted a law in 2015 (NRS 501.382) prohibiting the intentional feeding of large game mammals, including black bears. The impetus for enacting the law was the increasing public awareness surrounding human–bear conflicts (J. Drew, former Chairman, Nevada Board of Wildlife Commissioners, personal communication).

Due in part to the results of our long-term data and their use in subsequent management actions, the growth rate of the bear population (as measured by lambda, λ) increased from <1 in wildland–urban interface areas to an average of 1.16 across the study area during the first decade of the study (Beckmann and Lackey 2008, Lackey et al. 2013). These data were subsequently used by the Nevada Board of Wildlife Commissioners in 2010 to propose the state's first managed black bear hunting season, which began in 2011. One of the biggest benefits of the collaboration was the production of long-term data used to inform various management decision processes in Nevada and to monitor the impacts of those decisions.

Our Great Basin research provides an excellent model for other regions concerning how data-driven conservation and management efforts through long-term and consistent partnerships can result in natural recolonizing processes by large carnivores. The system is home to a population of black bears that is currently expanding both in numbers and geographical extent into historic range along a colonizing front due in part to the long-term cooperative effort of NDOW, WCS, and UNR. However, as with almost any long-term investment in a research and conservation effort, it is important to realize how delicate collaborations are and how important timing, combined with the correct individuals being in key positions, are in moving conservation forward. It is also important to note that dedication and long-term commitment not only by the various partnering entities, but by individuals within those entities, has contributed to the outcomes described here. In other regions, with higher turnover rates of individuals within agencies/entities, it would be more difficult to envision similar outcomes. Our collaboration has been fortunate in that all involved parties have been actively engaged for the entirety of the study.

We have collaborated through the entire process of collecting landscape-level field data and then using those data to inform and guide management decisions and conservation efforts. The GPS location data from bears have been used to develop resource selection function models across the Great Basin identifying core bear habitat, both in areas of the Great Basin where bears currently occur and key areas of habitat in historic range where bears have yet to recolonize. The partners have also modeled the genetics of this population that experienced extirpation followed by recolonization, and to understand for the first time the genetic consequences of carnivore recovery due to conservation at a landscape level (see Malaney et al. 2018).

All partners have engaged in a variety of conservation and management efforts across the Great Basin over the past 20 years. These efforts include, but are not limited to: 1) the above mentioned research and landscape scale analyses identifying core habitats and key areas for connectivity among other ecological aspects of the system; 2) helping to put in place >$3 million in bear-resistant garbage cans and dumpsters in the Lake Tahoe Basin and throughout the western Great Basin study site by increasing public awareness and tolerance of bears; 3) new BRC ordinances established in various counties in the Lake Tahoe Basin in both California and Nevada in response to data; 4) Nevada state law (NRS 501.382) prohibiting the intentional feeding of large game mammals, including black bears; 5) the first-ever extensive, long-term study investigating the impacts of the wildland–urban interface on American black bear behavior and demography at a landscape scale (Beckmann and Berger 2003*a*, *b*; Beckmann and Lackey 2008); and 6) initiating a nonlethal deterrent techniques program including the use of dogs to alter behavior of conflict bears to protect bear populations (Beckmann and Lackey 2004, Beckmann et al. 2004). We recognize there were multiple factors involved with the bear population increasing and ultimately recolonizing the Great Basin, and that the collaborative conservation efforts employed were not solely responsible. However, by taking a data-based approach to management and using the media to reach a regionwide audience with intensive public outreach, we were able to increase the public's

tolerance for bears. This was evidenced by an increasing growth rate of the bear population due to enhanced support for conservation efforts to increase bear-resistant infrastructure in the communities, and NDOW's nonlethal management techniques. We feel these efforts allowed the bear population to increase numerically and geographically at a rate higher than it would have otherwise.

Given the increasing bear population, we continued to work closely and frequently with local and regional media outlets in addition to national and international media to facilitate the educational process and to increase public tolerance for bears and reduce rates of human–bear conflicts. We do not believe that NDOW's educational programs would have been as successful had we not engaged the media as often as we did. We acknowledge that conflicts have continued to increase slightly statewide along with the increasing bear population (NDOW 2016); however, our efforts had a direct impact in lowering conflict rates in entire municipalities and homeowner associations in Nevada where our initial work was concentrated (i.e., Glenbrook, Stateline, Lake Village, and the Lakeview subdivision near Carson City). In Stateline, Nevada, for example, Beckmann and Berger (2003*b*) reported the second-highest density of black bears in North America (120 bears/100 km^2) during the early part of our study, and the majority of human–bear conflict complaints were received from this area. By the late 2000s, the use of BRCs had increased in Stateline, and subsequently numbers of complaints in these areas declined and most complaints were received from other areas in the Lake Tahoe Basin (NDOW 2009).

Challenges facing the collaboration

Bears had been absent from the Nevada side of the Lake Tahoe Basin and the Great Basin Desert for >80 years. Thus, most people we encountered were unaccustomed to living with bears. At times, we faced opposition from the public due to the rapid increase, geographically and numerically, of the bear population and the growing number of human–bear conflicts. The ability for each partner to play various roles in data collection, publishing, media relations, education, policy engagement, and other elements of this long-term effort were critical to our management and conservation successes over the past 20 years.

For example, funding a long-term effort such as the one we describe here can be a challenge as various funding sources wax and wane or funding fatigue sets in over time. For our study, the >80-year absence of bears from the state of Nevada meant there was no research funding available from NDOW at the beginning of the study. The ability of one of us to bring in funding that was raised at the university was a key to beginning this long-term effort and kept the project going for the first 5–7 years. Over time, NDOW has been able to direct funding toward the research, conservation, and management of bears, and funding the project was evenly spread across the various partners. Further, various aspects of the collaboration need a diversity of funders, and the 3 partnering entities have access to different sources of funding that can be used to address these aspects (e.g., research, educational efforts, and policy-engagement efforts).

Similarly, as various management decisions were being made by the state based on the data described herein, the diverse partnership allowed independent voices from entities with differing mandates (though all entities ultimately have the goal of conservation of wildlife in the region) to speak to the validity of those data and how they could inform these often contentious decisions. For example, when the state of Nevada decided to have a managed bear hunt for the first time in the state's history (2011), members of the collaboration from the university and the NGO could discuss the data in an unbiased yet informed manner to interject data into the discussion and decision process in the years preceding the hunt. Ultimately, the decision by the Nevada Board of Wildlife Commissioners to hunt this recolonizing bear population resulted in a challenge to each individual and entity of the collaboration, as some activist groups increased their scrutiny of the decisions, the individuals, and the underlying data. The fact that the 3 entities all came to the table from different perspectives (state agency, university, NGO) and in partnership gave credence to the unbiased nature of the data and publications used to inform the decision process. A similar process continues to play out whenever management

decisions are made by NDOW to lethally remove bears due to conflicts and public safety considerations. There is strength in the diversity of the entities involved in the collaboration, data collection, and analyses when such tough decisions are made.

Future directions

Continued expansion of the black bear population in the Great Basin will require conservation and management planning that takes into account how changes in human activity influence overall habitat suitability and connectivity for black bears. At the time of writing, NDOW and WCS are working together with university partners to develop additional resource selection probability function models, connectivity models including genetic structure, and mortality risk models (Wynn-Grant et al. 2018) to identify current and potential core habitat areas. The results will allow NDOW to stay ahead of (i.e., educate and work with various communities, decision-makers, and constituents to adequately prepare for living with bears) the recolonizing front of black bears. Given that Nevada is among the fastest-growing states in the United States (World Population Review 2018), the rapidly increasing human population will make continued expansion of the bear population challenging. Only through the state–NGO–university partnerships developed in Nevada will it be possible to address all the emerging threats to the continued recovery of this species across the Great Basin.

A final challenge will be that the Great Basin is among the most water-limited systems in North America, which already has experienced serious drought conditions in recent years (Beckmann and Berger 2003*a*). Projections are for the severity and frequency of such droughts to increase over time (Coats et al. 2006, Dolanc et al. 2013). Water availability will likely continue to drive many aspects of black bear dispersal and habitat use (Obbard et al. 2010, Atwood et al. 2011). An incomplete understanding of how male and female bears use various sources of water and how climate change, interacting with an increasing human population will impact water availability, will continue to be a threat to the continued recovery of this population.

Management implications

The current understanding of the impacts of human-altered landscapes on bears in Nevada was possible in large part through the long-term and joint partnership between NDOW, WCS, and UNR with data collected across the entire landscape comparing urban and wildland bears. Without this partnership, it is likely that: 1) either the data would have never been collected at this scale, and/or 2) the usefulness of the data in guiding management and policy decisions would have been more limited. Continued expansion of the black bear population in the Great Basin will require conservation and management planning including a detailed analysis of how changes in patterns of human activity may influence overall habitat suitability and connectivity for bears. Ultimately, the protection of key habitat is critical to continued recovery throughout this vast region (Nielsen et al. 2006). The partnerships between science-based NGOs and state agencies will become increasingly important, especially if funding for wildlife management agencies decreases, and as the Great Basin and other regions continue to experience stresses from an increasing human footprint. This could be exacerbated when coupled with recovering populations of other large carnivores (e.g., wolves are likely to also expand back into the Great Basin in the very near future).

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