Title: Evaluating demographic and behavioral responses of the Tibetan brown bear (*Ursus arctos pruinosis*) to the loss of a keystone prey species

Key words: human-wildlife conflicts, keystone species, Leslie matrix population model, plateau pika, population growth, space use, Tibetan brown bear, *Ursus arctos pruinosis*

Introduction: The study of the maintenance of biodiversity by keystone species in ecological systems is essential for the conservation of many endangered species. Loss of keystone species can have cascading effects on the members of a biotic community that rely on its presence for survival. The plateau pika (*Ochotona curzoniae*) is a keystone species on the Tibetan Plateau, serving as the most abundant food source for avian and mammalian predators [1]. Pikas are favorable prey species because they are ubiquitous across the plateau, occur in dense populations, live in easily accessible burrows, and are active year-round.

Current efforts are being conducted by the Chinese government to exterminate the plateau pika under the assumption that pikas compete with livestock and diminish the productivity of the landscape [1]. Between 2007 and 2009, 320,000 km^2 of plateau pika habitat were poisoned [2]. While a project is underway to study the effects of pika extirpation on livestock and herding communities [3], an in-depth study examining the loss of this key prey item on carnivore species is lacking. Preliminary studies indicate that carnivores are less abundant in areas where pikas are poisoned [4], however, more empirical evidence is needed to confirm this trend and investigate population-level responses by specific predator species.

The Tibetan brown bear (*Ursus arctos pruinosis*), an endangered subspecies, may be especially vulnerable to declines in available pika prey. These bears rely on pikas as a food source, which have been found in up to 78% of bear scats [5] and comprise as much as 60% of their diet [6]. Bears that are nutritionally stressed from the loss of a primary food source are more likely to target human communities and become nuisance animals. Human-bear conflicts in Tibetan herding communities have increased in recent years, resulting in destruction of property, loss of food supplies and livestock, and in some cases, injury or death [7]. Not only do these conflicts negatively impact local people, but they intensify challenges to encourage conservation of bears. While increases in human-bear conflicts began immediately following large-scale pika extermination [7], no study has examined the relationship between poisoning and bear attacks.

Questions: I propose to examine how loss of an essential keystone prey species impacts predators by studying the behavior and demography of brown bears inhabiting areas that have and have not been subjected to pika extermination. Specifically, I will compare the following population characteristics of bears between study areas: 1) movement and space use, 2) demographic parameters and population growth, 3) diet, and 4) human-bear interactions. I predict that bears will use larger home ranges, disperse greater distances, exhibit slower population growth, and engage in more behaviors that bring them into conflict with people in areas where pikas have been exterminated.

Research Plan: The study area will be the alpine grasslands of Qinghai Province, People's Republic of China. I will monitor two bear populations simultaneously for three years. The first will be located in an unpoisoned region to develop baseline dispersion and population models, and the second will be located in a region currently undergoing poisoning. I will select two study areas with minimal environmental differences beyond pika extirpation to minimize variation in other variables that may influence bear demography and behavior. I will live-trap bears with leg snares following protocols used by Nielson et al. [8]. Captured bears will be fitted with an Argos/GPS collar and PIT tagged to ensure identification upon recapture. GPS data will be used to track movement of individuals and locate den sites. I will estimate demographic parameters

using telemetry data (adult and yearling survival) and by visiting den sites identified with GPS data (litter size, annual proportion of females breeding, and cub survival). In addition, I will collect fecal samples opportunistically and on scat collection transects in both study areas to compare the diets of the two populations. Due to the status of Tibetan brown bears as a second class key protected species in China [5], I will obtain permission to trap these animals from the Qinghai Ministry of Forestry. In order to ensure the success of these methods, I have been in contact with local Tibetan brown bear experts Dr. Dajun Wang (Peking University) and Dr. Li Sheng (Smithsonian Conservation Biology Institute), as well as Dr. Marc Foggin, founder of Plateau Perspectives (an environmental NGO in Qinghai province).

Location data from the GPS collars will be used to develop a model following the approach of Nielson et al. [8] to predict the extent of movement and dispersion of bears after pika poisoning events. This model will incorporate territory size, density of individuals in the population, time since initial poisoning events, and human population density to provide insight into behavioral responses of brown bears to the loss of a major prey species. I will construct a stage structured Leslie matrix population model [9] to determine population growth (λ) using the following parameters: stage-specific survival rates, proportion of reproducing females, litter size, and cub recruitment. This model will evaluate how poisoning events influence bear long-term population viability by comparing population growth rates in the presence and absence of pikas.

To study the effects of pika poisoning on human-bear interactions, I will record all conflicts in communities neighboring my study sites from interviews [7], as well as the status of nearby pika populations, and when applicable, time since poisoning efforts began. The nature of conflicts will be documented to determine if encroachments were food-motivated. If a fecal sample is found, the sample will be used to genetically identify the individual and determine diet. These data will be used to determine behavioral modifications in bears and the spatial scale at which loss of primary prey species indirectly impacts human communities.

Intellectual Merit: The anthropogenic extirpation of the plateau pika provides us with an experimental system in which to study how the loss of keystone prey species impacts space-use, demography, and behavior of predators that are dependent on them. This comprehensive approach to the study of species' reactions to ecological change will advance our understanding of cascading effects of species loss at the population level. My research will also contribute to natural history by quantifying demographic characteristics of an understudied subspecies.

Broader Impacts: The integration of population biology and human-wildlife conflicts is essential for the development of management strategies for the conservation of the Tibetan brown bear. Better management of the Tibetan Plateau ecosystem will also result in the maintenance of the livelihood of a subjected cultural group, the Tibetan herding people, who are already being negatively impacted by Chinese development practices on the plateau [2]. This project is uniquely suited to study the ecology of an important predator on the plateau while simultaneously addressing human welfare issues. To ensure that my results reach the public, I will make them available to the IUCN/SSC Bear Specialist Group. As a university professor, I will share my research with students to encourage rigorous scientific study and to demonstrate the need to collaborate with local peoples to achieve optimal results in conservation.

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