WWF

24TH INTERNATIONAL CONFERENCE ON BEAR RESEARCH & MANAGEMENT

Bears of the World:

Learning from our Past to Inform our Future

ABSTRACTS

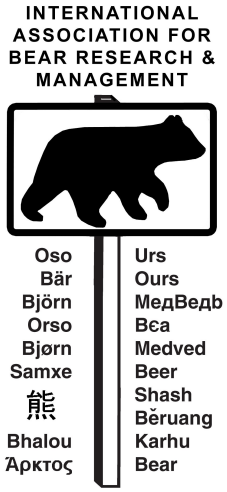
International Association for Bear Research and Management

The International Association for Bear Research and Management (IBA) sponsors international conferences and workshops about bear biology, research and management. The International Conference on Bear Research and Management is the largest of these conferences and is focused on all eight bear species. The international conferences are rotated between the Americas and Eurasia on an 18-month rotation. Many of the conference papers are published as peer-reviewed papers in the journal Ursus.

The IBA is a nonprofit, tax-exempt organization open to professional biologists, wildlife managers and others dedicated to the conservation of all bear species. The organization has over 550 members from over 50 countries. It supports the scientific management of bears through research and distribution of information.

The goal of the association is to promote the conservation and restoration of the world's bears through science-based research, management and education.

The eight bear species of the world pose significant research and management problems to governments, local authorities, wildlife biologists, land managers, park personnel, tribal councils, and private landowners. The public endures hardships caused by bears; the public wants bears to survive. Management responsibility for the bears and their habitats rests with numerous national and local agencies and councils. Encroaching civilization, involving land-use conflicts and resource utilization by human beings, has resulted in the decline or disappearance of bear habitat and bear populations in portions of their ranges. Continued viability of populations and the possible restoration of bears in certain areas will be largely contingent upon a cooperative approach towards research, management, land use, and education, and will increase in cost as land values escalate. The IBA, an association primarily of professional biologists with an interest in bears, recognizes these dificult bear research and management problems faced by agencies and governments.



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Session 1 – Conservation and Ecology of Polar Bears

Polar Bear Conservation Status in Relation to Projected Sea-Ice Conditions

Kristin Laidre, Eric V. Regehr, Øystein Wiig, H. Resit Akçakaya, Steven C. Amstrup, Todd Atwood, Nick Lunn, Martyn Obbard, Harry Stern, Greg Thiemann

The status of the world's 19 subpopulations of polar bears (*Ursus maritimus*) varies as a function of sea-ice conditions, ecology, management, and other factors. Previous methods to project the response of polar bears to loss of Arctic sea ice—the primary threat to the species—include expert opinion surveys, Bayesian Networks providing qualitative stressor assessments, and subpopulations-specific demographic analyses. Here, we evaluated the global conservation status of polar bears using a data-based sensitivity analysis. First, we estimated generation length for subpopulations with available data (n=11). Second, we developed standardized sea-ice metrics representing habitat availability. Third, we projected global population size under alternative assumptions for relationships between sea ice and subpopulation abundance. Estimated generation length (median = 11.4 years; 95%CI = 9.8 to 13.6) and sea-ice change (median = loss of 1.26 ice-covered days per year; 95%CI = 0.70 to 3.37) varied across subpopulations. Assuming a one-to-one proportional relationship between sea ice and abundance, the median percent change in global population size over three polar bear generations was -30% (95%CI = -35% to -25%). Assuming a linear relationship between sea ice and normalized estimates of subpopulation abundance, median percent change was -4% (95% CI = -62% to +50%) or -43% (95% CI = -76% to -20%), depending on how subpopulations were grouped and how inference was extended from relatively well-studied subpopulations (n=7) to those with little or no data. Our findings suggest the potential for large reductions in polar bear numbers over the next three polar bear generations if sea-ice loss due to climate change continues as forecasted.

Resilience and Risk - A Demographic Model to Inform Conservation Planning for Polar Bears

Erik Regeher

Loss of Arctic sea ice due to climate change has led to listing of the polar bear (*Ursus maritimus*) under the U.S. Endangered Species Act. Methods are needed to evaluate the effects of climate change on population persistence to inform conservation planning for listed species. For polar bears, this includes understanding interactions between climate and secondary factors, such as subsistence harvest, which provide economic, nutritional, or cultural value to humans. Specifically, an improved framework is needed to evaluate the effects of harvest on potentially declining populations, and to inform management strategies seeking to meet the concurrent goals of population persistence and continued subsistence use. We developed a matrix-based demographic model for polar bears that includes density dependence (the potential for a declining environmental carrying capacity), density-independent limitation, and sex- and age-specific harvest vulnerabilities. We also developed a state-dependent management framework,

based on harvest theory and the potential biological removal method, by linking the demographic model to simulated population assessments. This framework can be used to estimate a sustainable rate (alternatively, non-detrimental rate) of harvest that maintains a population above its maximum net productivity level and has a limited negative effect on persistence. This rate is calculated as a function of current population status, management objectives, the precision and frequency of population data, and risk tolerance. Our modeling results suggest that harvest of polar bears is unlikely to accelerate population declines that result from declining carrying capacity caused by sea-ice loss, provided that several conditions are met: (1) the sustainable harvest rate reflects the population's intrinsic growth rate—recognizing that harvest rate could be zero, and the corresponding harvest level is obtained by applying this rate to an estimate of population size; (2) the sustainable harvest rate reflects the quality of population data (e.g., lower harvest when data are poor); and (3) the level of human-caused removals can be adjusted. Stopgap measures may be necessary to minimize the incremental risk associated with harvest if environmental conditions are deteriorating rapidly.

Polar Bear Attacks on Humans: Implications of a Changing Climate

James Wilder

Continued loss of sea ice habitat and increasing human development in the Arctic will bring more polar bears (*Ursus maritimus*) into contact with humans in the future. Understanding polar bear attacks on humans is critical to ensuring both human safety and polar bear conservation. To accomplish this, we developed the Polar Bear-Human Information Management System (PBHIMS), a database designed to facilitate the range-wide analysis of human-polar bear conflicts. We populated the PBHIMS with conflict data from throughout the polar bear's range, analyzed attacks on people, and found that incidents of polar bear attacks on people have been extremely rare, historically. We know of only 71 attacks by wild polar bears that resulted in 21 human fatalities and 60 human injuries during the period 1870–2014. Sixty-three percent of bears involved in attacks on humans were in below-average body condition. We judged that bears acted as a predator in 61% of attacks, and in 87% of fatal attacks. Seventy percent of bears involved in predatory attacks on people were in below-average body condition. There are major differences between attacks by polar, black, and brown bears. Unlike other North American bear species, twenty-six percent of polar bear attacks occurred in towns. We have zero cases where a female polar bear with cubs killed a person. Forty seven percent of attacks, and 59% of predatory attacks, were by independent immature polar bears (subadults, two-year olds, and yearlings). Increased concern for human safety is warranted in light of predictions of increased numbers of nutritionally stressed bears spending longer amounts of time on land in close proximity to people due to the loss of their sea ice habitat. The methods and analyses presented here are a first step towards demystifying our understanding of human-polar bear conflicts. Continued expansion of this initiative will help increase human safety and help managers ensure the conservation of polar bears for future generations.

Using Synthetic Aperture Radar for Remote Detection of Polar Bear Dens

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In recent years, advances in Synthetic Aperture Radar Imaging (SAR) have led to the ability to detect and analyze disruptions in a generally uniform snow environment. Female polar bears in the Southern Beaufort population den in snowdrifts and are not detectable to the unaided eye once den drifts close. However, a polar bear's body, and the den chamber itself, comprise targets that should be readily detectable with SAR. In recent years, forward-looking infrared imagers (FLIR) have been used to locate denned polar bears along Alaska's North Slope (Amstrup et al. 2004), but recent work by Robinson et al. (2013) indicates dens may often be overlooked due to the small window for the efficient use of FLIR. Variables reducing the efficacy of FLIR include wind, solar radiation, and den wall thickness. Unlike FLIR, however, SAR is not affected by these same variables. Additionally, the survey swath-width of an airborne SAR can be up to 2 km wide, allowing more efficient census of potential denning areas. SAR represents a potentially new tool for den detection and, once developed, should provide a more robust and accurate tool for industry and polar bear managers alike. A more reliable detection tool will be less weather-dependent, will limit false positives and minimize disruption of planned activities. Here we present findings from two SAR surveys of polar bear denning habitat in the Prudhoe Bay, Alaska region.

Increased Arctic Sea Ice Drift Alters Polar Bear Movements and Energetics

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Recent thinning and reduced extent of Arctic sea ice has increased its drift from currents and winds. Increased ice drift could significantly affect the movements and energy balance of polar bears (*Ursus maritimus*) which rely, nearly exclusively, on a sea ice substrate for foraging. We examined the response of polar bears to ice drift in the Beaufort (BS) and Chukchi (CS) seas during two periods with different sea ice characteristics: 1987-1998 and 1999-2013. We used tracking location data from adult female polar bears and ice drift data to estimate the influence of ice drift on polar bear movements. Westward and northward drift of the sea ice used by polar bears in both regions increased from 1987-1998 to 1999-2013. Polar bears responded with higher eastward movements opposing drift, but frequently followed ice motion in the north-south direction. Efforts by polar bears to compensate for greater westward ice drift and melt in recent years translate into a model-derived estimate of 2.0–6.7% increase in energy expenditure. In conjunction with reduced foraging opportunities as a result of a 9.3–13.6% increase in time spent active, and likely lower encounter rates with seals because of habitat loss, recent changes in ice drift could exacerbate the physiological stress currently experienced by polar bears.

The Behavioral Response of Polar Bears to Habitat Degradation in the Chukchi and Beaufort Seas

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One of the greatest challenges to identifying the mechanisms by which polar bears are responding to sea ice loss is an inability to directly observe their behavior. Activity data, which have been collected over several decades from polar bears, may provide some insights into the behavior of bears during the summer sea ice retreat. We conducted experiments with captive brown and polar bears to validate the use of two activity sensor types for identifying resting versus active behaviors. Behaviors were accurately classified into resting and active categories using both sensor types, illustrating the utility of activity sensors in identifying broad behavioral patterns of bears in current and historical datasets. We applied these results to activity sensor data collected 1989-2014 from 202 adult female bears from the neighboring Southern Beaufort (SB) and Chukchi Sea (CS) subpopulations. We examined activity levels as a function of ice concentration and habitat for three habitat types thought to vary in prey availability: land (low availability), ice over shallow waters (higher availability), and ice over deep Arctic basin waters (hypothesized low availability). We found that bears in both subpopulations spent less time on ice over shallow waters during the recent years of study (2009-2013) compared to early years (1990-1995); two time periods in which data were available for both subpopulations. Bears were most active in ice habitats where ice concentrations were 50-80%, which is consistent with polar bear preference for these concentrations and where prey availability is thought to be greatest. Bears on ice over shallow waters had activity levels 15-25% higher than bears on land and 3-10% higher than bears on ice over the Arctic basin. Additionally, though activity was lower relative to the ice habitats, SB bears were more active (~10%), and therefore may expend more energy, than CS bears on land. Potential lower prey availability on land and in deep, Arctic basin waters and more frequent use of these habitats by SB bears may explain why this population has experienced reduced body condition, recruitment, and survival, whereas CS bears have not yet experienced such effects.

The Effects of Sea Ice Loss on Protein and Fat Stores of Food-Deprived Polar Bears

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In some regions of the Arctic, sea ice decline and the resulting loss of foraging opportunities have been associated with recent reductions in polar bear abundance, survival, and reproduction. It is often assumed that during food deprivation lipid reserves (e.g., adipose fat) are the limiting factor to polar bear survival, and the role of protein reserves (e.g., skeletal muscle) is often under appreciated. Structural tissues require a constant input of amino acids for maintenance; to provide these amino acids, fasting bears catabolize endogenous protein, potentially at a greater rate than endogenous lipid. Recent studies with captive vertebrates demonstrated that when feeding, animals may use carbon derived from dietary lipids to synthesize proteins used to build structural tissue. We hypothesize that fasting polar bears use a similar process to transfer carbon from stored adipose fat to stored protein. To test this hypothesis, we are using amino acid carbon isotope ($\delta^{13}C$) analysis, and archived samples from a previous study of nutritional ecology in the Southern Beaufort Sea, to track carbon flux between protein-rich (red blood cells, serum, skeletal muscle) and lipid-rich (adipose) tissues in individual, free-ranging polar bears that exhibit a spectrum of body condition and feeding status. Our preliminary data suggest that a portion of the non-essential amino acids in red blood cells of fasting polar bears were newly synthesized with carbon that had been transferred from endogenous adipose tissue. If carbon movement between lipid and protein is substantial, it will change our understanding of polar bear fasting physiology and endurance, influencing forecasts of how this species will respond to continued ice loss.

Consistency in Polar Bear Habitat Selection Patterns During a Period of Rapid Sea Ice Loss

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Habitat loss is one of the primary ways that wildlife are likely to be affected by climate change. As a result, current habitat selection patterns are often used to predict the impact of environmental change on the future availability of preferred habitats. For these results to be meaningful, habitat selection patterns must not change after habitat conditions change; a rarely tested assumption. We estimated polar bear habitat selection patterns in the Chukchi Sea and tested for changes in selection during a period before (1986-1994) and after (2008-2013) significant sea ice loss. We then used these results to determine how the distribution and area of high-value habitat has changed. Habitat selection patterns did not differ between time periods. There were no changes in the distribution or area of high-value habitat during most of the year. However, loss of summer sea ice, coupled with invariant habitat selection resulted in a nearly 90% decrease in the area of high-value habitat in September between periods. Our results suggest that polar bears in the Chukchi Sea are not adjusting their habitat selection to accommodate changing sea ice conditions. This invariant habitat selection supports the use of current habitat selection patterns to

project future habitat conditions for polar bears but highlight the apparent inability of polar bears to adjust habitat selection as sea ice conditions change.

Continued Declines in Reproduction in Western Hudson Bay Polar Bears Despite Short-Term Stability in Sea Ice Conditions

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Polar bears (*Ursus maritimus*) in western Hudson Bay, Canada, rely upon annual sea ice for access to their primary prey, ringed seals (*Phoca hispida*). During the summer months when Hudson Bay is ice-free, bears remain on land where they make little use of terrestrial food sources. Documented declines in population size, survival, body condition, and natality in the Western Hudson Bay (WH) subpopulation from the 1980s through early 2000s were linked to progressively earlier breakup of sea ice during the most important feeding time in spring, which also contributed to increasing length of the ice-free period through which the bears must fast on their stored fat reserves. Over the past decade, there has been no significant trend in date of sea ice breakup or freeze-up, or duration of the ice-free period in western Hudson Bay. To determine whether the WH polar bears had responded positively to shorter-term trends in sea ice, we estimated reproductive parameters, including litter production rate (LPR), mean litter size (MLS), number of cubs-of-the-year per female (CF), and birth interval (BI) from 496 adult female polar bears captured in the core summering area from 2001-2014. Although there has been no significant trend in MLS ($r=-0.763$, $p>0.20$), there have been significant declines in LPR ($r=-0.952$, $p<0.05$) and CF ($r=-0.985$, $p<0.02$), and a significant increase in BI ($r=0.974$, $p<0.05$). Our findings suggest that the response of WH polar bears to changing sea ice conditions may be more complex and non-linear and likely dependent on other factors such as sufficient availability of prey and whether sea ice conditions have reached a critical threshold beyond which polar bears are unable to accumulate sufficient energy reserves to be able to continue to reproduce at previous, more productive levels.

Shrinking Ice and Shrinking Bears: Long Term Trends in Sea Ice Extent and Polar Bear (*Ursus maritimus*) Body Size in Western Hudson Bay

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Polar bears (*Ursus maritimus*) require sea ice as a platform from which to hunt their primary prey, ringed seals (*Pusa hispida*) and bearded seals (*Erignathus barbatus*). Consequently, changes in the availability of sea ice have the potential to influence access to prey and therefore individual energetics. Herein we investigate trends in sea ice conditions and polar bear body length in western Hudson Bay, Canada to test the hypothesis that changes in the availability of sea ice during early development results in phenotypic variation in body size among cohorts. Temporal analysis of passive microwave sea ice data show that the extent of sea ice has declined significantly in western Hudson Bay from 1979-2015 resulting in earlier breakup, later freeze-up and an increased summer fasting period for polar bears. These results suggest that over the long-term, polar bears in western Hudson Bay have experienced reduced access to their primary prey during the important hyperphagic spring feeding period. From 1960-2006 the mean cohort body length of bears in western Hudson Bay ranged from 191.7 ± 2.2 cm to 206.3 ± 3.8 cm for females and from 224.2 ± 4.0 cm to 241.0 ± 8.1 cm for males. Temporal trends in adult body length showed declines in both males and females from 1960-2006. Subsequent cohort analysis revealed that sea ice conditions experienced during early development explained a significant proportion of the mean cohort body size in both sexes. Ongoing research has demonstrated that polar bear body size is heritable and under selection. We discuss our results in the context of life history, climate change, and the selective pressures that are likely to influence the fitness of the western Hudson Bay polar bear population.

Towards a New Tool for Investigations into Bear and Ecosystem Health

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Increasingly, gene transcription-based diagnostics of wildlife are being used in the assessment of health, not only in individuals or populations but also in ecosystems. Given that polar bears (Ursus maritimus) are a flagship, sentinel species in the Arctic with a distribution limited to regions with adequate sea ice, they are an ideal candidate species for detecting systemic perturbations with transcript-based tools. We present a two tiered approach for investigation into polar bear health as a model for application to this and other species.
We use quantitative PCR to identify the synergistic effects of multiple stressors on the individual physiology of polar bears from the Beaufort and Chukchi Seas as well as captive healthy polar bears. Polar

bears in the Beaufort and Chukchi Seas experience different environments due primarily to a longer history of sea ice loss in the Beaufort Sea. Ecological differences have been identified as a possible reason for the generally poorer body condition and reproduction of Beaufort polar bears compared to those from the Chukchi, but the influence of exposure to other stressors remains unknown. We identified transcript profiles consistent with immune function impairment in polar bears from the Beaufort Sea, when compared with Chukchi and captive polar bears.
We also use an emerging technology (transcriptomics) as a potentially guiding investigative approach aimed at elucidating the circumstances responsible for the susceptibility of certain polar bears to observed conditions. In 2012, 28% of polar bears sampled in a study in the southern Beaufort Sea region of Alaska had varying degrees of alopecia that was concomitant with reduced body condition. The primary and possible ancillary causative stressors of this condition are unknown, and related physiological changes within individual animals have been undetectable using classical diagnostic methods. Using transcriptomic analysis we identified enhanced biological processes including immune response, viral defense, and response to stress in polar bears with alopecia. Our results represent a foundation for implementation of a holistic system of surveillance and investigation that could provide early warning of health concerns in wildlife species important to humans.

Animal Growth in a Changing Environment: Polar Bears of Southern Hudson Bay

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Sea ice habitat for polar bears in Hudson Bay has changed greatly in the past three decades. As such, due to advancing break-up and delayed freeze-up, the open water season has extended and bears of the Southern Hudson Bay (SH) subpopulation spend about 30 days longer on land than in 1980. This has resulted in declines in body condition and survival rates in this subpopulation. In animals such as polar bears that have large annual fluctuations in body mass, body mass and body condition in any year reflect near-term food availability. In contrast, body size (e.g., body length, zygomatic width) reflects the conditions encountered by an individual over several years during the growth phase while a subadult. We were interested in determining whether growth rates and asymptotic size of polar bears in this subpopulation had changed over time with changing sea ice conditions. We compared morphometric data for >1,000 individual polar bears handled during 4 time periods: 1984-86, 1997-2002, 2003-2005, 2007-2009 that had differing capture effort but similar sample sizes of morphometric data.
We tested for changes in the size of cubs-of-the-year using linear models. For other age classes we used Von Bertalanffy growth equations in a nonlinear mixed effects model so we could include repeated measures of the same animal. Because polar bears lose mass during the period ashore we included ordinal day of capture as a covariate. We used AIC_c to evaluate support for candidate models. Cubs-of-the-year decreased in measures of body size and weight over years. By 2009, cubs were 35 kg lighter than in 1984 when standardized for day of capture. For other age classes, body size of both males and females decreased over time. Body mass of adult males decreased by 2.25 kg/yr between 1984 and 2009. Similarly, asymptotic weight of females in 2007-09 was 53 kg lighter than in 1984-86.
Abundance of SH appears unchanged since the mid-1980s so changes in body size documented here are unlikely to be a density-dependent response. Rather, they are likely a response to decreased resource availability due to a shorter ice-covered period in Hudson Bay.

Spring Field Metabolic Rates and Behaviors of Female Polar Bears on the Sea Ice of the Southern Beaufort Sea

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Recent declines in sea ice have been linked to reductions in body condition, survival, and population of polar bears (*Ursus maritimus*) in some Arctic regions. Reduced availability of ice seals are presumed to be the cause of these declines, but increases in energy expenditure associated with changing sea ice conditions may be an additional mechanism. Field metabolic rates of polar bears are unknown and little quantitative data exist on polar bear behaviors and foraging demands on the sea ice. We quantified the metabolic rate, feeding rate, behavior, and foraging success of wild female polar bears over 8–11 days during the spring of 2014 (n=4) and 2015 (n=3) on the southern Beaufort Sea pack ice using doubly-labeled water, tri-axial accelerometers, and GPS-equipped video camera collars. Polar bears had metabolic rates 1.3× greater than predictions from allometric equations and 1.3–1.6× greater than previously predicted for polar bears. Activity budgets derived from video camera collars and accelerometers corroborated differences in metabolic rates among individuals and bears spent 70% of the time resting (including still-hunting). Foraging success varied with 3 bears successfully killing and eating ringed seals, while the remainder either scavenged from old carcasses or fasted. Our results suggest polar bears have high energy demands that will limit their ability to behaviorally adapt to forecasted declines in Arctic sea ice.

Maternal Denning Phenology and Substrate Selection of Polar Bears in the Southern Beaufort and Chukchi Seas

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Global-warming induced sea ice loss may affect the phenology and distribution of polar bear (*Ursus maritimus*) denning by altering access to denning habitats. We examined trends in maternal denning substrate choice (land versus sea ice denning) in the southern Beaufort (SB) and Chukchi (CS) seas, and the potential influence of summer land use and fall sea ice conditions on substrate selection. We developed an algorithm based on statistical process control methods to remotely identify denning bears and estimate denning phenology from temperature sensor data collected on collars deployed 1985–2013. We evaluated cub survival relative to den entrance, emergence, and duration, and examined differences

in the timing of land and sea ice dens. Land denning in the SB was more common during years when ice retreated farther from the coast and off of the continental shelf in September. In contrast, there was no change in the frequency of land-based denning in the CS, but denning females selected for coastlines with later dates of sea ice retreat. All SB bears that summered on land prior to denning subsequently denned on land; however, only 29% of denning bears that summered on sea ice denned on land. Den entrance and duration in the SB and CS were similar, although CS bears emerged later. Land dens were occupied longer than those on ice. Bears later observed with cubs remained in dens 23 days longer and emerged from denning 17 days later on average than bears that denned but were subsequently observed without cubs, suggesting that den exit dates are related to cub survival. The increase in land-based denning in the SB when sea ice retreated farther from shore, along with the positive correlation between fall land-use and land denning, suggest that further sea ice declines may result in continued increases of onshore denning. Growing numbers of denning females along the coast may increase the potential for human-bear interactions.

Windscapes Shape Polar Bear Foraging and Travelling Behaviour

Ron Togunov

Understanding strategies for maximizing foraging efficiency is central to behavioural ecology. Olfactory predators must first search for the presence of an odour before localizing its source. Optimization of the search for odours among large carnivores and the role wind plays remains unexamined. We studied anemotaxis (orientation relative to wind) of polar bears, *Ursus maritimus*, in Hudson Bay within the context of optimal foraging. Polar bear velocities and orientation based on GPS tracks (controlled for ice drift) were compared to modelled wind velocity and direction. During freeze-up, the mean bear orientation was down-wind; corresponding to the autumn migration into the Bay, given the predominantly north-westerly winds. During winter and spring (when most predation on seals occurs), when wind velocities were <10 m/s and consecutive bear locations were >3 km apart, mean orientation was perpendicular to the wind. During the same period, when wind was >10 m/s or consecutive locations were <3 km apart, mean orientation was down-wind. During breakup, mean orientation was 45° right of down-wind; corresponding to southward movement toward land. During summer, while bears were on land, no pattern of orientation was observed. Down-wind orientation in winter/spring may reflect of traveling while wind conditions are not conducive for foraging. The observed perpendicularity to wind during winter/spring aligns with the predicted optimal search strategy. These findings represent the first quantitative description of anemotaxis for optimizing foraging among any large carnivore.

Application of 2D and 3D Photographic Technology to Estimate Body Size and Condition of Polar Bears

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Advances in digital imaging show potential for noninvasive collection of morphometric and condition data from free-ranging wildlife. Such images and the resulting data would allow monitoring the status of animal populations undergoing rapid environmental changes, including polar bears (*Ursus maritimus*). Several recent studies linked morphometric changes in polar bears, mainly reductions in body size and body condition to reduced cub recruitment and smaller litter sizes. These changes likely result from reduced foraging opportunities from declines in sea ice extent. Traditional methods for obtaining morphometric measurements from polar bears generally involve live-captures. While photographic analysis will not replace these methods, it may potentially augment findings in a safe, low-cost, and noninvasive manner. Our objectives are to develop new techniques and advance existing methods to noninvasively estimate polar bear body size and condition using 2D and 3D photography and geometric morphometric methods. We have been collecting photographs with location and distance-to-bear data using laser rangefinders near Churchill, Manitoba, Canada since 2012. In 2015 we also collected 3D data using a stereovision camera and began testing and calibrating methods on captive bears in facilities throughout the US and Canada. After developing methods we will evaluate possible changes in body condition and size of polar bears over the last 30-40 years using recent and historic photographs collected by our partner, Polar Bears International. Our ultimate goal is to develop this into a citizen science project where using an online tool, members of the public will contribute their photos and analyze existing photographs to collect morphometric measurements of animals in areas where current information is lacking.

Human-Bear Interactions, Climate Change, and Emerging Patterns of Polar Bear Habitat Use in the Chukchi Sea Region of Alaska

Hannah Voorhees

Over the last two decades, climate change has transformed polar bear habitat in Alaska. Our research team conducted two years of Local and Traditional knowledge (LTK) research with Alaska Native subsistence hunters in the Bering Strait region to assess changes in local habitat use, abundance, distribution, and seasonal movement for the Chukchi Sea polar bear subpopulation. Hunters' detailed observations demonstrate that changing patterns of polar bear habitat use—such as reduced coastal scavenging or increased presence in villages—cannot fully be understood with reference to large-scale climate change effects alone. Rather, these effects manifest only in interaction with highly localized ecologies (which include humans), and result in part from regionally specific cultures of human-polar bear interaction and legacies of wildlife management. Here, I provide ethnographic detail on interactions between patterns of sea ice loss and human-bear dynamics for the Chukchi Sea region. I argue that the

fine-grained detail found in LTK will remain essential for understanding how climate change translates into actual emerging patterns of habitat use "on the ground" for polar bear subpopulations in Alaska, and in turn, for crafting locally appropriate conservation strategies.

Temporal Trends in Foraging Patterns and Body Condition of Female Polar Bears in Western Hudson Bay

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Polar bears are specialized predators dependent on sea ice as their foraging platform to consume high energy marine mammal prey. In Western Hudson Bay (WH), the on ice foraging period is necessary to accumulate energy stores needed for survival during seasonal periods of open water, when prey species are no longer accessible. Spring hyperphagia is particularly important for pregnant females who require enough stored energy to meet the energetic costs associated with an 8-month on shore period, which includes gestation, parturition, and several months of lactation. Changes in the timing of sea-ice breakup and freeze-up are hypothesized to alter foraging strategies, with adult females less likely to adopt a broader dietary niche in comparison to larger bodied adult males. Individuals adapted to specific prey behaviour and offspring with learned hunting techniques may experience reduced hunting efficiency, altering diet composition and body condition. The objectives of this study were to: **(i)** investigate inter-annual changes (2004-2014) in female diet composition and adipose tissue lipid content (body condition) for adult females with and without dependent offspring; and **(ii)** investigate ontogenetic changes in diet composition and body condition of females to assess how age-specific energetic demands are met with changes in stored energy and prey selection. We sampled a total of 362 adult, subadult, yearling and cub-of-the-year (COY) females captured in the fall and 52 adult females with dependents captured in the spring. Body condition declined across season and was greatest for solitary females in the fall and lowest for females supporting cubs in the spring. Lipid stores also decreased with increasing litter size. Over the ten year study period, adipose tissue lipid content declined in subadult females and females supporting offspring, but did not decline in solitary females. Timing of sea ice breakup and freeze-up significantly predicted lipid content in subadult females, solitary adult females and females with dependent young, with trends of earlier breakup reflected in reduced body condition. Initial findings suggest that diet composition in WH female polar bears may be shifting over time with potential consequences for reproduction.

The Potential Role of Spring Fasting Behavior in Contributing to Differences in Body Condition of Polar Bears in the Southern Beaufort and Chukchi Seas

Karyn D. Rode, Vanessa Muhlenbrach, Elizabeth Peacock, Todd Atwood, Eric Regehr, George Durner, Ryan R. Wilson

One of the primary challenges to understanding polar bear ecology and population dynamics is the lack of data on the status and abundance of their prey; ice-associated seals. As polar bears in some parts of their range cope with substantial declines in sea ice loss, impacts to prey and the role prey availability may play in affecting polar bear populations is largely unknown. However, estimating ringed and bearded seal abundance, the polar bear's primary prey, is extremely challenging. A more direct method for determining the availability of prey to polar bears is to estimate prey consumption. Prey consumption can account both for variation in prey abundance as well as variation in ice conditions, which may affect accessibility of prey. The ratio of urea to creatinine in blood has been documented to indicate whether a polar bear has fed within the past 7-10 days. In this study, we examined urea:creatinine ratios in the blood of polar bears in the southern Beaufort (SB) and Chukchi Seas (CS) captured in the spring between 1982 and 2013 to determine long-term patterns in spring-time feeding behavior. SB polar bears exhibited steadily increased frequency in fasting behavior across 4 decades, particularly for adult females that had not denned the prior winter. In comparison, fasting behavior either became less frequent or remained stable over time in the CS and remained at substantially lower levels compared to the SB. Investigating trends in ice conditions during this time period, there was no change in mean ice concentration or the proportion of the continental shelf covered by sea ice during the spring in either the CS or SB. These results suggest that declines in spring prey consumption in the SB may be a result of reduced prey abundance or changes in other ice metrics that affect prey accessibility. Because declines in sea ice cover have been greatest in the summer/autumn, differences in population-level responses to sea ice loss have focused on polar bear summer/autumn behavior and ecology. Our results suggest that broader ecosystem changes – including spring prey availability – may be occurring and may be associated with differences in body condition of polar bears in the SB and CS.

Socially Learned On-shore Behavior for the Southern Beaufort Sea Polar Bear (*Ursus maritimus*) Subpopulation

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Polar bears (*Ursus maritimus*) are among the most ice-dependent marine mammals and are experiencing rapid and substantial changes to their environment due to climatic warming. Polar bears of the Southern Beaufort Sea (SBS) and other open basin subpopulations have historically spent most of the year on the sea ice. However, recent reports from Alaska indicate that the proportion of the population observed on-shore during late summer and early fall has increased from an average of 3.7% in the mid-2000s to 11.8% from 2010-2013. Our objective was to investigate if this behavior was acquired through genetic

inheritance, asocial learning, or social learning. From 2010-2013, genetic and behavioral data were collected from SBS polar bears in the fall via hair snares and remote biopsy darting on land, and in the spring from direct captures on the sea ice. Bears were categorized as either on-shore or off-shore individuals based on their behavior during summer and fall over the study period. Levels of genetic relatedness, 1st-order relatives, mother-offspring pairs, and father-offspring pairs were determined and compared within and between these 2 categories. Results suggested transmission of on-shore behavior through either genetic inheritance or social learning as there was a higher than expected number of 1st-order relatives exhibiting on-shore behavior. The genetic relatedness and parentage analyses results were in concurrence with this finding but further revealed mother-offspring social learning as the primary mechanism responsible for on-shore behavior in polar bears of the SBS.

Session 2 – Bear Viewing: Scientific, Management, and Recreational Perspectives

Bear Viewing: Economic Benefits and Management Challenges

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Wildlife viewing generates billions of dollars annually in North America, including $2 billion in Alaska. Over 300,000 people/year view bears on the coasts of Alaska and British Columbia. Bear viewing could be also become important on other continents. This session will identify and characterize bear viewing sites worldwide. It will promote advancement of viewing research and management by addressing controversial issues. (a) Wildlife management for harvest and conservation focus on populations occupying huge expanses of habitat, whereas viewing-oriented management focuses on small numbers of animals and their home ranges and travel corridors – a difference in scale unfamiliar to some management agencies. (b) Huntable bears are anonymous; viewable bears are often specific individuals whose survival is a priority for some viewers. (c) Conventional safety precautions focus on avoiding bears; deterring those that can't be avoided; and killing those which can't be deterred. A different strategy is needed to assure the safety of viewers who seek bears and want to spend hours or days at close range. This challenge is especially great with commercial video crews that want footage of 'stars' close to seemingly dangerous or friendly bears. (d) Most viewing focuses on or creates habituated bears, which can reduce risk of human injury in typical viewing situations, yet under some other circumstances can increase risk of human injury or property damage. How? (e) Hunters who relish the challenge of bagging 'wild' bears may resent habituation of their prey. (f) Some viewers consider it unethical to allow hunting of 'habituated' bears. (g) Little of the economic contribution by viewers is available to those agencies paying the costs of viewing management. These problems are likely to intensify as viewer numbers rise while hunter numbers decline. These issues will be explored through panel discussions and research reports. That body of information will be discussed, critiqued, and integrated during the following workshop. Debate triggered by controversy will be channeled into generation of testable hypotheses. Management recommendations may be offered.

The Where, What and How of Bear Viewing: A Worldwide Overview

James Paul Phillips

Viewing of wild Ursids occurs in various forms all over the world, from India and China to Alaska and Canada. Since viewing is an activity that often goes against the general rule to stay well away from bears it is imperative to know what strategies viewing organizations are employing to manage the space and safety between species. This presentation will highlight viewing opportunities around the world and

explain where viewing occurs and whether it is by platform, boat, car or foot, as well as the training levels of guides and under what circumstances the bears are located or attracted to the area. Other information will include bear species, what activities may be seen at each location and at what distances viewing occurs. Maps and video will be used to show locations and different techniques exposed that may or may not be species-specific. This is an invited paper that will serve as a broad introduction to subsequent presentations within the Bear Viewing breakout session. It will also provide valuable information for management and policy both at the conference and in future discussions.

Best Practices for Bear Viewing in the Tongass National Forest of Alaska

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"Best practices" for several bear viewing areas on the Tongass National Forest in SE Alaska will be presented. Despite varying natural and cultural histories of each viewing site there are commonalities that insure success and problems which continually present challenges to managers. Sites range from the lightly visited Pack Creek viewing area in the wilderness of Admiralty Island to the very heavily visited urban viewing area at Steep Creek near the Mendenhall Glacier of Juneau. Pack Creek struggles with inadequate funding for operational expenses of a remote site while Steep Creek bears must navigate among 250,000 human visitors during the salmon run each summer. Other sites such as Anan Creek near Wrangell and Fish Creek in Hyder share funding challenges that have managers considering moving toward concessions.

Best Practices for Bear Viewing in Alaska's National Parks

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Best practices for bear viewing in selected Alaskan national parks are reviewed and differences among parks contrasted. For example, Denali NP requires that people stay at least 300 yards from bears, whereas Katmai NP only requires that people stay at least 100 yards for any mother with cubs, or 50 yards away from other bears. Differences among parks are partly an adaptation to differences in bear behavior – e.g., Denali grizzlies being less tolerant of humans than are Katmai brown bears – topography, viewer numbers, whether viewers tend to be accompanied by a professional bear guide or ranger, etc. Assuring human safety and wildlife welfare are paramount goals.

Challenges of Managing Bear Viewing in the Central U.S. Rocky Mountain Parks

Kerry Gunther, Katharine Wilmot

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Yellowstone and Grand Teton National Parks are the premier bear viewing areas in the lower 48 states. Yellowstone and Grand Teton National Parks receive over 4 million and 2.7 million visits per year, respectively. Bear viewing contributes millions of dollars to the economies of the gateway communities surrounding both parks. Managing bear viewing is also the most significant bear management challenge faced by these parks, requiring significant allocation of staff time and budgets. Unlike many bear viewing areas in Alaska which occur in relatively concentrated areas with limited access, and in some cases restrictions on visitation, viewing opportunities in Yellowstone and Grand Teton are spread out over thousands of square miles accessed by hundreds of miles of maintained roads, with unlimited human access. Both parks attempt to make visitors' activity during bear viewing as predictable as possible to bears by encouraging visitors to stay at the roads edge, discouraging visitors from approaching, encircling or following bears, and enforcing regulations that require visitors to maintain a minimum 100 yard distance from bears and prohibit visitors from feeding bears. Managing large numbers of people at multiple bear viewing opportunities along hundreds of miles of roads on a daily basis requires a significant commitment of park staff time and budgets. With visitation to both parks increasing every decade, the commitment of staff and budget will likely only continue to increase into the foreseeable future. Challenges of managing bear viewing in the Central U.S. Rocky Mountain National Parks include visitor safety, bear safety, lack of sufficient roadside parking, trampling of roadside vegetation, compaction of roadside soils, and introduction of exotic weeds to roadside habitats. Management of people engaged in roadside bear viewing is currently hampered by insufficient numbers of staff, vehicles, budget, and staff housing. Despite these challenges, Yellowstone and Grand Teton National Parks have to date been able to manage bear viewing in a manner that has provided popular bear viewing opportunities for the public while still protecting both visitors and bears. Current bear and visitor management strategies and techniques used at roadside bear viewing opportunities in both parks are discussed

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Bear Viewing Management and Research in British Columbia

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Bear viewing had it's infancy in British Columbia (B.C.) in the late 1980's. Bear viewing has subsequently grown significantly in popularity and in 2014 an estimated 59 different businesses were conducting some form of grizzly bear (*Ursus arctos*) or American black bear (*Ursus americanus*) viewing. Several bear viewing-specific research projects were conducted in B.C. in the early to mid-2000s, but little bear viewing research has been done since then. Bear viewing management oversight is the responsibility of the B.C. Government, which they have tried to achieve through higher-level land-use planning, as well as, more site-specific management plans and bear viewing guidelines. A Commercial Bear Viewing Association of B.C. (CBVA) was formed in the early 2000's to help promote sustainable bear viewing in B.C. Member companies established a set of best management practices and a code of conduct for the bear viewing

industry and the CBVA has had a bear viewing guide certification program since 2005. However, CBVA members still only represent about 25% of identified commercial operators. I will review the history of bear viewing research and management in B.C. leading up to the most significant current management challenges. For example, there is considerable controversy in B.C. about the compatibility of bear hunting and bear viewing. Much of this controversy is based on differences in opinion about the ethics and the ecological value of bear hunting or bear viewing. However, there also are practical realities associated with trying to support bear hunting and bear viewing in the same geographic area that I will explore. Finally, I will provide recommendations for future action to further support sustainable bear viewing in B.C. that is compatible with bear conservation.

Bear Viewing: Are Spatial and Temporal Refugia Necessary?

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Since one of the first formal bear viewing programs in British Columbia was started in the Khutzeymateen Valley on the north coast of British Columbia in 1987, commercial bear viewing has grown significantly. In 2014 there were approximately 60 bear viewing operations in the province, most of them on the BC coast. Many operators are members of the Commercial Bear Viewing Association of BC (CBVA), which has set best viewing standards along with a standardized training program and certification process for bear viewing guides. Many operators have permits to conduct low-key commercial bear viewing inside the many new BC coastal protected areas that are jointly managed by BC Parks and coastal First Nations. Concerns regarding the impacts of bear viewing on grizzly bears has generated several research projects in the Khutzeymateen Grizzly Bear Sanctuary Class A Park and adjacent protected conservancies. Similar concerns have been expressed in several bear viewing reports by professional biologists related to commercial bear-viewing operations centered on the popular white-phased *Kermodei* subspecies of the North American black bear (also called the "spirit bear"). Concerns and field research have centered primarily on two types of behavioral modifications of bears attributed to association with humans viewing bears: habitation and avoidance. My presentation will focus on research done to date in coastal Alaska and British Columbia, and the implications of such behavioral modifications to bear survival, and the need for temporal and spatial refugia. My presentation will primarily be based on background research I have conducted in relation to my preparation of low-impact bear-viewing plans for joint BC Parks-coastal First Nations management in several BC coastal protected areas.

International Bear Viewing: The Good, the Bad and the Ugly

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Viewing bears supports a rapidly growing recreational industry in Alaska and British Columbia with highly diverse management on public lands by government agencies or private companies. This provides an opportunity for an historical perspective and comparative synthesis of these operations. Some sites have demonstrated significant growth in populations and positive nutritional effects of bear viewing, especially for females with young, when guides accompany visitors at predictable locations for limited time periods. Other situations displace bears from essential habitat when unguided visitors fail to provide temporal and spatial refuges for feeding bears. Much research has provided reliable models for accommodating bears needs and human safety. However challenges from private operators with political clout make values oriented toward bear conservation difficult to achieve.

Enhancing Tolerance by Bears for Close Range Research Observation

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Behavioral and ecological studies in forest habitat are often hampered by limited visibility. We describe how we safely established trust with wild black bears to closely observe them during active seasons and watch them with webcams during hibernation. In our first such study (1984-1991), we intentionally habituated and food-conditioned bears at a USDA Forest Service feeding station in northeastern Minnesota. During 1996-2015, we attempted to build trust with bears where a northern Minnesota community had maintained >10 bear-feeding stations since 1961. Although the bears in both study areas were habituated and food-conditioned at the feeding stations, they typically fled from humans in the forest. In time, a few accepted us in the forest and accepted observation periods of up to 48 hours that began with a researcher homing in on a bear's radio-collar while speaking. When the bear recognized the familiar voice and became visible, the researcher offered a handful of food. The bears did not seek our company other than for the initial handful of food. They foraged, napped, mated, tended cubs, scent-marked their territories, etc., as a researcher recorded data. They seemed unconcerned, seldom looking our way, as long as the researcher was within a few meters for easy identification. They maintained circadian and circannual rhythms similar to other bears we have studied. They did not become dependent on human food. They did not seek food from campers, hunters, or residents away from the feeding stations. When bears we were accompanying sensed hikers, they quietly retreated, usually unseen, with the researcher close behind. Hikers we surveyed all stated they seldom saw bears and never had one approach them in over 20,000 hours of hiking in the study area. No bear ever came after us and hurt us in our entire 49 years of research since June 1967. In our first study area, bear problems were 88% fewer than before the study. In the second study area, bear complaints per bear ran 80% below the statewide average. We discuss why consistent, significant feeding in these study areas reduced bear problems rather than increasing them as occurs with inconsistent tidbit-feeding.

Habituation: Diverse Forms and Consequences

Stephen Stringham

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People can't be harmed by bears that they don't encounter. So bear safety advice for the general public focuses on avoidance. The safety of viewers, who watch bears from nearby without benefit of physical barriers or firearms, depends on minimizing risk per encounter in ways that don't impair viewing. Although grizzly/brown bears (*Ursus arctos*) and black bears (*U. americanus*) are seldom motivated to attack, that small risk can be reduced by teaching bears what to expect during encounters – e.g, that viewers are non-threatening unless provoked. Expectation that humans will not attack under certain circumstances is *trust*. Expectation that humans will retaliate against aggression is *respect*. Trust inhibits defensive aggression, the primary cause of serious or fatal grizzly/brown bear attacks. Respect inhibits predatory aggression, the primary cause of fatal black bear attacks. Trust and respect both inhibit rivalry with humans who are distant from scarce attractive foods. Habituation of grizzly bears (i.e., inland *U. arctos*) seldom goes deeper than reducing the radius of their crowding zones, and of inhibition against foraging near humans. However, habituation of northern Pacific coastal brown bears also tends to minimize violence even when someone closely surprises a bear near a large animal carcass or a mother with cubs. Levels of habituation deeper than ignoring humans are seeking them (a) out of curiosity, (b) for protection, or as (c) as social rivals. The latter can be a major concern with some ungulates, but so far not with coastal bears. Regional differences in trust and respect towards humans appear to be functions of differences in density of preferred foods, social organization, genetics, and the methods by which coastal viewing is done – e.g., in professionally guided groups that don't carry bear-attractive food. I also discuss other methods used by coastal viewing guides to enhance reciprocal human-bear trust and respect. Habituation is a natural, fundamental component of risk assessment and adaptation – learning which potential hazards can be ignored (e.g., viewers) and which (e.g., hunters) must be guarded against, which is presumably one reason why mauling risk per viewer is far smaller than that per sympatric big game hunter.

Viewing Food-Conditioned Bears

Ann Bryant, Stephen Stringham

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We contrast the behavior of bears and viewers at natural vs. anthropogenic food sources, then discuss the pros and cons of allowing viewing at diversionary bait sites, and how the effects of such baiting varies according to whether the bears were previously food conditioned and habituated to humans. Bears that avoid humans are difficult to view, especially for prolonged periods or on a predictable schedule. Viewing is usually most successful at food concentrations large enough to attract numerous bears, and so attractive that bears tolerate human proximity in order to forage there. Wild brown bears (*Ursus arctos*) and black bears (*U. americanus*) commonly aggregate on salmon (*Oncorhynchus* spp) spawning streams, clam beds, and large mammal carcasses. These species also forage at garbage dumps, at homes where food is provided by residents to attract the bruins, and at diversionary bait stations. Polar bears (*U. maritimus*) also forage at garbage dumps and whale carcasses. Where such food sources also attract viewers, this can increase likelihood of close encounters. Whether such sources also increase risk of human-injury or property damage per encounter depends less on whether the food is domestic or wild, than on whether (a) the food tends to be especially attractive, available, or profitably-harvestable in physical proximity to humans or to vulnerable property; or whether (b) humans or their property (e.g., buildings or vehicles) interfere with bear access to these foods so much that the bear resort to threats, assault or property damage to obtain the foods, or to assure each bear's own safety. By contrast, domestic and wild foods which don't meet both of those criteria don't necessarily heighten either encounter probability or conflict risk per encounter. On the contrary, strategically-distributed baits can minimize conflicts, especially if bears eating those baits obtain enough food that they don't forage elsewhere in conflict zones. This is why viewers are almost never injured by bears that they don't try to touch or hand-feed, despite these bears being both habituated and food-conditioned, and viewing often taking place within 50-100 m of bears that could attack the viewers at will if so inclined.

Spying in the Den: The Hidden Play Life of Black Bears

Gordon M. Burghardt, Jordan N. Herche, Adam M. Partin, Jodi K. Agee, Kayce M. Miller, Susan A. Mansfield, and Lynn L. Rogers

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Play in bears is rich, complex, and frequently documented. Cubs, in particular, spend many hours in locomotor, object, and social play. However, the developmental origins of play in bears in the wild are little known since the early months of life are in dens. Through use of remotely monitored den cams in dens with known mothers and offspring, the ontogeny of play in bear cubs prior to and immediately after den emergence can be studied and will be described briefly here. As the dens were monitored and videorecorded virtually continuously from before cub birth to emergence, complete records were obtained. This paper will describe the early development of behavior from exploration to social play in 3 litters and one den with only a mother and her female yearling. The other dens contained mothers with, respectively, a male and female cub, two males and a female cub, and a female yearling and a male and a female cub. Two consecutive dens were occupied by the same mother, Lily. In the first season she had a female yearling and male and female cubs in the den and the following year only had the female who was her cub the year before. Thus, a variety of cub combinations existed. Various stages of play development in the cubs will be depicted as well as their play with both mother and yearling sibling. Play development begins with exploration and limited motor control even before eyes open at about 4-5 weeks of age. Typical wrestling play develops over several weeks, often, it seems, stimulated by the mothers sometimes rough interactions with the cubs. By eight weeks of age standup wrestling play was evident. Yearling-cub interactions were also frequent. However, the confined area in the dens made such wrestling play most evident when the mothers left the den for short periods. It is possible that leaving the den not only provides respite and resources to the mother, but also facilitates motor development in the cubs through their intrinsic motivation to play. Comparisons with the development of play in nonhuman primates, such as monkeys, are useful and informative.

Rivaling Apes: Cognitive Abilities of Bears

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Bear behavior in experimental settings is rarely studied, especially on topics of perception, learning, memory, and cognition. This paper will briefly review earlier and recent studies using bears to study a variety of research questions frequently asked of nonhuman primates. Work from a variety of laboratories will be presented. Bears turn out to have complex cognitive abilities, fine vision, rapid learning, long memories, and a variety of other skills. While the intelligence of bears has been long described in anecdotal reports by hunters and field observers, as well as park managers devising bear-proof trash containers, it is long past time for bears to be employed in testing theories arising from the field of comparative cognition. Bears, for example, can respond to visual displays in computer controlled systems, can learn to inhibit searching for food items when the trained number have been obtained, and have levels of curiosity rivaling apes. Such work has conservation and management implications where too often views of bears as unpredictable trump working with bears utilizing what we know scientifically about their social, foraging, learning, and perceptual characteristics. Furthermore, species differences need to be systematically addressed. Studying captive populations held around the world by trained comparative psychologists and cognitive ethologists could be encouraged and funded as an initial step in this direction.

Understanding Black Bear Vocalizations and Body Language for Research

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Using audio/video examples, we discuss the meanings of black bear vocalizations and body language: (a) Amiable grunts and tongue-clicks, (b) Ritualized displays of anxiety characterized by bears harmlessly exhaling sharply along with aggressive-looking body language (long nose, ears back, lunge and ground-slap, false charge, blow and clack), and (c) Vocalizations that express a range of emotions. Understanding black bear language enabled us to allay bears' fears, build trust, and conduct close-up observational studies like Jane Goodall pioneered with chimpanzees. No bear viewed us as significant food-givers or competitors, much less as enemies or friends. Instead, they learned to ignore researchers logging data 2-8 meters away for 24 to 48-hour periods. Using these methods, we conducted a U. S. Forest Service habitat-use study in 1984-1991 and did a comparative study in 1996-2015 around a community that had fed black bears since 1961. Bears we attempted to work with in the latter area fell in four categories: (a) Bears that remained too unapproachable to observe; (b) Bears that accepted touch, hand-feeding, and radio-collaring at community feeding locations but remained unapproachable elsewhere; (c) Bears that, even away from the feeding locations, learned our routines and could be approached briefly for adjustments to radio-collars, replacement of GPS batteries, etc.; and (d) Bears that recognized our routines, ignored us, revealed their lives and allowed us to place webcams in their dens. Popular predictions about deleterious consequences of habituation and food-conditioning did not materialize in our study areas. In the first study, bear problems were 88% fewer than before the study. Confirming the safety of the study, government officials protected the study area by closing it to hunting. In the second

study, there had been no attacks during the decades of community feeding, and bear complaints in the study area ran 80% below the statewide average on a per-bear basis. In all our black bear studies, no bear ever came after us and hurt us. Trust-based observational studies, combined with telemetry and GPS data, revealed more about black bear life and habitat needs than we could have learned in any other way.

The Language of Alaskan Brown Bears (*Ursus arctos*)

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Hundreds of thousands of bear-human encounters occur each year. Some involve bear-human interactions so close that safe, comfortable coexistence can depend on the ability of humans to read the bear's mood and intentions, and to convey appropriate impressions to the bear. Mood and intentions can be read from a bear's vocalizations, other sounds, gaits, postures, gestures, and facial expressions. Those signals are often misunderstood, in part because (a) few people are familiar with bears, and may expect them to signal like dogs or cats; or because (b) they see bears through preconceptual "lenses" colored rose by romantic fantasies or red by nightmarish imagination and media hype. Accurate interpretations of brown bear (*Ursus arctos)* body language will be illustrated using diagrams, slides, audio/video recordings. Signals will be identified which are diagnostic of various motives for aggression (e.g., protectiveness of self or cubs; competition for status, mates or resources; or predation) and for non-aggressive behaviors (e.g., play which may involve aggression-like actions; curiosity; appeasement). Methods will be presented for sounding out a bear whose signals are ambiguous, and for defusing aggression. The kinds of human behavior likely to appease a frightened bear can differ from those which effectively appease or deter a domineering bear and those which discourage a predatory bear. Other signals are needed to gently deter bears that are overly-curious but benign, without provoking defensiveness, either in the form of counter-threat or flight. This presentation's goal is better enabling humans to conduct their preferred activities – e.g., viewing, angling, or hiking – in the vicinity of bears, without unnecessarily interfering with the bears' own essential activities (e.g., foraging, courtship, mating, maternal care, predator avoidance). This presentation is based on the author's decades of personal research, synthesized with prior literature. Since 1972, observations have been made of brown bears on the coasts of the Alaska Peninsula and Cook Inlet, and at distances up to 100 km inland west of Cook Inlet or on the Kenai Peninsula's Russian River. These supplement observation of black bears (*Ursus americanus*) in Central and Southeast Alaska, as well as in the contiguous USA.

Session 3 – Bear Predation and Harvest Management

Big Enough for Bears? American Black Bears (*Ursus americanus*) at Heightened Risk of Mortality during Seasonal Forays Outside Algonquin Provincial Park, Ontario

M.E. Obbard, E.J. Newton, D. Potter, A. Orton, B. Patterson, and B. Steinberg

Parks and protected areas may not provide sufficient protection for carnivores such as bears with large home ranges and extensive seasonal movements. Even in protected areas, harvest can be the main cause of mortality if parks are small or individuals live close to the boundary. At >7600 km^2, Algonquin Provincial Park (APP) is the largest protected area in southern Ontario, yet wolves (*Canis lycaon)* experienced increased mortality when leaving APP to hunt white-tailed deer at wintering yards. American black bears (*Ursus americanus*) also undertake seasonal movements to fall feeding areas outside APP, and may incur increased risk of human-bear conflicts and harvest related mortality. We outfitted 72 bears with GPS or VHF radiocollars during 2006-2014 to determine overall and cause-specific mortality rates, and to examine if risk of mortality changed when bears left APP and during years of low natural food availability. Further, we compared the abundance of resident bears to harvest rates in Wildlife Management Units (WMUs) surrounding APP to determine whether harvest was higher in areas surrounding the park compared to WMUs farther from the park boundary.

Hazard analysis revealed that annual mortality for collared bears in APP was 15% (95% CI = 9.6-21%). Harvest mortality (10 %, CI = 5.0-15%) was double that of all other causes combined (4.9%, CI = 1.6-8.2%). GPS-collared bears were 7 times more likely to die outside the park as they were inside the park. For GPS and VHF-collared bears, years of lower natural food availability inside the park, or higher red oak (*Quercus rubra)* availability outside the park carried a slightly higher risk of mortality (Risk ratios = 1.4 and 1.2, respectively). Male bears were 5 times more likely to die than females, primarily due to their increased risk of harvest-related mortality. Finally, high harvests of black bears in WMUs near APP contrasted with low abundance estimates for resident black bears in those areas, suggesting that APP bears act as a source population for harvest that occurs near park boundaries. Meaningful maintenance of the ecological integrity of bear populations in protected areas may need to be undertaken at the landscape scale.

Towards Stable Caribou Populations: Considering Resource Selection by Grizzly Bears, Wolves, and Caribou to Prioritize Restoration of Legacy Seismic Lines in Alberta, Canada

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Throughout their range, the decline of woodland caribou is thought to be a result of habitat degradation and fragmentation from industrial activities. An increase in the number of moose and deer thriving on newly created early successional forests and linear features such as seismic lines and right-of-ways within caribou ranges is thought to have contributed to a numerical response in wolves. Bears also utilize food types found within early successional forests, and the combination of increased predator numbers within caribou ranges and reduced spatial separation between caribou, alternate prey, and their predators is believed to contribute to the decline of caribou. Land managers are under pressure to restore habitat and mitigate potential negative effects of resource extraction on caribou now and into the future. Seismic lines are of particular importance for habitat restoration because they are pervasive across the boreal forest where energy exploration has occurred, and are slow to regenerate naturally. Considering the extensive footprint of seismic lines in Alberta, Canada, restoration efforts need to be prioritized. Using LiDAR and animal GPS data, we investigated the influence of vegetation height on the selection of seismic lines, and the zone of influence of these features on grizzly bears, wolves, and caribou within four caribou ranges. Our objective was to identify areas with the highest probability of overlap among grizzly bears, wolves, and caribou to prioritize restoration and therefore decrease the probability of interactions between caribou and their predators, ultimately increasing functional habitat for caribou. Using step selection functions we found that predator movements in relation to seismic lines varied seasonally, were dependent on regeneration stage, and appeared to be primarily governed by access to food for grizzly bears and travel corridors for wolves. We will discuss our step selection function results and ongoing habitat selection analyses for grizzly bears and wolves in the context of prioritization for restoration towards increasing caribou functional habitat. This research is one of the first to use remote sensing tools to assess animal response to vegetation regeneration stages across a broad geographic scale, and increases our understanding of predator-prey interactions on a managed landscape.

Hunting Promotes Sexual Conflict in Brown Bears

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The removal of individuals through hunting can destabilize social structure, potentially affecting population dynamics. Although previous studies have shown that hunting can indirectly reduce juvenile survival through increased sexually selected infanticide, very little is known about the spatiotemporal effects of male hunting on juvenile survival. Using detailed individual monitoring of a hunted population of brown bears (*Ursus arctos*) in Sweden (1991-2011), we assessed the spatiotemporal effect of male removal on cub survival. We modeled litter survival before, during, and after the mating season. We used two proxies to evaluate spatial variation in male turnover; distance to the closest male killed and number of males that died in a female's vicinity. Male removal decreased cub survival only during the mating season, as expected in seasonal breeders with sexually selected infanticide. Cub survival increased with distance to the closest male killed within the previous two years. We did not detect an effect of the number of males killed. Our results support the hypothesis that social restructuration due to hunting can reduce recruitment and suggest that the distribution of the male deaths might be more important than the overall number of males that die. As the removal of individuals through hunting is typically not homogenously distributed across the landscape, spatial heterogeneity in hunting pressure may cause a source-sink dynamics, with lower recruitment in areas of high human-induced mortality.

Temporal Effects of Hunting on Foraging Activity and Efficiency of Scandinavian Brown Bears

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In Sweden, brown bears (*Ursus arctos*) mainly feed on bilberries (*Vaccinum myrtillus*) during the fall to increase body mass for hibernation. The period of hyperphagia, however, also coincides with the bear hunting season. Bears may respond to human hunting, like prey to a natural predator, but antipredator responses are often costly in terms of forage intake, thus limiting the extent to which bears may be able to respond. Based on the risk-allocation hypothesis, we hypothesized that bears are sensitive to variations in mortality risk on the scale of weeks (prehunting vs. hunting period) and hours (high vs. low mortality risk). We expected bears to reduce foraging activity at the expense of food intake when mortality risk is highest. We identified foraging behavior from GPS movement trajectories. Foraging was defined as slow (25 – 300 m) and continuous (at least 1.5 hrs) movements, based on 30-minute positions. At 268 foraging locations, we counted ripe bilberries in a sampling quadrate and measured sugar content as a proxy for nutritional quality. Risk of hunting mortality was highest in the morning and lower in the afternoon. We found that bears decreased foraging activity in the morning hours of the hunting period compared to the prehunting period. When they did forage, while controlling for phenological changes, bears used locations with fewer berries and lower sugar content. In the afternoon hours, bears were equally active and efficient as in the prehunting period, thus did not compensate for the reduced morning forage intake. Our findings suggest that bears are sensitive to fine-scale variations in mortality risk and allocate antipredator behavior to times of highest risk. Their response is costly in terms of reduced foraging time, food intake, and quality, all of which may translate into risk effects when bears need to increase mass for hibernation and reproduction.

Effects of Grizzly Bear Predation on a Low-Density Muskox Population

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Muskoxen (*Ovibos moschatus*) have long been considered to be highly effective at defending themselves from predators. However, several instances of grizzly bear (*Ursus arctos*) predation on muskoxen in northeastern Alaska were reported during 2000-2006, raising concerns about the effects of predation on this small and declining population. In response, we investigated potential factors that might be limiting muskoxen in this area. From 2007-2012, annual counts of muskox abundance ($\bar{x}$ = 191) and estimates of

population growth ($\bar{x}$ = 0.96) indicated the population was stable or slowly declining. Annual natality ranged from 0.45 to 0.82 ($\bar{x}$ = 0.66) births per adult cow (≥3-year old), whereas annual survival ranged from 0.37 to 0.64 ($\bar{x}$ = 0.52) for calves and from 0.74 to 0.91 ($\bar{x}$ = 0.84) for adult cows. Predation by grizzly bears accounted for 57 and 62% of deaths of calves and adults, respectively, and was the most important factor limiting population growth. Other causes of death were much less common, and included disease, accidents, starvation, and illegal shooting. Bear predation began soon after bears emerged from their winter dens in March or April and continued until denning began again in October. However, predation was most prevalent during late winter and early spring when snow cover was widespread and little other food was available to bears: 61% of predation on calves and 87% of predation on older muskoxen occurred before 1 June. The change from a period of significant growth in muskox abundance to a rapid decline suggests a change in either predator abundance or behavior. Although there is no evidence that bear abundance changed dramatically during this period, abundance of moose and caribou calves declined shortly before the decline in muskoxen began, suggesting bears may have increased predation on muskoxen in response to lower availability of other ungulate prey. Although muskoxen may be more challenging prey than moose or caribou calves, bears in arctic regions may need to alter their predatory behavior in response to changing prey abundance. Maintaining diversity of native ungulates may help bears cope with the natural fluctuations in prey abundance often seen in arctic ecosystems.

Field ID Manual: A Systematic Approach in Field Investigation of Ungulate Predation and Assigning a Standardized Probability by Predator Species to a Predation Event

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Black bear numbers have increased in many regions of North America and are often assumed to be the dominant predator on the landscape. However, wildlife managers can struggle to scientifically determine which predator is dominant in systems with multiple predator species. This can be explained by a lack of consistency in classifying a predation event or inaccurate classification of an event due to a lack of training or experience. Eliminating the uncertainty in determining what predators are responsible for killing prey will enhance the management of both the predators and prey.

This manual describes a systematic approach for field investigation. It also provides diagnostic keys that standardize a probability of predation using five categories, and based on these categories, to systematically classify the predation event by predator species. Killing strategies and carcass consumption characteristics are presented for eight widely distributed North American predator species, including brown bear, black bear, mountain lion, wolf, coyote, lynx, bobcat, and wolverine.

Spatiotemporal Patterns of Bear and Reindeer Habitat Selection on the Reindeer Calving Range Cells

Therese Ramberg Sivertsen, Birgitta Åhman, Sam M.J.G. Steyaert, Lars Rönnegård, Jens Frank, Peter Segerström Ole-Gunnar Støen and Anna Skarin

Depredation on reindeer by large carnivores represents an important human-wildlife conflict in Fennoscandia. Recent studies have revealed that brown bears (*Ursus arctos*) may cause substantial mortality among reindeer calves (*Rangifer tarandus tarandus*) in forest areas in Sweden. This has triggered a need for more knowledge about reindeer-brown bear behavioral interactions. Here our main objective was to document and compare habitat selection patterns of semi-domesticated reindeer and brown bears on the reindeer calving range. In particular we wanted to examine reindeer habitat selection in relation to bear encounter risk and other limiting factors (e.g. forage availability, insect harassment), and evaluate the simultaneous responses of bears and reindeer to roads and forest harvesting. The study was performed in two reindeer herding districts in the forest area of northern Sweden between 2010 and 2012. We used GPS-data representing 112 reindeer years and 33 brown bear years to compare bear and reindeer habitat selection in relation to temporal variation in bear predation risk. If reindeer used a spatial separation tactic to reduce the risk of bear predation we expected to observe shifts in reindeer habitat selection corresponding to bear avoidance between periods of high and low bear predation risk. Our study demonstrates marked differences between reindeer and brown bear habitat selection on the reindeer calving ranges. Interestingly, there were contrasting responses by bears and reindeer to forest modified by logging. Reindeer selected and bears avoided clear cuts, while bears selected and reindeer avoided young forest. However, because of the absence of a general clear avoidance of bears by reindeer, we suggest that reindeer may select their habitat predominantly with respect to food availability rather than to bear predation risk. Domestication and several decades with low abundance of large carnivores may have made semi-domesticated reindeer in Fennoscandia less adapted to cope with predators. Also, areal restrictions limit the opportunity for dispersion, possibly making the calves more susceptible to predation.

Factors to Consider when Evaluating Harvest as a Grizzly Bear Recovery Implementation Tool

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In 2006, the Alberta Government implemented a 3-year moratorium on sport hunting grizzly bears while reliable population estimates were developed. In 2008 the moratorium was extended until completion of a Status Review in 2010. The status review recommended grizzly bears be listed as a *Threatened* species provincially because of low population size and high rates of habitat change. While it is not unprecedented to hunt *Threatened* species in Alberta, upon completion of the Status Review it was determined that there was little public support for reinstating the grizzly bear hunt and no proposal was put forward. Recent inventory work in 2 of Alberta's 7 bear management areas (BMA), along with increased human – bear conflict, and an eastward expanding occupancy, suggests that grizzly bear populations are responding favorably to 8+ years of recovery activities. As bear numbers and conflict

increase, the Provincial Government is again looking at harvest as a population management tool. Using the most recent population estimates along with survival and reproductive estimates from known-fate monitoring of radio collared animals, I used the population viability model, RISKMAN (Risk Management) to determine the sustainable harvest rate for grizzly bears in 5 of 7 BMAs in Alberta. Results indicate that grizzly bears in some portions of the province could sustain a limited harvest. Considering the realities of wildlife management and the role that public opinion and politics play in it, our recommended number of tags for the early stages of a reinstated hunt are more conservative than the model recommends, once again demonstrating that there are factors other than just science that influence decision making in wildlife management.

Effects of Diversionary Feeding on Life History Traits of Brown Bears

Raoul Reding

Food availability is often a main driver affecting the life history traits of brown bears (*Ursus arctos*). Diversionary feeding, which is a common practice in several countries of the species range, could importantly affect body condition and reproduction rates. However, it's main (e.g. damage prevention) and side effects remain poorly studied. We analyzed the effects of temporal and spatial food availability (diversionary and natural) on brown bear body weight and litter size in Slovenia, where diversionary feeding is very intensive. We used spatial and biometric data of 663 bears shot from 2004 to 2012 (body weight analysis) and 615 litter size observations from 2004 to 2013 (litter size analysis) for the entire Slovenian bear range (6.231 km^2). Considering major factors that could affect the natural food availability (e.g. forest cover, proportion of mast producing trees), we developed a set of basic models with all possible combinations of variables and selected the best ones using AIC criteria. Results indicated that only forest cover showed an effect on body weight, but with an $R^2 < 0.005$ its effect is biologically most likely unimportant. None of the tested variables affected the litter size. Usually one would expect interannual and spatial variations in the life history traits, due to yearly fluctuations in the natural food availability (e.g. high variation in beech mast production, the most important natural food source for bears in the study area). But no such effect was observed, which suggests that intensive diversionary feeding buffers temporal and spatial variations in natural food availability. It also considerably increases the total habitat carrying capacity, which may explain the high reproduction rates (19-22%/year) and population densities (up to 40 bears/100km^2) reported for Slovenian brown bears. The high reproductive potential and low natural mortality are triggering the demand for artificial population control (up to 20% of population is culled annually), since the management goal is to prevent population increase. Thus for this population, the two evolutionary important processes – reproduction and mortality – are currently controlled mainly by humans. This could be seen as a step towards semi-domestication of bears, similar as already described for some ungulates.

Home Range Change of a Large Carnivore in Response to Hunter Harvest

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The concepts of a home range and a territory are important in defining animal space-use, which has important consequences for wildlife population conservation and management. In this study, we investigated the variation of intra- and inter-annual home range fidelity, expansion, and contraction among several reproductive classes of brown bears (*Ursus arctos*) in south-central Sweden. We then explore whether this variation depicts a spatiotemporal pattern in relation to hunter-removed bears (hereafter focal bears) and which demographic and environmental factors best explain the strength and speed of the patterns observed. We used an approach adapted from resource selection functions (RSFs), in which positions of neighboring bears, for a given focal bear, were contrasted with spatially random positions.

There was no difference among female reproductive classes in annual home range area. The largest differences, however, between years for female reproductive classes occurred when a female transitioned to or from being a female associated with cubs of the year, and the strongest HR areal difference between breeding and non-breeding seasons was for females with cubs. Same sex neighbor bears increased their relative probability of use of a focal bear's home range after the focal bear was hunter-removed, but this pattern was not present for intersexual comparisons. Density, focal bear age, and neighbor bear age appeared to modulate the strength of this pattern. Increased use of a hunter-removed bear's home range by same sex neighbors is consistent with sexually-selected infanticide theory (for males) and with suggestions that there could be stronger territorial behavior among females than previously thought.

Spatiotemporal Trends in Brown Bear (*Ursus arctos*) Management in Alaska, USA

Katie Low

In Alaska, USA, brown bears (*Ursus arctos*) are known predators of moose (*Alces alces*) and other ungulates. Recent declines in ungulate populations have prompted efforts to reduce bear populations in order to decrease predation on ungulates. In 2004, bears were included in several predator control programs, which had been used to control wolf populations for decades. In addition to predator control, hunting regulations have increased bear hunting opportunities in many parts of Alaska. We examine trends in Alaskan brown bear management, including predator control and hunting liberalization. We spatiotemporally represent changes in bear management policy, including bag limit, season length, number of permits issued and other hunting regulations, as well as hunter harvest levels in each Game Management Unit (GMU). By looking at both the policy changes and harvest rates, we were able to

examine the efficacy of policy changes on desired harvest outcomes. We also examined moose harvest, to determine any measurable changes in harvest in response to bear management. We show that trends in policy and in harvest vary greatly across the 26 GMUs in Alaska. This information will be useful for future management decisions regarding brown bear harvest.

Evaluation of Brown Bear Predation on Ungulate Calves in Southcentral Alaska Using Neck Mounted Cameras and GPS

Christopher Brockman

The predation of ungulate calves by brown bears (*Ursus arctos*) has population implications for both predator and prey species and as such it has been extensively studied. Due to the elusive nature of brown bears in many habitats the identification of predation rates have been limited to tracking of individual bears or monitoring prey species to estimate predation rates. Although these methods have provided population specific predation rates the methods have not until recently been available to determine individual kill rates of bears. In this study brown bears in the Nelchina area of Alaska were fitted with GPS collars equipped with cameras in the spring of 2011-2013. The collars were recovered in late June of each year and the video data with associated GPS location was recovered. The video clips were classified by primary behaviors for the 7 bears that provided adequate video samples. Individual ungulate kills were counted and kill characteristic such as handling time were calculated to determine likely-hood of missing kills. To compensate for incomplete sampling a calf risk model was constructed from previous calf mortality studies and was applied to predict total calf kills for each individual bear through the end of June. The mean kill rate for ungulate calves of the sampled bears was 34 calves/bear each spring. Median handling times for caribou calves was 40 minutes and for moose calves was 60 minutes. This short handling time indicates the difficulty in detecting calf kills with other methods, which is probably responsible for the considerably higher kill rates reported in this study.

Trends in Intensive Management of Alaska's Grizzly Bears, 1980-2015

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Since 1980, hunting regulations for grizzly bears (*Ursus arctos*) in much of Alaska increasingly were designed to reduce bear abundance in the expectation this would lead to increased harvests by hunters of moose (*Alces alces*) and caribou (*Rangifer tarandus*). We document these changes in the portion of Alaska we term the Liberal Grizzly Bear Hunting Area (LHR) which encompassed 76.2% of Alaska's area (Game Management Units 11-14 and 16-26). Extensive liberalizations of grizzly bear hunting regulations also occurred outside of the LHR as evidenced in recent major liberalizations on the Kenai Peninsula even

though grizzly bears were classified there as a "population of concern". In the LHR by 2015, regulation liberalizations resulted in longer hunting seasons (100% of area had seasons >100 days, 99.7 > 200 days, and 73% > 300 days, more liberal bag limits (by 2015, 99.5% with a bag limit $\geq$ 1/year and 18.1% with a bag of 2/year), and widespread waiver of resident tag fees (waived in 96.8% of the LHA). During 1995-2015, there were 127 changes that made grizzly bear hunting regulations more liberal and 4 making them more conservative in Game Management Subunits in the Liberal Hunt Area. In 9 Game Management Subunits, brown bear baiting has been allowed since 2012. The 4-year mean for grizzly bear kills by hunters increased 232% between 1980-81 (391 bears) and 2013/14 (910 bears). Since 2000, long-term demographic studies on grizzly populations in the Liberal Hunt Area have been terminated without replacement. Management of large predators by the State of Alaska is constrained by a 1994 state statute mandating "intensive management" in areas classified as important for human consumptive use of ungulates. Current grizzly bear management in the LHA is inconsistent with the recommendations of the National Research Council's 1997 report on predator management in Alaska. If current trends continue, they increase risks to portions of the largest and most intact population of grizzly bears in North America. This risk is perhaps highest on Alaska's Kenai Peninsula where the population is small, isolated, and subject to habitat deterioration based on intense and increasing human activity.

Patterns of Harvest and Management of Alaska's Brown Bears

Kim Titus

We evaluated brown bear (*Ursus arctos*) harvest and management patterns across Alaska from 1960 – 2014. Brown bears occupy all of their historic range in Alaska with densities varying from ~10 to >600 brown bears (all ages)/1,000 km^2. Brown bears are hunted across Alaska with the exception of some national parks, viewing and residential areas. During this period >65,000 brown bears were harvested, 55% by nonresidents. Mean annual harvest increased over time (1960-1979 = 752; 1980-1999 = 1226; 2000-2014 = 1701). Highest harvest occurred in coastal areas where bear densities typically exceed 300 bears/1,000 km^2. Harvest has been focused on male bears; protecting the adult female segment of the brown bear population (no harvest of females with cubs) is an excellent sustained yield management tool. For example, 74% and 66% of the bears harvested from Admiralty, Baranof, and Chichagof islands (ABC islands) and Kodiak Island respectively, have been males. Nonresidents are required to have a guide, and there is a strong incentive to harvest larger, male bears. Harvest goals and management approaches vary across Alaska. On the ABC islands the harvest goal is up to 4% of the total estimated population, or no more than a 1.5% harvest of females based on estimated abundance. In contrast, the harvest goal in other management units may be ~10% for some highly productive populations. Kodiak Island's bear harvest is managed at a fine scale whereas harvest is managed more coarsely across much of the state. Beginning in 2008 the Alaska Board of Game authorized various regulations to reduce brown bears in some areas via control (i.e., nonhunting) programs. Research from a number of areas indicates that brown bears can kill a high percentage of neonatal moose (*Alces alces*) calves in some areas. From 2004 – 2014, 100 brown bears have been culled to increase ungulate numbers in specific areas. Also, hunting regulations have been liberalized in some areas to increase harvest. When this occurs, there is a spike in hunter harvest for a few years, but then harvest subsequently declines to earlier levels. Overall, brown bear harvest is managed sustainably across Alaska.

Session 4 – Bear Physiology with Implications for Humans

Bears as Translational Models for Human Health and Disease

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Background. During hibernation the brown bear (*Ursus arctos*) has strategies to avoid organ damage despite lying still for months in a cold environment without eating, drinking, urinating or defecating. The objective of this collaborative project is to study the bear as a reverse translational model for human health and disease.
Project organization. The project fulcrum is an intimate collaboration between the Scandinavian Brown Bear Research Project and Örebro University Hospital, Sweden and a number of institutions in Europe and the USA. Following immobilization, blood and tissue samples are collected from subadult free-ranging GPS-collared brown bears in Dalarna, Sweden in the den each season in February and again, from the same bears, during active state, in June. All specific research projects are coordinated in an open collaborative framework and multidisciplinary meetings are held regularly.
Research strategy. The brown bear appears to have both general and organ-specific strategies protecting it from tissue damage during hibernation. Accordingly, we study functions of specific organ systems but also interaction between organs. Some findings are compared to findings in patients and some hypotheses are tested in cell cultures, laboratory animals and in humans.
Results. The project has been running for six years. Our findings point to dramatic changes between hibernation and active state in almost all organ systems investigated. During hibernation heart function is reduced (as in heart failure), platelet function is depressed (mimicking an aspirin-like effect), oxygen binding is tighter (as in high altitude activities), kidney function is put on hold (but symptoms of kidney failure are sidestepped), osteoporosis is avoided, muscle loss is much lower than expected, protein synthesis and breakdown is put on "smart mode" and the gut microbiota is optimized for an altered metabolism.
Conclusion. The brown bear has developed ingenious physiological solutions of relevance for a number of human disease states. Translating the findings holds promise for therapeutic applications.

The Naturally Reversible State of Insulin Sensitivity in Bears: Cell Autonomous and Exogenous Contributions

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Seasonal changes in adiposity accompany the annual metabolic cycles of bears and other hibernators. To further define the seasonal alterations in glucose/insulin homeostasis, we performed oral glucose tolerance tests (oGTT), i.v. insulin tolerance tests (ivITT) in captive brown bears at three different times of the year and obtained cells from the stromal vascular fraction of subcutaneous fat biopsies for *in vitro* studies of insulin sensitivity. Differentiated adipocytes were cultured with fetal bovine serum (FBS) or bear serum collected from different seasons then treated with insulin and glucose uptake estimated. During oGTT in conscious bears, blood glucose was rapidly absorbed and cleared by 120 min in May (active) and October (hyperphagic) while in January (hibernation) blood glucose rose with no clearance phase exhibited in the 120 min timeframe. Serum insulin exhibited similar seasonal trends to glucose. Glucagon was unaffected by insulin but was significantly elevated during hibernation. Bears were euglycemic (fasting glucose 58-66 mg/dl) throughout the year but were hyperinsulinemic in hibernation compared to the active season (870±216 vs. 330±6 pmol/L, $p<0.05$). In anesthetized bears, i.v. insulin (0.015U/kg) caused blood glucose to decline to 60±4% of baseline during the active season and 47±2% during the hyperphagic period. In stark contrast, during hibernation blood glucose was only minimally suppressed to 95±5% of baseline by 120 minutes after insulin. Unlike with FBS, when bear adipocytes were cultured in the presence of bear serum matching the season from which the cells were obtained, appropriate insulin sensitivity was expressed. Furthermore, hibernation cells (insulin-insensitive) treated with active season serum reinstated their insulin sensitivity while heat-inactivated active serum was not effective. Active cells appeared refractory to the inhibitory effects of hibernation serum. These results corroborate and expand previous findings in bears of reversible insulin resistance. Furthermore, euglycemia of conscious bears is maintained in hibernation likely as a result of a combined hyperglucagonemia and hyperinsulinemia. Lastly, we show that both cell-autonomous and exogenous (serum) factors underlie insulin sensitivity of bear adipocytes. Because bears evolved to maximize adiposity, uncovering the mechanisms involved in this adaptation could be potentially useful in developing treatments in humans and companion animals.

Biomarkers of Insulin Resistance and Bone Metabolism in Hibernating Black Bears

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Background. Osteoporosis and insulin resistance are common features in patients with kidney disease. Despite intensive research of the underlying risk factors and mechanisms driving these phenotypes, we still lack effective treatment strategies for this frail patient group. Thus, new approaches are needed to identify effective treatments. The hibernating bear (*Ursidae*) is of interest to the nephrologist as they remain anuric and immobile during hibernation. Methods: Nineteen free-ranging brown bears (*Ursus arctos*) were chemically immobilized and had blood drawn both during hibernation in winter and summer. Samples were collected for measurement of creatinine and urea, the calcium-phosphate axis, insulin resistance parameters (glucose, insulin, HOMA, and triglycerides) and bone biomarkers (sclerostin, total alkaline phosphatase [ALP], 25(OH)D-vitamin, klotho, undercarboxylated osteocalcin [ucOC], carboxylated OC [cOC], and ALP bone isoforms [B/I, B1x, B1 and B2]).

Results. Values given as medians. Despite a reduction in renal function (serum S-creatinine 213 vs 83 µmol/L; p<0.0001) and immobilization during winter, calcium levels remain stable during hibernation (2.39 vs 2.36 mmol/L; NS) compared to summer. Whereas sclerostin increased in winter samples (253 vs. 137 pg/mL; p=0.0005), total ALP (20 vs. 143 U/L; p<0.0001), 25(OH)D-D-vitamin (28 vs. 84 nmol/L; p<0.0001) ucOC (1.3 vs. 3.9 ng/mL; p=0.0013) and cOC (23.3 vs 55.1 ng/mL; p=0.0003) levels decreased during hibernation. During hibernation bears developed signs of insulin resistance with higher blood glucose (7.2 vs. 5.2 mmol/L; p=0.0014), isoinsulin (2.2 vs. 1.5 mU/L; p=0.006), HOMA index (0.65 vs. 0.34; p<0.0001) and triglyceride (3.8 vs. 2.1 mmol/L; p<0.0001) levels. Analyses of ALP bone isoforms demonstrate decreased activities during hibernation: B/I (1.27 vs. 0.01 µkat/L); B1x (0.93 vs. 0.02 µkat/L); B1 (1.16 vs. 0.03 µkat/L); B2 (1.29 vs. 0.06 µkat/L; all p<0.0001). A significant correlation (Rho=0.63; p=0.008) between changes in insulin and total ALP levels indicate a link between bone metabolism and insulin resistance.

Conclusion. Marked changes in bone and insulin resistance biomarkers are found when winter and summer samples are compared. Studies to understand how bears can prevent the development of uremia and its devastating complications during hibernation could provide new therapeutic avenues for the treatment of human kidney disease.

Changes in Energy Metabolism in Hibernating Black Bears: An Analysis of Gene Expression and Metabolites in Liver and Skeletal Muscle

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The physiology of bears during hibernation is unique; they can survive for up to 6 months without eating, drinking, urinating, or defecating. Understanding the mechanisms by which bears withstand the physiological extremes of the hibernation period could lead to new approaches for disease treatment and prevention in humans and other animals. In this study, we investigated changes in energy metabolism that occur during hibernation through metabolomic and gene expression analyses of liver and skeletal muscle from captive Japanese black bears (*Ursus thibetanus japonicus*). Liver and skeletal muscle (*m. vastus lateralis*) were biopsied during active (June) and hibernation phases (February), and differences in the levels of metabolites and mRNAs related to energy metabolism between the two phases were examined. Liver and muscle adenylate levels (ATP, ADP, and AMP) did not differ between the active and hibernating periods, suggesting that energy charge was maintained. During hibernation, there were significant reductions in glycolytic metabolites (e.g., lactate) and mRNA expression of enzymes in the liver (e.g., glucokinase), whereas mRNA expression of enzymes involved in gluconeogenesis (e.g., PEPCK) was up-regulated. Also, a reduction in TCA cycle activity was suggested by a decline in intermediates (e.g., citric acid and malic acid) in both tissues. The total concentrations of essential amino acids (e.g., leucine and phenylalanine) increased in both tissues during hibernation; however, those of non-essential amino acids (e.g., glutamine) differed between tissue types, decreasing in liver and increasing in skeletal muscle. This suggests that the liver selectively uses non-essential amino acids for gluconeogenesis or energy production in order to spare essential amino acids. Regarding nitrogen metabolites, there was no significant difference in urea levels among the liver samples, whereas the creatinine concentration was increased in skeletal muscle, consistent with the blood levels of creatinine during hibernation. These results reveal common and different metabolic alternations in liver and skeletal muscle, and demonstrate the usefulness of metabolomic analyses in deciphering the hibernation phenotype of bears.

Insulin-Like Growth Factor System Adaptations in the Free Ranging Hibernating Brown Bear

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Brown bears undergo 5-7 months of inactivity during hibernation without losing bone or muscle mass, in stark contrast to the deteriorating physiological response in humans undergoing even short periods of physical inactivity. The insulin-like growth factors (IGF) are well-known major regulators of both bone and muscle mass, where they serve as anabolic compounds. We therefore hypothesized that the extraordinary brown bear bone and muscle physiology during hibernation may involve adaptations within the IGF system.

The circulating components of the IGF system is comprised of the two growth factors IGF-1 and IGF-2, and six high affinity IGF-binding proteins (IGFBP-1 through -6). In general, IGF primarily circulates bound by inhibiting IGFBPs, preventing untimely and excessive IGF signaling. However, the circulating IGF/IGFBP complex represents a pool of non-active IGF, readily transported to the extra-circulatory tissue where localized release of bioactive IGF can be accomplished. In addition, some IGFBPs are known to elicit specific IGF independent effects on different cells and tissues.
Here, we investigated the circulating IGF system components in paired plasma samples from 19 free-ranging Scandinavian brown bears, two to three years old, obtained during the active summer period and during denning. Total IGF levels were determined by specific ELISA and IGFBPs measured by IGF-western ligand blotting.
We found significantly lower levels of IGF-1 (54%) and IGF-2 (58%) during hibernation. Further, we observed a clear influence of age and sex on the IGF levels, in particular during the active summer period. Hibernation was accompanied by markedly lower IGFBP-3 (42%), and significantly higher IGFBP-2 (166%). Interestingly, the IGFBP profile was markedly different in brown bear compared to human plasma. In humans, IGFBP-3 is by far the major circulating binding protein, whereas in the brown bear both IGFBP-3 and IGFBP-2 were observed in high concentrations. The fraction of IGFBP-2 associated IGF binding increased from 23% (summer) to 50% during hibernation.
In conclusion, the brown bears generally display a lower IGF signaling potential during the inactive period of hibernation, however, the dramatic remodeling of the IGFBP profile suggests a more specific targeting of the IGF anabolic potential to the bone and muscle compartment.

Regulation of Protein Metabolism and Muscle Mass in Hibernating Bears: An Attractive Model of Muscle Atrophy Resistance

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Hibernating mammals including bears experience prolonged periods of torpor and starvation during winter survival for up to 5-6 months. Though physical inactivity and malnutrition generally lead to profound loss of muscle mass and metabolic dysfunction in human, hibernating bears show limited muscle atrophy and can successfully maintain locomotive function following hibernation. These physiological features in bears attractively allow us to hypothesize that hibernating bears uniquely alter the regulation of protein and energy metabolisms in skeletal muscle which then contribute to the "muscle atrophy resistance" against to the continued physical inactivity. In this study, alteration of signaling pathways governing protein and energy metabolisms was examined in skeletal muscle of the Japanese black bear (*Ursus thibetanus japonicus*). Sartorius muscle samples were collected from bear leg on late November (pre-hibernation) and early April (post-hibernation). Protein degradation pathway through ubiquitin-proteasome system (as assessed by increased expression of Atrogin1 and MuRF1 mRNA) was significantly activated in skeletal muscle following hibernation. In contrast, as indicated by a significant increase in S6K1 phosphorylation, activation state of mTOR (mammalian/mechanistic target of rapamycin) which functions as a central regulator of protein synthesis was increased in post-hibernation samples. Gene expression of myostatin, a negative regulator of skeletal muscle mass, was significantly decreased at post-hibernation. In addition, we have also confirmed the phenotype shifting toward slow-oxidative muscle and mitochondrial biogenesis (as assessed by NADH-TR staining and increased gene expression of

mitochondria-related proteins UCP3, cytochrome c, COX4 and CPT1B). These observations suggest that protein synthesis rate and oxidative metabolism would be enhanced in skeletal muscle of hibernating bear through modulating intracellular signal transduction (up-regulation of mTOR-dependent signaling and down-regulation of myostatin), which then lead to limited loss of muscle mass and maintenance of physical performance. This work was supported by JSPS KAKENHI Grant Number 25702041 and 26560369.

Effects of Winter Bear Serum on Cultured Human Muscle Cells

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Muscle atrophy is one of the main deleterious consequences of ageing and physical inactivity. Apart from being a major clinical problem for older people, muscle atrophy is also observed during fasting, immobilization, low physical activity level and in several diseases. Although basic knowledge regarding the underlying mechanisms of muscle atrophy is continuously growing, there are still no efficient therapeutic strategies for its prevention and treatment.
Hibernating bears exhibit a strong and unique ability to preserve muscle mass in conditions where muscle atrophy is observed in humans. Underlying mechanisms are not yet understood, and recent demonstration of still unknown bear circulating factors controlling protein balance during hibernation holds promising potential as a starting point for a new therapy against skeletal muscle atrophy in humans.
Aiming at the characterization of the hibernating bear circulating factor(s) that promote(s) protein sparing in the muscle tissues, we have studied the differential effects of winter versus summer bear serum (WBS vs SBS) on cultured muscle cells. Sera were obtained from *Ursus arctos* bears through the Scandinavian Brown Bear Research project. Human primary myotubes from in house collection were fully differentiated in vitro, then exposed to either WBS or SBS. After 48 hours, mRNA, proteins and lipids were extracted and submitted to differential analysis to identify targets that are either up- or down-regulated upon WBS compared to the SBS condition.

Results
Combination of large scale (transcriptomics, proteomics) and targeted (enzymatic activities, signalling pathways) approaches allowed us to draw a detailed picture of the specific effects of WBS on muscle cells. We notably found that WBS increases cell size and protein content, modulates protein synthesis pathways, and triggers tissue remodelling through extra cellular matrix components expression.
This study represents the first step in developing new tools to fight against human muscle atrophy. Our next step will be to focus on bear serum composition toward the identification of circulating factor(s) specifically present or enriched in WBS that could be involved in the observed effects.

Tackling the Over*bearing* Burden of Muscle Atrophy: Insights from Hibernation

Gustavo A. Nader, Ferdinand von Walden, Ole Frobert, Peter Stenvinkel

During hibernation, bears display a remarkable ability to preserve skeletal muscle mass and strength. This adaptive strategy presents a unique opportunity to study muscle maintenance. This is orchestrated with metabolic flexibility and fuel management strategies to maintain metabolic function. Because muscle anabolism is largely determined by ribosomal mass, we measured ribosomal RNA levels and found a dramatic reduction (~60%) in hibernating muscle compared to muscle from active bears (n=3). Because of this reduction in ribosomal mass, we determined transcription of ribosomal DNA genes. 45S rDNA expression was significantly reduced consistently with a reduced ribosomal mass. We also determined myostatin gene expression which was elevated during winter. Gene expression of energy metabolism regulators (PGC1a and FNDC5/Irisin) did not differ between summer and winter. These results indicate that despite an unfavorable alteration in anabolic/catabolic balance, bears manage to maintain muscle mass for prolonged periods of inactivity. Furthermore, metabolic function does not involve gene expression changes in PGC1a or FNDC5/Irisin. Preservation of muscle mass and metabolic flexibility in brown bears during hibernation relies on unique, yet to be determined regulatory strategies.

Oxidative Stress in Hibernating Brown Bears

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Muscles play a crucial role in supporting overall health and wellness. However, muscle atrophy is an inevitable part of ageing and disuse (e.g. due to immobilization, sedentary behaviour, or microgravity), and it is a main deleterious consequence of various disease states. In particular, extended periods of inactivity in humans promote decreases in skeletal muscle strength and muscle fiber size. In humans, this disuse-induced muscle atrophy is caused by a disproportional decrease in synthesis compared to catabolism leading to a negative nitrogen balance. Although this is still debated, growing evidence suggest that oxidative stress possibly contributes to alterations of the muscle protein balance during disuse. Screening biodiversity may provide additional cues for an interrelationship between muscle integrity/wasting and the oxidative status. Indeed, brown bears (*Ursus arctos*) exhibit unique muscle protein sparing during shallow winter sleep and fasting. It could be that lower intensity oxidative stress could favor maintenance of skeletal muscle mass/function in inactive bears during dormancy. To test this hypothesis, Scandinavian brown bears were sampled in Dalarna County (Sweden) during their active and inactive periods. The general and regional oxidant/antioxidant balance and oxidative damages were explored. In inactive bears, increased systemic oxidant ability was paralleled by enhanced total antioxidant barrier, and a selective regulation of antioxidant enzymes. As a result, circulating oxidative damages during inactivity were restricted to a very small increase in lipid peroxidation, while protein carbonylation was decreased. In white adipose tissue, no change in the levels of peroxidized lipids and

carbonylated proteins was found, while a global upregulation of antioxidant systems was observed during the denning period. Finally, the levels of mitochondrial enzymes were in line with a decreased production of reactive species in muscles of inactive bears, where a global induction of antioxidant systems was also observed. Levels of muscle protein carbonylation and lipid peroxidation were lowered during inactivity, while protein nitrosylation and DNA oxidation were increased. As a conclusion, this study suggests that oxidative stress is restricted to a minimum during dormancy in brown bears, which could contribute to muscle protein sparing.

A Brown Fat Phenotype in Brown Bears?

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Fat tissue in brown bears demonstrates an extreme plasticity in terms of fat storage and lipolysis. Brown bears selectively burn their fat during hibernation while maintaining metabolic fitness. In contrast, although human fat tissue exhibit plasticity in terms of accumulating fat, there is no corresponding natural mechanism for decreasing fat volume. During as short as two weeks of bed rest humans mainly loose muscle mass and decrease insulin sensitivity. This indicates that the white fat in brown bears might be dramatically different from white fat of humans.
Brown fat was recently identified in adult humans and is interesting in terms of an obesity perspective as brown fat consumes energy by producing heat. Brown fat is common in smaller hibernating animals but has to date not been identified in brown bears. Interestingly, a brown fat phenotype has been shown to be induced within the white fat depots in mice and humans. This fat type is called brite or beige and can be induced into possessing some of the energy consuming properties of brown fat. We hypothesize that brown bears exhibit a large proportion of brite fat within their white fat depot and that this fat can switch between energy storing properties during summer/autumn and energy consuming properties during the hibernation phase.
To assess this, we have performed RNA sequencing of fat biopsies obtained from brown bears during winter (n=5) and summer (n=5) and we will compare this with white (abdominal subcutaneous, n=5) and brown (supraclavicular, n=5) fat biopsies obtained from adult humans. In the analysis, we will initially focus on genes known to regulate the brown fat gene axis. The study has the potential to unlock novel avenues for combating obesity in humans.
The project is ongoing and preliminary data will be presented at the meeting.

Understanding the Hibernating Brown Bear's (*Ursus arctos*) Cardiovascular System by Use of Ultrasound

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Background
Understanding the brown bear's cardiovascular adaptations during hibernation may provide insight to disease mechanisms and help develop novel human therapies in areas such as thrombosis prevention and treatment of cardiogenic shock.
Methods
We have performed state-of-the art ultrasound examinations on free-ranging Scandinavian brown bears (*Ursus arctos*), anesthetized with a mixture of tiletamine-zolazepam, ketamine and medetomidine, during late winter denning and again early summer for three consecutive years (2013-2015). The first year, we focused on hemodynamic indices by echocardiography and the second and third year on advanced echocardiographic measurements including tissue Doppler imaging and speckle tracking imaging. Also, the third and fourth year we conducted pilot studies of peripheral and renal flow measurements.
Results
In the 2013 season, we demonstrated in 7 bears that all hemodynamic indices were significantly decreased (hibernating vs. active state): mean (SD) heart rate was 26.0 (5.6) vs. 75.0 (17.1) beats/min (P=0.002), mean (SD) stroke volume 32.3 (5.2) vs. 47.1 (7.9) mLl (P=0.008), mean (SD) cardiac output 0.86 (0.31) vs. 3.54 (1.04) L/min (P=0.003), and mean (SD) cardiac index 0.63 (0.21) vs. 2.45 (0.52) L/min/m2 (P<0.001). Conversely, diastolic function was unaltered during hibernation. Spontaneous echo contrast was present in all cardiac chambers in all seven bears during hibernation.
In the 2014 season, we demonstrated in 5 bears decreased myocardial velocities: tissue Doppler peak systolic velocity (hibernation vs. active: mean (SD) 10.6 (1.4) vs. 6.5 (2.3) cm/s, P=0.008), peak systolic strain rate (hibernation vs. active: mean (SD) 0.62 (0.1) vs. 0.36 (0.1) cm/s, P=0.03), but not decreased function expressed as unaltered peak systolic strain (hibernation vs. active: mean (SD) -11.9 (2.4) vs. -10.6 (2.2) cm/s, P=0.43). We only obtained useful measurements of peripheral flow distribution in one 1 bear, which surprisingly showed a relative increased flow to the extremities compared to the head during hibernation (hibernation: femoral vs. head ratio: 2.2 vs active: femoral vs. head ratio: 1.2).
Conclusion
The use of ultrasound may provide important insight into the brown bear's hemodynamic changes during hibernation. The low flow phenomenon is accompanied by slow myocardial velocities but apparently normal systolic function. Further research on peripheral flow distribution is needed.

Monitoring the Heart Rhythms of Free-Ranging Bears

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Annual and episodic trends in heart rhythms of free ranging black (*Ursus americanus*) and brown bears (*ursus arctos*) were recorded using three generations of insertable cardiac monitors (Reveal® XT, Reveal® XT with custom BearWare software package, and Reveal LINQ™; Medtronic, Inc., Minneapolis). Heart rate, heart rate variability, and electrocardiograms were recorded and analyzed during active periods, winter months/hibernation, and in situations involving interactions with humans, including hunting in both the United States (black bears) and Sweden (brown bears). The devices also reported activity using an embedded accelerometer and respiratory rates were identified via variations in the amplitude of the electrocardiograms. A comparison of heart and respiratory rates identified a pronounced respiratory sinus arrhythmia occurring during overwintering, with long sinus pauses recorded in both species. During active periods and hunting, heart rates in excess of 220 beats/minute (bpm) were commonly recorded. Analysis of heart rate variability provided insight into the role of the autonomic nervous system (sympathico-vagal balance) in the control of heart rates and rhythms in the bears. This presentation will include a summary of the systems used, data recorded, and the implications of the findings to our understanding of cardiac physiology in wild bears. In addition, potential medical applications based upon these insights for the treatment of heart failure, cardiac dysrhythmias, and ischemic stroke will be discussed, with a particular focus on the respiratory sinus arrhythmia and the associated sinuses pauses.

Translational Research: From the Bear Den to Surgical OR

Paul Iaizzo

Hibernating (or overwintering) American black bears may remain in winter dens for 4-7 months, a period during which their core body temperatures are mildly hypothermic (32–35 °C), and they do not eat, drink, urinate or defecate. Yet, these overwintering animals conserve both skeletal and cardiac muscle form and function, thus retaining the ability to respond to external threats. Bears rely heavily on fat as an energy source during hibernation. They are also capable of extremely efficient nitrogen sparing during denning; they are known to recycle almost 100% of the urea produced from protein catabolism, which may be used to resynthesize lost muscle. It is considered that non-myofibrillar protein reserves may be used, which would spare structural muscle properties. Bears also elicit a profound modulations of their heart rates, resulting in the lowest transient heart rates recorded for a relatively normothermic land mammals (sinus pauses up to 25 s). Additionally, our lab continues to study the roles of both upregulated circulating hormones and ursodeoxycholic acid associated with bear hibernation, on minimizing ischemic damage to tissues. We consider that the unique hibernating abilities of American black bears may provide novel translational insights regarding how to prevent ischemic damage, promote healing, and minimize muscle loss associated with ICU immobilization, mild hypothermia (either whole body or limb) and/or prolonged nutritional deprivation.

Metabolic Suppression in Hibernating Black Bears

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Modern criteria for defining a hibernation state is the presence of a suppressed metabolism during periods of low energy supplies or when other conditions favor sequestration to hibernacula without feeding. This contrasts the classic criteria requiring a marked decrease in body temperature (Tb) into a torpid state, mostly present in smaller hibernators. Metabolic suppression in smaller hibernators is dominated by temperature effects on metabolic rate. With increased body size comes the capacity to carry more energy stores compared to scaling of basal metabolic rate (BMR), thus the metabolic rate suppression can be less pronounced. We have shown that minimum metabolism of black bears is suppressed to 25% in mid-hibernation. At emergence from dens in spring, Tb has increased to normal levels, while there is still a temperature independent suppression of metabolic rate of about 50% of summer BMR. Prying apart the different components of metabolic rate within hibernation is more complicated. Due to their suppressed metabolic rate, below a den temperature (Tden) of about 0°C black bears thermoregulate by shivering and also benefit from surplus heat from sporadic activity. This is further complicated by presence of deep multiday body temperature cycles that so far seems unique to hibernating bears at low Tden where they have to thermoregulate. At increasing Tb, of a cycle, shivering is most intense, while it is mostly absent when Tb decreases at the fastest rate. This can be used to our advantage, by allowing calculation of Q10 (the temperature coefficient normalized to a 10°C interval) from correlates of metabolic rate and Tb during the decreasing phase of temperature cycles with den temperatures close to thermoneutral. Q10 can then be used to temperature correct a time course of minimum metabolic rates during non-thermoregulating conditions to calculate the temperature independent metabolic suppression component throughout hibernation. Knowing the time course can be important for understanding regulatory mechanisms at organ, cell, and gene expression level. Harnessing the regulation of metabolic suppression could have wide applications in patients to decrease oxygen demands as well as allowing safer long duration space flights in the future.

Session 5 – Informing the Conservation of the World's Bears

Bears in Pakistan: Distribution, Population Biology and Human Conflicts

Fakhar Abbas

We conducted questionnaire based interviews (n = 1873) of respondents coming from 258 localities about bear tracts in northern parts of Pakistan in 2012-2014 to study Himalyan brown (*U. arctos isalbellinus*) and Himalayan black (*U. t. laniger*) bears. Brown bears were more frequent in northern latitudes (northern Chitral, Ghizer, Gilgit and Skardu), while black bears were widely distributed in southern latitudes (Battagram). Both brown and black bears are present in central latitudes (Astor, Diamir, Kohistan and Mansehra). We identified 34 populations of brown bears; a large population in the Deosai Plateau and small to very small populations in other localities. We identified 9 isolated meta-populations sharing common gene pools; 7 (Bomborat, Gias, Chowgram, Laspur-Malkov, Koshi-Palas, Phunder-Yasin, Khunjerab) very small with serious inbreeding and threat of extinction, while Deosai and Diamir-Astor populations were large but were expected to have a high level inbreeding. Black bears were present in 45 localities; larger populations in three localities of Battagram (Nagram, Rahing and Shamli). We identified 6 meta-populations of black bears; Kohistan-Batagram-Mansehra, Diamir-Astor and south Chitral meta-populations were large; but 3 other populations (Thack, Hisper-Minipin and Chasma) were small/very small, possibly having high inbreeding. Bears raid standing maize crops (regular and severe in 2 localities and irregular and severe in 6) and fruit (apricot, grape, mulberry and walnut). Average annual bears depredation of 54 cattle, 188 goat/sheep, 4 yaks, and 9 horses/donkeys/mules were reported, inflicting an economic loss of Pak Rs. 2,840,000 (US$ 28,400) to the livestock farming community. Respondents reported 4 incidences of bear attack (1 killed, 3 injured) and 2 cases of cub poaching during 2013.

Bears of the World: Can We Talk About the Future?

Erme Can

We have seen significant achievements in research and conservation in the last hundred years. As of today, the number of trained biologists and tools for data collection are at its highest levels. Researchers are now using satellites, airborne sensors and unmanned aerial vehicles to collect field data in cost effective ways. We never had this amount of data throughout the history. Meanwhile, humans are becoming more and more demanding of earth's resources. The world population will be around 9.6 billion by 2050. Also, the natural and human-caused disasters are posing a risk to conservation achievements. Thus, keeping bears and other large carnivores in the wild is becoming more challenging and as in the case of last 3200 tigers, more urgent. For conservation practitioners, making a positive change for large carnivores is becoming harder. In hundred years from now, perhaps large carnivores will exist only in areas where people tolerate them today but not in areas where research and conservation efforts are concentrated now. All this may sound depressing but, we can find courage to tackle the conservation challenges and threats to our existence if we become aware of the way the world could be and the way it

is now. In fact, we can shape the future according to the decisions we make, and the actions we take today. For a better future for bears and other large carnivores, we need to work on five priority areas. First, we need to give greater recognition to researchers and conservation practitioners of the developing world. Secondly, we need to address the growing gap between research and conservation. Research per se and copious data rarely lead to conservation success on the ground. Thirdly, we need to reform the way we educate and train conservation researchers and related institutions. Fourthly, we need to find ways to link saving the lives of animals and livelihoods of people. Finally, we need to think about future, debate on future and sketch the kind of future we want. More than anything else, we need to embed long-term thinking in conservation now.

A Population Level Approach to Bear Management in the North Dinaric and Alpine Populations

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Brown bears require large habitats that often transcend political boundaries. This is especially true in the case of the Dinaric-Pindos and Alpine bear populations, which span through several national borders and need to maintain connectivity in order to meet long term viability thresholds. Management and monitoring efforts often end at national or even regional borders and this causes “management fragmentation”. It is difficult to imagine successful conservation and management of a species like the brown bear without strong cooperation among countries that share the same population.
To overcome this obstacle partners from Slovenia, Austria, Italy and Croatia joined efforts and in 2013 applied for the LIFE DINALP BEAR project. Within this project we recognize the critical need to monitor, manage, and conserve a shared brown bear population. We are developing a joint monitoring program as a basis for future transboundary management. Additionally, we are working to improve outlooks for maintaining connectivity of bear habitat in the project area. This is crucial for connection of the Dinaric – Pindos and Alpine populations and for the long term viability of the Alpine population.
On the other hand, each participating country is facing different problems and need different solutions for solving these problems on local scale. Partners in the LIFE DINALP BEAR project are collaborating with communities who are living with bears and face various problems in achieving coexistence with them. The main effort is focused on reducing human-bear conflicts with the use of effective tools like bear-resistant garbage or compost bins, and improved protection of livestock and beehives. We are also reducing road collisions with installation of fences or deterent devices on the most critical sections of highways or regional roads. Finally, we are developing opportunities for local communities to gain economic benefits from bear presence through ecotourism and bear friendly products.

We believe that our multi-scaled partnership-oriented approach will help ensure long term coexistence of people and bears at local and national scales and thus improve outlooks for connectivity and conservation of the northern Dinaric- Pindos and Alpine populations.

A Survey of Worldwide Monitoring and Estimation of Food Production for All Bears Species

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The IUCN Bear Specialist Group is the only worldwide organizational effort that monitors and reports on the status of all 8 species of bears, and that develops scientifically based recommendations to ensure their long-term survival. Climate change will likely influence the production and variability of bear foods, which, in turn, will influence bear demographics. Many researcher and managers monitor production of bear foods for some species, but it is unknown how food monitoring efforts vary worldwide. We present the results of our worldwide survey (via Survey Monkey©) directed at bear biologists and their efforts to estimate and monitor food production. Our objectives were to (1) determine how bear biologists monitor production of bear food, (2) how monitoring effort and method vary among bear biologists worldwide, and (3) how food production data are used in conservation and management. Questions address whether key bear foods have been identified, whether food production is being estimated and monitored, and which methods are being applied. The results of this work can be used in regional workshops to identify needs and standardize efforts for each species.

Change in Sloth Bear Habitat Loss: Its Impacts on Current Sloth Bear Distribution in Gujarat

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The forest connectivity and corridors are critical for biodiversity conservation. These corridors help in dispersal and movement of individuals between different habitats for food, shelter, breeding and other activities. Forest cover has been drastically changed in last sanctuary. Main reason behind these changes is the change in land use patterns and the way forest lands are overused by humans for several activities to cater the need of the society. In central India, particularly in Gujarat, the sloth bear habitats are greatly affected and the result is patchy and fragmented distribution of sloth bear population. In present study we used change detection method through remote sensing and GIS, which provides a modern foray into

the issues of ecosystem management. We acquired the oldest available Landsat remote sensing images of 1973 and 1993 of Gujarat state and which are compared to the latest remote sensing LISS IV image of 2014 to understand the change in land use pattern. We have also overlaid the sloth bear presence locations on the images to see impact of habitat loss on sloth bear population distribution. We found the habitat loss has affected the major corridors for sloth bear movement. The forests are mainly converted into agriculture lands and irrigation activities, followed by human settlement. The change in land use and land cover may be the major factor for increased human-bear interaction and can be minimized through reforestation activities. We are currently working on identifying such possible corridors in Gujarat and its neighboring states to enable sloth bear movement and population exchange.

Dead Bears as a Monitoring Tool

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With the elusive and sparsely distributed species as brown bears, each monitoring method is time and money consuming, and in most cases provides incomplete results. One way to mitigate those limitations is to collect each bit of data available. Large amount of data can be obtained from the bodies of dead animals. It is true that those are not any more part of the population in concern, but comprehensive approach will allow drawing useful and important conclusions on the state and the trend of the entire population.
The first necessary step is to prepare the legal framework and build the human capacity to get the information of each bear death case, which must include the unique ID of the body, the exact date and time, location, the cause of death and the basic information about the animal (sex, age, and at least some body measurements). Next key action is collecting samples. The best option is to have a professional and trained team to visit such a site or to organize the transfer of the body to the qualified institution for full autopsy. The alternative is that local wildlife managers (typically hunters) do get some training, written protocol and tools to collect and store the samples. The list of samples depends on the state (freshness) of the body. The very minimum includes any piece of tissue for genetic studies (e.g. for genetic diversity and effective population size), the premolar tooth for aging and a hair sample (e.g. for stable isotopes to reveal the diet and for stress and/or reproductive hormones). The full list of samples includes pieces of nearly all organs and tissues: muscle (including diaphragm and heart), bone, fat, intestine (including content), liver, spleen, kidney, adrenal gland, lungs, brain, testicles or ovaries with uterus. Those can be checked for living pathogens (parasites, bacteria, viruses, and fungi), various potential toxicants (heavy metals, pesticides, radionuclides) and even immunological status. The very cause of death is in majority of cases quite obvious like hunting or traffic collisions, in some cases only the autopsy reveals it, or it remains undetermined. In any case the knowledge of the distribution of the causes of deaths and the trend of each type of casualty can be used as a powerful management tool. When combined with the results of analyses of all samples showing eventual pathology which did not cause the death itself, the managers will have a well backed picture of the population health, potential threats and quite clear directions for future management.

Andean Bear Occupancy Monitoring: Why, What, and How

Robert Marquez

Andean bear (*Tremarctos ornatus*) populations have experienced dramatic range declines over the past few hundred years, due to the synergistic impact of habitat reduction and fragmentation and direct hunting, being regionally or locally vulnerable, near-threatened, threatened or even extinct. Reliable knowledge about the status and trends of Andean bear populations and the factors that affect them is critical for the development and execution of conservation and management plans. The use of occupancy models to assess alternative ecological/management predictions has been proposed as a tool for the improvement of carnivore population's science and conservation. Occupancy models are being used to assess carnivore populations' conservation state at a landscape scale as there is a strong positive relation between abundance and occupancy at the appropriate scales, and they explicitly deal with imperfect detection and the factors that affect the colonization/extinction dynamics.
A set of 15 occupancy and detection covariates were defined based on *a priori* hypotheses as a result of the evaluation of the factors that influence occupancy probabilities of Andean bears at the landscape scale. The presented covariates focus on habitat quality (vegetation types, land use, size of habitat patch) and vulnerability (human access, level of protection, probability of encounter). A key issue regarding an effective monitoring program is being able to estimate and compare the state of our system with model-based predictions, and thus evaluate the success or need of interventions. We need to have an acceptable precision of our estimates of change, that is, we should know the statistical power and significance associated to the evaluation of the magnitude of change that we want to be able to detect. The sampling design should take into account the size of the sampling unit, the selection of the sampling area (size, composition and structure), the season length, the sampling methods, the effort and temporality. We develop a table of sampling effort and designs depending on the sampling methodology used (activity signs transects or camera traps) and the level of precision required, considering the occupancy and probability of detection found at pilot localities.

Emerging and Aggravating Threats in Deosai Imperil Recovering Brown Bear Population

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The Himalayan brown bear is a critically endangered species in Pakistan. The Deosai National Park (DNP) supports the only stable population. A conservation program targeting brown bears in DNP was initiated in 1994, which continued until 2006. This program helped in the recovery of the population from 20 in 1993 to 43 bears in 2006. This recovery was significant and provides hope for the survival for the brown bears in Pakistan and rest of its range in Himalaya. The reproductive potential of this population is the lowest among all documented brown bear populations across the world, which necessitates careful

monitoring of the DNP population to ensure its long term survival. Though the park staff has been protecting bears from poaching, there has been no assessment of the population in past five years.
The aim of this study was to assess change in the population of bears in past five years. We used direct count method in combination with double observer approach to enhance reliability of the results. The direct count method is feasible in DNP, as it is a tree-less plateau which allows detecting bears from 2- 3 km. Brown bears are morphological distinguishable in Himalaya due to pelage variation and variable white patches, which allows identifying different individuals. We divided DNP into 45 blocks and two teams survey each block. Based on sightings of the two teams a capture history for each block was developed; 1-1 if bear/group is observed by the both teams, 1-0 or 0-1 if one team missed the bear/group. We used program MARK to estimate the population size and detection probabilities in different scenarios.
We also conducted park resource use survey to identify and quantify the resource use by human activities and by their livestock. Predation losses were also recorded to measure the conflict of local people with bear.
Our survey is still in progress, and so far we have completed 25 grids. In 25 grids we made 14 sightings, and counted 28 bears, excluding double counting. The Peterson estimate of the population comes to 34 (95%CI: 10.38) individuals in DNP. This estimate is based on partial data, and much less than what we expect. In the conference we will be able to report population estimate based on complete data set, and change in the population since 2006.
We documented 28 human occupations, mainly of nomad and local communities, who stay in the park for 3-4 months for livestock grazing. Total livestock holding of these communities was about 14,000, which is a 35% increase since 2006. This means an increasing pressure in brown bear habitat.

Understanding Attitudes and Usage of Bear Parts in Southeast Asia: Early Approaches and Outcomes Using Citizen Scientists Bears

David O'Connor

On behalf of the collaborative team of Free the Bears, University of Bristol, and San Diego Zoo Global

The illegal trade in wildlife is a leading threat to the continued existence of the Asiatic black bear Ursus thibetanus and sun bear Helarctos malayanus. Both species are in demand across Asia for their gall bladders and bile used in traditional medicine, and for their paws, claws and other parts used as delicacies or trinkets. In addition, wild cubs are taken for the pet trade or to supply bile farms. Despite synthetic and herbal alternative treatments being available, the demand for bear bile remains strong. The purchasing behavior of consumers is a main driver behind poaching and declining bear populations. Because attitudes often predict such behaviors, we developed quantitative surveys to better understand people's motivations behind bear part usage in northern Lao PDR. We investigated Chinese and Lao PDR nationals use of bear bile and bear parts, as well as differences in attitudes, value orientations, and knowledge between these two groups. These differences were statistically analyzed and indicate that the availability of the product leads to greater reliance, especially in Chinese respondents. Lao PDR nationals, though less reliant, were more likely to prefer wild bear bile.

Chinese respondents appeared to be more knowledgeable about bear conservation, versus Lao PDR respondents. In general, we note substantial differences in attitudes, behaviors, and knowledge of bear part consumption between Lao PDR nationals and Chinese nationals. These results seem to indicate the need for informed and localized demand reduction campaigns. Building on this previous research in Lao PDR, we are now surveying people in Cambodia working with a team of local citizen scientists in several rural and urban locations to gather this vital data for the first time in Cambodia.

Population Status and Attitudes of Local People Towards Sun Bear and Sun Bear Conservation in and Around Damapa Tiger Reserve, Mizoram, Northeast India

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Sun bear (*Helarctos malayanus*) is the smallest bear species and remains the least known bear species in the world. Reliable estimation of sun bear population and knowledge about its status and distribution pattern are very important for the field managers to develop management plan of sun bear populations. The attitudes of people towards sun bear impacts the latter's survival to a great extent. Northeast India is part of a global biodiversity hotspot and has the highest animal diversity in the country. This region is also home to over 7 ethnic groups, whose customs and traditions critically affect wildlife conservation practices. We conducted an informant-based survey in and around Dampa tiger reserve in Mizoram to investigate people's awareness of sun bear species and their attitudes towards sun bear conservation. Field surveys, questionnaires and direct observation were used in data collection. A total of 321 households in the nine selected villages were surveys from July 2014 to October 2015 and collected information on sun bear presence as well as the nature of human-sun bear interactions. Most (96%) respondents depended on land to generate income making the competition with wildlife more direct and intense. We used 20 camera-trap units. Our survey was designed to capture a range of ground-living mammals; however traps were deployed along animal trails, streambeds, and ridgelines, in locations with evidence of animal movement and were also suitable for recording small carnivores. We recorded the GPS location, altitude and other habitat parameters at each trap-site. Population status and abundance estimates were made through individual identification using camera trapping. A total 360 trap nights over the period of one and half years resulted in 42 sun bear photographs with 7 individual sun bears were trapped during the study periods. The results of our study provide valuable information on the extent of sun bear presence in Damapa tiger reserve and factors affecting their future existence in this region. Educated and young people with access to information and awareness mostly supported the sun bear conservation. All respondents from all villages without any significant variation agree sun bear of the area is depleted. Increasing anthropogenic pressure, due to continuously expanding human settlements and increasing demands for farming and grazing land, is the main reason why relatively large wildlife areas have been subjected to over-exploitation, degradation and destruction. Competition for land and resources has led to intense human-wildlife conflicts in the area.

The Status of Brown Bear Population Monitoring in Europe

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Public and wildlife management agencies usually require reliable estimates of the numbers and trends of brown bears (*Ursus arctos*), because this is a species of management concern wherever it is found. Here we will present an overview over the methods used to monitor brown bear populations in Europe and specifically discuss monitoring of the transboundary population in Scandinavia. Although all countries in Europe have some form of population estimation and monitoring, their scientific quality varies considerably. Here, we define scientific quality in terms of providing a method that has been tested and verified independently and providing a quantitative measure of confidence in the accuracy of the estimate. Of course, the requirements for scientific quality vary based on the needs of management, which are affected by the level of the conflict, the conservation status, size of the population, whether it is hunted or not, and the society's financial resources. Many countries use collected DNA (from scats or hairs) to estimate population size (Norway, Sweden, Italy, Austria, Spain, France, Greece, Slovenia) and others use genetic methods to compliment or confirm data obtain by other methods, such as counts at feeding sites, snow tracking, and telemetry (Croatia, Poland, Slovakia). In other countries, estimates are often based on reported observations and/or expert opinion. In hunted populations, harvest data is used to identify population trends. The Scandinavian countries have a comprehensive monitoring scheme to fulfill their management needs based on yearly DNA surveys and observation systems involving the public.

Monitoring Andean Bear Populations in Tropical Ecosystems: A Review of Methods, Limitations and Opportunities Across the Species Range

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The Andean bear (*Tremarctos ornatus*) is one of the largest mammals in tropical Andes ecosystems of South America. Besides technological and economic constraints, the animal's elusive behavior and characteristics of the ecosystems where Andean bears live have made it challenging to study this species. Although research efforts started in the late 1980´s and have provided limited information for this species, in the last fifteen years the amount of data on basic ecology and population parameters has increased substantially. This is partly due to the alternative and adapted monitoring methods where the participation of local people and the role of traditional knowledge have proved crucial to studying Andean

bears. In addition, technological improvements now permit the collection of data previously not possible. In an effort to contribute with the current state of knowledge about techniques for monitoring Andean bears, a group of Andean bear experts of the Bear Specialist Group (BSG) have conducted an exhaustive literature review from different sources (peer-reviewed journals, newsletters, book chapters, national documents, and technical reports, in Spanish and English). We also review methods used by presenters at the Third International Symposium for Andean bear Conservation (Cartagena, Colombia December 2014), and the results of the Round Table discussion among members of the Andean Bear Expert Team on techniques for Andean bear research and monitoring. Methods are classified as direct (observations and telemetry) and indirect (sign survey, habitat modeling, genetic sampling and camera traps). We will discuss the trends, limitations and opportunities of all these methods and propose guidelines for best practices for monitoring Andean bears in support of their conservation across the species' range.

Camera Trapping for Tigers Across the Terai-arc Landscape of Nepal Yields Valuable Information on Occupancy and Habitat Selection of Sloth Bears

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Sloth bear (*Melursus ursinus*) populations are declining, and the species is listed as Vulnerable by the IUCN because of rapid habitat loss and degradation. This lowland-dependent species was extirpated in Bangladesh, and it appears that only vagrants occur in the lowlands of Bhutan. Their diet varies seasonally from mainly termites and ants to fruits, but constraints of availability of different foods and elevation on sloth bear occurrence are unknown. A lack of information on their ecological requirements hinders conservation efforts. In Nepal, they have been recorded in high densities in alluvial grasslands and deciduous, dry Sal (*Shorea robusta*) forests within the lowland Terai. Because of their reliance on lowland habitat types that are generally inhabited by people, sloth bears are thought to be particularly vulnerable. Nevertheless, a recent study in India (Puri et al. 2015) indicated that sloth bears are more widespread (higher occupancy) than previously thought, and that they exist in diverse habitats alongside people (Ramesh et al. 2012); another recent study (Dutta et al. 2015) indicated that they are able to use narrow corridors of sparsely forested habitat between reserves. However, a previous survey across the Terai of Nepal (Garshelis et al. 1999) indicated that their distribution is very restricted. We had the opportunity to use camera-trapping data on sloth bears obtained as "by-catch" from a 2013 investigation of tiger abundance within 5 protected areas in the Terai. We obtained 2567 photos of bears from 187 sites in the 5 parks. We also obtained records of camera traps that recorded no bear photos (pseudo-absence). We used these data to investigate spatial distribution, occupancy, and habitat selection, and to discern human disturbances that result in a lower probability of occupancy. Nepal is an especially suitable place for investigating ecological limits on sloth bears because it is the northernmost extent of their range. Findings from this research will be valuable in establishing a baseline for future monitoring of sloth bears in Nepal, and for preparing an Action Plan for their conservation.

Population Ecology of the Andean Bear *(Tremarctos ornatus)* in the Northwest of the Metropolitan District of Quito, Ecuador

Santiago Molina

The objectives of this research were: a) Estimate structure and size of a population of Andean bear in an area within the Metropolitan District of Quito (MDQ); b) Record movement patterns and preferences for habitat use; and c) Estimate density through a monitoring system with camera traps and capture-recapture analyses.

Since 2008 a significant population of more than 40 wild Andean bears, representing all life stages, have been observed and recorded in an area within the MDQ, 70 km away from Quito, capital city of Ecuador, through direct observations and use of camera traps. For the first time, between February and March 2008 (and for the next years afterward), several bears were observed feeding from fruits from *Nectandra acutifolia,* a wild species related to avocado, family Lauraceae. This feeding behavior with aguacatillo (local name for the fruit) has not been reported before locally or in the region, and has been a unique opportunity to observed behaviors and photograph and record face patterns of a significant number of bears, and start to monitor and study the ecology of this population.

From 2010 to 2013 a system of camera traps was deployed in an area of 25 thousand hectares capturing 27 bears, most of them observed before but also new bears. 10 bears where captured in more than two cameras allowing to infer some of their movement patterns and use of habitat within the study area and estimate density. Camera traps also recorded the presence of an important community of other 18 species of medium and big mammals, including 5 species of felines that co-habitat with the Andean bear. This scientific information has been used to promote the creation of an ecological corridor for the species and guarantee their survival in the future.

Session 6 – Bear Toxicology

Polar Bear (*Ursus maritimus*) Health Assessment in Relation to Toxicants and Climate Changing in the International Polar Year 2007-2008

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The aim of the International Polar Year (IPY 2007-2008) project "BearHealth" was to study adverse health effects of persistent organic pollutants (POPs) in polar bears, and how various POPs, biological variables, and climate change interact in causing endocrine health effects in polar bears (*Ursus maritimus*). Thus, endocrine health biomarkers were studied in two populations of polar bears (Svalbard and East-Greenland). In both populations, POPs were found to affect the homeostasis of thyroid, reproductive hormones and vitamins. Furthermore, associations between individual POPs and deiodinase activities in liver, kidney and muscle tissues were identified, indicating that POPs may have a direct effect on thyroid function in target tissues. Analysis of blood-chemical variables indicated dose-dependent effects related to liver and kidney function. Statistical multivariate modelling indicated that the complex mixture of POPs in the blood of the bears had both additive and antagonistic effects on hormone concentrations and deiodinase activities, presumably due to simple similar action (dose addition), simple dissimilar action (response addition) and complex dissimilar action (antagonism) of the individual chemicals in the blood of the polar bears. There were also interactions between the effects of the POPs and a range of biological factors, such as sex, age, and reproductive status of the bears. Some endocrine variables were also affected by the geographical location at which the bears were caught. This could indicate that there are interacting effects between climate conditions and POPs on endocrine health of polar bears. The plasma concentrations of polychlorinated biphenyls (PCBs) and their hydroxylated metabolites (OH-PCBs) in Svalbard polar bears were about 50% lower in 2008 than in 1998. This indicates that implementation of the Stockholm Convention has resulted in decreased levels of PCBs in the Svalbard marine ecosystem. Higher plasma concentrations of thyroid hormones in Svalbard polar bear cubs in 2008 as compared to in 1998 may indicate that the thyroid health of polar bear cubs was improved due to decreased exposure to PCBs and OH-PCBs from 1998 to 2008.

Metabolomic Profiling in Relation to Persistent Organic Pollutants in Polar Bears from Two Canadian Arctic Subpopulations in Hudson Bay

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Persistent organic pollutants (POPs) are transported to the Arctic and bioaccumulate in biota and wildlife. Legacy and emerging POPs include an increasingly complex array of e.g. per-/poly-fluoroalkyl substances (PFASs), flame retardants and pesticides. The polar bear (*Ursus maritimus*) is the apex predator of the arctic marine ecosystem and food web. We are finding an increasingly complex array of legacy and new bioaccumulative POPs are in the tissues of bears from circumpolar subpopulations, and especially in animals from the Arctic POP "hotspot" of Hudson Bay (Canada). It is a challenge to fully realize the effect and toxicological implications of POP exposure in top Arctic predators such as polar bears, as there are numerous modes of action and mechanisms by which exposure to a complex mixture of POPs can elicit such effects. Metabolomics profiling and assessment offers the opportunity to examine on a broad scale, an array of hundreds of metabolism-related endogenous endpoints. That is, to study comparative differences in metabolomic signatures, e.g. between individual animals (and as a function of sex and age), animal populations as well as variations over time, and to assess the possible relationships of these metabolite signatures to e.g. POP exposure profiles in tissues. In the present study, 2014-collected liver and muscle sample pairs from western (adult males (n=14) and females (n=4)) and southern (adult males (n=14) and females (n=9)) Hudson Bay polar bears were analyzed for a profile of 216 metabolites. The metabolite profile was developed for the AXYOMICS targeted metabolomics approach project, which was completely validated for these polar bear tissues. These metabolite signature profiles were found to differ between muscle and liver tissues for individual bears, and well as differing for bears from the western versus the southern Hudson Bay polar bears. For liver only, and for PFASs, relationships to the metabolite profiles were observed. The significance to bear exposure and health of these endogenous-POP relationships will be discussed in this presentation.

Mercury Concentrations and Trends in Southern Beaufort Sea Polar Bears: Influence of the Recent Increase in Onshore Habitat and Resource Use

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Polar bears face anthropogenic stressors of both climate change and elevated exposures to environmental contaminants, including mercury. In 2005, mean mercury levels (7.4 µg/g dry weight, dw) in hair of polar bears from the southern Beaufort Sea (SB) were found to exceed their threshold level for neurochemical

alterations (5.4 µg/g dw). Over the same time, increasing the length of the ice-free season appears to have contributed to rising numbers of SB polar bears coming ashore in the fall and length of their onshore stay. Large carcasses of subsistence-harvested bowhead whales also likely have contributed to rising onshore use, and these 'onshore' polar bears are in good or above average condition. Given this ongoing change in habitat use and in a human-provisioned food, our objectives here were to re-evaluate mercury levels in this subpopulation using hair samples, determine hair mercury level trends, and relate mercury levels to prey species (i.e., including bowhead whale carcasses) consumption and body condition. We determined total mercury (THg) in 97 hair samples from biopsies of adult female, adult male and immature SB polar bears from 2004-2011. We used fatty acids analysis to estimate prey species consumption and body mass index (BMI) as an indicator of body condition. THg levels obtained for 2004-2005 were similar to those reported in the earlier study. However, THg levels declined significantly over time in adult males ($r2 = 0.69$, $p = 0.01$) and in immature bears ($r2 = 0.79$, $p = 0.008$), but not in adult females ($r2 = 0.41$, $p = 0.09$). Overall, THg levels dropped to less than half of the 2004-2005 values by 2011 (3.2 µg/g dw). Further, analyses suggest that lower THg values were associated with higher BMI values, while individual prey consumption did not seem to explain variation in THg levels. Mercury declines observed in SB polar bears stand in contrast to generally increasing or unchanged trends reported in other subpopulations of polar bears and in other arctic biota. Links to body condition suggest that the THg variation may, at least in part, be related to dilution of body mercury stores in better condition bears.

Putting the Eco in Ecotoxicology: A Polar Bear Perspective

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Polar bears (*Ursus maritimus*) carry high pollutant loads due to their high trophic level and high fat diet. As such, they have been the focus of many ecotoxicological studies. This presentation will provide an overview of the results of a systematic literature review assessing the integration of ecology with toxicology in the study of polar bears, along with a discussion of whether the approach to ecotoxicology to date has helped us answer questions pertinent to their conservation.

Ecotoxicology involves a multidisciplinary approach to studying the effects of toxic substances on the environment, combining our knowledge of ecology and toxicology to create a more comprehensive understanding of the biological effects of any given pollutant. As a research field, ecology encompasses a broad range of biological disciplines including analyses of, among other, the physiology, evolution, genetics, behavior, energetics, and population dynamics of the study species. The research field of toxicology, in contrast, deals with the detection, properties, and effects of toxic compounds. Ecology examines the larger-scale effects, but not necessarily their underlying cause, while toxicology tells us that

variables are changing, but not what the larger scale effects may be. If approached with an interdisciplinary perspective, combining the two fields in an ecotoxicological approach creates a synergy that allows us to extract more information than we would otherwise have been able to.

Studying Biological Rhythms in Captive Bears

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Species in the family Ursidae are often difficult to sample in the wild, emphasizing the need for studies of captive individuals. Primary advantages of captive studies include controlling for habitat and diet variables, and more frequent and predictable sampling than is typically possible in the wild. Based on these strengths, an important application of captive studies is to describe biological rhythms, to provide context for interpreting data from wild animals. Here, we discuss ongoing studies that are investigating circadian rhythms in body temperature of brown bears; seasonal rhythms of body mass gain and loss in sloth bears and other Asian species; and seasonal rhythms of hormones in sloth and polar bears.

Urinary Hormone Metabolites Identify Breeding and Pregnancy Status of Polar Bears

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Physiological adaptations such as seasonal breeding, delayed implantation, and extended periods of lactation have allowed polar bears (*Ursus maritimus*) to thrive in an arctic climate. The annual reproductive cycle of polar bears was examined during 2011-2014 through studying changes in urinary progestins, androgens, and glucocorticoids. Urine was collected from polar bears held in North American zoos and concentrations of hormone metabolites were determined through enzyme immunoassay. In males (n=3), androgen concentrations began to increase as early as Dec and remained elevated 2 to 19 fold above baseline (0.63 ± 0.02 ng/mg cr) through March/April. A second elevation in androgens occurred for one male during May/June and corresponded to a second period of breeding activity, with a different female. Reproductive cycles of females were classified as pregnant (n=3), anovulatory (n=4), or ovulatory, nonparturient (n=4) based on the changes in urinary hormone metabolite values and cub production. Increases in female androgens began 18 –22 days after parturition in Nov/Dec, and were greatest (0.76 ± 0.09 ng/mg cr) during mating events in Jan-April. The pregnant luteal phase was identified by a 1.8-fold increase of progestins 12 – 49 days after breeding that lasted 17 –20 weeks. A secondary increase in progestins (2.2-fold above basal progestins) occurred during fall, coinciding with presumed implantation and subsequent fetal development. Androgen concentrations remained low after ovulation in pregnant females, whereas the non-pregnant luteal phase was characterized by the elevation of androgens over progestins during summer and fall. Concentrations of glucocorticoids were elevated during mating events and also corresponded to periods of acute stress such as medical procedures and antagonistic interactions between conspecifics. Our data suggest that androgens play an important role in spermatogenesis and breeding behaviors in male polar bears, and androgen production can be stimulated by the presence of an estrous female as well as photoperiod. Furthermore, this research supports a role of androgens in follicular development and sexual receptivity in female polar bears. Non-invasive hormone monitoring allows for accurate pregnancy diagnoses and preparation of offspring care. This research confirms previous reproductive studies of captive and free-ranging ursids and provides guidelines facilitating captive management of this threatened, iconic species.

Mass Loss Rates of Fasting Polar Bears

Nicholas Pilfold, Daryll Hedman, Ian Stirling, Andrew Derocher, Nicholas Lunn, Evan Richardson

Polar bears (*Ursus maritimus*) have adapted to a seasonal, cyclic regime of feeding and fasting, which is especially severe in seasonal sea ice regions of the Arctic. As a consequence of climate change, the duration of the open water period through which polar bears must rely on fat reserves has increased. However, there is limited empirical data with which to evaluate the potential energetic capacity of polar bears to withstand longer fasts. We measured the incoming and outgoing mass of inactive polar bears (*n* = 142) that were temporarily detained by Manitoba Conservation & Water Stewardship during the open

water period near the town of Churchill, Manitoba, Canada in 2009 – 2014. Polar bears were given access to water but not food, and held for a median length of 17 days. Median mass loss rates were 1.0 kg/day, while median mass specific loss rates were 0.5%/day, similar to other species with high adiposity and prolonged fasting capacities. The inferred metabolic rate was characteristic of a basal rate for mammals, corroborating previous estimates from free-ranging polar bears and suggesting that while on land, polar bears can maintain a rate significantly lower than a field metabolic rate. Finally, we estimated time to starvation for subadults and adult males for the on-land period. At 180 days of fasting, results suggest that 56 – 63% of subadults and 18 – 24% of adult males in this study would die of starvation. Results corroborate previous assessments on the capacity of polar bears to withstand lengthening ice-free seasons and emphasize the sensitivity of subadults to changes in sea-ice phenology.

Using the *Ex Situ* Population to Advance the Reproductive Science of Polar Bears

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Little is known of the precise intricacies of the reproductive processes of polar bears (*Ursus maritimus*). Advances in reproductive science would allow field biologists to better evaluate the effects of climate change and environmental contaminants on reproductive parameters and pregnancy loss. Increased knowledge also would arm zoo staff with information that would enable improved husbandry, an environment that supports successful propagation, and optimized welfare of individual bears. Due to the inherent challenges of performing intensive, longitudinal research on wild bears, the *ex situ* population may serve as a model for studying the unique reproductive physiology of this species.

Scientists at the Center for Conservation and Research of Endangered Wildlife (CREW) at the Cincinnati Zoo & Botanical Garden are utilizing the captive population of polar bears to: 1) increase the knowledge-base of polar bear reproductive processes; 2) expand reproductive monitoring techniques, and; 3) develop assisted reproductive technologies such as semen collection/cryopreservation and artificial insemination. Approximately 60 captive polar bears with known ages, histories, diets, and health statuses, from 27 zoological institutions throughout North America have contributed to multiple research projects, resulting in significant advances in our understanding of their reproductive function.

Regular, non-invasive fecal steroid metabolite monitoring has documented seasonal shifts in testosterone concentrations in adult male polar bears, whereas progesterone and testosterone metabolites have provided insight into ovarian activity, pregnancy and pseudopregnancy of females. Differential analyses of fecal proteins have uncovered several specific peptides excreted in higher concentrations by pregnant versus pseudopregnant females and current research aims to confirm their use as diagnostic biomarkers of pregnancy. A rapid, field-friendly method of semen collection has been validated for this species and sperm cryopreservation trials resulted in the establishment of a polar bear sperm bank, preserving valuable genetics. Endeavors investigating the use of exogenous hormones in females indicate that ovulation may be induced for scheduled artificial insemination procedures. Finally, advances in operant conditioning at some zoos has enabled staff to perform more invasive procedures like trans-abdominal ultrasound examinations that provide even greater insight into the reproductive physiology of this species.

Measuring Hair Cortisol Concentrations and Faecal Glucocorticoid Metabolites in Polar Bears *(Ursus maritimus)*- Methods and Validation

A. Hein, L. von Fersen, K.Baumgartner

Measuring glucocorticoids, particularly cortisol, is a common and often used procedure to evaluate an individual's condition. In carefully controlled experiments cortisol can be a reliable indicator of stress. Particularly in the field of wildlife research faeces and hair have been proved suitable matrices for the analysis of glucocorticoids as the sampling procedure is performed non-invasively resp. without – potentially stressful- contact to the animal.
There are several methods in use for detecting glucocorticoids in these sample materials, yet for every material and every animal species a complete validation of the specific applied assay is essential. Furthermore for many species, as in the case of polar bears, reference values are missing, which makes it difficult to interpret the data obtained.
In this context the key role of zoos in wildlife conservation and species preservation becomes clear: an investigation of cortisol base lines and possible circannual fluctuations in captive polar bears helps in better understanding cortisol levels from wild bears, since a validation and establishment of reference values is hardly possible under field conditions.
Thus, as a first step varying methods of analysing glucocorticoids in hair of zoo-housed polar bears are being investigated in the course of this study, comparing different sample preparations (minced/powdered hair; different weights) and measuring methods (Immunoassay IBL/ Salimetrics, LCMS).
The analysis of glucocorticoid metabolites in polar bear faeces via EIA (group specific in-house test) is being validated using zoo-to-zoo transports.
First results of the project will be presented and aspects where further research is needed will be addressed.

Use of Accelerometers to Remotely Identify Polar Bear Behavior

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Tri-axial accelerometers have been used to remotely identify the behaviors of a wide range of taxa. Assigning behavior to accelerometer data often involves the use of captive animals or surrogate species. While it is assumed that accelerometer behavior signatures of captive or surrogates are similar to signatures of their instrumented wild counterparts, this has rarely been tested. Validated accelerometer data are needed for polar bears (*Ursus maritimus*) to understand how habitat conditions influence behavior and energy demands. We developed accelerometer behavior signature libraries in order to remotely distinguish resting, walking, swimming, and eating. We calibrated accelerometer data with video-taped captive polar bears (*n*=3) and captive brown bears (*U. arctos*; *n*=2) while they wore accelerometer-equipped collars, and with video collected from accelerometer-equipped camera collars deployed on wild polar bears on the spring sea ice of the Beaufort Sea (*n*=5). With the captive data and a subset of data from wild polar bears we used random forest models to predict behaviors. With the remaining subset from wild polar bears, we discriminated resting with 99% ability, walking with 97% ability, eating with 55% ability, and swimming with 30% ability. When we included salt-water conductivity sensor data in the model, swimming was discriminated with 73% ability. Using captive brown bear data alone to train the model resulted in poor ability to distinguish walking (54% ability) or eating (12% ability) behaviors in wild polar bears, whereas captive polar bear data alone exhibited similar ability as wild data in distinguishing wild resting, walking, and eating behaviors. Our results indicate that accelerometer data can reliably distinguish resting and walking in wild polar bears and when conductivity measures are included, swimming. Ultimately, these behavior signature libraries can be used to assess the implications of forecasted declines in Arctic sea ice on polar bear behaviors and activity rates.

Can We Use Photos of Captive Bears to Estimate Ages of Wild Bears?

Russ Van Horn, Megan Owen

Six of the eight extant bear species are threatened with extinction. However, there's relatively little demographic information from wild populations of several bear species and no non-invasive methods exist to gather some of the lacking information. Recent work on Andean bears (*Tremarctos ornatus*) demonstrated that nose color provides some information on the ages of adults, while the size of young cubs relative to their mothers can be used to estimate their ages and derive their birthdates. Because of the potential benefits of applying visual age estimation in studies gathering visual information on bears (e.g., camera trapping studies), we're evaluating whether we may visually estimate age in other bear species. To do so, we're extracting information from photos of bears whose age is precisely known (e.g., captive-born bears) to construct and test age estimation models. To evaluate whether we may be able to

perform meaningful tests of the two visual parameters (i.e., nose color, cub size) we've used studbooks to tally the number of bears of each species born in captivity since digital photography became readily available. Some constraints limit our ability to collect enough photos for analysis; there are few captive-born individuals of some species (e.g., American black bears *Ursus americanus*) and there have been few recent captive births among some other species (i.e., Asiatic black bear *Ursus thibetanus*, brown bear *Ursus arctos*, and sun bear *Helarctos malayanus*). However, for polar bears (*Ursus maritimus*, giant pandas (*Ailuropoda melanoleuca*), and sloth bears (*Melursus ursinus*) we should have enough samples to assess visual age estimation. To the degree we're able to visually estimate bears' ages, we'll enhance the ability of researchers to gather demographic information from wild bears, supporting conservation research and planning.

Session 7 – Population Monitoring

Absence of Capture Impacts on Annual Survival Estimates for Grizzly Bears in the Greater Yellowstone Ecosystem

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Live-capture, chemical immobilization, and handling of ursids is commonly used to obtain information useful for conservation and management, and some studies have reported immediate and long-term impacts to grizzly (*Ursus arctos*) and black bears (*Ursus americanus*) from capture-related stress. Capture and subsequent radio-monitoring is an integral component for demographic monitoring of the grizzly bear population in the Greater Yellowstone Ecosystem (GYE). Using the known-fate routine in Program MARK, we investigated effects of research capture(s) on the survival of 367 individual, independent-aged (≥2 years old) bears captured 668 times during 1983-2012 in the GYE. Building on a base model consisting of covariates that were predictive of survival in previous analyses, we tested for associations of capture-related covariates, including: type (culvert or foot snare); number of captures/year (by type); cumulative number of captures (by type and total); and a reverse-trend variable describing number of years since last capture (by type). Among our sample, number of culvert captures (*n* = 514) ranged from 0–7/year; number of snare captures (*n* = 154) ranged from 0–3/year; cumulative number of captures ranged from 1–17/individual, and years since last capture ranged from 1–5. We found that: 1) our base model was within 2 Akaike Information Criteria (AIC) units of all models with capture-related covariates; 2) all of the 95 % confidence intervals for capture-related covariates in all models overlapped zero, and 3) most capture-related covariates had positive beta coefficients. Although captures may be stressful events, especially for some individuals, we found no evidence that survival was negatively associated with the either type of capture or repeated capture events for independent-aged grizzly bears in the GYE.

Grizzly Bear Population Trend Estimated Using Genetic Detection

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We use genetic detection data from natural bear rub sites to estimate annual rate of change for a threatened grizzly bear (*Ursus arctos*) population in 2 study areas in northwestern Montana, USA: GNP (4,100 km^2) and NCDE (31,400 km^2). Bear rubs were surveyed twice annually in GNP 1998-2000, 2004, 2009-2011 (226-947 rubs) and in NCDE 2004, 2009-2011 (3,808-4,795 rubs). Using spatially explicit capture-recapture (SCR) models in a maximum likelihood framework, we estimate growth rate from the slope of a linear regression fit to the log of density estimates. To evaluate the usefulness of our estimates, we compare them to estimates of λ made using genetic detection data from a systematic grid of baited hair traps and the above bear rub data in traditional mark-recapture models and to estimates made using independent data from known-fate telemetry monitoring for our population. Total annual population rate of change was 1.066 (95% CI = 1.062-1.071) for females and 1.057 (95% CI = 1.051 – 1.063) for males. These rates of change are similar to those estimated using systematic data from hair traps but higher than telemetry estimates. Local rates of change within the NCDE were higher in areas of lower density and population expansion than in Glacier NP, the area with highest density. As density increased, the amount of space used by bears estimated by the SCR models, σ, decreased. Using simulation, we explore how reduction in bear rub survey effort impacts the accuracy of λ estimates and cost of data collection. Spatial capture-recapture models are ideal for rub-tree data because they have been shown to provide robust density estimates when confronted with unstructured data collection.

Exploring More Efficient Methods for DNA-Recapture Analysis for Bears

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Mark-recapture based on DNA extracted from hairs collected at barbed-wire sampling sites have revolutionized bear research and monitoring. Non-invasive sampling helps reduce sampling biases and can result in increased sample sizes for more rigorous estimation of population abundance. However, logistical difficulties remain because traditional mark- recapture is based on the assumption that every individual in the population being estimated have some non-trivial probability of capture. Animals along the periphery of the trapping grid have lower capture probabilities which can bias estimates. Furthermore, the monetary costs for genotyping can be prohibitive. Here, I discuss several options that can be used to make DNA mark-recapture more statistically robust, more logistically efficient, and more cost effective. Spatially explicit mark-recapture, for example, relaxes the assumption that every

individual must be available for sampling based on its spatial location. This allows for efficient cluster sampling designs for estimating abundance and density over large areas. Also, subsampling by genotyping only 1 hair sample from every site/week combination can result in greater efficiency with minimal bias. Additionally, genotyping only females can produce significant cost savings. Finally, estimating abundance for areas where bear densities vary spatially can be accomplished efficiently using stratified trapping designs, with greater trap densities in areas with greater bear densities. Simulation data will be presented to compare costs and evaluate bias associated with the various sampling options.

Grizzly Bears without Borders: Monitoring Grizzly Bears in Southwestern Alberta

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Agricultural grizzly bear-conflicts have increased in southwestern Alberta since 1999, potentially because of an increased grizzly bear population. The last population estimate for southwestern Alberta, completed in 2007, was 51 grizzly bears. We monitored grizzly bears using noninvasive genetic sampling and established 899 bear rub objects across the study area. We visited rub objects every 3 weeks from late May through early November (7 occasions/year). We also allowed for opportunistic hair samples, e.g., trapped bears and at bear-conflict sites. Bear species, individual identity, and sex were determined via analysis of nuclear DNA extracted from hair follicles. From 2013 through 2014, we identified 164 grizzly bears. Using spatially explicit capture recapture models, we estimated density. First, we estimated density for each sex and year separately (2013: males = 8.8 bears/1,000 km2 (95% CI 7.1 – 10.9), females = 14.4 bears/1,000 km2 (95% CI 11.0 – 18.7); 2014: males = 6.6 bears/1,000 km2 (95% CI 5.3 – 8.2), females = 8.8 bears/1,000 km2 (95% CI 6.6 – 11.7)). Second, we did not allow density to vary yearly and estimated a single density for the area (males = 7.7 bears/1,000 km2 (95% CI 6.6 – 9.0), females = 13.5 bears/1,000 km2 (95% CI 10.4 – 17.6) in the Recovery Zone, and 8.8 bears/1,000 km2 (95% CI 6.1 – 12.7) in the Support Zone). Though yearly variation occurred, we derived an expected abundance of approximately 68 resident grizzly bears, a 4.2% per year increase since 2007. Our density estimates pertain only to bears whose home ranges were centered within the study area; the estimate of bears using the study area from traditional capture mark-recapture (CMR) models was higher (2013= 165.4 (95% CI 139 – 229), 2014 = 154.2 (95% CI 126 – 219)). Our CMR estimate represents the number of bears with potential to have been involved in conflict. Management decisions should consider both resident bear density and the number of bears using the area. Over 50% of the bears identified in our study were previously genotyped in Montana or British Columbia highlighting the international nature of this bear population. We recommend increased inter-jurisdictional monitoring and management of this international grizzly bear population.

Density Dependence in Brown Bear P

Assessing Biological Realism of Brown Bear Population Estimates in Data-Poor Systems

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Regulated hunting is a common management tool in many jurisdictions, yet relevant decisions are commonly taken in the absence of reliable population data. We used the brown bear (*Ursus arctos)* management in the Romanian Carpathians, and compared it to gray wolf (*Canis lupus)* and the European lynx (*Lynx lynx*) management to evaluate the biological plausibility of population estimates used in hunting decisions in data-poor systems for species with different incentives for hunting. Brown bear is a species generating high revenue from hunting in Romania, while wolf and lynx are less desirable by hunters. Romania is not only large carnivore data-poor, but the public and private game managers responsible for population estimation are beneficiaries of revenue from hunting activities. We asked how population growth rates calculated from reported abundances between 2005 and 2012 compare to published growth rates empirically derived from other European and North American carnivore populations. We evaluated whether the reported carnivore population estimates fell within the bounds of biologically plausible trajectories using simulations. For the brown bear, annual population growth rates derived from reported estimates were frequently greater than the maximum published growth rates (up to 1.5, compared to literature λ_{max} = 1.136). Reported estimates were greater than maximum simulated populations in 32% of cases, and the difference was positively correlated with hunting pressure (r_s = 0.576), suggesting that population overestimations could be driven by the desire for higher hunting quotas. In comparison the population growth rates for *C. lupus* overshot literature λ_{max} (1.35) less frequently, and reported estimates were largely within the bounds of biologically plausible estimates (91%); for the *L. lynx* population growth rates derived from reported estimates were lower than minimum simulated populations (60%). For wolf and lynx there was a weak correlation between hunting pressure and differences between reported estimates and maximum simulated populations (r_s = 0.182 respectively r_s = 0.164). Our study suggests that comparing population estimates used by management agencies to demographic data obtained through peer-reviewed studies is a useful approach for evaluating the biological plausibility of wildlife data in data-poor systems, especially where management decisions might be influenced by non-scientific incentives.

A Non-Invasive Mark-Resight Survey Approach for Estimating Brown Bear Abundance in Arctic Alaska

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Assessing the size and distribution of brown bear (*Ursus arctos*) populations in the Arctic is challenging due in large part to low bear densities dispersed over large landscapes. Effective management of brown bears requires reliable population estimates. Meanwhile, existing survey approaches such as double-observer distance sampling or capture-mark-resight approaches tend to be expensive and are often logistically difficult to complete. Although these approaches provide useful inference, the high numbers of detections (distance methods) or costly capture and marking operations (capture-mark-resight) elevate cost, particularly in the Arctic. Our primary objective was to develop a statistically valid and cost-effective survey approach for estimating brown bear abundance that could be implemented at the landscape-scale in Arctic habitats. We designed a grid-based survey that used aerial repeated area search techniques and mark-resight methods to produce detection-corrected estimates of abundance. Spatially separated sample units were surveyed by independent pilot-observer teams twice on the same day within ~1 hour, limiting the possibility of bears moving in or out of units between revisits. Observed bear groups were temporarily 'marked' using high-resolution photographs and their location within the sample unit. Pilot-observer teams compared photos and locations daily to identify which groups were seen or missed by each team and to create associated 'capture' histories. Using these techniques, we surveyed a 20,000 km2 study area on the Seward Peninsula in western Alaska between May 19-29, 2015. The survey included 191 sample units covering approximately 25% of the area of interest. We estimated that a team's probability of detecting a bear group was 0.40, and there were 372 (95% CI: 256-557) independent bears within the entire survey area (CV=21%). This translates to a density over the entire survey area of 18.6 bears/1000km2 (95% CI: 12.8-27.8) or 1 bear/54km2. These estimates are consistent with those based on a collar-based capture-mark-resight survey that was completed within our study area in 1991. Our findings suggest that a photo-based mark-resight approach is a feasible alternative for assessing bear populations over large non-forested areas in the Arctic.

A Harvest-Based Estimation of Brown Bears in Hokkaido, Japan

Tsutomu Mano, Hiroyuki Matsuda, Shosuke Natsume Hifumi Tsuruga, and Mami Kondo

Brown bear populations in Hokkaido have been in the face of being harvested for a very long time. We analyzed population dynamics of brown bears (*Ursus arctos*) in Hokkaido for the period from 1990 to 2012 by the bear subpopulation ranges using a harvest-based age-structured population dynamics model. We considered population trend, upper limit of the simulation obtained by an independently estimated population density and uncertainty of demographic parameters in the simulation. Although an accurate population trend of brown bears in Hokkaido is uncertain, we assumed that the four out of six subpopulations increased from 1990 to 2012 and the remaining two subpopulations were uncertain

considering another independent indices obtained by bear sign survey. The estimated population sizes in 1990 were 1,087 + 166 for Oshima Peninsula, 340 + 184 for Shakotan-Eniwa, 266 + 216 for Teshio-Mashike, 2,328 + 994 for Doto-Soya, 1,540 + 592 for Hidaka Mountains, 272 + 122 for Yubari Mountains, and 5,883 + 2,274 for the whole Hokkaido range; those in 2012 were 1,430 + 648, 775 + 649, 951 + 694, 4,157 + 2775, 2,757 + 1,618, 535 + 337, and 10,601 + 6,721 respectively. On average the population sizes in 2012 were 1.8 times higher than those in 1990. In spite of the estimation with relatively low accuracy, it was suggested that various previous population size estimations of brown bears in Hokkaido were underestimation.

Experiences from the Long-Term Monitoring of an American Black Bear Population Using Various Harvest Sex–Age Models: And the Winner Is?

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Estimating population size and trend of bears has long been a challenging prospect. This is especially so for large areas, where commonly-used mark–recapture approaches are costly and logistically complex. Sex and age data from harvested animals are readily available and less expensive to collect. However, the use of these data to assess abundance and trend with sufficient reliability to inform year-to-year management decisions has been an elusive quest. We present an historical perspective (1983–2014) of our attempts to deal with this challenge for a harvested population of American black bears (*Ursus americanus*) in Minnesota, USA. Over the past 30 years, we used (1) a method posed by Paloheimo and Fraser (1981) based on change in age-specific harvest sex ratios, (2) a deterministic sex-age model that included ancillary data on reproduction and non-harvest mortality, (3) integrated population models, (4) Downing (1980) population reconstruction, and (5) statistical population reconstruction. Each attempt to improve the method produced new problems, required heroic assumptions or unobtainable ancillary data, or did not allow for the use of ancillary data that were available. We compared abundance estimates and trends from all 5 methods with 4 statewide tetracycline-based mark–recapture estimates. Mark–recapture estimates indicated a mound-shaped population trend in which the population increased by >30% from 1991 to 1997, remained high through 2002, then declined >30% by 2008. The modelling-based estimates varied in the degree to which they matched these mark–recapture estimates. Estimates of abundance and trend conflicted among methods: results from some methods indicated a recent population decline whereas others indicated growth, using the same dataset. Some population changes were biologically impossible. All methods failed to generate estimates that fell within the 95% confidence bands of all 4 mark–recapture estimates. Not knowing which, if any, results were accurate made management decisions difficult, and led to some poor management decisions. Population reconstruction has been a non-trivial pursuit over the past 30 years. Our findings serve as a cautionary tale about model

Session 8 – Physiology of Bears

Cardiac Response of American Black Bears to Roadways

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It is well established that roadways and traffic produce negative impacts on most wildlife species through vehicular-related mortality, altered movement and foraging behaviors. These impacts are typically quantified through movement rates, presence near roads and habitat selection. Coupling GPS tracking with recent advances in biologger technology allows measuring physiological responses of wildlife to environmental stressors, such as roadways, at fine temporal scales. While many studies have attempted to link stress, usually via stress hormones, to fragmented or urban areas, little progress has been made towards measuring physiological stress responses during discrete behaviors or interactions. We deployed GPS-collars and cardiac biologgers on eight American black bears (10 bear-years) throughout Minnesota. We tested whether bears exhibit acute stress responses, as defined by significant changes in heart rate, during road crossings while accounting for movement rate, habitat type, time of day and time of year. We looked for differences in responses among females with cubs of the year, females without cubs of the year and males. Additionally, we quantified the distance from roadways at which bear heart rates were no longer elevated. Road crossings resulted in higher maximum heart rates (9 of 10 bear-years), higher mean heart rates (9 of 10 bear years), and more mean heart rate variation (8 of 10 bears) relative to movements that did not include a road crossing. Bear heart rates became elevated at a mean distance of 118 meters from roadways (range 0-391 meters). Female bears with cubs showed the strongest responses to road crossings, whereas, bears located in study areas with lower road densities exhibited stronger cardiac responses than bears in areas with higher road densities. Our novel approach of pairing GPS locations with cardiac biologgers provides a unique insight into the physiological response of bears to roadways that was previously undetected with traditional technologies and methodologies. Our findings suggest that roads cause an acute stress, and the impacts are largest for females with cubs. Differences among study areas suggest a potential habituation toward roadways by bears that cross them with regularity.

Monitoring the Reproduction on Female Spectacled Bear by Non-Invasive Methods

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Spectacled bear (*Tremarctos ornatus*) is the only bear species that lives in South America and it is important for the ecosystem maintenance and for its relationship with Andean cultures. The species is threatened due to habitat loss and fragmentation, and poaching. Assisted reproduction is an alternative conservation tool; nevertheless, little information regarding basic knowledge on reproductive endocrinology of the Andean bear is available. The aim of this study was to study the ovarian cycle in the female Andean bear using non-invasive techniques to monitor the concentrations of faecal metabolites of reproductive hormones (oestradiol and progesterone). The study was carried out with samples collected over a 13-month period (Feb/2010 to April/2011), from six captive females located at two zoological institutions in Lima, Peru. The metabolites were extracted using 80% methanol, and hormone analysis was performed using an enzyme immunoassay (EIA) for epiandrosterone (antibody: 5α-androstane-3,17-dione 3-CMO:BSA) and pregnanediol (5β-pregnane-3α-20α-diol 3HS:BSA). The results strongly suggest that at least in captive conditions the Andean bear is a polyestrous species, with a non-seasonal ovarian activity. It was also possible to characterize complete ovarian cycles and the occurrence of ovulations. Based in our results were identified from 3 to 4 oestrous cycles by year; being that the follicular and luteal phases lasted on average 8 and 22 days, respectively. These results demonstrated the feasibility of the method and produced consistent and original information on the reproductive endocrinology of this endangered species.

Does Coitus Induce Ovulation in American Black Bears?

Lauren N. Stewart, Penny S. Dye, and Thomas J. Spady

It is often accepted that American black bears (*Ursus americanus*), and other bear species, are coitus-induced ovulators. Data from our lab suggests that coital stimuli may not be the only means to trigger ovulation in the *U. americanus*. The objective of this study is to better understand ovulation mechanisms in bear species by studying *U. americanus*, a species of least concern. I hypothesize that if coitus is required for ovulation to occur, estrus will be shorter in mated females than in nonmated females because ovulation should occur shortly after coitus, ending estrus.
Behavioral observation and enzyme immunoassays were performed on samples collected from a semi-captive population of *U. americanus*. Periods of physiologic estrus were recorded using a vulva scoring method and were overlapped with dates where mating was observed. Physiologic estrus was determined by a score greater than 2.5 on a rating scale of 0 to 3. The length of one physiologic estrus was determined by the number of consecutive days that a female scored greater than 2.5. Urine samples were collected

to measure estrogen (E2) concentrations throughout estrus in isolated females. Serum samples were collected during late-embryonic diapause to measure progesterone (P4) concentrations in mated females, females not observed to have mated (considered nonmated), and isolated females.
The average length of physiologic estrus for mated females was 9.188 days and for nonmated females was 6.714 days. The length of physiologic estrus in these groups were not different (DF=28, t stat=1.229, p=0.2295). We observed a gradual increase followed by rapid decline in E2 concentration in isolated females, indicative of ovulation. Average P4 concentration during late embryonic diapause for mated females was 9.075 ng/ml and nonmated females was 10.894 ng/ml. The average P4 concentrations between mated and nonmated females were not different (DF=6, t stat=-1.401, p=2.447).
Data from our lab suggests that *U. americanus* may use a mechanism in addition to, or in place of, coitus to induce ovulation. Spontaneous ovulation cannot be ruled out from this study. For the persistence of bear species, it is crucial to better understand their reproductive mechanisms.

Contemporary Serological Survey for Selected Pathogens and Zoonoses of Alaskan Brown Bears

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Previous research provides historical information on the exposure of Alaskan brown bears (*Ursus arctos*) to numerous pathogens of human and veterinary importance; however, contemporary information to assess how patterns of exposure may have changed through space and time are limited. In order to gain inference into possible changes in pathogen exposure, blood and serum samples were collected from 73 bears in 2014 and 47 bears in 2015 from four populations in Alaska: Gates of the Arctic National Park and Preserve (GAAR, n = 62); Lake Clark National Park and Preserve (LACL, n = 39); Katmai National Park and Preserve (KATM, n = 9); and Kodiak National Wildlife Refuge (KOD, n = 15). Sera were screened for antibodies to a suite of pathogens. The prevalence of antibodies to canine adenovirus 1 (CAV-1) ranged from 5–93% with higher prevalence at KATM and KOD as compared to the other two sites. Contemporary seroprevalence rates for CAV-1 at KATM and KOD are higher compared to samples collected during 1988–1991. Antibodies to parvovirus were found in 0–13% of samples from four populations which contrasts an earlier report in which antibodies to parvovirus were not detected. Antibodies to *Francisella tularensis* were detected in 0–20% of samples, and seroprevalence rates for *Brucella* spp. were 7–15%, comparable seroprevalence rates as found during 1988–1991. Antibodies to *Toxoplasma gondii* were detected in 16–36% of samples with significantly higher prevalence in LACL as compared to GAAR. This contrasts with a previous investigation which highest exposure to *T. gondii* was detected in northern Alaska. Antibodies to

Canine distemper virus (CDV) were only detected at GAAR (13% seropositive). Few bears had detectable antibodies to influenza A viruses. No bears had antibodies to *Trichinella* spp., in contrast with previous research where *Trichinella* antibodies were detected in up to 91% of brown bears sampled in northwest Alaska. Collectively, these data indicate that exposure of bears in Alaska to pathogens varies spatially and temporally and that research to understand drivers of variation may be useful for understanding potential population level impacts of disease.

Biologging in Brown Bears: Filling in Ecophysiology Knowledge Gaps

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Biologging techniques are becoming an integral part of wildlife ecology, research, and management. Here we report results from 5 years of biologging experience, including temperature loggers and heart rate loggers. We have used these loggers to assess the timing and duration of pregnancy, impacts of capture on hibernation, the interplay between physiological and ecological drivers of den entry and den exit, and effects of body mass and latitude on hibernation depth and duration. The mean date of blastocite implantation was 1 December, the mean date of parturition was 26 January, and the mean duration of the gestation period was 56 days (SD = 2). The body temperature, T_b, of pregnant females was higher during gestation and lactation periods than that of nonpregnant bears. Nonpregnant bears entered the den when snow arrived and when ambient temperature reached 0°C. Heart rate variability, HRV, taken as a proxy of sympathetic nervous system activity, dropped dramatically once the bear entered the den. This indirectly suggests that denning is tightly coupled to metabolic suppression. During arousal, an unexpected early rise in T_b (two months before den exit) was driven by ambient temperature, T_A, but was independent of HRV. HRV increased only three weeks before exit, indicating that late activation of the sympathetic nervous system likely finalized restoration of euthermic metabolism. Interestingly, it was not until T_A reached the presumed lower critical temperature that bears exited the den. Hibernating bears took 15-20 days from capture before their T_b and HR returned to the hibernation curve, but capture did not influence the length or magnitude of hibernation. In 40 bears, we divided bears into four groups based on size and evaluated mean daily temperatures throughout the year. We found that bears of different size categories have similar body temperatures

during the active period, but that smaller bears had consistently lower body temperatures winter (Dec-March). The use of biologging, including heart rate and body temperature, has allowed us to fill in important knowledge gaps in the ecology of free-ranging brown bears, and there is great potential for further studies including analysis of already collected data.

Serum Biochemistries of Bile-Farmed Asiatic Black Bears (*Ursus Thibetanus*) in China: Survival Analysis and Comparisons with Non-Farmed Japanese Asiatic Black Bears (*Ursus Thibetanus Japonicas*)

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Asiatic black bears (*Ursus thibetanus*) are the predominant species targeted and farmed for bile throughout Asia despite their vulnerable status.[3] Animal welfare charity Animals Asia (www.animalsasia.org) has rescued 578 bears from the bile industry. Bile-farmed bears experience numerous health and welfare issues[4-7] and leading causes of death are liver cancer (29%), deteriorating mobility including paralysis (19%) and cardiovascular disease (11%).[1,2] The objectives of this study were to perform the first comprehensive analysis and comparison of bloodwork values between bile-farmed and non-farmed Asiatic black bears and perform survival analyses to identify biochemical predictors of death in bears who have had bile extracted. Due to difficulty accessing non-farmed Asiatic black bears in China, comparative samples were obtained from an accessible subspecies, the Japanese Asiatic black bear (*Ursus thibetanus japonicas*). Comparisons were made between four groups: farmed bears in China who had bile extracted (BE; n=176) or who did not have bile extracted (NBE; n=25); and non-farmed bears in Japan from a bear park (NF; n=20) or free-range (i.e. wild) (FR; n=13). Biochemical parameters of greatest interest included liver enzymes (alanine transaminase (ALT), gamma glutamyltransferase (GGT)), kidney markers (blood urea nitrogen (BUN), creatinine (CREAT)), and inflammatory parameters (lactate dehydrogenase (LDH)). Boxplot comparisons revealed that BE bears upon rescue from farms exhibited elevated ALT and GGT with markedly higher variability compared to all other bears groups, consistent with expected liver inflammation and damage associated with bile extraction. This was supported by simple linear regression demonstrating significant differences ($p<0.05$) in ALT levels between BE and non-farmed (NBE and NF) ($p=0.007$) bears. GGT levels were significantly different between BE bears and both non-farmed (NBE and NF) ($p<0.001$) and FR ($p=0.003$) bears. Analyzing trends over time from day 0 (arrival) up to day 5000 post-arrival, BE bears continue to demonstrate marked elevations and variability in ALT, GGT and CREAT compared to NBE bears, consistent with long-term physiological compromise in BE bears. Survival analyses using a modified Cox model[8] identified significant predictors of death such as elevated GGT ($p<0.001$) and LDH ($p=0.039$) for liver cancer, BUN ($p<0.001$) and LDH ($p<0.001$) for mobility, and CREAT ($p=0.007$) for cardiovascular disease.

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Chronic Stress Evaluations in European Brown Bears (*Ursus arctos*): A New Methodological Approach Using Ultrasonography

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Quantification of chronic stress becomes more and more important in welfare questions concerning captive wildlife and for evaluating the success of reintroduction projects or different management situations in free-ranging wildlife. Traditionally fecal glucocorticoids are measured to make comparisons between different life events in individuals or between two study groups. However, quite a few samples per animal are needed to interpret the result. Scientific quantification of stress via ultrasonography focuses on chronic stress exposure and can give results immediately after only one measurement. The mesodermal adrenal cortex is subdivided in three layers; *zona arcuata*, *z. fasciculata* and *z. reticularis*. The *zona fasciculata* is responsible for the secretion of glucocorticoids. As in many other organs, if the demands on these specific cells are increased, the cells can undergo hypertrophy and hyperplasia in order to meet their task of secreting glucocorticoids in appropriate concentrations. Hence, if an animal experiences chronic stress and the demand for glucocorticoid secretion is elevated, the cells of the *zona fasciculata* will undergo hypertrophy and hyperplasia, increasing the size of the *z. fasciculata*. In gross pathology, macroscopically an increased cortical area would be visible. Hence, in living animals a possible way to assess the adrenal cortex would be via ultrasonography.
Confiscated European brown bears (*Ursus arctos*) from illegal husbandry conditions (baiting bears, restaurant bears, etc.) were examined on the day of confiscation. The ratio between the adrenal cortex and the adrenal medulla (C:M ratios) from that day and from one year after rehabilitation within a naturalistic sanctuary with adequate medical support, were compared. The C:M ratio significantly reduced from on average 1,5 to 1,09 within the rehabilitation year.

We could show, that the C:M ratio, which can easily be measured by 2D-ultrasound, reflects a stress-induced enlargement of the *z. fasciculata* and can be applied to assess chronic stress in animals. We suggest that the same comparisons could be done to compare different reintroduction sights and their suitability, and hence contribute to a better understanding of different stress exposures in different habitats.

Chemical Communication in Bears (Ursidae)

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Chemical signals play a fundamental role in the communication systems of many and varied taxa. For solitary and wide-ranging mammals the utility of communication *in absentia* is clear, enhancing fitness by enabling animals to navigate their social landscape without the costs associated with tracking an individual for visual, acoustic or physical/competitive assessment. Thus, the generally solitary lifestyle of bears Ursidae likely shaped the evolution of olfaction as a major method of communication, and it is likely that bears developed their keen sense of smell as a result. Historically, chemical communication had been generally understudied across bear species (except for giant pandas), in part due to logistical constraints of their solitary wide-ranging lifestyle. However, recent studies are beginning to shed light on the role of chemical communication in the social lives of bears and, importantly, the environmental characteristics that are key to its efficiency. Here we provide a review of the current knowledge within and between bear species to highlight similarities and differences, and develop hypotheses to aid future research. We discuss how environmental and social constraints, along with species anatomy and physiology, may have shaped the observed variation in chemosensory behaviours among bears. Although generalisations can be made concerning chemical signalling behaviour for some bear species, we chose a more comprehensive approach by focusing on socio-ecological context, and comparing this between species. Through this approach, we determined that observed variation in chemical signalling strategy, both between and within species, appears to be dependent on food availability, population density and generalised habitat characteristics. These variables now provide a platform from which future hypotheses assessing chemical communication in the Ursidae can be formulated.

Feet that Bring News: Histological, Chemical and Field Evidences of Pede Marking in Brown Bears

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The aim of the study was to disentangle pede marking in brown bears and its potential relevant role. Presence of scent-marking glands is a common feature of the mammalian skin and plays an important role in diverse olfactory communication of animals. The analysis of such glands in various species has revealed a considerable diversity in respect to its anatomy, but also structural principles they have in common. Typical glandular structures are often composed of various types of glands. Apocrine and sebaceous glands are primarily observed in a hairy skin while eccrine sweat glands appeared to be confined to specific regions, e.g. footpads of carnivores. In ursids, chemical signaling appears in a variety of forms, including rubbing against trees, biting and clawing, urinating, and depositing anal gland secretions. Bears have been also observed ground pede marking while walking. We first sought histological evidence that brown bears possess pedal glands, and compared the findings to skin sections of other parts of the body. Second, we explored the chemical compounds of the scent with gas chromatography techniques. Third, we provided field evidence of ground pede marking by brown bears in two European populations (Carpathian and Cantabrian), which occurred throughout the year, performed mostly (if not uniquely) by males, but not only during the mating season. The ground marking has been observed primarily in connection with tree rubbing and might suggest a combination of chemical signaling being used: higher-cost (rubbing against tree) and lower-cost (active or passive while walking). The origin of scent actively or passively deposited is suggested to be from pedal glands, urine, or a combination of these two. Twenty distinct compounds of pedal scent were recognized in all scent samples, and additional six only in samples collected from males. Although we did not fully identify the compounds of pedal scent, histologic examination of the interdigital and metacarpal/metatarsal regions revealed relatively prominent apocrine sweat glands. Relatively large size and abundance of those suggest its functional role in producing chemosignals.

Session 9 – General Session

A Search for Chemical Cues in Giant Pandas

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Chemical cues in urine are thought to play an important role in mate identification in the solitary giant panda (*Ailuropoda melanoleuca*). Identification of the volatile chemicals produced by giant pandas may provide insight into which biogenic compounds are involved in signaling sexual receptivity. The goal of this study was to identify differences in volatile compounds present in the urine and enclosure air of captive giant pandas relative to sex and breeding status. We hypothesized that a subset of compounds consistently produced from breeding animals would be detected in urine and environmental samples because highly volatile chemicals are likely to facilitate mate detection. Samples were collected from urine and enclosure air, representing a total of 8 giant pandas (n=4 male, n=4 female), housed among four institutions (Memphis Zoo, Zoo Atlanta, Edinburgh Zoo, and Toronto Zoo). Samples were collected during the Feb-May breeding season and the Aug-Jan non-breeding period from 2012-2015. Volatile compounds were captured by solid phase micro extraction (SPME) using a polydimethylsiloxane (PDMS) fiber. Each fiber was placed was placed 2 cm above a bottled urine sample for 2 hours or mounted approximately 3 meters above the ground within a panda enclosure for 6-10 hours (air samples). Compounds adsorbed onto the SPME fibers were analyzed by gas chromatography mass spectrometry. Over 200 and 250 compounds were detected from urine and enclosure air samples, respectively, of which 59 were tentatively identified using both sampling techniques. These volatile compounds were detected in urine and enclosure air samples from all individuals during at least one sampling year and occurred in relatively high proportion of samples (>10%) from the given year. Given the consistent production and prevalence of these 59 compounds, we suspect that this group includes chemicals that are important in giant panda communication. With low population numbers of giant pandas in the wild and limited reproductive success in some captive institutions, a better understanding of chemical communication in this species may benefit conservation efforts. In addition to improving captive reproductive success, we aim to build upon this research to understand how habitat fragmentation influences chemical communication among giant pandas in situ.

Heritability of Body size in a Wild Mammal: The Brown Bear (Ursus arctos)

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Wild animal populations experience selection pressures from many environmental sources, including both natural and anthropogenic sources. With extensive pedigrees becoming available, it is now possible to quantify the heritability of phenotypic traits in the wild, and thus the potential for evolutionary change in these populations. The state of the environment is also expected to affect the gene expression in individuals, and thus the phenotypic expression, which may again affect the selection potential. Habitat characteristics, climatic effects and population density are all covariates which may affect the availability of important resources, such as food and shelter. Knowledge about the relationship between the genetic and environmental components operating on the phenotypes are of key importance under recent climate and land use changes, as such global changes have a large effect on resource availability in many species. Using animal models, we aim to disentangle the genetic and environmental components of phenotypic variance. We use an extensive pedigree covering ~1200 individual brown bears (*Ursus arctos*) over 6 generations, as well as data on bear density, habitat composition and quality (derived from the Normalized Difference Vegetation Index; NDVI), and climatic conditions. As found in earlier studies of wild animal populations studying the heritability of morphometric traits, we expect a substantial contribution of the environment on the phenotype, such as increased body size under favorable environmental conditions (e.g. optimal habitat qualities and climatic conditions for increased bilberry (*Vaccinium myrtillus*) production in autumn). Our study is to our knowledge the first quantifying heritability in a wild brown bear population, and shows that including important environmental variables when analyzing heritability is key to understanding the dynamics of the evolutionary potential of phenotypic traits.

Den Monitoring in the Eastern Romanian Carpathians by an Independently Operating Video System

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We specially designed and implemented an independently operating visual system for long-time monitoring of bear dens in autumn 2013. The Hard- and Software were developed by the company Procontrol Electronics from Szeged in Hungary. Each unit consists of at least one camera equipped with motion sensors, which are powered by a solar panel through a storage-battery. Data transfer is enabled through a wireless radio transmitter linked to a receiver with internet connection from where the images

reach the central server for recording and storage. The system permits real-time access to the cameras. This independently operating technique therefore allows a safe operation from the distance and simultaneously minimizes disturbance of the dens by field technicians. The former system functioned with batteries that had to be changed every week. Besides the difficult access of the terrain due to high snow cover, field technicians were exposed to a high risk of encountering bears directly at the dens. Since October 2013 we are monitoring five den entrances at three sites in the Eastern Romanian Carpathians. Den sites were selected on the basis of a few criteria such as previous usage of the den and accessibility of the location. Additionally, the antenna at each den site had to be placed in line of sight with another antenna mounted at a roof of a house to facilitate the wireless transmission between the camera at the den and the receiver. During the winter periods we could capture and successfully record diverse bear activities at the dens. At one study site a female brown bear gave birth to two cubs that left the den for the first time at the end of March. The footage of the female and her cubs revealed interesting aspects of bear behavior such as their long-lasting presence at the den until the end of May and her defensive behavior against foreign bear attacks. During the monitoring period the sow was rarely licking snow and not ingesting at all. We consider our project that was funded by the National Geographic Society as a valuable contribution to the research about denning behavior of bears.

Grizzly Bears and People in Space and Time – Using an Interdisciplinary Approach to Bear Research and Management

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Protected area managers are continually challenged to balance ecological integrity with human recreation needs and expectations. Through an interdisciplinary approach, we investigated this complexity in Canada's Rocky Mountain National Parks by looking at the grizzly bear and human dynamics of trail use. By integrating biological and social science data, our goal was to define management tactics that maximized grizzly bear habitat security and met trail user expectations of bear management in the study area. Data was collected from May to October 2013 to 2015 through three sources: a series of remote cameras on trails, GPS collars on 12-14 grizzly bears, and a survey of trail users disseminated at trailheads. Remote cameras showed that grizzly bears and people share trails spatially and temporally throughout the year. Grizzly bears were more likely to use trails of lower human use, in higher quality habitats, and at dusk/dawn. Human use was concentrated on trails of less difficulty (as measured by terrain ruggedness) and on weekends, but was abundant throughout the Parks. A use/availability analysis of the GPS data showed that at the bear home range scale, bears selected for high quality habitat and areas closer to trails than random in the spring and summer. Females with cubs had higher trail densities in their home ranges than adult females and adult males. The trail user survey found a high level of support for prioritizing grizzly bear habitat needs over personal recreational needs. Trail users were also supportive of restrictive management actions, such as closing trails, when bears were in the area. The interdisciplinary nature of this work helps managers to not only make decisions founded in biological sciences, but also to identify when and to what degree those decisions will be supported by trail users.

Managing the Move: Factors Affecting the Success of Grizzly Bear (*Ursus arctos*) Translocations in Alberta, Canada

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As carnivore populations decline globally, preservation of individuals often becomes important, particularly for at risk populations. Grizzly bears are a Threatened species in Alberta and recovery efforts are underway, however human bear conflicts continue and management actions are required; a standard response for managing problem bears is translocation. Nonetheless, there is a lack of knowledge on how different management decisions and biological factors affect translocation success and a limited understanding of the behavioural effects of translocation on individuals. Evaluating translocation outcome is a key step for improving our understanding of this common management action and for determining the proper management responses needed to increase its success. Therefore, the goal of our study was to investigate management and biological factors that may affect the outcome of a translocation and to compare the behaviour of translocated grizzly bears to those of local residents to assess the ability of released bears to acclimatize to new environments and habitats. We used logistic regression to test relationships between translocation outcome, management factors (translocation distance, season), biological factors (sex, age class, conflict type), and habitat characteristics (habitat type, habitat quality) of the capture and release site for 177 translocation events that occurred in Alberta between 1999 and 2014. To better understand the energetic costs of translocation and the adaptability of translocated bears over time, we used logistic regression and mixed effects generalized linear models to compare seasonal movement rates, home range size, and habitat selection, as well as denning dates and total denning days, of translocated bears (n=10) and resident bears (n=56) monitored with GPS satellite collars. Movement rates were calculated as the total distance travelled by individual bears for each daily and weekly time interval and the sinuosity of each path was calculated as the total distance of all line segments divided by the net displacement of the start and end location. The results of this study improve our understanding of the biological consequences of translocation and focus on providing specific management recommendations necessary for improving grizzly bear translocation success rates in Alberta. Our findings can also inform other grizzly bear recovery efforts that require translocation, such as population augmentation or possibly the release of orphaned or captive-reared individuals.

Changes in Body Temperature and Heart Rate Related with Hibernation in Captive Japanese Black Bears (*Ursus thibetanus japonicus*)

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In order to investigate physiological and metabolic changes related with hibernation of Japanese black bears (*Ursus thibetanus japonicus*), core and subcutaneous body temperatures and heart rates were monitored from pre-hibernation to post-hibernation periods under captive condition by using some implantable loggers and devices. Throughout the entire hibernation period, core and subcutaneous body temperatures showed parallel fluctuation and a significant correlation between both temperatures. In the pre-hibernation period, body temperatures and heart rates drastically declined just after moving bears to denning rooms. In the early stage of hibernation, body temperatures of pregnant and pseudo-pregnant bears were higher and more stable than those of non-pregnant bears from December to early January ($P<0.05$), and then dropped to similar levels to those of non-pregnant bears from late January to early February. From mid- to late-stages of hibernation, body temperatures indicated cyclic pattern with various day length. In the cycle, heart rates and body temperatures showed parallel fluctuation and a significant correlation between them. In the post-hibernation period, heart rates returned to the higher level from hibernation state about two weeks after body temperatures rising. These findings suggest that moving bears into a denning room may accelerate to be physiological condition of hibernation, and that, in the first-term of hibernation, endocrine change such as progesterone increase would maintain high body temperatures without affecting heart rates in pregnant and pseudo-pregnant bears. The parallel fluctuation between body temperature and heart rate suggests that sympathetic nervous system is involved in the regulation of body temperatures and heart rates during hibernation in the Japanese black bear.

Reproductive Ecology of Black Bears in North Carolina

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Long-term datasets are important in understanding underlying trends and important ecological relationships not evident over short time spans. We analyzed 2,862 female black bear reproductive tracts collected from 1976 to 2008 in the mountain and coastal regions of North Carolina. We also conducted hard mast surveys in the mountains from 1982 to 2008. Ovulation rates, based on counts of corpora lutea

(CL), increased with age in both regions, with no differences after 4 years of age. Placental scar (PS) rates also increased with age with no differences after 5 years of age. For bears aged two to 5+ years old, ovulation incidence ranged from 2.0 to 2.5, respectively, in the coastal region, and from 2.1 to 2.8, in the mountains. Ovulation and PS rates were higher for 3, 4 and 5+ year olds in the mountains than the corresponding age classes on the coast. However, female weights were higher on the coast than in the mountains. We hypothesize that long-term evolutionary adaptations to environmental and food conditions may pre-program these reproductive parameters especially given that bears now exist in radically different conditions than prior to European settlement. Neither ovulation incidence nor PS rates varied significantly with mast crop categories of poor, average or good. The percent of reproductive tracts that contained both CL and PS (possible reproductive failures) differed based on mast category (poor - 30.4% > good-20.2%). The weights of females with both CL and PS were less than females with only CL, but more than females with only PS. These results may indicate that despite poor nutritional condition, a female will attempt to produce cubs, but lose them due to their inability to meet the energetic demands of lactation. The weights of females with only CL (breeders) were higher than weights of females with only PS (producers). This difference in weight may represent the energetic cost of raising cubs. Using long-term reproductive tract information, along with fall weights and mast abundance data, is useful for discerning the factors that influence successful reproduction and determining if reproductive parameters differ among regions. This information is also valuable to managers for building black bear population models within a state or other jurisdiction.

The Challenges and Opportunities of Bear Education in Alaska

Elizabeth Manning

Wildlife Education and Outreach, ADF&G

Educating the public about wildlife safety is a dynamic and never-ending job, especially in Alaska where wildlife populations are healthy and where our state's overall human population is marked by high transiency rates and a high degree of ethnic diversity. Anchorage is a particularly unusual city in regards to bear education. Both black and brown bears are commonly found inside city limits, and the city is home to a multicultural human population that ranks among the most diverse in the nation. This presents interesting communication challenges, as well as inevitable human-bear conflicts with so many humans and bears sharing the same habitat. The Alaska Department of Fish and Game Wildlife Education Program has long taken a leading role in organizing public education and outreach on safety around wildlife species such as bears, moose and wolves, but this outreach work is a highly cooperative effort, relying on many partners, ranging from federal agencies to nonprofits. This session will explore how wildlife safety outreach is organized throughout the state, and on the role played by Alaska's various bear committees, including groups in Anchorage, Juneau, Kenai and Kodiak. This session will also explore the variety of techniques and programs employed by ADF&G and its partners to educate the public about how to minimize conflicts with bears. Some of the approaches discussed will include a stewardship project by Girdwood K-8 School, a story map educational project using ArcGIS Online involving camera-collar footage and location data, as well as robust classroom presentation programs in Anchorage and Juneau. Other efforts have included special events such as an annual bear aware day at the Alaska Zoo, a bear aware scavenger hunt at the Sportsman's Show in Anchorage, wildlife safety clinics for adults, bear spray trainings, a DVD about bear safety aimed at elementary children and a new bear unit for educators. Some

evaluation of programs has also been undertaken in recent years, and results from those efforts will be shared.

Impacts of Human Recreation on Brown Bears (*Ursus arctos*): A Review and New Management Tool

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Increased popularity of recreational activities in natural areas has led to the need to better understand their impacts on wildlife. The majority of research conducted to date has focused on behavioral effects from individual recreations, thus there is a limited understanding of the potential for population-level or cumulative effects. Brown bears (*Ursus arctos*) are the focus of a growing wildlife viewing industry and are found in habitats frequented by recreationists. Managers face difficult decisions in balancing recreational opportunities with habitat protection for wildlife. Here, we integrate results from empirical studies with expert knowledge to better understand the potential population-level effects of recreational activities on brown bears. We conducted a literature review and Delphi survey of brown bear experts to better understand the frequencies and types of recreations occurring in bear habitats and their potential effects, and to identify management solutions and research needs. We then developed a Bayesian network model that allows managers to estimate the potential effects of recreational management decisions in bear habitats. A higher proportion of individual brown bears in coastal habitats were exposed to recreation, including photography and bear-viewing than bears in interior habitats where camping and hiking were more common. Our results suggest that the primary mechanism by which recreation may impact brown bears is through temporal and spatial displacement with associated increases in energetic costs and declines in nutritional intake. Killings in defense of life and property were found to be minimally associated with recreation in Alaska, but are important considerations in population management. Regulating recreation to occur predictably in space and time and limiting recreation in habitats with concentrated food resources reduces impacts on food intake and may thereby reduce impacts on reproduction and survival. Our results suggest that decisions managers make about regulating recreational activities in time and space have important consequences for bear populations. The Bayesian network model developed here provides a new tool for managers to balance demands of multiple recreational activities while supporting healthy bear populations.

Forbidden Fruit: Human Settlement and Abundant Fruit Create an Ecological Trap for Grizzly Bears

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Habitat choice is an evolutionary product of animals experiencing increased fitness when preferentially occupying high-quality habitat. However, in the case of novel stimuli, an animals' assessment of habitat quality using evolutionary cues may be poorly matched with realized fitness. The decoupling of the evolutionary habitat-fitness relationship produces an ecological trap. Here we use demographic, movement and habitat data for grizzly bears to test for an ecological trap in an area of rich food resources and intense human-settlement. Our results demonstrate that the ecological trap was more attractive than surrounding areas, yet bears that occupied this region faced 17% lower apparent survival than surrounding areas were unable to compensate via reproduction. Despite lower fitness, we detected a net flow of bears moving into the trap from source areas already in decline. These results demonstrate the presence and pervasiveness of an ecological trap for an apex omnivore.

Are Urban and Wild Bears Affected Differently by Historic Four Year California Drought?

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California is in a multi-year drought, leading the Governor to declare an emergency. We intended to understand how the drought was affecting bears. Our camera sampling dataset from 2007 to 2014 included wet years and four consecutive dry years, making it possible to analyze how bear biology; and included habitat use, fecundity, hibernation patterns and how bears would cope with a much dryer environment. Camera sampling was often limited to understanding single-season effects; the design for this study included resampling many of the same plots for seven years, as well as newly sampled areas. Understanding drought implications was urgently important. A dryer climate may generate more bear nuisance concerns within communities as bears pursue access to water and food, and reduce bear densities in wild area. We used a mixed effects resource selection model and contrasted our findings with urban black bears captured in Lake Tahoe. The contrast provided insights into how bears with access to anthropogenic resources are affected differently by drought. Bears in Tahoe remained active longer, did not change elevational occupancy, fecundity was not affected, and preferred urban patches over wild land patches during times of droughts.

Comparative Diet and Seascape Use by S. Beaufort Sea and Svalbard Polar Bears

Jeff Welker

Polar bears are facing a rapidly changing Arctic that is being influenced by anthropogenic climate forcing. These rapid and dramatic changes are leading to shifts in sea ice, polar bear prey distribution/abundance and subsequently bear access to reliable diets and accompanying habitat selection. In this presentation we compare the habitat use and diet patterns of trans-Arctic polar bear subpopulations from the S Beaufort Sea and Barents Sea (Svalbard archipelago). Our studies include the habitat use and diets of solitary females and those with cubs of the year and with two-year old cubs. We have used collared animals to track and record locations of bears over multiple years and collected hair and blood samples for isotope and fatty acid analysis in spring and fall. We have used serum blood isotopes ($\delta^{13}C$ and $\delta^{15}N$) and tissue of prey to estimate diet proportions.
We now have evidence that groups of bears and bears with different life history traits are using the sea- and landscapes differently, than their traditional reliance on sea ice and pelagic species (seals), whereby their serum $\delta^{15}N$-values are depleted compared to those that rely on seals only. Some individual bears and groups of bears are seasonally switching their primary prey base from classic pelagic prey to prey that are seasonally available in association with discarded Native community whale caucuses (SBS) ($\delta^{13}C$ and $\delta^{15}N$ depleted) or alternative resources such as sea birds and their eggs (BS) that have distinct FA (22:1n-11) properties that are higher in fish and seabirds than in seals or whales. In addition, bear habitat choice and diets appear to reflect the consistency of sea ice, whereby groups of bears which occupy areas with very consistent sea ice have less variable diets while those along the northwestern coast of Spitsbergen, for instance have a more varied diet (broader serum $\delta^{13}C$ and $\delta^{15}N$ values). Collectively, our studies reflect the broadening of polar bear sea and landscape habitat use of individual and groups of bears reflecting opportunistic prey selection. And, prey and habitat selection appears to be dependent upon life history traits that may be driven by physiological needs and mobility.

Assessing and Forecasting Starvation Trends in Southern Hudson Bay Polar Bears Using Dynamic Energy Budget Models

A.E. Slater, Obbard, M.E.

Polar bear (*Ursus maritimus*) populations are at risk due to habitat loss caused by increasing global temperatures and declining sea ice. Sea ice provides an essential platform required to hunt seals and build necessary energy reserves. The Southern Hudson Bay (SH) subpopulation occupies the most southerly portion of the range. Here, declines in sea ice duration of 1 day/year since 1980 resulted in 30 additional ice-free days by 2012. Bears of SH may incur increased rates of starvation in the future as bears are faced with surviving increasingly longer seasonal ice-free periods on stored fat reserves accumulated over shortened hunting seasons. The population is currently stable; however, declines in body condition and survival rates have been documented since 1984. The neighboring Western Hudson Bay subpopulation has already experienced declines in survival followed by declines in abundance, which were correlated with advances in sea ice break-up; highlighting the importance of monitoring

changes in survival of SH bears as a precursor to declines in abundance. We used dynamic energy budget models (Molnar et al. 2010) to predict energy reserve depletion over the ice-free season. We used data on straight-line body length and mass from 1984–2014 to estimate individual fat reserves and combined it with known resting metabolic rates to estimate rate of depletion to starvation in days. We used sea ice concentration (40%, 20%, and 5%) data for the same period to calculate number of ice-free days and enable comparison of potential starvation rates between years. Declining trends in body weight and decreasing sea ice duration in Hudson Bay support the expected decrease in survival rates for future ice conditions forecasted under three IPCC greenhouse gas emission scenarios and will be used to determine critical starvation years in the near future. However, further analysis is required to test the relationship between sea ice duration and starvation rates in Southern Hudson Bay. Establishing polar bear energy budgets and starvation rates based on historical, current, and projected sea ice conditions is a useful tool for predicting changes in population abundance and may be useful for assessing the impact of wildlife management strategies.

Bear Viewing in Alaska's Capitol: A Contrast with Wilderness Bear Viewing Settings of the Tongass

John Neary

Managed viewing of bears in SE Alaska takes place in four primary viewing areas of the Tongass National Forest operated by the USDA Forest Service for diverse experiences. At the wild end of the spectrum is the Kootznoowoo Wilderness of Admiralty Island where the Pack Creek bear viewing area attracts up to 24 people per day for a six-hour visit. Approximately 1500 people per summer fly on chartered float planes to this remote destination where facilities are minimal and agency or guided oversight is guaranteed. At the other end of the spectrum is the Steep Creek bear viewing area in Juneau, the Capital City. Black bears there navigate among a half-million people each summer to reach a salmon stream located near the receding Mendenhall Glacier. Up to five thousand tourists arrive by busses from cruise ships each day to join residents walking their dogs, kids riding bikes and a very diverse human throng.

John Neary will contrast the facilities, staffing strategies and relative success of these two, and other Tongass NF viewing areas. He will focus on facility improvements now proposed for Steep Creek near the Mendenhall Glacier Visitor Center. Feedback will be sought on fencing strategies to steer bears toward wildlife underpasses of a road that receives over 13,000 vehicle passes per week, and a system of trails and platforms intended to improve the flow of people. The ultimate goal is to reduce stress in bears and people while improving viewing opportunities through successful design.

John will also touch on funding strategies being considered by the Forest Service for management of bear viewing. Concessions are being considered for some sites where high costs and flat budgets are requiring changes to agency staffing levels.

John Neary has worked for the USDA Forest Service in Juneau since 1983, most recently as director of the Mendenhall Glacier Visitor Center. With a B.S. from Colorado State University in Parks and Recreation Administration, John spent his first 30 USFS years as Wilderness Manager on the Juneau and Admiralty Island districts, with a break to serve as Peace Corps volunteer to Rwanda.

Baseline Monitoring of Grizzly Bears to Ensure Sustainable Bear Viewing

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Commercial grizzly bear viewing (*Ursus arctos* L.) is increasingly popular drawing visitors from around the globe. On the west coast of British Columbia, Canada, the Homalco Nation (Xwemalhkwu) has territorial land within the Bute Inlet. Spanning only 3.3 km^2 the territory boasts prolific runs of spawning salmon (*Oncorhynchus keta, O. gorbuscha)*. Commercial bear viewing began in 2002 and is one of the major economic drivers for the Homalco Nation. To ensure sustainable viewing we wanted to determine bear use of the area, the number of bears, and family relationships. Capture was not permitted nor were any visible markings or invasive techniques (e.g., colour or biopsy darts). We paired 7 infrared motion-activated cameras with barb wire stations at rub trees and along bear trails. From August to November 2016, 1,059 bear hair samples were gathered. Camera images were used to assign DNA samples to individual bears. For each sampling session the number of bears observed at the site and the number of bears observed rubbing on the object was recorded. When possible we further classified the bears by age class, gender, and number of cubs. We also attempted to visually identify individual bears by distinctive markings or pelage in order to assign hair samples to known bears. Images were classified using Timelapse-2 Image Analyzer. We used repeat observations, behaviour, and grouping of bears by cohort to identify individuals and family groups. Over 30 individual grizzly bears ranging from cubs of the year to large adult males were identified. Identification was tricky because distinct colouration or markings within the population are rare. The number of bears is being confirmed through DNA. We used the activity data to evaluate the effect of viewing on bear behaviour. Daily activity rates (i.e., distribution of detections by hour) were calculated as the number of detections that occurred during each hour of the day, summed over the entire sampling season. We found that grizzly bear behaviour followed a bimodal circadian pattern of activity, which is consistent with other studies on non-viewed bears. The bears had a higher probability of resting mid-day (13:00-16:00) and at night (22:00–06:00). To provide sustainable viewing, and minimize negative effects viewing may have on bears, monitoring and evaluation of activities is ongoing.

Including Human Dimensions in Bear Conservation: A Recipe for Successful Bear Viewing Management

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If you want to experience brown bears and polar bears, Arctic and Kodiak National Wildlife Refuges are your frontier destinations. To maintain minimal visitor regulations and few facilities while providing wildlife viewing opportunities to the public, these refuges developed bear viewing programs incorporating social science to optimize management outcomes. Both refuges engage stakeholders in supporting wildlife and habitat conservation efforts using a range of methods to provide high-quality bear viewing experiences, thereby contributing to the greater conservation mission of the USFWS.

Although Arctic and Kodiak Refuges steward different species under differing management mandates, human dimensions provides a common ground. Arctic Refuge hosts polar bear viewing dependent on a small, isolated, subsistence-based Alaska Native community within its boundary, where large numbers of polar bears congregate seasonally. This combination of setting and stakeholders necessitates relationship-based collaborative management. The refuge addresses gateway community issues while insuring that professional standards for polar bear viewing are sustained to engage residents that are directly affected by refuge management actions.

With different viewing settings, key stakeholders, jurisdictional authorities, and legislative and policy mandates, Kodiak Refuge achieves its bear viewing conservation goals through social science using a mixed-methods approach. Results from interviews and surveys, and input from public forums integrate public opinions into wildlife conservation strategies. The refuge also uses other standard practices such as monitoring bear densities and human-bear interactions to implement conservation measures in areas of high bear use and of special management concern. For example, many sensitive brown bear concentration areas are closed to commercial public use.

Despite these differences, both bear viewing programs seek to structure viewing opportunities to convey positive, conservation-related knowledge, and inspire responsible behaviors among participants while also protecting bears. Managing successful bear viewing opportunities to deliver conservation benefits requires addressing ecological processes, but also human social processes and their consequences. By engaging stakeholders that are affected by bear viewing, providing public input, and including theory-based social science in management decision-making, the US. Fish and Wildlife Service aspires to provide the best future for recreationally-viewed bear populations and the best opportunities for the people who cherish them.

Understanding and Predicting Huckleberry Patches, Grizzly Bears Most Important Food in Southeast British Columbia

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Huckleberries (*Vaccinium sp.)* are grizzly bears' primary hyperphagia food resource in many interior mountain populations of western North America where these berries often fuel the reproductive engine. Huckleberries in our Canada-USA trans-border study region are of particular importance as animal-based resources are limited. However, little is known about huckleberry abundance, distribution, trend, or their influence on the conservation status of many grizzly bear populations. Because grizzly bear population viability is driven by bottom-up (food) and top-down (mortality) forces, we need to better understand the influence of huckleberries in grizzly bear status and management, particularly the interaction between the region's huckleberry crop and forestry activities such as timber harvest and fire suppression. Our project goal was to predict huckleberry patch presence and distribution and the ecological conditions that foster them across the South Selkirk and Purcell Mountains in the trans-border Canada-USA region. Using 10 years of GPS telemetry from ~60 bears we located huckleberry patches by visiting habitat-use clusters during the huckleberry season. Over 2 years, we found 340 of 509 sites we visited met our criteria of being a huckleberry patch. We used the ecological characteristics at these sites in a logistic regression comparing them to a set of random locations where huckleberry plants were present but not necessarily forming a patch. AIC methods were used for model selection. Ecological conditions that favored huckleberry patches important to bears were characterised by cool, dry sites with low forest canopy cover, well-drained soil with lower proportions of coarse fragments, and an eastward aspect with a mid-range slope. The Area Under the Receiver Operating Characteristic Curve was 0.84 suggesting our model did a good job of predicting our suite of huckleberry patches while not predicting them where they didn't occur. Our identification of important huckleberry patches across 2 mountain ranges will inform land-use management activities to ensure minimal disruption and a measure of habitat security where bears access these important sites. In subsequent analyses, we will assess the role of timber harvest on huckleberry patch presence and make recommendations for post-harvest silvaculture activities that might promote huckleberries on appropriate sites.

Complementary Food Resources of Carnivory and Frugivory Affect Local Patterns of Abundance in Grizzly Bears

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An unresolved question for omnivorous carnivores, like most species of bears, is to what degree are populations influenced by bottom-up (food supply) or top-down (human-caused mortality) processes. Most research on bear populations has focused on factors that limit survival assuming little effect of food resource supply. When food resources are considered, most often it addresses the supply of a single resource, particularly marine-subsidized or terrestrial sources of protein (carnivory) or alternately hard or soft mast (frugivory). Little has been done to compare the importance of each of these factors or test whether complementary resources better explain individual animal and population measures such as density, vital rates, and body size. We compared landscape patterns in estimates of digestible energy (kcal) for buffaloberry (a key source of carbohydrate) and ungulate meat (a key source of protein and lipid) to local measures in grizzly bear (*Ursus arctos*) abundance at DNA hair snag sites in west-central Alberta, Canada. We tested support for bottom-up hypotheses in either single (carnivory [meat] vs. frugivory [fruit]) or complementary (additive or multiplicative) food resources, while accounting for a well-known top-down limiting factor affecting bear survival (road density). We found support for both top-down and bottom-up factors with complementary resources (co-limitation) supported over single resource supplies of either meat or fruit. Our study suggests that the availability of food resources that provide complementary nutrients is more important in predicting local bear abundance than single foods or nutrients (e.g. protein) or simply energy *per se*. This suggests multidimensional bottom-up limitation for a low density interior population of bears.

The Community Ecology of Brown Bears in Salmon Ecosystems

Taal Levi

In temperate coastal ecosystems throughout much of the world, anadromous fish historically supported large omnivorous bear populations. In Alaska and British Columbia, where anadromous fish are still prolific, bears are well-known to distribute salmon derived nutrients to plants, insects and vertebrate scavengers, yet little is understood about the how salmon, by supporting large bear populations, indirectly contribute to coastal ecosystem processes. In contrast to the relatively simple trophic cascades that can be characterized as a chain or direct effects from top predators, to herbivores, to plants, large omnivores may serve as keystone hubs that fulfill many roles in ecosystems. For example, it is now known that bears are effective top predators that can maintain ungulates at low abundance in AK and BC, but it is currently unknown whether bears rather than birds are the primary seed dispersers of the fleshy fruited plants that dominate the understory in coastal AK and BC, whether their seed-filled bears scats influence the dynamics of small mammal populations, and whether secondary seed dispersal from bear scats by small

mammals improves seedling recruitment and plant community dynamics. During 2014 and 2015 we addressed these questions by (1) quantifying the number of seeds in brown and black bear scats, (2) by monitoring small mammal activity at bear scats, (3) by using cameras to monitor the rate of fruit consumption by different vertebrate seed dispersers and seed predators, and (4) by monitoring the response of small mammal populations to experimental bear scat addition.

Engaging Citizen Scientists in Grizzly Bear Population Monitoring in Alberta, Canada

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The value of engaging volunteers in citizen science has been demonstrated around the globe, across a variety of topics from climate change, to water quality and species monitoring. Scientist seeking to collect large volumes of data across extensive study areas can benefit from the ability of volunteers to gather information at scales or resolutions unachievable by individual researchers, at reduced costs. Additionally, volunteer participation in research contributes to the preventative and educational components of conservation by reconnecting people with nature, and providing a heightened awareness of ecological issues.

Researchers in Scandinavia work with hunter volunteers to collect scat samples for DNA analysis to inventory and monitor brown bear populations. In Alberta, Canada, grizzly bears are provincially listed as a threatened species, with a range largely restricted to mountainous and boreal habitats, presenting formidable challenges for population inventory work. Efforts to estimate grizzly bear population size and trend have, to date, utilized costly DNA mark-recapture studies using barbwire hair traps. Our goal was to develop a program to engage volunteers in the collection of grizzly bear scat as a source of DNA for estimating population distribution and abundance.

During the past two decades, the widespread adoption of the internet and associated technological devices into daily life has increased the accessibility and functionality of citizen science projects. To address the unique needs of this project, the research team developed a multi-platform smartphone application to gather the necessary spatial data accompanying scat samples, and importantly, communicate results back to participants. While participation in this pilot project was limited, the development of this app provided us with a useful tool for future population monitoring and inventory work. This work identified important considerations for designing studies which rely on citizen scientists and the types of data collected in this manner. We identified challenges in engaging volunteers, the importance of designing communication to suit the target demographic, and the potential benefits to offering participation incentives. The findings from this project revealed important considerations for citizen science programs well beyond grizzly bears in Alberta and highlight a new tool that can aid in conservation efforts.

Using Integrated Population Models to Understand Spatio-Temporal Patterns of American Black Bear Population Ecology in Southwestern Colorado

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Understanding how biotic and abiotic factors affect the distribution and population dynamics of American black bears (*Ursus americanus*) is an important and growing priority for wildlife managers throughout North America. In the western U.S., weather and habitat conditions are known to influence black bear demographics and space use, but how those factors affect bear populations that use urban environments is not well understood. We integrated spatial capture-mark-recapture data and GPS-telemetry data from an ongoing study to understand factors affecting spatial and temporal patterns in American black bear population ecology in southwestern Colorado. Our unified analysis resulted in inference on population abundance and density, demographic processes, and 2nd- and 3rd-order resource selection. We were able to draw inferences on how factors such as habitat conditions and annual food availability influence spatial and temporal variation in demographic rates and space use. Coordinating independent studies to achieve such inferences can be logistically or financially difficult, whereas study designs that formally integrate multiple data sources may be more feasible and yield inferences across multiple components of wildlife population ecology. We discuss our results in light of current needs for accurate and obtainable information on multiple aspects of Ursid population ecology, especially for populations that occur near urban environments. We also discuss potential extensions to our models that would be pertinent to other wildlife studies.

Use of Multiple Detector Types in Estimating Brown Bear Density and Abundance from Spatially Explicit Capture-Recapture Models in Coastal Alaska

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Conservation of brown bear (*Ursus arctos)* populations requires managers to reliably and efficiently estimate abundance. With the recent development of spatially explicit capture-recapture (SECR) models, bear density can now be estimated from detection parameters relative to the spatial distribution of detectors and animal movements, and abundance estimated within a defined survey area. Our objective was to examine brown bear population density and abundance near Yakutat, Alaska, in a 2,636 km^2 area between the Gulf of Alaska and the Saint Elias Mountains. Using noninvasive sampling techniques, we collected bear hair from 15 July 2013 to 30 August 2013 to genetically identify individuals and develop capture histories for SECR models using multiple detector types: single-catch hair snares; scent-baited barbed wire corrals; and bear rub trees. We deployed 565 detectors over the first 10 days and revisited these hair traps during 4 consecutive ~9 day sampling occasions. We set 518 hair snares along bear trails adjacent to prioritized salmon streams and other frequented land cover types, such as herbaceous habitats with abundant wild coastal strawberries. To uniformly sample the landscape, scent lures were

used to attract bears to 41 barbed wire corrals within 36 systematically distributed 8-km × 8-km grid cells. Bears also used marking trees to transmit chemical signals and we collected hair samples from 6 traditionally used trees equipped with barbed wire. Our spatial array of multiple detectors identified 152 unique individuals from 389 detections, with 1-10 detections per individual. We incorporated 35,293 telemetry locations from 27 GPS radio collared bears to refine population parameters. We examined models that accounted for trap type, sex, time, behavioral changes, and site-specific capture probability, and integrated spatial capture histories based on non-Euclidean movement patterns to estimate bear density and abundance. We estimated the density of brown bears at 87.2 ± 8.7 bears/1,000 km^2 (95% CI = 71.8–105.9) and an abundance of 229.8 ± 22.8 bears (95% CI = 189.3–279.1). The results from this study provide reliable baseline density and population estimates from which state and federal managers can successfully guide brown bear harvest management strategies in Southeast Alaska.

Session 10 – Challenges and Approaches to Human-Bear Co-Existence

Do Brown Bears and Other Large Carnivores Contribute to the Recreational Value of Forests?

Marek Giergiczny, Jon Swenson, Andreas Zedrosser, Nuria Selva

The main aim of this study was to test to what extent large carnivores (LC; i.e., brown bear, wolf, Eurasian lynx) are perceived as indicators of natural landscapes. We combined approaches used in landscape research (stand visualization techniques) with non-market valuation techniques (choice experiments) to document human recreational habitat selection for in relation to forest naturalness. We generated visualizations of 200 forest stands differing in tree age, tree species composition, and volume dead wood. These visualized forests differed also in relation to the presence or absence of LCs. The last attribute was the distance that respondents would choose to travel to visit a given forest. Each person was asked to choose the forest that he/she would like to visit in a sequence of 9 choice experiment questions. We carried out two separate studies with the use of the same questionnaire on representative samples of 1,000 respondents in Norway and Poland.

The results showed that unmanaged forests with high biodiversity were significantly more attractive to humans than other forests. We found that LC species are perceived as indicators of naturalness in both countries. Considerable proportions of respondents (67% Poland, 48% Norway) were willing to drive extra distances to visit forests with LCs. In this group, the most attractive species (measured as extra distance average respondents would travel to visit a forest with a given species) was lynx (27 km in Poland, 52 km in Norway), followed by wolf (17 km in Poland, 30 km in Norway) and brown bear (14 km in Poland, 11 km in Norway). In contrast, in both countries we identified similar proportions (23% Poland, 27% Norway) of respondents who were willing to drive extra distances to avoid visiting forests with LCs. In this group, the least attractive species was the brown bear (45 km less travel in Poland, **131 km Norway**) followed by wolf (35 km Poland, 46 km Norway) and lynx (15 km Poland, 18 km Norway).

Our research combines approaches from socio-economics, landscape ecology, as well as wildlife management, and may provide wildlife managers but also politicians and tourism operators with important decision-making tools.

Human Shields Mediate Sexual Conflict in a Top Predator

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Sexually selected infanticide (SSI) is an important factor that drives survival in several brown bear (*Ursus arctos*) populations. Because SSI is very costly for females with dependent offspring, several counterstrategies to SSI have evolved, including multi-male mating, aggression, and spatiotemporal avoidance of potentially dangerous males. In predator-prey systems, prey often can anticipate on the habitat use of their predators, and use protective associates (i.e., typically an apex predator) as shields against predation. Such mechanisms should also evolve in systems in which sexually selected infanticide drives survival. Here, we assessed the relationship between cub survival, habitat selection, and the use of protective associates (i.e., human shields), in a system in which sexually selected infanticide (SSI) rather than predation drives offspring survival. We hypothesized 1) that habitat selection of the mothers is an important component of offspring survival, and 2) that using human shields against SSI enhance offspring survival. We tested our hypotheses in a Scandinavian brown bear population with SSI, and used resource selection functions to contrast habitat selection of GPS-collared mothers that were successful (i.e., surviving litters, N = 19) and unsuccessful (i.e., complete litter loss, N = 10) in keeping their young during the mating season (2005-2012). Habitat selection was indeed a crucial component of litter survival. The most important factor that distinguished successful mothers from unsuccessful mothers was the use humans as protective associates; i.e., successful females strongly selected for areas relatively close to human habitation, whereas unsuccessful females strongly avoided humans. Our results have important consequences for bear management and concur with several recent studies that identified social organization and intraspecific predation risk as the ultimate explanation why bears often occur close to people, rather than being attracted to humans because of good foraging opportunities. Our results also suggest that principles of predator-prey and fear ecology theory (e.g., non-consumptive and cascading effects) can also be applied to the context of sexual conflict.

Human-Bear Conflicts on Kamchatka: On the Way to Peaceful Co-Existence

L. Pokrovskaya, I. Seryodkin, V. Zhakov

Density of the Kamchatka brown bear is the highest throughout the Eurasia. Human-bear conflicts on Kamchatka frequently lead to fatalities in both bears and humans. While conflict-preventing instructions were developed, management strategy remains ineffective, and shooting nuisance bears is the only measure for ceasing conflicts. Our project aims to increase human safety and decrease bear mortality and

to provide critical scientific data to help guide effective wildlife conservation on Kamchatka. The first objective was to analyze the causes, trends and consequences of human-bear conflicts and to suggest initial preventive measures.
We have analysed 780 conflict cases (1981−2015) documented by the Agency of Forestry and Wildlife Conservation of Kamchatka and 177 cases (1982−2011) documented by Kronotsky Natural Reserve and South Kamchatka Sanctuary. We graded the data into four equal periods: 1981−1989, 1990−1999, 2000−2007 and 2010−2015.
Frequency of conflicts was the highest during first and last decades. In 1981−1989, mean number of conflicts per year on unprotected areas was 25 ± 17, in 1990−1999 – 6 ± 5, in 2000−2007 – 14 ± 11, in 2010−2015 – 63 ± 43, totally 740 conflict bears were eliminated. Since 2005, the conflict rates tend to increase. In 1981−1989, bears killed seven people, in 1990−1999 – 2, in 2000−2007 – 8, and in 2010−2015 – 8. Before 2005, the most usual types of conflict were predation on livestock (45% of conflicts, N = 337) and household damage (27%), since 2005 – intrusions into settlements and foraging on garbage. In 1982−2011, 15 bears were shot and four humans were killed by bears on protected territories. In 2013, total crop failure and low salmon abundance resulted in high rates of enforced shots of hungered bears (N = 140), entering villages and cities in search of food.
The main reasons of the recent rise of human-bear conflicts on Kamchatka are: 1) absence of organic waste transportation and treatment system, leading to attraction of bears to human lodgings and 2) high density of bears coupled with low ecological culture of the local people. We suggest the following non-lethal measures for preventing human-bear conflicts: removal of bear attractants, immobilization and translocation, harassment, repellents and exclusion techniques.

Changes in Grizzly Bear Movements and Selection in Response to Recreationists in Alberta's Eastern Slopes

Andrew Ladle

Grizzly bear habitat use has been well documented in Alberta, with food availability being a driving force behind grizzly bear movement and selection, as well as avoidance of human activity such as roads. In the foothills of west-central Alberta, the effects of an expanding trail network and increased frequency of human recreational activity on grizzly bears is less well documented. How grizzly bears alter their space use in response to recreational activity has strong implications for grizzly bear survival, reproduction, and management practices aimed at population recovery. We hypothesized that grizzly bears will use trails, however reduce their use where and when recreational activity is high. We also predicted that bears would show increased displacement (longer steps) when activity is high.
Between 2012 and 2014, we collected GPS radiocollar data from 21 grizzly bears as well as concurrent trail camera data at 240 different sampling locations, giving us information on the different types and magnitudes of recreational activity within a complex trail network. Using an integrated Step Selection Analysis (iSSA), we assessed grizzly bear habitat selection within a mechanistic movement model, with an emphasis on how recreational activity impacts grizzly bear movement attributes and habitat use. Bears showed avoidance of trails in general which was unexpected. Avoidance was far greater when near high-use trails, specifically when the probability of motorized use (Off-Highway Vehicles) was high. In terms of movement behavior, grizzly bears showed increased step lengths when on trails. This shows bears use trails primarily for faster movement through the landscape, rather than for foraging opportunities. At the population level, during times of high motorized activity, bears displayed a reduction in step length,

contrary to our predictions. This response was highly variable between different bears, which highlights that individuals display variable responses to recreational activity in their home range. The result identifies that the magnitude of activity, not just the density of linear features, has implications for grizzly bear behavior. This has strong implications for access management in bear habitats, with steps required to monitor and moderate the frequency of outdoor recreation in protected and crown lands.

Sloth Bear Attacks: Determining a Behavioral Approach to Safety

Thomas Sharp

Sloth bears (*Melursus ursinus*) are known for their potential to behave aggressively towards humans. Sloth bears were responsible for 48 human deaths and 687 maulings between the years 1989 and 1994 in 1 of 29 Indian States (Rajpurohit and Krausman 2000). The total number of sloth bear-inflicted injuries and deaths that occur in India are largely unknown, though the annual number of attacks likely approaches 1,000. Unlike previous studies of sloth bear attacks, this work focuses on developing a behavioral approach to sloth bear safety by attempting to understand the motivation of sloth bears involved in attacks. We used four methods of studying sloth bear attack behavior: relevant literature, interviews with attack victims, videotaping sloth bear behavior in the Wildlife SOS sanctuaries, and comparing the findings to those of other well-studied bear species. To date, we've interviewed > 200 sloth bear attack victims in the state of Karnataka with a focus on the behavior of the attacking bear and its reactions to the behavior of the victim during the encounter. We then compared our findings to that of attacks by other bear species, namely American black bear, grizzly bear and polar bears. The final step of the project is determining a consistent message of how to behave in the face of a sloth bear encounter and disseminating it to those who live in sloth bear country.

Shifting Perceptions of Risk and Reward: Dynamic Selection for Human Development by Black Bears in the Western United States

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As landscapes across the globe experience increasing human development, it is critical to identify the behavioral responses of wildlife to this change given associated shifts in resource availability and risk associated with human activity. This is particularly important for large carnivores as their interactions with

people are often a source of conflict, which can impede conservation efforts and require extensive management. To examine the adaptations of a large carnivore to benefits and risks associated with human development we investigated black bear behavior in three systems in the western United States. Our objectives were to 1) identify temporal patterns of selection for development within the active bear season and across years based on natural food conditions, 2) compare spatial patterns of selection for development across systems, and 3) examine individual attributes associated with increased selection for development. Using mixed effects resource selection models we found that bear selection for development was highly dynamic as the benefits and risks of foraging in human-dominated landscapes varied as a function of changing environmental and physiological conditions. Bears increased their use of development in years when natural foods were scarce, throughout the summer-fall, as they aged, and as a function of gender, with males exhibiting greater use of development. While patterns were similar across systems, bears at sites with poorer quality habitat selected development more consistently than bears at sites with higher quality habitat. Black bears appear to use development largely for food subsidy, suggesting that conflicts will increase when the physiological demand for resources outweighs risks associated with human activity.

Recreational Harvest and Incident-Response Protocols Reduce Human-Bear Conflicts in an Anthropogenic Landscape

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Faced with declining budgets and escalating wildlife conflicts, agencies in North America continue to grapple with the efficacy of socially divisive management actions, such as recreational harvest and lethal control, as means to reduce conflict. We used multistate capture-reencounter methods to estimate cause-specific mortality for a large sample (3,533) of American black bears (*Ursus americanus*) in northwestern New Jersey, USA over a 33-year period. Specifically, we focused on factors that might influence the probability of bears being harvested, lethally controlled, or dying from other causes. We analyzed temporal correlations between 26,582 human-black bear incidents reported to the New Jersey Division of Fish and Wildlife (NJDFW) between 2001-2013, and estimates of harvest from newly implemented public hunts, lethal management, and total mortality rates. Black bear harvest probability was best explained by an interaction between age and sex: adult females were twice as likely (0.163 ± 0.014) as adult males (0.087 ± 0.012) to be harvested during the study period. Cubs (0.444 ± 0.025) and yearlings (0.372 ± 0.022) had a higher probability of dying from other causes, primarily vehicle strikes, than adults (0.199 ± 0.008). Reports of nuisance behaviors in year $t + 1$ declined with increasing mortality resulting from harvest plus lethal management in year t ($P = 0.028$, $R^2 = 0.338$, $\beta = -136.5$ conflicts per 0.10 increase in mortality components). Reports of nuisance behaviors in year $t + 1$ was weakly correlated with

total mortality in year *t* ($P = 0.081$, $R^2 = 0.201$, $\beta = -101.1$ conflicts per 0.10 increase in mortality), suggesting declines in undesirable behaviors were largely attributable to variation in preceding harvest and lethal management rates, and not simply a numeric response resulting from population reductions. Estimates from our best-fitting behavioral model corroborated these results: adult bears previously designated a nuisance and/or threat were more likely to be harvested (0.176 ± 0.025) than those never identified as a problem (0.109 ± 0.010). Within human-dominated systems, the integration of a well-regulated black bear harvest with incident-response protocols (both lethal and non-lethal practices) and educational outreach programs, can result in subsequent reductions in problem behaviors reported.

Public Opinion About Food-Conditioned Bears in the Tatras National Park, Slovakia

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Bears which gain access to anthropogenic food, including refuse, may become food-conditioned, causing deleterious effects on humans ranging from nuisance behavior through property damage to injury and death. There are also psychological aspects, such as anxiety or fear for property, health and safety, experienced by a greater number of people than those suffering actual damage. The opinions, attitudes and actions of affected communities play a key role in both understanding conflicts and implementing effective solutions, with implications for bear conservation.

We studied public opinion regarding bears and waste management in the Tatras National Park, Slovakia, in 2014. Food-conditioned brown bears (*Ursus arctos*) have been recorded in the area since the 1960s but management actions have yet to resolve the issue despite widespread public concern. We gathered qualitative and quantitative data through semi-structured interviews with stakeholder representatives and a written questionnaire distributed to residents. General attitudes to bears among residents tended to be neutral to positive, although the majority of respondents (77%, n = 300) considered bears feeding from garbage containers to be a major problem. Only 7% of respondents thought responsible authorities were dealing with the issue adequately, while 58% thought they were not doing enough.

Both residents and stakeholders rated bear-proof containers as an appropriate and effective measure to reduce the incidence of food-conditioned bears, and yet few of these have been installed. Stakeholder representatives considered the main barriers to progress to be lack of information, expertise or willingness and insufficient finances. However, there also seemed to be a lack of clarity on which entities were responsible and evident distrust and disharmony among stakeholders. We therefore identified a need to address human-human conflicts as well as bear-human conflicts. A clear policy on waste management in relation to bears is called for which should specify roles and responsibilities as well as guidelines for effective management.

The Power of Social-Ecological Models in Wildlife Management: Predicting Spatially-Explicit Perceptions of Bear Encounters in Southcentral Alaska

Kim A. Jochum, Todd J. Brinkman, Kris J. Hundertmark, Dave Gregovich

Managing wildlife near urban areas and in active recreation areas has become increasingly challenging due to human population growth, climate change, and economic demands evoking changes in land and resource use. The presence of bears (*Ursus spp.*) in these areas increases management complexity because of human-safety concerns. Our study explores the complexity of bear management in populated areas by analyzing ecological and social data related to human perceptions of bear encounters. Our objectives were to (1) quantify perceptions of bear encounters (*U. arctos* and *U.americanus*), and (2) evaluate how social and ecological variables contribute to positive and negative perceptions toward bear encounters. We used spatially-explicit data and generalized linear models to estimate maximum likelihood probabilities of social and ecological variables affecting people's perceptions toward encountering free-ranging bears in southcentral Alaska. Results varied depending on whether the bear encounter occurred within an urban or non-urban area. In non-urban areas, positive encounters were predicted by social variables only; negative encounters were predicted mainly by ecological variables. A higher education level and no engagement in hunting caused increased positive encounter experiences, whereas being close to rivers and away from trails when encountering a bear, and thus access to fish resources, triggered increased negative perceptions in people. In urban areas, ecological variables best predicted positive and negative encounters. Models revealed increased positive bear encounters during fall and when away from buildings but close to trails, whereas negative encounters were best predicted by people being in a non-sheltered environment. Our study demonstrates the utility of integrating ecological or social variables to examine human-wildlife systems. Our results may be used to refine monitoring of human-bear interactions and to enhance actions that mitigate negative human encounters with bear in populated areas.

Conducted Electrical Weapons as a Bear Deterrent and Their Role in Human-Bear Management

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In Southeast Alaska, remote fish hatcheries rear salmon for the commercial fishing industry. Brown bears *(Ursus arctos*) are attracted to salmon returning to these hatcheries as adults, which can lead to conflicts between bears and hatchery staff. At the Armstrong-Keta Hatchery (AKH) on Baranof Island, 4 bears were killed in Defense of Life and Property (DLP) conflicts during 2002-2009. Hazing tools such as rubber bullets, bean bags, cracker/screamer

rounds proved largely unsuccessful for long-term prevention of bear incidents at this site. To address these concerns, the Alaska Department of Fish and Game tested Conducted Electrical Weapons (CEWs), commonly referred to as Tasers, as a deterrent to reduce bear incidents. In 2010, we evaluated the use of CEWs at the hatchery for hazing and aversive conditioning treatments of bears. Objectives were to modify existing CEWs for use on bears; field test various CEWs to improve our application technique; standardize methodology to improve overall effectiveness; and determine if CEWs are effective and safe as a deterrent in hazing and aversive conditioning treatments. From 2010-2015, we delivered >300 CEW exposures to bears; resulting in a 100% immediate flight response. Full and partial neuromuscular incapacitation (NMI) of bears was produced in 247 exposures. Adult bears responded by reducing daytime activity and increasing nocturnal activity. All age classes of bears exhibited an increased overt reaction distance (ORD) during any human-bear interaction. We incorporated FLIR (forward looking infrared) technology during nocturnal periods in order to retain consistency of treatment delivery over a 24 hour day. Since the initiation of the CEW program, AKH has experienced fewer bear incidents and no bears have been killed in DLP situations. CEWs have demonstrated to be effective for hazing and aversive conditioning treatments.

"It's Just a Matter of Time": Lessons from Institutional and Community Responses to Polar Bear-Inflicted Human Injury in Churchill, MB

Problematic Document Submitted

Aimee Schmidt

Bear-inflicted human injuries or deaths are often widely publicized, highly controversial, and evoke substantial social responses that articulate public expectations about bear management. Historically, these types of bear-human conflicts have driven significant changes in institutional behaviour and policies. The objective of this research is to examine how local people and management institutions respond to polar bear-inflicted human injury in Churchill, Manitoba.
On November 1st, 2013 two people in Churchill were badly mauled by a polar bear. This was the second attack of the year that resulted in human injury and came near the end of a season that had seen a rash of bear-related incidents. The November 1st mauling shocked the community, highlighted problems such as a lack of bear safety education for transient workers, and led to reviews of intuitional policies for preventing polar bear-human conflicts. These incidents proved to be central events during the data collection for this study and provide a unique opportunity to examine reactions and responses. Roughly half of my data was collected before the attack and half afterwards. I used social science methods, including semi-structured interviews and focus groups, to describe what is said (about polar bears, about people, and about management) and what is done (changes in behaviours and changes in policies/practices) when someone is attacked by a polar bear in Churchill, MB. This research provides a deeper understanding of why the community and management institutions react the way they do, and lends important insights into what is working and what is not working about current polar bear management responses. Results from my research show that while polar bear management institutions in Churchill respond remarkably well to errors in procedure, they are often unable to address the many underlying systematic drivers of polar bear-human conflict, particularly those related to human behaviours and demands. Hence, managerial reactions to bear-human conflicts are frequently successful at addressing the proximate cause of the problem, but offer few long-term solutions.

While the current polar bear management system in Churchill has demonstrated significant resilience in the face of crisis, the management system engages primarily in single-loop learning. Single loop learning involves fixing errors in procedures and routines and does not involve correcting errors by rethinking management goals, adjusting values or changing polices.

The management of polar bear-human conflicts in Churchill is unique from other northern contexts because of the Polar Bear Alert Program. The Polar Bear Alert Program represents the most elaborate and extensive program designed to prevent and mitigate polar bear-human conflicts in the Canadian north, and much stands to be learned from it.

This paper specifically relates to Objective 2 and will take the form of a focused case study that explores how polar bear-related crisis is managed in Churchill, Manitoba. This manuscript will document what local people and managers think, say, and do, with regard to polar bear-human interactions before and after a significant focusing event (Birkland, 1998). On November 1st, 2013 two people in the Churchill were severely mauled by a polar bear. This was the second attack of the year that resulted in human injury and came near the end of a season that had seen a rash of bear-related incidents. The November 1st mauling shocked the community, highlighted problems such as a lack of bear safety education for transient workers, and led to substantial reviews of intuitional policies for preventing polar bear-human conflicts.... This gives me the unique opportunity to examine how the community and management institutions have reacted and responded to the crisis. I will examine data from interviews, as well as, observations about events following the attacks (such as the formation of various committees, and an awards ceremony commemorating the people involved). The Management of polar bear-°©-human conflicts in Churchill Is unique from other northern contexts because of the Polar Bear Alert Program – An intensive management program designed to prevent and mitigate polar bear-°©-human conflict. I will also examine how media portrayed this event. Finally, Churchill has a long history of similar polar bear-related incidents (Struzik, 2014) and I will compare responses to the most recent crisis with documented incidents in the past.

Potential contributions: It is important to understand what kinds of responses to polar bear-human conflicts are permissible within the existing discursive system. Doing so will highlight potential limitations of existing discourses and **will provide insights into why the community and management institutions react the way they do**. A critical analysis of current discursive reactions and their implications is important because it will aid in developing more effective coping mechanisms for future bear attacks**.** It will also **lend important insights into social responses to conflicts involving large carnivores by drawing attention to what is not working about current reactions;** in doing so, this output may potentially make important contributions to carnivore conservation.

Impacts of Sympatric Brown Bears and Asiatic Black Bears on Local People in a Remote Valley in Northern Pakistan

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Populations of brown and Asiatic black bears in northern Pakistan are likely connected to those in India via the Neelum Valley/Gurez Valley (elevation: 1,942-4,968 m). We set camera traps and interviewed local people (who depend on livestock and agriculture for their livelihoods) in the first study of bears (and other carnivores) in Musk Deer National Park, within Gurez Valley, in the Neelum Valley district of Azad Jammu and Kashmir. We surveyed 149 households in 18 villages (located within the park) to gauge intensity of conflicts. We set 40 passive infrared cameras (of which 4 were stolen), with scent lure, during May–June, 2014, to assess relative abundance of different carnivore species.

Of all the carnivores, local people saw black bears most often (3.28 sightings/respondent/year). People reported lower sightings of wolves (1.81), brown bears (1.72), snow leopards (0.50), common leopards (0.32), and lynx (0.20). Conversely, the camera-trap photo-capture rate of brown bears was 0.68/100 trap-nights (highest among the large carnivores), whereas no camera trap photos of black bears were obtained. We learned from local people that black bears visit the area in late summer, attracted to the crops, so our camera-trapping in May–June occurred before their arrival.

Local people reported that brown bears were responsible for 26% of total livestock (sheep, goat, cattle, yak and others) killings, which resulted in an average loss of US$42 per household, whereas black bears accounted for 17% of killings and an economic loss of US$34 per household. Black bears, though, were responsible for far more crop (maize and potato) damage ($104 per household) than brown bears ($6 per household). On a 1 to 6 scale, with 6 being most dangerous, the carnivores were ranked as follows: wolf (4.8), brown bear (3.9), black bear (3.4), snow leopard (3.4), common leopard (2.1), and lynx (0.2).

Further extensive study is recommended to determine the status of the black and brown bear. Moreover, an accurate and regular record should be kept of all livestock killings and crop damages and there should be a compensation or insurance program to cover local people's economic losses.

Development in Wildlife Forensics in Dealing with Offences of Bears in India

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Wildlife poaching has been serious threats to the conservation of species and lack of appropriate wildlife forensics has precluded proper implementation of national laws and international treaties in the south and south-east Asia. A beginning in establishing wildlife forensics was made through a collaborative project of USFWS for better implementation of laws and treaties. Of the 3000 cases received by the

Institute since 1986, 46 cases were of bears. Of these 56 percent were of Himalayan black bears (HBB) whereas remaining were of sloth bear (SB). Reported parts in Bears offences were bear bile (40.0%), canine (3.1%), skin (12.3%) bones (15.4%), paws (6.2%) penis (1.5%), claws (6.2%), fat (1.5%), meat (10.8%) and others. 92% bile of HBB were only from Uttarakhand and most of the seizures were from 1 to 14 bile and in 20 per cent cases, bile were traded along with the pods of musk deer. The majority of cases of were of Police and seizures were made through information provided by the informer. Hence, we suggest for establishing a strong network of intelligence collection in the range states of HBB. Given international demand for bear parts, we discuss the development of protocols for identifying species using hair characteristics (13 to 17 characters) in cluster analysis, claw characteristics and measurements in Discriminate Function Analysis, TLC and DNA-based techniques. For avoiding false positive, we used three genes (Cyt b, 12s and 16s RNAs) for identifying species having unique SNPs between 4 to 16 among four bear species. We also suggest using multiple analytical approaches for the conclusion. We discuss observed sex in the bile of HBB and likely implications for population demography. Our optimized protocols may be shared through training with other enforcement agencies of the south and south-east Asia countries for effective implementation laws and treaties. We need to establish fatty acid signatures of all the bear species for dealing with offences related to body fats.

Session 11 – Bears and Ecosystems

Long-Term Research on Brown Bear Predation on Sockeye Salmon: Views from Prey and Predator Perspectives

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Predation by bears on Pacific salmon has been known to the scientific community for decades, and common knowledge to humans coexisting with them for much longer. However, many aspects of the relationship have been poorly known, as research has commonly been conducted at atypical locations, for short durations, or been limited in focus to the bears or to the salmon rather than considering both perspectives. This talk will review over 25 years of research that has been conducted in sites in the Wood River and Kvichak River systems of Bristol Bay. We have determined that stream habitat controls predation rate among sites, and salmon density controls year to year variation in predation in each stream. The salmon that are killed are a non-random set, biased in terms of the size and sex of the salmon, and the length of time the fish has been in the stream. However, these forms of choice depend on habitat; where fishing is more difficult, bears cannot be as selective. Additionally, the body parts of salmon eaten by bears depend on the size and sex of the fish, how long it has been alive in the stream, and also the stage of the salmon run and salmon density. Combined with recent DNA data on the numbers and movements of individual bears, these studies provide a rare, landscape-scale examination of bear predation on salmon, revealing how important bears have been in the evolution of salmon, the importance of salmon as food for bears, and the ways in which bears mediate the flow of nutrients from salmon to the aquatic and terrestrial ecosystems.

Kleptoparasitism of Wolf Kills by Brown Bears in Scandinavia

Andrés Ordiz, Camilla Wikenros, Richard Bischof, Jonas Kindberg, Jon E. Swenson, and Håkan Sand
Oral

In Scandinavia, the recovery of the wolf population since the early 1990's is taking place in areas where the species is sympatric and allopatric with brown bears. Both species have been monitored for decades, allowing us to study interspecific interactions at the population level. Wolves and bears in Scandinavia rely on moose as the staple prey, wolves all year round and bears seasonally. At the landscape scale, a negative effect of bear density, among other factors, influenced the probability of wolf pairs' establishment. At finer scale, we set camera traps at kill sites of wolves and bears in spring-early summer to assess the use of wolf kills by bears and, conversely, bear kills by wolves. In an area with three wolf territories and low bear density (close to 0 bears in most of the area), bear pictures were taken in 2 out

of 13 wolf kill sites (15%). In other area that also included three wolf territories and up to 30 bears/1000 km^2, bears used wolf kills extensively, with bears photo-captured in 26 out of 49 wolf kills (53%). Twenty one of the wolf kills used by bears (80%) were moose ≥1 year old, and the rest were neonate calves. Up to 4 different bears were photo-captured at a wolf kill. Interestingly, no wolves were photo-captured at any of 22 bear kills, which were always neonate moose. Whereas bears mainly kill small neonate calves that they consume right away, wolves also kill larger moose that provide scavengers with more food and time to find the carcasses. Regarding detectability, wolves might be more difficult to camera trap than bears, but GPS data confirmed that bears were prone to use wolf kills, whereas the opposite did not occur. In our system, kleptoparasitism of wolf kills by brown bears is likely a major mechanism driving their interspecific competition.

Why Brown Bears of Kola Peninsula Do Not Like Fishing?

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The area of the Kola Peninsula is about 100 thousand square kilometers and it is home for about 1,000 bears. The peninsula is located in the North-West of Russia, bordered on the west by Finland and Norway, washed by the White and Barents Seas. Most of the peninsula is located to the north of the Arctic Circle. Brown bear population penetrate to the north along rive valleys into the forest tundra and tundra zones till the Barents Sea shore.

In our research we focused on the coastal population of White Sea because of here the most various and rich biotopes of Peninsula and rivers with Salmon species. The rivers of the study area are a place of a mass spawning of two species of salmonid fish: salmon (*Salmo salar* L.) and introduced humpback salmon (*Oncorhynchus gorbuscha*).

The results of our counts showed that bear density here varied and sometimes reached by 7 animals per 10 km^2, in average 1,8-2. So ways of forming these concentrations became one of the goals of our research.

In our study we had wanted to make observation of bear fishing here. For this purpose we organized four field expeditions of varying duration in the period from May to October. Before the start we have collected a lot of evidence about bears fishing in the rivers of the Kola Peninsula like bears do in Alaska and the Russian Far East. However over the whole period of the fieldwork, we've never been able to observe this kind of bear foraging activities. No one of 300 collected and analyzed feces did not contain the remnants of fish. The report will present the results of our research and analysis of the possible causes of the observed phenomenon.

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How Diet and Food Restriction Affect Reproduction in Bears: Implications for the Recovery of Alberta's Brown Bear Population

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Recovery of threatened brown bear populations is most often addressed by reducing human caused bear mortality rates (e.g. poaching, road accidents). However, nutritional factors may also play a role in population recovery by affecting both reproduction and survival. Brown bears in Alberta (Canada) are listed as a threatened species due to their small population size, slow population growth and increases in human activity within bear habitat. To examine how dietary restrictions affect female brown bear body size and reproduction in Alberta, we integrated three bioenergetic models to simulate the daily body mass dynamics under different diets and environmental conditions. Model simulated a one year life cycle period starting from den entrance (start of hibernation) until the next den entrance. We used previous published bear diets to create generalized diets varying the consumption of key nutritional foods (e.g. ungulates and berries), and simulated different hibernation lengths and thus length of period with no food intake Results demonstrate that lactation and body mass gain are limited most by levels of energy and protein in bear diets, especially in areas with shorter growing seasons (e.g. Mountain ecosystems). Under these conditions, two reproductive strategies emerge. First, a strategy of higher denning body mass reserve to support lactation after den emergence, although this may require more years before reproduction. And second, a strategy of reducing the investment lactation by reducing production and/or quality. Overall these results suggest that reproductive success of female brown bears is restricted by the nutritional quality of the foods available in their environment. This has two management consequences for Alberta's threatened population: (1) it limits the carrying capacity of bears resulting in lower population sizes; and (2) it limits the rate of population recovery, being slower than what has been observed in other populations (e.g. Greater Yellowstone Ecosystem). This study provides insight into the potential effects of nutritional factors and how they influence population trends for a large omnivorous predator and the importance of considering these factors for management and conservation of brown bears.

Foraging Variation of Asiatic Black Bears in Ashio-Nikko Mountains: Evidence for Individual Differences in Diet

Tomoko Naganuma

Foraging variation within populations in various animal species contribute to individual fitness through a life history and recognized as an important phenomenon for ecological and conservation implication. In particular, diet of the omnivore composed of multiple trophic levels has enriched diversity among individuals, due to ecological plasticity. In many omnivore species, however, it was difficult to reveal

individual differences in their diet, depending on the temporal and spatial variation in resource availability.
We measured the carbon and nitrogen stable isotope ratios from 62 Asiatic black bears *Ursus thibetanus* (total 158 hair samples) collected during 2003-2013 in the Ashio-Nikko Mountains, central Japan. In order to confirm individual dietary variation of the bears and to clarify the factors for it, we conducted the fine-scale stable isotope analysis using guard hair sectioned from root to tip. We calculated the monthly $\delta^{13}C$ and $\delta^{15}N$ values and estimated relative source contributions to the diet of individual bears.
We recognized the individual foraging variation on the bears and the factors varied seasonally and yearly. In summer, when food availability is low for the bears, the older bears and males consume more sika deer *Cervus nippon*. In autumn, which is the hyperphagia period for the bears, most bears depended on more hard mast such as acorn in the good mast years. On the contrary, in the years of poor mast years, getting enough hard mast took significant cost and most bears might consume more animal matter such as insects as an alternative food.
We conclude that there are individual foraging variation of bears during summer and autumn. Additionally, the difference of individual diet for the bears in summer might be influenced by the difference of body mass relevant to increasing age or sexual dimorphism. In contrast, the autumn diet of the bears might be similar within population but be varied according to temporal and spatial variation of food availability.

Interspecific Resource Partitioning in the Diets of Two Sympatric Ursids

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Fundamental to our knowledge of community ecology is understanding resource partitioning among species, which is further complicated when species are sympatric. Moreover, when resources are limited greater niche overlap is expected. We use stable isotope analysis to examine resource partitioning for two sympatric omnivores, the grizzly (*Ursus arctos*) and black bears (*U. americanus*) of Alberta, Canada. Fragmentation can reduce habitat quality, creating favourable conditions for greater interspecific competition, and we predicted that broad dietary patterns would overlap significantly between the two species in such areas. We used samples of mandibular bone from museum-curated specimens to estimate isotope values of carbon (δ13C) and nitrogen (δ15N). Although common in paleontology, use of bone in ecological studies remains uncommon because collecting from live animals is often unfeasible. Unlike soft or inert tissues that provide a relatively narrow dietary snapshot, bone reflects a lifetime dietary profile (>10 years) because it is continually being re-substituted. As predicted, grizzly and black bears showed high dietary overlap (P=0.50). Black bears have shown more resilience, compared to grizzlies, to conditions of reduced habitat quality, therefore, we were also interested to see if these diet similarities would persist across two natural regions (mountain, boreal/foothills) and four land use zones (protected, green, white, forestry). We used ANOVAs to test these relationships further. Our results suggest that resource partitioning was more pronounced in mountains compared to boreal/foothill regions ($F_{1,32}=5.98$, $P=0.02$), where we saw more dietary overlap. Also, grizzly bears in the mountains were trophically higher than black bears ($F_{1,32}=5.07$, $P=0.03$), suggesting a greater fraction of their diet was derived from animal protein. Similarly, grizzlies were trophically higher in protected areas, which occur primarily in mountains, than either species inhabiting other land use regions ($F_{3,28}=5.53$, $P=0.04$). In Alberta, intact habitat is

found more in mountains and protected areas, whereas habitat is more fragmented and limited in boreal/foothills regions. Because fragmentation reduces habitat quality, conditions in the boreal/foothills may be more favourable to black bears, who can adversely influence grizzly bear recovery through exploitive or scramble competition. Within this context, we discuss our results in light of future bear conservation.

Kodiak Brown Bears Surf the Salmon Red Wave: Direct Evidence from GPS Collared Individuals

William Deacy

One of the goals of Ecosystems Base Fisheries Management (EBFM) is recognizing and mitigating indirect effects of fisheries on trophic interactions. Most research on indirect effects has considered how the abundance of managed fishes influences trophic interactions with other species. However, recent work has shown that attributes besides abundance, such as life history variation, can strongly mediate species interactions. For example, phenological variation within prey species may enhance foraging opportunities for mobile predators by increasing the duration over which predators can target vulnerable life stages of prey. Here, we present direct evidence of individual brown bears exploiting variation in sockeye salmon spawning phenology by tracking salmon runs across a 2,800 km^2 region of Kodiak Island. Data from 40 GPS collared brown bears show bears visited multiple spawning sites in synchrony with the order of spawning phenology. The average time spent feeding on salmon was 67 days, while the average duration of spawning for one population was only 40 days. The number of sites used was correlated with the number of days a bear exploited salmon, suggesting phenological variation in the study area influenced bear access to salmon, a resource which strongly influences bear fitness. These results suggest fisheries managers attempting to maximize harvest while minimizing impacts on brown bears should strive to protect the population diversity that underlies the phenological variation used by wildlife consumers. These results underscore the need to understand how fisheries affect life history diversity in addition to abundance in order to minimize negative effects of fisheries management on non-target species, a goal of EBFM.

Diet Composition and Body Condition of Northern Continental Divide Grizzly Bears, Montana

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The Northern Continental Divide Ecosystem (NCDE) population in Montana is currently in the process of moving towards consideration for delisting under the Endangered Species Act. Recent estimates of population growth rate (2004–2013) indicate that it is likely increasing. From 2009–2013, we documented apparent population health by investigating food habits and resulting physiological outcomes of ingested foods associated with habitats used. Analysis of carbon and nitrogen stable isotopes provided information on percent terrestrial meat and plant matter in the diets of captured bears from 366 capture events. We also estimated body fat content of bears at 199 capture events. The use of animal matter differed within the grizzly bear population. Adult females used less meat compared to subadults and adult males ($P < 0.0001$). Regions on the southwestern, southern, and eastern periphery of the ecosystem used a significantly higher proportion of meat than those in the interior or northwestern periphery ($P < 0.0001$). Diets of bears in the Whitefish Mountains and North and South Fork of the Flathead River were, on average, composed of 70% less meat than those on the East Front. Body fat content of NCDE grizzly bears differed by sex and age. Adult males had significantly higher den entrance fat contents than adult females and subadults ($P < 0.0001$). Average body fat of adult females varied significantly between those in areas of high consumption of meat and those otherwise. However, we find adult females across all regions enter dens at mean fat levels above those thought to be critical for cub production (i.e., > 20%). We report slightly lower mean values and higher variation in body condition of female bears within the southern and western periphery (Lower Swan and South Fork Flathead drainages) of the ecosystem, which may reflect more variable food resource base in these areas. We have no evidence to conclude that the widely varying food resources across the NCDE are inadequate to meet the needs of reproductively-active adult females. As truly opportunistic omnivores, grizzly bears in all regions of the NCDE exploit diverse combinations of food items to arrive at productive body conditions.

An Introduction to a Brown Bear Research Consortium in Alaska: Evaluating Anthropogenic and Climatic Influences to Habitats of an Ecologically Plastic Large Carnivore

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Brown bears (*Ursus arctos*) are generalist omnivores that display striking behavioral and physiological responses to the diverse habitats they occupy in northern systems. Large gradients in vegetative productivity, hydrographic and thermal regimes, and resource availability and quality (e.g., foraging windows for vegetation, berries, fish, ungulates, marine mammals, and marine invertebrates) produce populations of bears that vary markedly in their capacity to deposit nutrients as well as reproduce. Given this inherent diversity among populations, estimating this species response(s) to current and prospective anthropogenic and (or) climate-induced habitat changes remains a management and conservation challenge that will likely require large-scale and collaborative efforts. In 2011−12, in response to 1) two proposed large-scale industrial developments (i.e., Pebble Mine and Ambler Road), 2) concerns of climatic influences to primary forages and pathogen ecology, 3) insufficient demographic monitoring techniques for brown bears, and 4) the potential influence of increasing viewing activities to brown bears, we formed a research consortium that currently consists of almost two dozen biologists, faculty members, graduate students, and (or) post-doctoral researchers from 3 federal agencies and 5 universities. Since 2014, we have captured, collared, weighed, sampled (blood, hair, claw, and feces), estimated body composition, and (or) monitored ≤151 brown bears (39 males and 112 females; range in body mass = 53−411 kg and age = 4−25 yrs) from 3 National Parks and Preserves (i.e., Gates of the Arctic, Lake Clark, and Katmai) and one National Wildlife Refuge (Kodiak). We have acquired over 280,000 GPS relocations and currently have 75 active GPS-collared bears; projects will be completed in 2017. We are using this evolving and extensive dataset to examine empirical and (or) modeled spatial, behavioral, pathogenic, and nutritional characteristics and potential responses to habitat changes and develop genetic and demographic monitoring approaches and tools for brown bears. We will briefly introduce this consortium and describe early findings related to variation both within populations across individuals and seasons as well as compare populations residing in varied ecosystems and physical environments. Further, we will discuss the implications of varied management regimes and potential human threats.

Competition Between Apex Predators: Brown Bears Decrease Wolf Kill Rate

Aimee Tallian

Trophic interactions are a fundamental topic in ecology, yet we still have a narrow understanding about how competition between apex predators affects predation patterns, the ultimate mechanism that drives top-down forcing in ecosystems. We used long-term datasets from Yellowstone National Park, North America (2008-2015) and Scandinavia, Europe (2002-2015) to evaluate how gray wolf (*Canis lupus*) kill rate was affected by a sympatric apex predator, the brown bear (*Ursus arctos*). We used kill interval, or the number of days between consecutive ungulate kills, as a measure of kill rate. Despite the ability of brown bears to monopolize wolf kills, we found no evidence to support the traditional assumption that they caused wolves to kill more often in either system. On the contrary, our results suggest the opposite effect. In Scandinavia, wolves that were sympatric with brown bears actually killed less often than allopatric wolves, both in the spring after bear den emergence and in summer. Similarly, the presence of bears at wolf-killed carcasses increased wolf kill interval during the summer in Yellowstone. Though opposite of expected, the similarity in results between the two systems provides compelling evidence that bears dampen wolf predation. While the exact mechanism remains unknown, our results suggest that the influence of predation on lower trophic levels may depend on the composition of predator communities.

Spatio-Temporal Factors Affecting Bark-Stripping of Conifer Trees by Bears in Japan

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Bark stripping (BS) of conifer trees by Asiatic black bears (*Ursus thibetanus*) has seriously affected forestry in Japan. It primarily occurs between May and July in conifer plantations. It is not clear why bears damage coniferous trees; however, the scarcity of food during this period is a likely explanation because bears consume cambium from the stripped bark. Effective measures for preventing BS have not been established because there is no way to predict the targeted areas; therefore, we aimed to clarify the annual and spatial factors associated with BS. This study was conducted in Kusaki University Forest, Tokyo *University* of Agriculture and Technology, central Japan. We set 65 quadrats in conifer stands of varying status, calculated the number of damaged trees, and measured several environmental variables to clarify the factors that affected the spatial fluctuations of BS. We collected recorded data for acorn masting (*Quercus crispula*: it is dominant hard mast species) and meteorology to clarify the factors that affected the annual fluctuations in BS. From our results, BS occurred in areas that were stripped the previous year, and BS happened continuously at the same area. The number of bark-stripped trees increased when acorn masting was low in the previous autumn or when the average temperature of the previous winter was high. Furthermore, the distribution of bark-stripped trees in young stands expanded faster than in older stands. Therefore, forest owners should preferentially protect the young stands where BS has occurred in the past. Protective measures should be strengthened in years following a low acorn masting or a mild winter.

Session 12 – Genetics and Genomics

Monitoring of Brown Bears in Trention- Italian Alps

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The small and isolated population of brown bears in Trentino-Italy originated from 9 young bears moved from Slovenia to Trentino in 1999-2002. Monitoring is based on genetic (14 years non-stop), radiotracking (GPS), camera traps and traditional survey techniques. Intensive and constant monitoring is required with regard to the high human density in the area and the consequent pressure on managers coming from public opinion, media and government. Monitoring a close population originated from 9 genetically known founders allowed to set out the pedigree of the population, its trend and structure, sex ratio, average age (general, by sex, for primiparous etc), fertility and survival rates, number of litters and cubs, effective population (Ne). Data pointed out that the population recorded a constant growth from 2002 to 2012 (average yearly growth rate of 17.3%, considering the minimum certain population data), moving to a substantial stability in the last three years (around 45-50 bears presently estimated). Size and density of the population have been established according to both minimum population hard data and estimation of the population based on CMR methods. Genetic monitoring also showed that females roam in a relatively small area (around 1.000 km^2 - density 3,5 bears/100 km^2), while the territory occupied by males considering dispersion movements is on average 12.000-15.000 km^2 wide. Genetic information shared with bordering regions through cooperation between different genetic labs allowed to monitor dispersion of males as well, stating how many did disperse, died or disappeared and how many have returned in the females range, emigrated to different populations or are still out of the province. The lucky initial conditions, together with an intensive monitoring effort, allowed to state several demographic parameters that are usually hard to point out in bear populations. The challenge in the long term is now to balance the constant need of high standard monitoring data with related human and financial costs. Different prospects about that will be shortly analysed.

Black Bear Genetic Diversity in Alabama

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Black bears (*Ursus americanus*) have been restricted to a very small population in the Mobile River Basin (MRB) since the 1920's. Recently bears have been immigrating back in to the north eastern corner of the state and establishing a new breading population in and around Little River National Preserve. Both of these populations are very small with minimal if any genetic exchange with other populations. The MRB population has extremely low genetic diversity with an observed heterozygosity of Ho=0.289, effective heterozygosity of He = 0.278 and an average number of alleles per locus of Na= 2.125. All indicating isolation with little to no genetic exchange with an outside population. The north eastern population however has much higher genetic diversity with, Ho = 0.569, He = 0.484 and Na = 4. The relative youth of this newly established breeding population makes predicting future genetic health more difficult. There has not been sufficient time since colonization to allow for drift to begin to take effect, or for the level of continuing immigration to be observed or quantified. However baselines for this population have now been established and the existence of a healthy breeding population of black bears has been confirmed in north eastern Alabama.

Mitochondrial Diversity and Population Structure of Himalayan Brown Bear (*Ursus arctos isabellinus*) in India

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In India, the Himalayan brown bear (HBB) occurs in low density in the alpine regions of the greater and trans-Himalaya in the States of Jammu and Kashmir, Himachal Pradesh and Uttarakhand. Of all the sub-species, HBB has remained little studied except for a few studies on status, conflict surveys and ecological aspects. Till date, genetic information is lacking across distribution range of HBB except a study of Deosai Plains of Pakistan. Understanding genetic diversity and population structure is crucial for effective conservation planning. Therefore, we describe first time regional and global positions of southernmost population of HBB in India. We utilized 269 bp control region of mitochondrial genome using fecal samples (n=25) collected from three locations each from Jammu and Kashmir (JK) and Himachal Pradesh (HP) respectively and were separated by 25 to 350 km. Nucleotide (π) and haplotype (h) diversity was 0.00 to 0.0019 and 0.00 to 0.509 respectively. The Bayesian-based phylogenetic analysis reveals the presence of four haplotypes in three different lineages and all these were with the Gobi-Pakistan clad with a higher posterior probability value of 0.99. Only one haplotype of these was shared between Ladakh, JK and Pin Vally National Park (PNP), HP, which are separated at least by 250 km. The median-joining network analysis of reported and observed mtDNA haplotypes (Gobi-Pakistan-India) indicate the presence of core haplotype of Ladakh, JK-PNP, HP. Significant F_{ST} indicates strong genetic differentiation among the brown bear population in India and that might be due to strong female philopatry and human-mediated

disturbances. We discuss observed exclusive specificity of haplotypes in relation to landscape features and determine global status by comparing sequences of the other brown bears.

Evaluating Changes in Genetic Diversity and Reproductive Success of Grizzly Bears in Northwestern Montana, USA, Using a Family Tree

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Current range expansions of bears are occurring following anthropogenically-induced range contraction. Contractions are often incomplete, leaving small remnants in refugia throughout the former range, but little is known about underlying eco-evolutionary processes that influence how remnants are affected during range expansion. We used data from a spatially-explicit, long-term genetic sampling effort of grizzly bears (*Ursus arctos*) in the Northern Continental Divide Ecosystem (NCDE), USA to identify the processes underlying spatial patterns of genetic diversity. We used parentage analysis to evaluate how reproductive success and migration contribute to spatio-temporal patterns of genetic diversity in remnant groups of grizzly bears existing in 3 regions of the NCDE. Highly skewed reproductive success and local inbreeding caused distinct signatures in remnants that eroded rapidly (~1 generation) during population expansion. Our results highlight that individual-level genetic and reproductive dynamics play critical roles during genetic assimilation, and show that patterns of genetic distinctiveness on the leading edge of an expansion may result from historical demographic patterns that are highly ephemeral. We will discuss how these results compare with other relevant studies from brown bear populations elsewhere in the world.

The Ecology of Human-Bear Conflicts: Estimating the Fraction of the Population Causing Damages in the Polish Eastern Carpathians Using Molecular Techniques

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Conflicts between wildlife and humans are a challenge for conservation biologists at the global scale. Essential for managing wildlife damages is to understand the mechanisms underlying these conflicts, which still remain unclear. Nowadays, animal personality and individual behavior are increasingly recognized to play an important role in the ecology of species. Taking the Eastern segment of the brown bear population from the Polish Carpathians as the study population, we aimed to (1) identify bears involved in damage occurrence, and estimate their proportion in the population, (2) check whether the

bears producing damages are kin-related, and (3) assess sex differences in bears responsible of the damages with respect to sex ratio in the population.
We conducted noninvasive sampling in autumn 2014 and spring 2015 in the Polish Eastern Carpathians using a study design that allows for spatially-explicit capture mark recapture modelling. Genetic samples were collected systematically in the area of 3,700 km^2 over five field sessions. Hairs were collected at 148 baited tree-traps distributed in the centre of 5x5 km cells, and faeces along walking routes through bear habitat. Additionally, we carried out an opportunistic sampling of hairs at natural rub trees and faeces at feeding sites. In parallel, hair and faecal samples from individuals involved in damages were obtained during damage inspections in 2014 and 2015.
Overall, we collected 191 bear faeces and 412 hair samples. All the faeces and 207 hair samples which contained follicles, were used for DNA extraction. Nine per cent of faeces and 27% of analysed hair samples were found at the damage sites. The identification of individuals was performed using 12 microsatellite loci and 1 sex identification locus. The estimation of the population size was done based on several capture mark recapture methods. We present results of our analyses and discuss the potential implications of individual aspects in damage occurrence.

Biogeography of Black (*Ursus americanus)* and Brown Bears (*U. arctos*) in a Recently Deglaciated Landscape: Glacier Bay, Alaska

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Southeast Alaska has a long, complex history of advancing and retreating glaciers and changing sea level throughout the Pleistocene and into the Holocene. We used DNA microsatellites of 105 brown bears and 272 black bears to examine contemporary genetic structure of bears and identify the number and geographic range of populations, the level of admixture, landscape features that limit or promote genetic connectivity, and probable population sources of bears in Glacier Bay following the end of the Little Ice Age. We identified the number of genetically distinct populations and the degree of admixture using Bayesian allele frequency assignment tests, determined colonizing population sources based on fixation and differentiation indices, and tested correlations between the genetic relatedness and a suite of landscape models. The shoreline surrounding Glacier Bay hosts brown bears from two distinct genetic populations which may represent contemporary colonizing sources and a third group endemic to Glacier Bay that likely represents a historic colonizing population. The three genetic groups overlap in northern Glacier Bay although the extent of admixture between the groups is relatively low, indicating recent or current immigration. The same area hosts five distinct populations of black bears, four of which occur only on the east side of Glacier Bay and one of which occurs only on the west side. Glacier Bay fjord appears to inhibit dispersal and funnels recolonizing bears from east and west refugia in a northward direction. With the retreat of glacial ice, brown bears have expanded their range into the northern end of Glacier Bay and are currently coming into secondary contact after hundreds and possibly thousands of years of separation, creating a population-level biological contact zone. The range expansion of black bears into the north, however, is likely limited by suitable habitat and possibly by competition with brown bears.

Genetic Characterization of the Brown Bear (*Ursus arctos*) of the Caucasus (mtDNA and 8 Microsatellite Loci)

V. Salomashkina, M. Kholodova, U. Semenov, A. Muradov, A. Malkhasyan

Caucasian brown bear has extremely high morphological variability and specific geographic location. So there were different hypotheses for its genetic heterogeneity and connections with bears of both East European Plain and Middle East. Yet for the major part of the Caucasian region bears genetic structure is still unknown. Currently, there is one main publication about the brown bear genetics from Georgia (Murtshkavaladze et al., 2010) which showed that Georgian bears belong to the Eastern European mitochondrial clade. No shared haplotypes were found between the Georgian and Iranian bears (Ashrafzadeh et al., 2015).

We have studied genetic diversity of the brown bears (n=37) from the northern (Sochi national park, Russia) and southern (Ilisu state reserve, Azerbaijan) slopes of the Greater Caucasus and from the Lesser Caucasus (Armenia), based on the mtDNA control region sequencing (570 bp) and microsatellite analysis (8 loci).

We described 4 mtDNA haplogroups. Comparison of our data with sequences from the GenBank revealed that two of these haplogroups belonged to the Eastern European clade, one of them being close to the haplotypes from Georgia, while another relating directly to the Eastern European haplotypes. Third group of our haplotypes was very close to the Iranian clade (Calvignac et al., 2009). Fourth haplogroup was in the central position on the median-joining network, being highly different from any other haplotypes, including Iranian, but according to the Bayesian phylogenetic tree it turned out to be a sister group to Iranian haplotypes. We found no identical haplotypes between our and Georgian samples.

Microsatellite analysis showed no well-defined structure among the Caucasian samples, although bears from the northern part of the Caucasus (Sochi) were slightly different from those of the southern part (Azerbaijan and Armenia). There were no significantly different individual samples which may indicate the absence of recent migrants.

This leads to the conclusion that current population of the Caucasian brown bear has a complex origin and still carries ancestral genetic lines. We propose that originality of the genetic structure of the Caucasian brown bears is the result of both the existence of an ancient refugium and some later migrations.

Andean Bear Genetics

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Information on the genetics of Andean bears (*Tremarctos ornatus*) is still very limited and constrained to either phylogenetic analysis of bear evolution, or to few articles on Andean bear population and conservation genetics. Molecular data is advantageous because DNA is inherited from one organism to its offspring, which allows determining historical and current patterns of diversity and structure in animal populations. Here I present a comprehensive review of methods and results of a long-term study on Andean bear conservation genetics in Ecuador. This research focused on using conservation genetics to individually identify wild Andean bears from noninvasive samples, and evaluate levels of diversity and structure among Andean bear populations. The research objectives were: (1) to develop molecular methods to study Andean bears in tropical ecosystems (2) to determine the levels of genetic diversity and structure on wild Andean bears, and (3) to reconstruct the evolutionary history and phylogeography of the species. DNA was extracted using Qiagen tissue and stool kit. Individual genotypes were obtained by PCR amplification of eight unlinked nuclear DNA microsatellite loci. We also designed and optimized primers to amplify a segment of 450 bp of the Andean bear mitochondrial DNA (mtDNA) control region. To evaluate levels of genetic variation, we measured allelic richness and heterozygosity (He vs. Ho) for all loci. Gene flow and the number of distinct populations were determined using Bayesian clustering methods (STRUCTURE) and Fst, assignment tests. Private alleles and phylogeographic analysis informed us about the evolutionary history of the species. Andean bears in Ecuador present medium levels of genetic diversity. Preliminary analysis show genetic differences between north vs. south, and east vs. west bear populations. Six haplotypes were detected for the Ecuadorian Andean bears. Genetic differences and haplotypes follow geographical and anthropological barriers. I will discuss these results in a broader context by comparing them with published information on Andean bear genetics across the species range.

Twenty-Five Years of Bear Genetic Studies: What Have We Learned?

Lisette Waits

Over the past twenty-five years, the use of molecular genetic methods has revolutionized wildlife science and greatly enhanced our knowledge and understanding of all bear species. This presentation will review and summarize the contributions of molecular genetic research to addressing key questions in bear biology, ecology and evolution. The presentation will cover four main research areas: 1) taxonomy and evolution, 2) genetic diversity and gene flow, 3) demographics and monitoring, and 4) behavior and mating system.

Realizing the Potentials of the New Molecular Toolbox for Bear Research and Conservation

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Recent technological and computational advances are revolutionizing molecular studies by providing unprecedented access to genetic resources and changing the amount of and the speed at which DNA data are generated. Specifically, high throughput sequencing technologies and associated bioinformatic pipelines for data analysis are greatly facilitating the discovery and development of genetic markers and the production of genomic data available for conducting ecological studies. These new methods hold great potentials for gaining unprecedented ecological insights, and therefore for producing research outputs relevant for effective conservation. However, conservation practitioners, including field biologists, ecologists, and managers, have yet not realized the possibilities offered by these so-called next-generation approaches and are not taking full advantage of their application. Our goal for this talk is to fill this knowledge gap, by illustrating how novel approaches in molecular ecology can be used in bear research and conservation. We will show how these methods can be used to 1) complement information provided by other techniques for gaining a deeper understanding of bear ecology, and 2) to increase the information content and the efficiency of genetic analysis for implementing management and conservation actions. We will present example applications including the combined use of DNA metabarcoding and other non-DNA methods for population and individual level diet assessment, and the use of high throughput sequencing for simultaneous genotyping of several microsatellite loci and other genetic markers for individual identification, forensics, and population studies. We hope this will motivate bear biologists to make greater use of these new approaches and to add them to their toolbox along with other available methods to acquire the most comprehensive knowledge of bear ecology for effective conservation.

Quantifying Range-Wide Genomic and Cranial Morphometrics Differentiation in American Black Bears (*Ursus americanus*) and Implications for Subspecies Designations

Emily Puckett

Studies of species with continental distributions continue to identify intraspecific lineages despite continuous habitat. Lineages may form due to isolation by distance, adaptation, divergence across barriers, or genetic drift. We investigated genomic lineage diversification in American black bears (*Ursus americanus*) across their range using 22k SNPs and mitochondrial DNA sequences. We identified three subcontinental nuclear clusters which we further divided into nine geographic regions: Alaskan (Alaska-East), eastern (Central Interior Highlands, Great Lakes, Northeast, Southeast), and western (Alaska-West, West, Pacific Coast, Southwest). We estimated that the western cluster diverged 67 kya, before eastern and Alaskan divergence 31 kya; these divergence dates contrasted with those from the mitochondrial genome where clades A and B diverged 1.07 Mya, and clades A-east and A-west diverged 169 kya. The

delineation of the genomic population clusters was inconsistent with the ranges for 16 previously described subspecies. Ranges for *U. a. pugnax* and *U. a. cinnamomum* were concordant with admixed clusters; additionally, *U. a. floridanus* has not diverged from *U. a. americanus*. The genomic data questioned how to order taxa below the species level. Thus, data on cranial morphometrics was collected to quantify shape variation over the range of the species. This new morphometric dataset will be compared to the genomics to understand variation within the species across its range, specifically in relation to possible taxonomic revisions.

Landscape Relatedness: Insights into Contemporary Structure of the Swedish Brown Bear

Anita Norman

Population sub-structuring is typically identified through genetic differentiation between spatial areas. However, a lack of genomic resolution, uninformative markers, skewed sampling, or a lack of sampling resolution can lead to inferences that are not representative of the actual underlying substructure. In this study, we use a set of 96 SNPs designed for the purpose of inferring relatedness in the Scandinavian brown bear (*Ursus arctos*). Consequently, the SNPs lack the characteristics to properly show population sub-structuring since they are fairly evenly distributed throughout the geographic range. To maximize the utility of the SNPs, we take a different approach to studying spatial structuring. Our approach uses pairwise relatedness with 412 individuals to predict overall relatedness across a landscape larger than 46,000 km^2. The results of this interpolation reveal novel insights into structuring of brown bear. We show that some areas contain individuals that are significantly more related and others that are significantly less related than what is expected by chance. We also show how these areas vary with males and females. These findings have implications for conservation efforts as they contribute a contemporary, fine-scale spatial analysis of an important umbrella species.

Paleogenetic Survey of Brown and Black Bear Diversity in Pleistocene Southeast Alaska

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During the peak of the Last Glacial Maximum (LGM), ice sheets divided the Old and New Worlds, extensively curbing biotic exchange across the Bering Land Bridge for thousands of years. Geological and biological evidence have suggested, however, that refugia along the North Pacific Coast may have played crucial roles as "stepping stones" for movements of species between the Old and New Worlds, forming an early postglacial corridor for the recolonization of North America. Building on an unparalleled

vertebrate bone collection excavated from limestone caves in Southeast (SE) Alaska we are performing paleogenetic analyses – based on state-of-the-art ancient DNA approaches – of brown and American black bears that occupied SE Alaska during the late Wisconsin glaciation and into the Holocene. We aim to directly test if bears occupied these caves at the peak of the LGM, if the same bear populations inhabited this region continuously for the last 50,000 years, or if they were recolonized following the LGM, and if they contributed to postglacial (modern) mainland populations. We have screened numerous bear specimens from the Alexander Archipelago and produced both incomplete and complete mitochondrial genome sequences. Many fossil specimens that were presumed to be brown bear based on morphology are clearly diagnosed as black bear based on genetic data, demonstrating that morphology alone can be insufficient in species diagnosis. Furthermore, affinities to several contemporary matrilineal genetic lineages, and possibly also extinct lineages, have been found among these specimens. For example, pre-LGM black bear specimens have a phylogenetic affinity to both contemporary coastal and continental lineages, suggesting that both these lineages were present in the archipelago prior to the LGM. The contemporary brown bear lineages on the Admiralty, Baranof, and Chichagof islands were apparently more widespread in the archipelago 10-12,000 years ago. This research will have broad significance toward understanding past and present black and brown bear diversity and for assessing the impact of late Pleistocene climate change on their diversification and historical biogeography of the region.

When Translocation is Not Enough to the Rising Conflicts: Understanding Movement Patterns of Translocated Bears by Molecular Tracking

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Dachigam landscape, Jammu and Kashmir harbors one of the highest density bear populations in India and managing bear-human interactions is not only challenging but also a serious threat to the survivorship of black bears due to resultant retaliatory killings of bears by locals. As a strategic planning to mitigate bear-human conflicts, the provincial wildlife department prefers translocating 'nuisance bears' (involved in conflicts) from different sites in Dachigam landscape to Dachigam National Park. While it sounds positive, it is not always effective as all translocated bears do not just settle to their new home. Instead majority bears often return to their capture sites due to retaining sharp memory and homing tendency. We conducted genetic analysis of wild caught hair samples to investigate the pragmatic fate of bear translocation in Dachigam National Park and. We have identified 109 unique genotypes in an area of ca. 650 km^2 and bear population was under panmixia. Molecular tracking of translocated bears revealed that mostly bears returned to their capture sites, possibly due to homing instincts or habituation to the high quality food available in horticulture croplands, while only four bears remained in Dachigam National Park after translocation. Results indicated that translocation success was most likely to be season dependent as bears translocated during spring and late autumn returned to their capture sites, perhaps due to the scarcity of food inside Dachigam National Park while bears translocated in summer remained in Dachigam National Park due to availability of surplus food resources. Thus, the current management practices of translocating conflict bears, without taking into account spatio-temporal variability of food resources in

Dachigam landscape seemed to be ineffective in mitigating conflicts on a long-term basis. However, genetic tagging of translocated bears would be tempting to wildlife managers to monitor bear movements in tough terrains and understanding their socio-biology in the landscape.

Assessing Ecological Connectivity and Kin-Related Social Organization Among Brown Bears Around the Wildlife Migration Zone and Human-Bear Conflict Area Baile Tusnad, Romania

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The IBA R&C-Grant supports an on-going genetic study assessing the function of the wildlife corridor around the town Baile Tusnad for brown bears (*Ursus arctos*) and investigating the existence of matrilinear assemblages of food-conditioned individuals in human-bear conflict areas. In the first step, we collected DNA samples from April until December 2013 in the field. Besides collecting faeces, we set up 16 fixed hair traps spread over a surface of 23 km^2 that were weekly baited and verified. For genetic analyses we obtained a total of 98 hair and 21 scat samples. Among the 47% successfully genotyped samples, we were able to identify a minimum number of 43 different genotypes. About 84% of pairs of individuals were unrelated. Our preliminary results clearly prove the important function of this area as a wildlife migration zone connecting the Eastern and Western mountain range, whereas the surrounding landscape is already strongly fragmented. The results of our genetic study helped to restrict the urbanization plans of the mayor's office in September 2014 to fully extend housing in the Northeast part of Baile Tusnad and thus to maintain crucial passages within this wildlife corridor. In the second step, we analyzed 46 tissue samples of harvested bears (2012-2014) to examine how genetic relatedness changes with increasing geographic distance from this core area towards the East and West. Continuing the project by analyzing a lager sample size and extending the study area on county level at the same time, would clarify to which extent (1) gene flow between bears occur and (2) philopatry and dispersal influence social organization in bear populations. Matrilinear assemblages (MA) might only form in habitats with sufficient food resources, since competition among females determines whether MA or dispersed matrilines are formed. So far, results of pairwise relatedness indicate that the highest value for parent-offspring relationship in relation to the analyzed number of samples exists between female-female dyads. Due to the fact that bears in the zone B. Tusnad have access to garbage all over the year, we expect kin-related social organization to be strongly manifested in the behaviour of food-conditioned bears.

Session 13 – Habitat Use and Needs of Bears

Identification of Suitable Habitats and Corridors to Conserve Sloth Bear Landscape in Gujarat Using Ecological Modeling

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Sloth bear in Gujarat is patchily distributed along the eastern edge of the state, from the foothills of Arawali mountain ranges in Banaskantha district in the north, to the Narmada district in the south. This area, once thrive with rich forest is now fragmented in small patches due to continuous exploitation of forest resources and other developmental activities. The main objective of our study is to identify the suitable sloth bear habitat among these fragmented patches so that it can be developed as a sloth bear corridor. We have collected the information of sloth bear presence in this area through sign survey and attempted to update our knowledge of the potential distribution of sloth bear by generating a climatic, topographic and vegetation approach models. As a basic for development of habitat suitability model we used 19 layers of bioclimatic variables which represents current climatic conditions and elevation. Further, we divided all occurrence points in 80:20 ratio as of the total sample records, 80% was selected for training data; and the rest of 20% was used for test data to evaluate the models. Here, we used different algorithms such as Climate Space model, Bioclim model and Envelop Score model to find potential distribution of sloth bear in OpenModeller and found Bioclim as best suitable model showing sloth bear habitats in the state as it overlaps most of our sloth bear presence data with AUC value close to 1. To know the suitable habitat within the Bioclim model, we added layers of vegetation through Normalized difference vegetation index (NDVI) and processed to create 12 monthly mean composite NDVI images over 10 years from 2005 to 2015. These values to each pixel can lead to understanding of species occupancy as a suitable habitat to develop a corridor. We will now approach to state forest department for protection of these corridors and to rejuvenate the elevated barren land for conservation of sloth bear landscape.

The Need to Focus on Severally Limited Season-Specific Habitat for Asiatic Black Bears in Japan

Chihiro Takahata

In the Wildlife Conservation and Management Plan (WCMP) for Asiatic black bears *Ursus thibetanus* instituted by several Japanese prefectural governments, the main goal described was “Mitigation of human-bear conflicts and incidents”. To monitor impacts of prevalent lethal control on a local bear population, scientific basis for the population estimate has improved for the last decades while there is

still lack of habitat study necessary to establish an effective habitat management scheme to achieve the goal.
Even though limited quantitative habitat studies in Japan, there is a strong belief in broad-leaved deciduous forests consisted of acorn trees as the critical bear habitat of the first priority for being conserved whereas high mortality of bears caused by negative human-bear interactions chronically occurred during summer not the acorn season, autumn. In order to establish practical habitat management in the WCMP for both bear conservation and conflict mitigation, we aimed to evaluate habitat quantity and quality in different seasons for bears using a statistically rigorous method to provide reliable base line information to wildlife managers.
We collected GPS data in 2007-14 from 28 bears to build a habitat model seasonally separated because of omnivore's nature of bears depending on diverse food distinctively changed as seasons shift. Using Resource selection function (RSF), we delineated the sex-season specific 6 predictive maps of habitat distribution on the central Japan Alps region. Our results indicated that bear's summer habitat was significantly restricted and maldistributed in the peripheral areas close to human-dominated lower lands. This means it is highly likely that many bears are suffered from the deficiency of secure habitat during summer, a concurrent period of the prevailing human-bear incidents.
We recommend to focus on bear habitat in summer instead of in autumn, and to plan summer habitat restoration in remote mountains to reduce negative human-bear interactions near human settlement.

Density-Weighted Connectivity for Corridor Design

Angela K. Fuller, Dana J. Morin, J. Andrew Royle

The intended purpose of corridors is to provide regions of the landscape that facilitate movement of individuals. Specific objectives include increasing gene flow, reducing isolation and inbreeding, increasing fitness and survival of species, and allowing species to move and adapt to changes in the landscape or climate. Corridor conservation typically focuses on either 1) conserving areas that support high abundance of species to reduce the risk of demographic stochasticity or 2) conserving areas that allow individuals to move between reserve areas to maintain gene flow. Most corridor design applications focus on patterns of habitat and landscape structure (structural connectivity). However, the impetus of corridor design is the process of animal movement (functional connectivity). Functional connectivity considers the degree to which the landscape facilitates or impedes the movement of organisms and is the product of landscape structure and the response of organisms to this structure. We suggest that maintenance of spatially structured populations requires considerations of both species abundance as well as functional landscape connectivity. We present a model for corridor design in the Chocó-Andean region of Ecuador, located within two of the world's biodiversity hotspots, and home to the endangered Andean bear (*Tremarctos ornatus*) and numerous endemic and threatened birds. We describe a novel metric related to biodiversity conservation and corridor design using pilot data from a camera trapping study of Andean bears. The metric we describe, density weighted connectivity, is derived from encounter history data commonly collected in capture-recapture studies, and allows for simultaneous calculation of population density and landscape resistance to movement using a spatial capture-recapture model. We demonstrate how density-weighted connectivity models two ecological processes on the outcome of density – movement and resource selection. The corridor design application has relevance to not only creating corridors for conservation of rare species such as Andean bears, but also in identifying hotspots of conflict for abundant species like black bears.

Movement Patterns and Space Use of Asiatic Black Bears in Yushan National Park, Taiwan

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Animal's foraging and movement strategies often involve a trade-off between nutrition requirement and minimizing predation risk, including poaching. We evaluated the annual movement patterns and space use of Formosan black bears (*Ursus thibetanus formosanus*), locally endangered in Taiwan. Previous studies documented seasonal variation in space use of bears related to acorn production in the Dafen area of Yushan National Park (YNP). However, few have addressed bear movement patterns and space use year around. We monitored 6 GPS collared bears in YNP from fall 2014 to fall 2015. Bears congregated in an oak-dominate forest in Dafen during the acorn masting season in 2014. Five bears dispersed from Dafen at the end of the acorn season between 7 January – 22 February and moved eastward 5-20 km to their spring core areas. Half of the bears travelled outside of YNP. The annual home ranges of adult males were larger than those of females, 59.3 km^2 (n=2, SE=43.5) and 64.7 km^2 (SE=37.7) VS. 39.4 km^2 (n=2, SE=11.6) and 38.7 km^2 (SE=22.5) for minimum convex polygons (MCP) and 95% kernel density estimation (KDE), respectively. Males used 2-6 core areas for a total of 17.3 km^2 (SE=10.3), while females used 1-2 core areas for a total of 8.9 km^2 (SE=0.8). Core area size and distribution varied by individual and season, mainly due to food availability. The bears did not migrate back to Dafen in the fall of 2015 due to an extreme acorn failure, though some migrated to areas near Dafen.. Bears used a wide gradient of elevation (250-3,200m), which was highly related to natural resource availability and potential human disturbance. The seasonal core areas of bears were mainly located between 1,000 and 2,000m. We suggest that bears are able to exploit suitable habitat and avoid areas with human disturbance. However, half of the bears had missing toes caused by illegal bycatch, suggesting that the influence of illegal hunting has not declined in 15 years.

Selection of Natal Dens and Den Sites by Andean Bears (*Tremarctos ornatus*) in the Seasonally Dry Tropical Forest of NW Peru

Russ Van Horn, James Sheppard, Megan Owen, Robyn Appleton, Isaí Sanchez, Javier Vallejos, José Vallejos, and Ron Swaisgood

Natal dens are critical for bears, protecting altricial cubs from climatic conditions, predators, and potentially infanticidal conspecifics. However, we know little about dens used by several bears of conservation concern, including the Andean bear (*Tremarctos ornatus*). Even less is known about the preferences of Andean bear females for characteristics of dens and den sites, so resource managers are unable to assess whether females might use the denning locations available to them. To address these issues we've compared the den and site characteristics associated with 8 natal dens and den sites used in

the tropical dry forest of NW Peru with data from 21 potential (unused) cavities located during random and subjective searches, and 30 randomly selected sites. Natal dens were cavities beneath and between large boulders with nests of vegetation on a soil or stone substrate, below a rocky ceiling. Natal dens had 1-2 entrances whose maximum dimension ranged from 25-160cm. All natal dens were ≤50m from a cliff, while only 42.9% of unused cavities were close to cliffs. To assess cavity preferences we used AIC_c to assess logistic models with ≤3 (of 7) cavity-specific independent variables. Two models had ΔAIC_c ≤2: a model including the number of entrances, the minimum distance to a cliff, and the depth of the den chamber below the surface of the ground (R^2=0.46, p=0.04, w=0.41, ER=2.43), and another model including only the latter two variables (ΔAIC_c=1.585, R^2=0.13, p=0.31, w=0.19) reflecting site ruggedness. To assess site preferences we used AIC_c to assess logistic models with ≤3 (of 5) site-specific independent variables. There was not strong support for any model. Four models had ΔAIC_c ≤2, with R^2≤0.1, p≥0.34, and w≤0.26; the only variable in all those models was the minimum distance to a cliff. Thus, it appears that ruggedness may affect whether a site contains a natal den and that ruggedness, in addition to the number of entrances, affects the probability that a cavity is used as a natal den. We're gathering data for analyses of landscape-level parameters but at present it appears managers should consider ruggedness as an indicator of potential denning habitat.

Denning Ecology and Insights on the Hibernation Behavior of Asiatic Black Bear in Dachigam National Park, Kashmir, India

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Dachigam landscape (DL) in central Kashmir provides important habitat for Asiatic black bear (*Ursus thibetanus)* and holds one of the best known black bear in India. The increasing incidences of bear—human conflict cases in this landscape are threatening the bear population. Dachigam landscape is undergoing increased human induced modification to fulfill the growing needs of human population and moreover anthropogenic activities in protected areas are affecting the bear behavior. Therefore to understand the denning behaviour and den site selection by black bear in Dachigam landscape denning sites inside the protected areas as well as in human dominated landscape were visited. During the study period from 2009-11 seven black bears were satellite radio tagged and in addition to it 15 bears were genetically identified by using the non-invasive hair samples collected from possible den sites. Resource selection function (RSF) was performed to predicting the possible denning sites in the landscape. Based on the denning behavior data black bear in DL spent an average of 66 days. Male spent the least time in dens (mean=67 days) and females the most (mean=74 days). No significant difference was observed in den entrance dates and the mean den entrance date was 25 December. However the den entrance date differed between the years, late den entrance appeared associated with the food production failure and late snowing during 2010.

The majority of the den used in DL was located in natural rocky crevices (65%), tree cavities (25%) and burrows excavated (10%). Typically den sites were located in rugged slopes with north-east facing den entrance and temperate mixed forest. RSF suggested that black bear selected dens in pine mixed forest with high canopy, close to water stream with mid to upper elevations. However, RSF also revealed that

>78% of the dens occurred in potential denning sites that occupied 21% of the total study area. The 5-fold cross validation to assess the predictive capability of the top-rank model showed good predictive capacity. The findings of the model will be presented and discussed during the presentation.

Linking Grizzly Bear Movements to Spatial-Temporal Patterns of Landscape Disturbance Using a Multi-Scale Hierarchical Regionalization Approach in Alberta, Canada

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Quantifying the relationship between grizzly bear movements and landscape characteristics in important for understanding how individuals and populations respond to disturbance and environmental conditions. However, detection of landscape disturbance, and mapping of change magnitude and recovery, at scales relevant for identifying relationships with grizzly bear movement has been restricted by data limitations in the spatial and temporal domains. In this study, we used Landsat image composites to identify natural (e.g., forest fires and non-stand replacing events) and anthropogenic (e.g., forest harvest, roads, well-sites and infrastructure) disturbances in grizzly bear habitat of Alberta, Canada from 1985 to 2012. We employed an object-based multi-scale hierarchical clustering approach to regionalize the study area using pattern indices (e.g., edge and patch number counts, and fractal characteristics), change magnitude, post-change evolution, and data characterizing the landscape (e.g., topography, land cover, and primary productivity). We then quantified grizzly bear movements as the net displacement at hourly, daily, and weekly intervals using GPS telemetry data from 200 individuals collared between 2000 and 2012 within the identified regions.
From 1985 to 2012 approximately 580 000 natural disturbance patches (mean = 2.24 ha, sd = 176.40 ha) and 280 000 anthropogenic disturbance patches (mean = 4.93 ha, sd = 32.84 ha) were detected, with an increasing trend in the cumulative annual area of anthropogenic disturbance (Kendall's tau = 0.55, $p < 0.001$). At broad spatial scales (~1000 km^2), regional clusters were largely defined by variability in topography, land cover, primary productivity, and dominant disturbance type (natural or anthropogenic). Net displacement of individuals was generally greater in higher elevation regions with less anthropogenic disturbance. At finer scales (~100 km^2), an increase in the number of regionalized clusters was linked to local spatial disturbance patterns, particularly increase edge counts and higher fractal dimensions associated with high density anthropogenic disturbance, and the trend of the post-change vegetation recovery. In these regions, net displacement tended to be lower potentially reflecting increased foraging opportunities. Regionalization approaches using dense Landsat time series provide an effective means for synthesizing complex spatial-temporal patterns of disturbance and recovery, and understanding how these patterns influence grizzly bear movements.

Temporal Features of Tundra Ecosystems Influencing the Distribution and Abundance of Barren-Ground Grizzly Bears in the Canadian Southern Arctic

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The western population of grizzly bears in Canada, including those inhabiting the barrengrounds of the Southern Arctic, are listed as a species of 'Special Concern' by the Committee on the Status of Endangered Wildlife in Canada because of their vulnerability to population declines and human disturbance. We report initial findings of a multi-year, DNA based hair snare program in a 30,000km2 study area in the Northwest Territories, Canada. Microsatellite analysis of 2,174 hair samples collected from 2012 to 2013 identified 127 individual bears (89 female, 48 male). We are developing quantitative models of the distribution of bear food sources in space and time using a combination of remote sensing, ground based photo plots and timelapse vegetation cameras. A negative binomial regression model of bear abundance demonstrated that grizzly bears are found in the highest abundance where there is a more even temporal distribution of food sources ($p < 0.01$). Our results indicate that the temporal variation of food resources, including plants and barren-ground caribou, may be the best indicator of bear abundance in the tundra since landscapes exhibit low spatial heterogeneity and pronounced seasonality. As northern ecosystems continue to undergo rapid changes in climate and human activity, understanding the relationship between the availability of food sources and the abundance of species of concern such as the grizzly bear will help form the basis on which sound management decisions are made.

Living in Sympatry: Habitat Selection by Grizzly and Black Bears in a Multi-Use Landscape

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Southwestern Alberta is an important area for maintaining connectivity with wildlife populations in British Columbia, Canada and Montana, USA; it is also a biologically diverse and multi-use landscape with agriculture as the primary industry. The area supports populations of both grizzly bears (*Ursus arctos*) and black bears (*U. americanus*), where population-level effects of competition may result in habitat partitioning. While both species use similar food resources, black bears typically have lower nutritional requirements and a higher tolerance for human-disturbed landscapes relative to grizzlies. In 2013 and 2014, we established 899 non-invasive genetic sampling stations to collect hair samples from grizzly and black bears. Rub objects were sampled every 3 weeks from May to November (7 sampling occasions/year).

We identified species, sex, and unique individuals using nuclear DNA extracted from hair follicles. In southwestern Alberta the resident grizzly bear population is growing 4.2% annually and expanding their range eastward, while anecdotally black bears appear also to be shifting their spatial patterns of habitat use. Preliminary analyses indicate a high-density black bear population. We hypothesized that relative to grizzly bears, black bears would be more likely to select habitats closer to roads, areas with higher road density, and closer to human settlements. We examined black and grizzly bear habitat use during summer and fall, along a gradient of human use, and in a diversity of habitats. We used logistic regression to estimate coefficients for a latent selection difference function to quantitatively contrast the differences in habitat selection between the two species. While there are limitations in evaluating interspecific competition based on species' habitat selection patterns, the inherent variation across our study area allowed us to evaluate selection patterns based on proximity to human developments and habitat types. We examined how spatial variation in human-bear conflicts for each species of bear was correlated with habitat selection by that species and as a function of the differences in habitat selection between the species.

Movement Behavior and Habitat Selection of Eurasian Brown Bears in a Human-Dominated Landscape in Eastern Turkey

Mark Chynoweth, Gabriele Cozzi, Josip Kusak, Emrah Çoban, Ayşegül Çoban, Arpat Ozgul, Çağan Şekercioğlu

Plastic behavioral adaptation to human activities can result in the enhancement and establishment of alternative behavioral morphotypes within a population. Such inter-individual behavioral variations, if unaccounted for, can lead to biases in our understanding of species' feeding habits, movement behavior, and habitat selection. We deployed radio collars on 16 adult brown bears in eastern Turkey to closely monitor their movements. Our aim was to identify inter-individual behavioral variations associated with the use of a garbage dump and to examine how these influenced ranging patterns, movement behavior, and habitat selection. We identified two behavioral morphotypes: bears that regularly visited the dump and remained sedentary all-year-round, and bears that did not visit the dump and migrated > 100 km prior hibernation searching for food. We observed differences in habitat selection between bears resident all year round and migrants, the latter avoiding human settlements. During migrating trips through unfamiliar landscapes, bears were generally less selective in their habitat choice than during the sedentary phase, and forest cover appeared to be the only important environmental characteristic. Our study reinforces the growing evidence that animals' use of the landscape largely depends on their behavior and movement phase. Identification and consideration of variation in behavioral morphotypes is thus fundamental for the correct implementation of evidence-based conservation strategies. Failures to detect such differences could result in the erroneous allocation of the limited resources for conservation, such as setting aside portions of land characterized by landscape features that are critical to only particular morphotypes. This work represents the first large scale study of large carnivore movement in Turkey and will guide ongoing conservation and management efforts for brown bears in the region.

Humans and Climate Change Drove Range Loss of the Brown Bear in Europe During the Holocene

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At the end of the last glacial maximum, the European range of the brown bear covered the entire continent, whereas today's distribution is limited to a few isolated populations. It remains unclear to which extent this range loss was driven by humans, climate change or both. Using hierarchical analysis, we combined an extensive archaeological dataset of brown bear bone remains across Europe with climate and land-use data since the end of the last glacial maximum. We show that increasing winter temperatures and land-use intensification have been important drivers of accelerating range loss. Considering both the temporal and spatial pattern of extinction events revealed climate as a key direct and human-mediated cause of range contraction and fragmentation. In addition, the study introduces a novel approach for disentangling climatic and anthropogenic influences on species distributions.

Influence of Infanticide Risk on Brown Bear Den-Site Selection

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The risk of infanticide in brown bears (*Ursus arctos*) may influence den-site selection and chronology for female brown bears with dependent young. Strategies to reduce risk of infanticide include females avoiding larger, more dominant adult males through spatial or temporal segregation. We assessed whether variation in den location, den habitat, and den entrance and emergence dates of male and female bears supported sexual segregation in Lake Clark National Park and Preserve, Alaska. Den-sites (n = 56) were located using GPS telemetry data from bears in 2014 (n = 21) and 2015 (n = 35). We used mixed model analysis of variance to compare slope, elevation, and aspect of den sites for adult male and adult female bears with and without dependent young. We also used these variables to model probable denning habitat using maximum entropy modeling. We examined timing of female den entry and emergence in relation to males using generalized linear mixed models. Our preliminary results using 2014 data suggest that females with dependent may den at higher elevations (944 ± 140 m, $\bar{x}$ ± SD) than solitary females (866 ± 189 m) but at lower elevations (984 ± 118 m) than males. They also may use less steep slopes (25 ± 11.8°) than solitary females (29 ± 9.9°) or males (34 ± 4.9°). Additionally, females with dependent young (Julian day: 289 ± 8 days) denned 2 days later than solitary females (287 ± 6 days) and

20 days earlier than males (309 ± 21 days). Females with dependent young (122 ± 17 days) also emerged from dens 6 days earlier than solitary females (128 ± 9 days) and 10 days earlier than males (132 ± 10 days). Differences in den entrance and emergence dates suggest support our hypothesis that females with dependent young temporally segregate from male bears.

Using Diet Analyses to Inform Behavior-Specific Models of Resource Selection by Brown Bears

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Space use by animals is influenced by selection for resources that meet their life history requirements. For wide-ranging mammals, understanding resource selection can be challenging when the influence of behavior-specific selection processes are not included and when distribution as well as selection of resources changes through time. To overcome these challenges, we integrated analyses of diet, activity, and movement with temporally-explicit resource selection models to gain a better understanding of the mechanisms influencing habitat selection by foraging female brown bears (*Ursus arctos middendorffi*) on Kodiak Island, Alaska. We first used activity sensor and movement data from GPS-collared bears to distinguish between bedding and active behaviors such as foraging. To define the timing and magnitude of use of important food resources, we microscopically analyzed 283 fecal samples. These results were then used to inform models evaluating spatial and temporal patterns of foraging habitat selection by 30 collared females. While active (i.e., not bedded), habitat selection was influenced by the distribution of different food categories across seasons. During spring, brown bears selected for areas with fresh herbaceous growth receiving greater solar radiation at lower elevations. Summer and autumn foraging areas were closer to streams with active anadromous salmon runs, and later in autumn when the abundance of salmon declined, bears selected areas with greater abundance of berry-producing shrubs and roots. Selection of resources also varied among individuals, likely related to maternal status and potentially differing strategies for avoiding risk and optimizing mass gains prior to winter. Our work illustrates an approach that linked behavior of a wide-ranging mammal to GPS location data, and facilitated evaluation of selection for temporally varying food resources. The results suggest that brown bears are likely to change patterns of space use if distribution and/or timing of availability of forage resources are altered under future climate regimes or if access is limited due to human activities.

Influences on Home-Range Size and Shape of Recolonizing American Black Bears in Missouri, USA

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Disentangling the complexities that influence animal space use poses substantial challenges based on decision trade-offs and constraints imposed on animals. We tested the spatial resource variability hypothesis (increasing landscape heterogeneity results in increasing amount of space use) and the temporal resource variability hypothesis (temporal variation in resources reduces amount of space use). We also evaluated whether the shape complexity (i.e., an index of circularity) of home ranges was influenced by 2 extrinsic (landscape heterogeneity, preferred habitat [i.e., deciduous forest]), and 2 intrinsic (sex, intensity of use [i.e., core versus peripheral areas]) factors and assumed that the spatial complexity of home-range shapes was inversely related to energy conservation and fitness. To test our hypotheses, we estimated utilization distributions (UD) of radiomarked American black bears (*Ursus americanus*) using fixed kernel techniques and conducted independent analyses for size and shape of home ranges using linear modeling and small-sample Akaike Information Criterion. For home-range size, the best model supported the spatial resource variability hypothesis and included Shannon Diversity Index (95% CL of coefficient = 1.56–2.42) and sex (male; 95% CL of coefficient = 0.05–0.49). As land-cover heterogeneity increased, UD size increased, likely a consequence of bears responding to greater patchiness to maintain sufficient resources. Further, the Shannon Diversity Index was greater for males ($\bar{x}$ = 0.93) than females ($\bar{x}$ = 0.66), suggesting larger-bodied males used larger areas to meet their higher energetic costs due to landscape fragmentation. For shape complexity, coefficients for the best model were contour (0.133; 95% confidence limit [CL] = 0.070–0.196), sex (0.144; 95% CL = 0.079–0.209), and intercept (0.259; 95% CL = 0.208–0.309). Shape complexity was less for core areas than peripheral areas and less for females than males. Considering complex resource selection patterns within a fragmented landscape, adult female bears achieved more efficient energy maximization than males as manifested through a tendency toward more circular, and smaller, home ranges. Studies of resource hypotheses in solitary species should consider intraspecific allometric relationships such as sexual-size dimorphism as has been addressed using group size in social species.

Use of Radio-Collars Equipped with Accelerometers, GPS, and Video to Create a Behavioral Based Resource-Use Map

Tyler R. Petroelje, Jerrold L. Belant, Dean E. Beyer, Jr.

Studies of animal behavior ideally would involve direct observations of individuals by researchers to document their activities. Global positioning system (GPS) technology identifies movements of collared animals, however investigations of GPS locations do not always inform the behavior of the individual and field investigations can be time consuming and expensive. Recording animal behavior without an observer present could greatly reduce both time and personnel costs. Collar mounted video cameras are an

increasingly accessible and compact technology that has potential to lend considerable insight into animal behavior. During 2013–2015 we captured and collared black bear and fitted each with a radio-collar equipped with video, GPS, and accelerometer capabilities. We programmed collars to record 20–30 second video clips every half hour during morning and evening activity periods from capture until the battery failed. We programmed collars to obtain a GPS fix every 15 min and to average and store accelerometer readings every 5 min from 1 May to 31 August of each year. We used a resource selection function to compare use of GPS locations with and without video and accelerometer data to describe resource-use across the landscape. We identified behaviors from recorded video footage as breeding (2.0%), foraging (38.3%), resting (16.1%), traveling (39.5%), and unknown (4.1%). We recorded accelerometer measured behaviors as active (79.8%) or inactive (20.2%) during the same period as video data. We recorded GPS cluster location behaviors as foraging (16.9%), resting (49.6%), and unknown (32.4%). Combining video data with GPS and accelerometer data better described resources-use and reduced unknown behavioral assignment Continued use of remote video with GPS collars may provide improved understanding of predator-prey relationships through direct observations of predation events and refine our understanding of seasonality and variability of prey selection to improve our understanding of black bear ecology and better inform management.