Biological Sciences – Terristrial

The following Abstracts are from presentations made at a Joint Meeting of the Montana Chapter of the Wildlife Society, The Society for Northwestern Vertebrate Biology and Partners for Amphibians and Reptile Conservation

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Brucellosis Surveillance in Free-Ranging Montana Elk — Surveillance Challenges and ReSults

Neil Anderson and Jen Williams, Montana Fish, Wildlife and Parks, 1400 S 19th, Bozeman, MT 59718

Montana Fish, Wildlife and Parks has conducted surveillance for brucellosis in elk (*Cervus elaphus*) since the early 1980s. Occurrence of brucellosis in a domestic cattle herd in Montana has raised a concern producers have about potentially infected elk transmitting the disease to cattle. Recent events have increased the challenges of obtaining adequate samples and interpreting standard serologic tests. Based on historic records brucellosis in free-ranging elk has only been documented within the Greater Yellowstone Area with a sero-prevalence of < 4 percent. Sero-prevalence seemingly has not changed greatly over time, but new confounding factors are influencing surveillance activities. A brief history of surveillance efforts, new challenges faced in conducting surveillance and interpreting serologic test results and recent survey findings were presented.

CWD Surveillance in Montana

Neil Anderson and Jen Williams, Montana Fish, Wildlife and Parks, 1400 S 19th Ave., Bozeman, MT 59718

Chronic Wasting Disease (CWD) is a fatal neurological disease of cervids. Montana Fish, Wildlife and Parks has conducted surveillance for CWD since 1998. During 2007-2008, surveillance was conducted in the eastern portion of Montana near the borders of Wyoming and Canada where CWD has been detected in free-ranging deer and elk. Samples from over 1450 deer, elk and moose were collected and tested. The prion associated with CWD was not detected among samples collected. Samples consisted primarily of hunter-harvested animals (n = 1381), road kills (n = 81) and symptomatic animals (n = 15). A total of 177 elk (*Cervus elaphus*), 1060 mule deer (*Odocoileus hemionus*), 239 white-tailed deer (*O. virginianus*) and one moose (*Alces alces*) have been tested. A total of 11,777 deer, elk and moose have been tested since 1998 with no evidence of CWD in Montana's free-ranging populations. Montana has also adopted a management plan should CWD be detected in wild cervids. The recommended alternative presented in the record of decision was discussed.

Northwest Gap Analysis Project: Innovative Approaches to Species Distribution Modeling for Local and Regional Species Conservation

Jocelyn Aycrigg, National Gap Analysis Program, University of Idaho, Moscow, ID 83843

Gary Beauvais, Wyoming Natural Diversity Database University of Wyoming Laramie, WY 82071

Accurately representing species occurrences across large landscapes is vital for species conservation at local and regional scales. Previously, spatial and thematic resolutions at which Gap species modeling was conducted have been too coarse to optimally inform local conservation. Primarily this is because species modeling needs to be consistent across large regions, which require coarser, region-wide environmental data. We attempt to address this mismatch of resolutions by modeling species' range, distribution, and habitat quality as distinct products. Range models express species' spatial arrangement at coarse resolutions using 10-digit hydrological units as map units. Species' distributions were modeled as functions of regionally-mappable environmental variables but also of select fine-resolution variables not available as region-wide layers. Habitat quality models highlighted portions of region-wide distributions determined, via expert input, to support high or low rates of reproduction and survival, and thus present more detailed thematic information. Our approach is being applied to ~ 650 Northwestern terrestrial vertebrates and relies on both deductive and inductive modeling approaches. A web-based expert review system has been developed to obtain invaluable knowledge about species habitat preferences, historical and current range expansion or contraction, and important environmental variables. We believe our approach will make Gap species distribution modeling in the Northwest more applicable to local and regional conservation goals.

Wolf Kill Rates: Predictably Variable?

Matthew S. Becker and Robert A. Garrott, Fish and Wildlife Management Program, Department of Ecology, Montana State University, Bozeman, MT 59717

P. J. White, USDI National Park Service, Yellowstone National Park, WY 82190

Abundance and diversity of the prey assemblage affects ability of predators to successfully capture and kill prey; such variation is a fundamental driver of ecosystem dynamics because per-capita consumption rate strongly influences stability and strength of community interactions. Descriptions of predatory behavior in this context typically include the functional response, specifically the kill rate of a predator as a function of prey density. Thus, a major objective in studying predator-prey interactions is to evaluate the strength of numerous factors related to kill rate of a predator, and subsequently determine forms of its functional response in natural systems because different forms have different consequences for ecosystem dynamics. Recent controversies over the nature of predation focus on respective roles of prey and predator abundance in affecting a functional response. However, resolution requires more direct measures of kill rates in natural systems. We estimated wolf (*Canis lupus*) kill rates in a tractable and newly established wolf-elk (*Cervus elaphus*) bison (*Bison bison*) system in the Madison headwaters area of Yellowstone National Park during winters 1998-1999 to 2006-2007 to document the transition from over seven decades without wolves

to a well-established top predator population. Wolf abundance, distribution, and prey selection varied during the study concurrent with variations in demography, distribution, and behavior of elk and bison. These dynamics enabled us to evaluate factors influencing variations in wolf kill rates and the forms of their functional response.

Citizen Science for Monitoring Common Loons in Glacier National Park

Jami Belt and Sallie Hejl, Crown of the Continent Research Learning Center, Glacier National Park, P.O. Box 128, West Glacier, MT 59936

Steve Gniadek, Glacier National Park, P.O. Box 128, West Glacier, MT 59936

Glacier National Park harbors approximately 20 percent of Montana's breeding common loons (*Gavia immer*), a Montana Species of Special Concern, with an average of 45 adults and five chicks each year. Surveys of Glacier's loon population have been conducted annually since 1988, but limited resources have restricted data collection to a one-day event known as Loon Day. In 2005, the Citizen Science Project for Common Loons was created to gain a better estimate of population health and to begin to identify factors affecting l on nesting success. Since that time, we have recruited and trained nearly 300 volunteers to monitor lakes with loons repeatedly throughout the nesting season. These volunteers conducted more than 1000 surveys of 45 priority lakes, which resulted in a robust estimate of loon population health. The large data set has also given us valuable information about Glacier's loons, uch as chick hatch dates, migration dates, chick mortality, and chick detectability that would have been missed by monitoring only on Loon Day. Volunteers also helped us locate and map nest sites, areas of potential disturbance, and probable nursery areas on each of the lakes with known nesting activity for use in future monitoring and management. Challenges to using the Citizen Science model for this project include investing a substantial amount of effort to find, train and manage volunteers and to maintain data quality. The rewards include educating volunteers in depth about a resource issue, fostering stewardship, and increasing the quantity and quality of data.

Habitat Comparisons of Historically Stable and Less Stable Bighorn Sheep Populations

Ashley C. Beyer, Department of Animal and Range Sciences, Montana State University, 119 Linfield Hall, Bozeman, MT 59717

Management of Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*) focuses on 1) population demographics, 2) immunological state, and 3) habitat characteristics. Demographic targets have been identified for successful populations. Habitats suitable for bighorn sheep have also been identified, and bighorn sheep population response to immunological stressors has been documented. Research has identified domestic sheep (*Ovis aries*) as a potential source of pneumophilic bacteria to bighorn sheep although not all bighorn die-offs are attributed to such contact. Limited research has documented how habitat differences between stable and less stable bighorn populations influence their success. Understanding these habitat differences may help explain how habitat contributes to bighorn

population stability. This study attempts to evaluate differences in spatial, vegetative, and geographic habitat characteristics of summer and winter ranges between historically stable and less stable bighorn sheep populations that occupy rangeland and open forest habitats in Montana in the presence of domestic sheep. Habitat variables will be evaluated for two summers on summer and winter ranges of two bighorn sheep populations in Montana in both their entire seasonal ranges and areas identified as foraging habitat. Land cover, slope, aspect, elevation, solar radiation index, and distance to escape terrain will be quantified in each habitat using a Geographic Information System (GIS). Field sampling will determine shrub canopy cover, frequency of graminoids and forbs, and horizontal visibility of each habitat. Habitat characteristics of historically stable and less stable populations will be compared. Preliminary results were presented.

A Comparison of Non-Invasive Genetic and Traditional Approaches to Estimating Animal Abundance

Ellen Cheng and L. Scott Mills, Wildlife Biology Program, University of Montana, Missoula, MT 59812

Karen E. Hodges, University of British Columbia Okanagan, Kelowna, B.C. V1V 1V7, Canada

Non-invasive genetic population estimation, in which capture-mark-recapture (CMR) statistics are applied to individual genotypes obtained from hair or fecal samples, has gained interest among wildlife managers and researchers as a promising alternative to traditional live-trapping methods when working with rare and elusive species. This study explored another potential advantage of non-invasive genetic population estimation—surveying relatively common and trappable species occurring in difficult-to-access areas. We evaluated efficacy of non-invasive genetic sampling for CMR estimation of snowshoe hare (*Lepus americanus*) densities in the remote backcountry of Glacier National Park, Montana. We tested various combinations of pellet collection methods, plot numbers and sizes, sampling duration, and baits to maximize sample sizes (number of pellets collected for genotyping) and minimize time, labor, and costs in the field. At five study sites in Glacier National Park, we estimated hare abundance using this optimized non-invasive genetic approach as well as traditional live-trapping and pellet index methods. We present findings from this field study and a simulation-based cost-benefit analysis of abundance estimation using traditional live-trapping vs. non-invasive pellet sampling.

Spatial and Temporal Relationships of Adult Male Black Bears to Roads in Northwest Montana, 2003-2004

Tonya Chilton and Richard Mace, Montana Fish, Wildlife and Parks, 490 N. Meridian Rd., Kalispell, MT 59901

Donald Christian[1], Division of Biological Sciences and Wildlife Biology Program, University of Montana, Missoula, MT 59812

Roads have direct and indirect consequences for wildlife. Vehicle collisions are a direct cost of roads on wildlife. Indirectly, roads may increase mortality of game species by

[1] Current address: College of Arts and Sciences. University of Wisconsin-Eau Claire. Eau Claire, WI 54702

increasing hunting pressure along these roads. Little is known about how roads affect hunting vulnerability of black bears (*Ursus americanus*), especially adult males. Adult males are the most desirable age and sex class to many hunters, which could lead to over-harvest of this sex and age class. I hypothesized that adult male black bears will avoid roads during spring and fall hunting seasons compared to summer; so road use, and therefore hunting vulnerability, should decrease during hunting times. I used a sample of six GPS-collared adult male black bears and ANCOVA methods to evaluate whether these bears avoided roads between seasons. This study illustrates the importance of season in determining how bears use roads. My results showed that road metrics proximate to bears decreased from nonhunting to hunting seasons. Adult male black bears were less likely to be near open roads during legal hunting seasons, which may reduce bear vulnerability during the fall hunt. This is consistent with the idea that bears survive to maturity by avoiding roads thus avoiding hunting and traffic; however other possible explanations exist. Especially in the roaded area, elevation and roads were confounded, making it difficult to tease apart individual effects. Thus, interpretations of bear avoidance of roads should be treated with caution, as bear responses to roads may also be a response to elevation.

Ongoing Surveying for Flammulated Owls in Montana Via Citizen Scientists and Technicians

Amy Cilimburg, Avian Science Center, University of Montana. Missoula, MT 59812

Flammulated owl (*Otus flammeolus*) populations in the Intermountain West may be declining due to habitat alterations, yet their secretive nature and scattered distribution have made monitoring difficult. In 2005 the Avian Science Center (ASC) and the Northern Region of the USDA Forest Service (USFS) initiated the first-ever Region-wide survey for flammulated owls in lower elevation, dry forest types of Montana and northern Idaho. Sampling methods using GIS modeling proved effective, and we now have a clearer understanding of owl distributions both east and west of the Divide. However, a long-term monitoring program using an established protocol is needed to understand habitat associations and population trends. A citizen-science approach has potential to provide a cost-effective means of collecting population data across a large area over time, and flammulated owl surveys are particularly appropriate for citizen monitoring because identification is straight forward, equipment is simple and inexpensive, and the public has a keen interest in both hearing owls and contributing to valuable science. In 2007 we initiated a successful pilot project with the help of volunteers from local Audubon groups who "adopted" survey route we plan to expand this monitoring in 2008. I will highlight the successes and challenges of a citizen science approach and discuss how our future surveys will draw on strengths of this approach together with a program using paid USFS technicians. Ultimately our goal is to better assess the habitat association of these owls particularly in the wildland urban interface.

Habituation, Hunting, and Recreation: Understanding Human Influences on Elk Behavior on the Wildland-Urban Interface

Shawn Cleveland. and Mark Hebblewhite, Wildlife Biology Program, University of Montana, 32 Campus Drive. Missoula, MT 59812

Mike Thompson, Montana Department of Fish, Wildlife and Parks, 3201 Spurgin Road, Missoula, MT 59802

Elk (*Cervus elaphus*) are increasing in many areas throughout the west, especially in the wildland-urban interface (WUI). Wildlife managers are unable to use traditional public hunting to manage these elk given the resistance WUI homeowners to hunting near their homes. As an example of this problem, the intrinsic growth rate of the North Hills Elk Herd in Missoula has been ~11 percent since the early 1980s, and the herd now numbers over 300 animals. North Hills' landownership is a complex matrix of public and private lands that range from partial to complete exclusion of hunting; thus, elk harvest is low and provides little population-level regulatory ability. Little research has been done assessing either the effects of hunting on elk distribution or the specific effects that hunting has on elk and human avoidance in the WUI. We used resource selection functions (RSF) based on GPS-collared adult female elk during the fall 2007 hunting season to test the effects of hunting on elk resource selection and avoidance behaviors in the WUI. Preliminary RSF results suggest that elk avoided areas of human use only during hunting season. Building on this work, a series of approach trails will be implemented to determine the degree of avoidance of humans by elk for hunted and non-hunted populations. This knowledge will allow managers to better understand the degree of hunting necessary to reduce elk habituation while providing needed information on the efficacy of current hunting seasons for managing WUI elk populations.

The Effect of Global Climate Change on a Snow Dependent Species: a Case for the Wolverine

Jeffrey P. Copeland, Kevin S. McKelvey, John R. Squires, and Michael K Schwartz, USDA, Rocky Mountain Research Station, 800 E. Beckwith. Missoula, MT 59807

Keith B Aubry, USDA Forest Service. Pacific Northwest Research Station, Olympia, WA 9 512

Arild Landa, Norwegian Institute for Nature Research, Tungasletta 2, N-7485, Trondheim, orway

Jens Persson, Department of Animal Ecology, Swedish University of Agricultural Science , 901 83, Umea, Sweden

Jason Wilmot, Northern Rockies Conservation Cooperative, PO Box 2705. Jackson, WY 83001

Robert Inma, Wildlife Conservation Society, 2023 Stadium Drive, Suite 1A. Bozeman, MT 59715

Howard Golden, Alaska Department of Fish and Game, 333 Raspberry Road, Anchorage, AK 99518

John Krebs, Columbia Basin Fish and Wildlife Compensation Program, 103-333 Victoria St., Nelson, BC. V1L 4K3, Canada

Eric Lofroth, Ministry of Environment. P.O. Box 9338. Victoria, B.C. V8W9M1. Canada,

Audrey Magoun, Wildlife Research and Management, 3680 Non Road. Fairbanks, AK 99709

Wolverine (*Gulo gulo*) show a circumpolar arctic distribution with southern peninsular extensions occurring in mountainous regions of orth America and Eurasia. It has been hypothesized that wolverines require snow for reproductive denning. If wolverines are associated with a climatic zone associated with persistent snow during the denning season (Feb-May), they could be adversely affected by global warming. To investigate the association of wolverine reproductive denning to the presence of persistent spring snow, we overlaid all documented wolverine den sites on a MODIS-based snow coverage for the period 24 April to 21 May, from 2000 through 2006. Of the 631 dens, all but six occurred in pixels which were typed as snow throughout the period in at least 1 of 7 yrs. Additionally, we found that year-around habitat use was also constrained to these same areas. In 6 radio telemetry studies in the western U. S., over 90 percent of year-around relocations occurred within areas associated with persistent spring snow. Coupled with recent analyses of historical occurrence and genetic studies (see Schwartz et al), these data provide strong evidence that wolverines are confined to a narrow and easily defined climatic niche.

Status of Spotted Knapweed Invasions in Wildlife Habitat

Janelle G. Corn, Jim M. Story and Linda J. White, MSU Western Agricultural Research Center. Corvallis, MT 59828

Spotted knapweed (*Centaurea stoebe micranthos*) is a widespread noxious weed in the western U.S. and Canada. Spotted knapweed can be controlled using herbicides, mowing, grazing, cultivation, and biological control (natural insect enemies introduced from the native range of the plant). We are beginning to see reduction of knapweed density in rangeland wildlife habitat, which we can attribute at least in part to biological control insects. Some recent findings are summarized. The root weevil (*Cyphocleonus achates*) kills knapweed plants and reduces thriftiness of surviving plants. At two sites where *C. achates* was released and weevil populations and knapweed density subsequently measured, dramatic increases in weevil populations were followed by equally dramatic declines of knapweed density (77 and 99% decline after 11 yrs). In field releases of *C. achates* that incorporated control plots, declining biomass of knapweed could be attributed to effects of weevil attack within 4 years of their release. Knapweed density was also impacted by flooding, drought, and grazing by white-tailed deer. Although drought reduces survival and vigor in knapweed plants, *C. achates* effects are demonstrable and additive. Finally, larval development of some biological control agents, and evidence of accelerated development over the last 7 yrs were discussed.

Climate Change Impacts to Amphibians and Reptiles

Stephen Corn, USDI Geological Survey, Aldo Leopold Wilderness Research Institute, 790 E. Beckwith Avenue, Missoula, MT 59801

Amphibians and reptiles may show greater responses to climate change than will other terrestrial vertebrates because, as ectotherms, life history, particularly reproduction, growth, and development, are directly affected by temperature. All species will be faced with indirect effects of climate change, such as changes in habitat due to changing hydrology or vegetation, but herpetofauna are less vagile than birds and mammals and will be less able to shift their distributions to match changing climates. For amphibians, effects that have been documented often involve changes in phenology. The timing of snowmelt is the primary influence on when montane amphibians breed. In the northern Rocky Mountains and the Pacific Northwest, amphibians are likely breeding earlier than in 1950. Climate models predict reduced extent and duration of future snow packs and increasing summer temperatures, which may alter the hydrology of the small wetlands that most species require for breeding. Increasing temperature has been hypothesized to facilitate the spread of a pathogenic fungus into some populations of tropical frogs. The relevance to Montana's amphibians is uncertain. For reptiles, particularly those with temperature-dependent sex determination, increasing temperatures may have large demographic effects. Specific predictions about effects of climate change are difficult and reflect the complexity of the issue. Montana herpetofauna occur mostly at the extremes of their climate envelopes, and some species may benefit from climate change.

Sustaining Wildlife Populations in the Madison Valley, Montana, in the Face of Subdivision Development and Human Population Growth

Lance Craighead, Brent Brock and Thomas Olenicki , Craighead Environmental Research In titute, 201 South Wallace Ave., Suite B2D, Bozeman, MT 59715

A Madison Valley Wildlife Overlay district was developed for the Madison Valley to help ensure that new development in the Valley protects the wildlife resource by identifying areas critical for wildlife and developing guidelines and requirements for development within these areas. This is a needed planning tool throughout the Intermountain West. In most counties wildlife habitat is given little consideration and is usually input into the planning process after many crucial decisions have already been made. Little consideration is given how development will impact neighboring properties or fit into a larger planning area. The Overlay district is based upon *A Wildlife Conservation Assessment of the Madison Valley, Montana* by the Wildlife Conservation Society, the Craighead Environmental Research Institute, and the Madison Valley Ranchlands Group. The assessment was based on analysis of 15 focal species. Priority areas derived from the Assessment were divided into four categories: Wildlife diversity habitat areas, Wildlife habitat connectivity areas, Riparian willow/cottonwood habitat areas, and Riparian corridors. The first phase of the project identified and mapped the most critical areas in the valley for wildlife habitat. General consensus was reached with area biologists and results were discussed and refined with other stakeholders. The second phase will develop specific guidelines for proposed development within the conservation overlay for various habitat quality 'zones' that maintain wildlife value of the area. A final proposal, maps, and development guidelines will then be presented to the County Commissioners for approval.

The Trivers-Willard Model and Southwestern Montana Elk

Julie A. Cunningham and Kenneth L. Hamlin, Montana Fish, Wildlife and Parks, 1400 S. 19th Avenue, Bozeman, MT 59718

Thomas O. Lemke, Montana Fish, Wildlife and Parks. 406 Chestnut Ln, , Livingston, MT 59047

The Trivers-Willard (1973) model (TWM) suggests maternal control of offspring sex (*in utero* or by the end of parental investment) may be an adaptive advantage in some species. In sexually dimorphic, polygynous ungulates, the TWM suggests male offspring should be favored when the female is in superior condition. Population and harvest models for elk (*Cervus elaphus*) often assume sex ratios of 50:50 at parturition and recruitment. We tested this assumption using 11,094 known-sex fetal elk and 4404 known-sex calf elk (age 6-8 mos) from hunter harvest in three herds in southwestern Montana (1961-2007). We included maternal, individual, and environmental condition covariates to test the TWM *in utero* and near recruitment. After 30 logistic regression and chi-square te ts on fetal sex ratios using data from three populations, five distinct time periods, and 11 variables, we found significance in three tests ($P \leq 0.05$); two supporting the TWM, and one opposing it, suggesting little evidence to support maternal control of fetal sex. However, all populations

tested demonstrated a significant female-biased ratio of calves at harvest (60:40; $P \leq 0.003$). We concluded that differential mortality of males must occur between the first trimester *in utero* and age 6-8 months. However, due to inconsistent evidence from six elk calf mortality studies across Montana, Wyoming and Idaho, further research is necessary to determine when and how sex ratios become biased. We suggest that elk population managers take into account potential differences in sex ratio at recruitment when building population and harvest models.

Influence of Nutrient Acquisition and Habitat Selection on Breeding Propensity of Female Lesser Scaup on Lower Red Rock Lake, Red Rock Lakes National Wildlife Refuge

Kyle A. Cutting and Jay J. Rotella, Department of Ecology, Montana State University, Bozeman, MT 59717

Jeffrey M. Warren, USDI Fish and Wildlife Service, Red Rock Lakes National Wildlife Refuge, Lima, MT 59739

Susan E. Wainwright and John Y. Takekawa, U.S. Geological Survey, San Francisco Bay Estuary Field Station, Vallejo, CA 94592

North American lesser scaup (*Aythya affinis*) populations have been declining for nearly 3 decades. Evidence suggests that female lesser scaup are arriving at breeding areas in poorer body condition then historically, leading to reduced female breeding propensity. We undertook the current study to investigate relationships among nutrient allocation and acquisition strategies, pre-breeding habitat selection, and breeding propensity of adult female lesser scaup. During summer 2007, we conducted the first year of data collection for this 3-yr study. We captured 30 female lesser scaup on Lower Red Rock Lake, Red Rock Lakes NWR in mid-May, marked them with radio transmitters, and followed them intensively through the breeding season. Extreme drought conditions persisted throughout the field season. One radio-marked female mortality occurred in May, 12 females emigrated prior to mean nest initiation, i.e., 21 Jun, 17 remained throughout the egg laying period, and 13 remained until tracking ended in late August. We found six nests from 17 females that remained throughout the egg-laying period. Home-range habitat attributes of pre-breeding females investigated include average water depth, number and size of ponds, percent open water, total open water/emergent vegetation edge, and number of islands within the core area. Female body tissues (blood and claw), local forage items, and an egg from successful breeders were collected for stable isotope analysis to assess nutrient strategies likely affecting breeding propensity. Preliminary analysis is underway and results of those analyses were presented. Our goal is to gain insights into important life history strategies that limit reproduction in female lesser scaup.

Blood-Lead Levels of Fall Migrant Golden Eagle in West-Central Montana

Rob Domenech, Raptor View Research Institute, P.O. Box 4323, Missoula, MT 59 06

Heiko Langner, Environmental Biogeochemistry Laboratory, Geosciences Department, University of Montana. Missoula, MT 59812

Tyler Veto, University of Montana. Missoula, MT 59812

Lead has long been documented as a serious environmental hazard to eagles and other predatory, opportunistic and scavenging avian species. Due to lead poisoning in the bald eagle (*Haliaeetus leucocephalus*) and the golden eagle (*Aquila chrysaetos*), the use of lead shot for waterfowl hunting on federal and state lands was banned in 1991. At that time, this was thought to be the only major source of the lead exposure. More recently, lead poisoning from ingested lead-bullet fragments and shotgun pellets has been identified as the leading cause of death in California condors (*Gymnogyps californianus*), leading to the recent ban of lead ammunition within the "California Condor Recovery Zone." Another on-going study on common ravens (*Corvus corax*) and Bald Eagles in Wyoming has shown a direct correlation between very high blood-lead levels and the onset of rifle hunting season. Indeed, overwhelming evidence shows that lead toxicity is still prevalent in the environment, and mounting data points to fragmented rifle bullets as the source. We sampled blood from 39 Golden Eagles during fall 2006 and 2007 to quantify a suite of heavy metal contaminants with emphasis on lead. We performed a simple field test on 18 eagles and found eight to contain elevated blood-lead levels. All 39 samples were lab analyzed, and full results of this analysis were presented.

Understanding Climate Change Interpretation

Phillip Farnes, Snowcap Hydrology, PO Box 691, Bozeman, MT 59771-0691

Climate change has been in the news recently with impacts projected to vary from little change to catastrophic. To adequately understand what is being presented, one needs to understand how the data is being interpreted and in some cases "spun." Examples of how earlier records are ignored, data is interpreted, and the same data can be interpreted differently was presented with numerous examples. Examples will consist mostly of Montana data. The main emphasis will be on weather records, mountain snow pack, fires, and stream flow. Long-term records will be compared to short term records that are currently being used to advance the impact of climate change. Words such as "if," "when," "current trends," and "should" are being interpreted as "will," "inevitable," or "absolute" by many ob ervers. ometimes, changes that are reported to be caused by climate change result from other factors. In some cases, natural variability is interpreted to imply climate change. By understanding how the data is collected, modified, and reported, individuals will be better able to evaluate how climate change might impact their operations, or how it might influence their interpretation of field data or natural processes.

Strong Substructure of Greater Yellowstone Area Bison Revealed by Mitochondrial DNA from Amplified Fecal Samples

Florence M. Gardipee, Richard L. Wallen, Michael P. O'Brien, Gordon Luikart, and Fred Allendorf, Wildlife Biology, University of Montana, 32 Campus Drive, Missoula, MT 59812

Bison (*Bison bison*) in the Greater Yellowstone Area (GYA) congregate in distinct geographic areas during the rut. We hypothesized that fidelity to breeding areas would result in genetic differences among GYA breeding groups. We analyzed fecal samples from 120 bison in five breeding groups during the ruts of 2005 and 2006. Sequencing and restriction fragment length polymorphism analysis of a 470 bp segment of the mtDNA control region revealed significant differentiation between bison in Yellowstone National Park (YNP) and Grand Teton National Park ($F_{ST} = 0.236$, $P < 0.001$). We found even greater differentiation within YNP between the Lamar Valley and Hayden Valley breeding groups ($F_{ST} = 0.505$, $P < 0.001$), which are <50 km apart. This fine-scale genetic differentiation among breeding groups within YNP suggested strong female philopatry to natal ranges. These findings also suggested that these breeding groups should be considered separate management units with respect to conservation of current levels of genetic diversity. However, examination of nuclear loci is necessary to assess male mediated gene flow and better understand population structure of GYA bison. Decision-makers should consider genetic monitoring in the future to determine which breeding group winter migrants have emigrated from when taking actions to resolve brucellosis risk management priorities at park boundaries. The probability of conserving current levels of genetic diversity under various management scenarios should be evaluated as well.

Monitoring Common Loons in Glacier National Park

Steve Gniadek, Glacier National Park, P.O. Box 128, West Glacier, MT 59936

The common loon (*Gavia immer*) has been documented from Glacier National Park since at least the early 20th Century. Sporadic observations were recorded until 1986 when the Montana Loon Day Survey was initiated. Efforts by park employees and volunteers increased during the 1990s; number of lakes surveyed on Loon Day increased from 31 to 50, the number of lakes with loons varied between 13 and 19, the number of adults varied between 26 and 48, and the number of chicks detected varied between 2 and 14. Mean chick production for the park during 1989-2004 was ~ 5/yr. Some lakes, particularly in the northeast part of the park, appeared to decline in loon productivity, although others on the west side exhibited increased chick production. However, prior to the advent of the Citizen Science Loon Project in 2005, variability in annual survey effort, inconsistencies in the abilities, dedication, and dependability of volunteers, and the limited time devoted to sampling loons in the park together cast doubt on survey results and reliability of trends. Lack of adequate staff and funding to coordinate loon surveys precluded intensive educational efforts, confirmation of questionable observations, clarification of ambiguous information, or maintenance of long-term data bases. Non-biologist volunteers have been a powerful force in some wildlife survey efforts, but coordinating and supporting such endeavors can be very labor and time-intensive. Because Glacier NP is host to ~ 20 percent of Montana's breeding Common Loons, a state species of special concern, improving reliability of park

estimates of status and trend are necessary to ensure per istence of this specie . A itizen cien e approach is one way to help achieve that goal.

Predicting the Impacts of Land-Use Policies on Habitat for Amphibians Across a Privately-Owned Landscape in Northern Idaho

Caren S. Goldberg and Lisette P. Waits, Fish and Wildlife Resources, University of Idaho, P.O. Box 441136, Moscow, ID 83844-1136

Predicting impacts of landscape change on wildlife population i e sential for designing strategies to ensure persistence of species in a changing environment. We surveyed for presence of pond-breeding amphibian larvae at 105 randomly-selected wetlands in rural northern Idaho. We compared algorithmic (random forest) and information theoretic approaches to modeling breeding habitat for olumbia spotted frog (*Rana luteiventris*), Pacific treefrogs (*Pseudacris regilla*), and long-toed alamanders (*Ambystoma macrodactylum*) using these data. The information theoretic approach indicated that all three species were negatively associated with presence of fish, while the algorithmic approach indicated that fish were an important predictor of occurrence for Pacific treefro s and long-toed salamanders and that soil type was an important predictor for all specie . The best models from the information theoretic approach indicated that long-toed salamanders were positively associated with wetlands in forests and grasslands and negatively associated with agriculture, while Pacific treefrogs were positively associated with wetlands in agriculture and low-density forests and negatively associated with development. Both algorithmic and information theoretic models found that solar insulation was strongly associated with Columbia spotted frog presence. We used these models in conjunction with sets of stochastically predicted landscapes based on landowner surveys to predict the impact of land-use policies on amphibian breeding habitat. Policies that encouraged forest thinning and transitioning land from agriculture to grassland resulted in increased habitat for long-toed salamanders and Columbia spotted frogs. Concentrating future development around existing towns resulted in reduced breeding habitat for all three species.

Landscape Analysis of Baling Twine in Osprey Nests

Erick Greene and Anicka Kratina-Hathaway, Division of Biological Sciences, University of Montana, Missoula, MT 59812

Max Egenhoff and Matt Parker, Hellgate High School, 900 South Higgins Street, Missoula, MT 59801

Rob Domenech, Raptor View Research Institute, P.O. Box 4323, Missoula, MT 59801

Heiko Langner, Environmental Biogeochemistry Laboratory, Geosciences Department, University of Montana, Missoula, MT 59812

Baling twine is polypropylene rope used by farmers to tie together bales of hay. After the hay is used to feed livestock, loose strands of baling twine are sometime left in fields. ospreys (*Pandion haliaetus*) have a propensity to collect baling twine and use it to line their

nests. For example, one osprey nest near Missoula, Montana contained > ¼ mile of baling twine. Chicks and adults can easily become entangled in baling twine causing significant mortality: some studies estimate that over 10 percent of osprey chicks become so tangled that they die in the nests before fledging. Our goal was to describe the general extent of this problem. We sampled 115 osprey nests in parts of western Montana, Wyoming, Idaho and Washington. To test what landscape features are associated with the amount of baling twine in Osprey nests we used GIS analyses to describe land use within several different distances of nests. Not surprisingly, nests that are far (≥ 3 km) from any agricultural land tend to have no baling twine. However, the amount of agricultural land and livestock pastures within 1 km of osprey nests are poor predictors of the amount of baling twine in nests. These analyses suggest that Ospreys travel considerable distance to collect baling twine, and that fairly distant point sources of baling twine, e.g., a single, small dirty field, can be important. Our initial efforts in public education about the importance of picking up baling twine are promising.

Winter Survival and Habitat Selection by Female Greater Sage Grouse in South Phillips County, Montana

Erick Greene, Division of Biological Sciences, University of Montana, Missoula, MT 59812

Angela Battazzo, 1720 SW 354th Place, Federal Way, Seattle, WA 98023

Heather Sauls, USDI Bureau of Land Management, 1246 Cleveland Street, Meeker, CO 81641-3214

Chris Guglielmo, Department of Biology, University of Western Ontario, London, Ontario, Canada N6A 5B7

Populations of greater sage grouse (*Centrocercus urophasianus*) have been seriously declining throughout their range. Most research has focused on demography, survivorship, habitat selection, and reproductive success during spring and summer. In contrast, there have been fewer ecological studies of survival and habitat and food selection during winter. We focused on over-winter survival and habitat selection of female sage grouse in South Phillips County, an area where greater sage grouse still occur in relatively high densities. We tested the long-held assumption that overwinter mortality of juvenile and yearling birds is about twice that of adult females. We followed 159 radio-marked juvenile, yearling, and adult females during the 2005 and 2006 winters. During these two winters all cohorts survived better than most published accounts (~ 90% survivorship) with juvenile and yearling hens surviving as well as adult hens. Greater sage grouse are sagebrush specialists during winter, subsisting almost entirely on a diet of *Artemisia* species. This narrow diet presents some physiological challenges, since sage leaves are generally difficult to digest and contain many secondary defensive compounds such as monoterpenes, sesquiterpene lactones, coumarins, and flavonoids. During winter, sage grouse in our study tended to select winter feeding sites that were relatively flat, and selected sage plants that contained higher crude protein levels than available across the landscape. We discussed general implications of our results for management and conservation of sage grouse.

Spatial Responses and Foraging Dynamics of Elk in Relation to Winter Wolf Predation Risk in Yellowstone National Park

Claire N. Gower and Robert A. Garrott, Montana State University, Fish and Wildlife Management Program, Department of Ecology, 310 Lewis Hall, Bozeman, MT 59717

P.J. White, Yellowstone Center for Resources, Yellowstone National Park, WY 82190

In the absence of an effective predator, food acquisition and energy conservation during winter largely influence spatial patterns of large herbivores in northern temperate regions. Resources are scarce and the energetic cost of movement is high; as a result animals would be expected to minimize movement to avoid unnecessary energetic costs. When a top predator is added to the system, such a strategy may not be compatible with avoiding predation risk, animals may increase their movement to avoid detection or facilitate escape. While avoiding predation, large herbivores must also balance conflicting demands of satisfying physiological needs. To evaluate spatial responses and foraging dynamics of elk (*Cervus elaphus*), with and without wolves (*Canis lupus*), we conducted an intensive telemetry-based study of the Madison-Firehole elk herd during 1991-2007. This occurred prior to significant wolf reestablishment (1991-1997), and when wolves had an established presence in the study system from 1998 through 2007. Prior to wolf-reintroduction, we randomly collected ~ 6000 elk locations, representing 5000 elk groups and 1900 independent behavioral observations (~ 950 hrs of observation time). Our data were complimented by > 5000 elk locations, representing 3500 elk groups, and 1850 independent behavioral observations (~ 925 hrs) after the reintroduction of wolves. We observed modest changes in home range size and reduced site fidelity as elk adjusted to presence of wolves, and some long distance dispersal away from core wolf use sites. Foraging behavior remained relatively stable with and without presence of wolves.

Keeping Common Species Common: What Does the Future Hold for Western Painted Turtles In The Mission Valley, Montana?

Kathleen A. Griffin and Daniel H. Pletscher, Wildlife Biology Program, University of Montana, Missoula, MT 59812

Understanding population dynamics at the local and metapopulation level is critical for long-term conservation of wildlife. Survival and movement patterns provide valuable information for making management decisions in the face of environmental changes. I used capture-mark-recapture methods to estimate apparent survival rates and movement probabilities of adult and juvenile western painted turtles (*Chrysemys picta bellii*) across space and time in northwestern Montana. I also conducted road mortality surveys to examine the potential impacts of road mortality on the overall population size and structure. Five pond complexes were sampled three times a year from fall 2002 to spring 2005. I captured 1072 individual adults 5050 times and 442 individual juveniles 3078 times. Although both juvenile and adult apparent survival rates were influenced by pond, seasons, and year, I found very different patterns, spatially and seasonally, between age classes. Movement rates were

very low (< 4 %) and were influenced by distance between ponds and depth of originating pond. Road mortality averaged 185 individuals/year. Annual road mortalities ranged widely depending on pond characteristics but in general were higher than the 2-3 percent mortality suggested by other research to likely affect long-term viability in turtle populations. Population growth rate was negatively influenced by the presence of roads and positively influenced by movements. These survival and movement patterns illuminate the importance of maintaining habitat connectivity for long-term population viability. This population will be discussed in relation to the planned Highway 93 reconstruction project and the potential for climate change to alter wetland habitats.

Common Loon Movements over the Past 28 Months

Brett Gullett, Tribal Wildlife Management Program, Confederated Salish and Kootenai Tribes, P.O. Box 278, Pablo, MT 59855

Each year hundreds of common loons (*Gavia immer*) stage on Flathead Lake during their fall migration. Banding data has provided information on winter locations and a few stop locations in between. Documenting the timing, route, duration and destinations are goals of this project. In October 2005 four adults were captured and surgically implanted with intra-abdominal Argos PTT-100 satellite transmitters (Microwave Telemetry, Inc.). Modifications of each PTT included doubling the battery capacity and fusing attachment materials to the exterior (final weight 65 g). Transmitter duty cycles were eight hrs on and 26 hrs off during the first six weeks to intensely monitor migration timing. Along with the PTTs, each bird was banded with USFWS and color bands. Updated information on loon movements was made accessible by using Satellite Tracking and Analysis Tool (STAT). Upon release each individual occupied separate locations of Flathead Lake. While one loon departed within the first week after surgery, three individuals remained on Flathead Lake until early November. Two general routes have led to four separate winter locations. Three individuals returned north along the eastern route to breeding areas in Alberta and Saskatchewan, Canada. Only one transmitter remained active since the fall/winter 2006-2007 to migrate along the same route as the earlier fall two more seasons. The distance between breeding and winter locations ranged from 2300 and 3535 km for each of the loons.

Estimating Territory Occupancy, Colonization Rates, and Extinction Rates for Common Loons in Northwest Montana

Christopher A. M. Hammond, Wildlife Biology Program, College of Forestry and Conservation, University of Montana. Missoula, MT 59812

Michael S. Mitchell, USDI Geological Survey, Montana Cooperative Wildlife Research Unit, 205 Natural Sciences Building, University of Montana, Missoula, MT 59812

Our research was designed to investigate the key biotic and abiotic factors influencing loon presence and identify, in addition to breeding lakes, other lakes that are important to common loons (*Gavia immer*) in northwest Montana. Specifically, we investigated the relationships between habitat characteristics, disturbance, and intraspecific interactions, and how they may be related to territory occupancy. Landscape scale intraspecific covariates

were the mo t important factors influencing occupancy while colonization and extinction rates remained constant. Models with habitat covariates and disturbance covariate ranked low. These results suggest that colonization and extinction rates are in a state of equilibrium, i.e., if an occupied territory is lost an unoccupied territory becomes occupied. Re ult al o support that while habitat and disturbance characteristics may have considerable influence on nest success and chick survival, they have little influence on territory occupancy. Prior to any management action, managers should evaluate the potential effects a ociated with increasing the probability of an unoccupied territory becoming occupied as increasing the number of occupied territories may not only have a positive effect on nest success and chick urvival, but at some threshold may also have a negative effect.

The Potential Effect of Energy Development on Ungulates in Eastern Montana: A Literature Review

Mark Hebblewhite, Zachary Voyles, and Darin Newton, Wildlife Biology Program, University of Montana. Mis oula, MT 59812

Windy Davis. Montana Fish, Wildlife and Parks. Miles City, MT 59301

Energy development is arguably one of the biggest threats to wildlife conservation in eastern Montana. Drawing on the published and gray literature, we review the effects of energy development throughout similar habitats present in ea tern Montana throughout Alberta, Montana, Idaho, Wyoming, Colorado, and elsewhere in the Rocky Mountain west on ungulates including mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), bighorn sheep (*Ovis canadensis canadensis*), and pronghorn antelope (*Antilocapra americana*) We summarized effects of different kinds of energy development (treatments), different study designs (from weaker to stronger inference; observational, comparative, experimental, before-after-control-impact), response variables (vigilance, group size, resource selection, survival, etc), and general conclusions of each study. In general, we found that most studies focused on short-term effects of energy development on individual ungulate species during initial development phases. Despite the short-term perspective, most studies showed negative effects on some response variable during energy development. However, we argue that short-term, individual species-focused studies are unlikely to demonstrate the cumulative, community-level impacts of broad-scale landscape conversion associated with extensive energy development on wildlife. We illustrate this point with two case studies; cumulative impacts on woodland caribou in Alberta's boreal forest, and mule deer in Wyoming. We conclude by reviewing principles of adaptive management as applied to landscape scale energy development and provide a template for future studies of the effects of energy development on the ecological communities of eastern Montana.

Wildlife Use of Two Existing Bridges and Citizen Documentation of Wildlife Sightings Along State Highway 75, Blaine County, Idaho

Marcel P. Huijser, Angela Kociolek, and Doug Galarus, Western Transportation Institute, Montana State University (WTI-MSU), PO Box 174250, Bozeman, MT 59717-4250

A 26-mi section of State Highway 75 between Timmerman Junction (Jct. with Hwy 20) and the Trail Creek Bridge in Ketchum, Idaho, is likely to be widened because of an increase in traffic volume and traffic safety concerns. The increase in traffic is associated with human population, and job growth. Currently, about 30-50 wildlife-vehicle collisions per year occur on this road section, mostly with mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*). We monitored wildlife passages under two existing bridges across the Big Wood River with photo cameras between 15 April and 11 September 2007. During the same time period, wildlife sightings (dead and alive) were recorded by citizens who traveled the 26-mi road section. Species that passed under the two existing bridges included mule deer (n = 129), red fox (n = 44), mice (n = 35), ground squirrels (n = 21), raccoon (n = 15), weasel (n = 14), red squirrel (n = 10), skunk (n = 5), pine marten (n = 3), black bear (n = 2), and mountain lion (n = 1). Sightings of wildlife (dead and alive) along the entire 26-mi corridor included elk (n = 207), mule deer (n = 117), red fox (n = 24), moose (n = 3), black bear (n = 3), and wolf (n = 2). We conclude that, at least during summer, the two existing bridges were not used by elk, whereas elk did cross the road elsewhere, apparently in large numbers. In addition, there were a minimum of 18 deer- and three elk-vehicle collisions during this time period, indicating that animal-vehicle collisions were substantial, and that mitigation measures may be warranted, both because of human safety and habitat connectivity concerns.

Are Montana's Severe Wildfires Catastrophic or Natural Events?

Richard L. Hutto, Avian Science Center, Division of Biological Sciences and Wildlife Biology Program, University of Montana, Missoula, MT 59812

Many scientists and forest land managers concur that past fire suppression, grazing, and timber harvesting practices have created unnatural and unhealthy conditions in the dry, ponderosa pine forests of the West. Specifically, such forests are said to carry higher fuel loads and experience fires that are more severe that those that occurred historically. It is unclear, however, how far these generalizations can be extrapolated to other forest systems. Insight into historical forest conditions can be gained through careful consideration of the ecology of plant and animal species that could be considered fire specialists. In western Montana there is one bird species (Black-backed Woodpecker [*Picoides arcticus*]) that is so specialized on exploiting the abundance of beetle larvae in severely burned forests that it is nearly restricted in its habitat distribution to such conditions. This distribution pattern has profound implications because it brings into question the hypothesis that the severe fires we see burning in many, if not most, western forests are "unnatural" or "unhealthy" and suggests instead that severely burned forest conditions across a broad range of forest types must have occurred naturally for millennia. These findings highlight the fact that there are ecological benefits associated with severe fire and suggest that the presence and importance of severe fire may be much broader than what has been assumed on the basis of historical fire-scar studies.

Montana Avian Influenza Surveillance Project

Rosemary Jaffe and Neil J. Anderson, Montana Fish, Wildlife and Parks, 1400 S 19th, Bozeman, MT 59718

Gerald W. Wiscomb and John E. Steuber, USDA APHIS Wildlife Service , PO Box 193 , Billings, MT 59103

The USDA and USDI Fish and Wildlife Service initiated a nationwide avian influenza (AI) surveillance project in 2006 in response to concern about the potential expansion of the Highly Pathogenic Avian Influenza (HPAI) H5N1 Asian strain to North America. Montana is a priority state in the nationwide surveillance because it borders Canada and contain both the Pacific and Central Flyways. Montana Fish, Wildlife and Parks (FWP) and USDA/APHIS/ Wildlife Services (WS) have therefore conducted AI surveillance in Montana during the la t two years. Multiple sampling strategies were employed to maximize the chance of detecting HPAI H5N1. Wild and urban live and hunter-harvested bird surveillance targeted specific species spatially distributed across the state and temporally distributed across the sampling period. Environmental sampling was also spatially and temporally distributed. Mortality/ morbidity samples were collected opportunistically during 2006, while mortality transect were added as a mortality/morbidity surveillance technique in 2007. Statewide surveillance was initiated in August 2006 and July 2007 and was conducted for five months each year. FWP and WS collected a total of 2200 and 1502 live and hunter-harvested bird samples during 2006 and 2007, respectively. FWP collected 65 mortality/morbidity sample in 2006 and 48 in 2007, and 120 mortality transects were conducted during 2007. WS collected 998 environmental samples in 2006 and 649 in 2007 statewide. Low pathogenic avian influenza was found in samples from both years as expected. The HPAI H5N1 Asian strain was not detected in Montana or elsewhere in North America during the 2006-2007 surveillance.

Rocks to Riverscapes: Factors Influencing Rocky Mountain Tailed Frog Tadpole Abundance at Multiple Spatial Scales

Jason L. Jones, Idaho State University, Department of Biology, Box 8007, Pocatello, ID 83209

The ecology of stream organisms can vary with ontogeny, spatial scale, and network context, especially if the species' range encompasses strong biogeoclimatic gradients. The goal of my study was to evaluate the influence of abiotic and biotic factors on Rocky Mountain tailed frog (*Ascaphus montanus*) tadpole densities across a nested hierarchy of spatial scales in two large, biogeoclimatically distinct stream networks. Specifically, my objectives were to use the Akaike's information criterion (AIC) modeling approach to (1) examine habitat relationships at the microhabitat, reach, and sub-basin scales, (2) examine the importance of periphyton (food) and predation (fish) versus abiotic models for explaining tadpole abundance at the microhabitat and reach scales respectively, (3) evaluate the differences observed in tadpole ecology between the two different stream networks based on the model outputs, and (4) determine whether habitat relationships change for older tadpole age classes. I conducted my surveys in western Montana and northern Idaho. To detect patterns across a hierarchy of spatial scales, I stratified each network into basins, reaches, and channel units, and randomly sampled a minimum of 240 channel units in each, from headwaters to the largest stream order occupied by tadpoles. Tadpoles were relatively abundant and ubiquitous in both stream networks. The lowest ranking, best fitting, AIC model

(abiotic and biotic) for tadpole densities differed between the age classes, across each scale, and between the two stream networks. My findings illustrate the potential problems with the typical habitat modeling and "one size fits all" approach to managing sensitive stream taxa.

Modeling Utilization Distributions in Space and Time

Kim A. Keating, USGS Northern Rocky Mountain Science Center, Forestry Sciences Laboratory, Montana State University, Bozeman, MT 59717

Steve Cherry, Department of Mathematical Sciences, Montana State University, Bozeman, MT 59717

Van Winkle's (1975) concept of the utilization distribution (UD) has seeded important progress in home-range studies, where it forms the quantity of interest when modeling frequency of animal occurrence in two-dimensional space. However, it lacks generality. We extend the definition of the UD to encompass the four dimensions of space and time. We then extend the application of kernel home range estimation methods to enable estimation of UDs in this higher-dimensional space. In particular, our extension of the product kernel estimator incorporates a new kernel appropriate for circularly distributed covariates, like day of year. Using Monte Carlo simulations, we examine the performance of temporally dynamic UD models. Empirical application of such models is illustrated by estimating the UDs of bighorn sheep (*Ovis canadensis*) in the Many Glacier area of Glacier National Park, Montana. For this application, we model UDs in three dimensions that include geographic (x,y) coordinates and day of year.

Grizzly Bear Density in Glacier National Park

Katherine C. Kendall, USGS-NOROCK Science Center, Glacier Field Station, Glacier National Park, West Glacier, MT 59936

Jeffrey B. Stetz, University of Montana, Missoula, MT 59812

David A. Roon and Lisette P. Waits, University of Idaho, Moscow, ID 83843

John B. Boulanger. Integrated Ecol. Research, British Columbia, Canada

David Paetkau, Wildlife Genetics International, British Columbia, Canada

We present the first rigorous estimate of grizzly bear (*Ursus arctos*) population density and distribution in and around Glacier National Park (GNP), Montana. We used genetic analysis to identify individual bears from hair samples collected via two concurrent sampling methods: systematically distributed, baited, barbed–wire hair traps and unbaited bear rub trees along trails. This study is the first to use detections from rub tree sampling to improve the precision of population estimates made with data from hair traps. We used the Huggins closed mixture model in program MARK to estimate total population size and developed a method to account for heterogeneity caused by unequal access to rub trees. We also developed a new method to correct our estimate for lack of geographic closure based on radio–collared bear locations weighted by mean distance from the study area edge to account for uneven distribution of bears on the sampling grid. Adjusted for closure, the average number of grizzly

bears in our study area was 240.7 ($CI_{95\%}$: 202–303) in 1998 and 240.6 bear ($CI_{95\%}$: 205 304) in 2000. Mean grizzly bear density was 30 bears/1000 km^2 with 2.4 times more bears detected per hair trap inside than outside GNP. We provide ba eline information important for managing one of the few remaining populations of grizzlies in the contiguous United tates

Mining-Related Contaminants in Osprey Along the Upper Clark Fork River

Heiko Langner and Johnnie Moore, Environmental Biogeochemistry Laboratory - GeoScience Department, University of Montana, Missoula, MT 59812

Rob Domenech. Raptor View Research Institute, P.O. BOX 4323. Missoula, MT 59806

Erick Greene, Division of Biological Sciences, University of Montana, Missoula, MT 59812

Osprey (*Pandion haliaetus*) are widely recognized as environmental sentinels of the health of aquatic ecosystems. Until the time of fledging, nestlings feed exclusively on fish caught within a few kilometers of the nest. Therefore, tissues of these young birds reflect the level of contamination of local fish and more generally, the aquatic ecosystems they inhabit. Ospreys are nesting along the Upper Clark Fork River corridor, which is the largest site on the Environmental Protection Agency's National Priorities (Superfund) List for cleanup. Small blood samples can be easily obtained from the chicks, making them ideal subjects for assessing the success of remediation projects that are currently underway. We have started monitoring the levels of priority pollutants (arsenic, cadmium, lead, copper, zinc, mercury and selenium) in Osprey chicks along a 250-km section of the Clark Fork River. Objectives are to establish current contaminant status, pinpoint pollution hotspots, and assess the success of restoration efforts. Our results suggest mercury to be of highest concern with blood levels of up to 500 micrograms per liter (reference dose for human health is 5.8). Interestingly, we found mercury levels increased in downstream direction, in contrast to concentrations of other pollutants. Reasons may be different sources of mercury such as historic placer mines and the presence of contaminated wetlands where mercury can be transformed into more bioavailable methylmercury. Blood levels of selenium are also elevated throughout the Upper Clark Fork River drainage. We discussed the implications for restoration and remediation of the Clark Fork River.

Bat Conservation on the Flathead Indian Reservation

Janene Lichtenberg, Wildlife Management Program, Confederated Salish and Kootenai Tribes, P. O. Box 278, Pablo, MT 59855

The Confederated Salish and Kootenai Tribes' Wildlife Management Program is working on conservation projects to benefit bats on the Flathead Indian Reservation. The Reservation has at least eight species of bats including Townsend's big-eared bat (*Corynorhinus townsendii*) a state listed 'Species of Concern.' One of only five known or suspected big-eared bat maternity colonies in the state is located in an abandoned mine on the Reservation. Surveys have confirmed that C. townsendii and other bat species are using other abandoned mines for hibernacula and roost sites. In August 2007, two bat-friendly gates were installed with cost-share funding from the Natural Resource Conservation ervice, Wildlife Habitat

Incentive Program. Within less than one week, big-eared bats were observed roosting in one of the gated mines. In 2008, a third bat-friendly gate will be constructed and mine surveys will be conducted to identify if there is a need for additional gating projects. Long-term monitoring of bat activity at gated sites will provide information on gate success. Additional plans include 1) Reservation-wide baseline field inventories to gain information on species distributions and key resource needs, 2) the construction of roosting structures to provide additional bat habitat, and 3) the distribution of educational materials and presentations to increase public awareness of the benefits of bats.

Efforts to Re-Establish Northern Leopard Frogs on the Flathead Indian Reservation

Janene Lichtenberg, Wildlife Management Program, Confederated Salish and Kootenai Tribes, P. O. Box 278, Pablo, MT 59855

J. Kirwin Werner, Department of Environmental Science, Salish Kootenai College, P. O. Box 70, Pablo, MT 59855

The northern leopard frog (*Rana pipiens*) has disappeared from much of its recorded range in western Montana including the Flathead Indian Reservation. In 2001, the Confederated Salish and Kootenai Tribes' Wildlife Management Program began efforts to re-establish northern leopard frog on the Reservation. Preliminary studies included: 1) genetic sampling of remaining northern leopard frog populations in western Montana and potential source populations east of the Continental Divide for relatedness; 2) chytrid fungus testing of source populations and Columbia spotted frogs (*R. luteiventris*) at potential release sites; and 3) testing methodology for rearing tadpoles. Beginning in 2003, we translocated egg masses from source populations to the Reservation. We achieved highest success in hatching eggs and rearing hatchlings indoors in tanks. Rearing of tadpoles in outdoor enclosures imbedded in wetlands had mixed success in terms of mortality and growth. After several years, we concluded the disadvantages of enclosures outweighed the benefits. From 2003 to 2005 we focused our efforts at one release site. Although we located many metamorphs during fall surveys, we were unable to document over-wintering success. In 2006 and 2007, we chose a second release site. In 2007, we found northern leopard frog at the second site that were large enough to suggest some individuals had over-wintered successfully. We also observed extensive movements of frogs following metamorphosis. We plan to continue reintroduction efforts with the goal of establishing five successful breeding populations on the Reservation.

A Novel, Automated Remote Sensing Tool for Detecting Wolves

Teresa M. Loya, Wildlife Biology Program, University of Montana, 302 Fore try Building, Missoula, MT 59812

David E. Ausband and Michael S. Mitchell, Montana Cooperative Wildlife Research Unit, 205 Natural Sciences Building, Missoula, MT 59812

Curt M. Mack, Gray Wolf Recovery Project, Nez Perce Tribe, P.O. Box 1922, McCall, ID 363

The USDA Fish and Wildlife Service recently propo ed removing ndangered Specie Act protections for wolves in the Northern Rockies. As the wolf (*Canis lupus*) ı delisted, federal funding to monitor and protect the wolf population will disappear. The task of monitoring wolves must be taken up by the states with limited resources therefore new monitoring methods that are robust yet cost-effective are nece sary. We have developed an automated remote sensing tool, "howlbox," that can broadca t a wolf howl, record responses, then hibernate for a specified time period until the next scheduled howl broadcast. The howlbox is non-invasive and is ideal for use in Wilderness Areas where access is difficult and sampling is labor intensive and expensive. We recently tested the howlbox on wild wolves in the Bitterroot Valley and obtained 12 responses over 2.5 days of remote sampling. We plan to test the howlbox widely on radio-collared packs in the summer of 2008 to further refine this novel tool. The howlbox can also be used in roaded areas to decrease the costs and concerns associated with trapping and radio-collaring wolves for monitoring purposes.

Candidate Gene Microsatellite Variation is Associated with Parasitism in Wild Bighorn Sheep

Gordon Luikart, Centro de Investigação em Biodiversidade e Recursos Genéticos (CIBIO-UP), and Universidade do Porto, 4485-661 Vairão, Portugal and Division of Biological Sciences, University of Montana, Missoula, MT 59812

Vanessa O. Ezenwa, Division of Biological Sciences, University of Montana, Missoula, MT 59812

Michael K. Schwartz, USDA Forest Service, Rocky Mountain Research Station, Missoula, MT 59801

The loss of genetic variation in host populations is thought to increase host susceptibility to parasites. However, few data exist to test this hypothesis in natural populations. Bighorn sheep (*Ovis canadensis canadensis*) populations occasionally suffer disease-induced population declines, allowing us to test for associations between reduced genetic variation and parasitism in this species. Here we show that individual mean heterozygosity for 15 microsatellite loci is associated with lungworm abundance (*Protostrongylus* spp.) in a small, recently bottlenecked population of bighorn sheep (linear regression , $R^2 = 0.339$, $P = 0.007$). This association remains significant for seven microsatellites located in genes ($P = 0.010$), but not for eight neutral microsatellites ($P = 0.306$). Furthermore, heterozygotes at three of four microsatellites located within disease-related genes had lower lungworm burdens. This study corroborates theoretical findings that increased parasitism and disease may be a consequence of reduced heterozygosity in wild populations, and that certain individual loci influence

parasite resistance. The results illustrate the usefulness of using genomic information, strong candidate genes, and noninvasive sampling for monitoring both genetic variation and fitness-related traits, such as parasite resistance, in natural populations.

Home Range and Habitat Selection of the North American Porcupine in the Bitterroot Valley

Katie A. Mally, Wildlife Biology Program, 32 Campus Drive, University of Montana, Missoula, MT 59812

Kerry R. Foresman, Division of Biological Sciences, 32 Campus Drive, University of Montana, Missoula, MT 59812

In the past several decades it has been noted by Montana Fish, Wildlife, and Parks biologists that the occurrence of porcupine (*Erethizon dorsatum*) sightings in western Montana has been reduced. This observation sparked interest in current population demographics within this area. During the summer of 2006 surveys requesting information on sightings of porcupines or their sign was distributed throughout western Montana. The results from this survey allowed for further narrowing of the study area to the Bitterroot valley. In the spring of 2007 trapping and radio-collaring of individuals began in the Bitterroots in hopes of targeting home range and habitat selection at the third and fourth order, with notes made on mortality and reproduction. The spring trapping session resulted in the successful capture of seven individuals on both private and public lands. Individual home ranges will be calculated using a minimum convex polygon due to small sample size. Habitat selection will be quantified by building resource selection functions using both land cover data from satellite imagery as well as data collected on the ground. Trapping and data collection will continue into the summer of 2008.

Wildlife Information in Montana: Acquisition, Management, and Dissemination by the Montana Natural Heritage Program and Montana Department of Fish, Wildlife and Parks

Bryce A. Maxell, Montana Natural Heritage Program, 1515 East 6th Avenue, Helena, MT 59620

Scott J. Story, Information Management Bureau, Montana Fish, Wildlife, and Parks, 1420 East 6th Avenue, Helena, MT 59620

The Montana Natural Heritage Program (MNHP) was established by the Montana State Legislature in 1983 and charged with statutory responsibility for the acquisition, storage, and retrieval of information documenting Montana's flora, fauna, and biological communities. To provide the information needed for wildlife stewardship, Montana Fish, Wildlife, and Parks (MFWP) has long collected and managed data on harvested animal species, primarily at local or regional offices. Since the 1990s, information on harvested as well as federally listed animals and nongame fishes has increasingly been managed by the agency's Information Management Bureau. MNHP and MFWP started working more closely on gathering, managing, and distributing information on Montana's vertebrate animal species during the development of Montana's Comprehensive Fish and Wildlife Conservation

Strategy (CFWCS). After development of the CFWCS, MNHP and MFWP have continued to integrate management of information on Montana's animal species. This recently culminated in the development of an MOU which outlines the relationship and respective roles of the two agencies in the acquisition, management, and dissemination of animal information. MFWP and MNHP closely coordinate management of animal information in shared statewide databases with MFWP solely responsible for harvested species data and data associated with scientific collector's permits. MFWP takes the lead on data associated with managed nongame species while MNHP takes the lead on unmanaged nongame species. Both agencies have recently developed a variety of map products for Montana's wildlife, and these are delivered with different levels of access to the general public and agency biologists or resource managers.

Patterns and Consequences of Columbia Spotted Frog Size at Metamorphosis in High Elevation Ecosystems

Rebecca M. McCaffery, Wildlife Biology Program, College of Forestry and Conservation, University of Montana, 32 Campus Drive. Missoula, MT 59812

Bryce A. Maxell, Montana Natural Heritage Program, P.O. Box 201800, 1515 East Sixth Avenue, Helena, MT 59620-1800

The importance of temporary ponds and wetlands on the landscape is a central point of debate in wetland conservation. Amphibian ecologists argue that small wetlands are often essential to the maintenance of amphibian populations. However, few studies have examined the importance of small, temporary ponds to amphibian populations in montane ecosystems. We conducted a mark-recapture study of a Columbia spotted frog (*Rana luteiventris*) population in the Bitterroot Mountains from 2001-2007, catching metamorph, juvenile, and adult frogs each year. Using pond-specific batch marks each year, we tracked production and survival of metamorphs emerging from ephemeral ponds and permanent ponds over time. Specifically, we wanted to know (1) if metamorphs emerging from ephemeral ponds and wetlands were smaller in size than those emerging from permanent water bodies, (2) whether metamorphs showed higher or lower rates of dispersal depending on their pond type of origin, and (3) whether size at metamorphosis correlated positively with apparent survival probabilities. Preliminary results indicate that metamorphs from ephemeral ponds are smaller in mass than metamorphs from permanent ponds, but that these differences are no longer as apparent at one year. Metamorphs from ephemeral ponds show higher rates of dispersal than those from permanent ponds. To date there is no correlation between size at metamorphosis and apparent survival to one year. Further analyses will determine whether long-term differences in survival are detected. These results will clarify the contribution of ephemeral wetlands to montane amphibian populations.

Influence of Beaver on Brook Trout Invasion and Native Westslope Cutthroat Trout Displacement in Rocky Mountain Streams of Southwestern Montana

Magnus McCaffery, Wildlife Biology Program. College of Forestry and Conservation, University of Montana, Missoula, MT 59812

Invasion of ecosystems by nonnative species is often responsible for reshaping natural biological communities. In the Rocky Mountains, brook trout (*Salvelinus fontinalis*) invasion has been implicated in the decline of westslope cutthroat trout (*Oncorhynchus clarkii lewisi*), a native species of special concern in Montana. Although research has established that negative interactions between these species likely occur at the juvenile stage, there remain gaps in our understanding of the landscape factors that influence the extent of invasion, and resulting cutthroat declines. For example, beaver (*Castor canadensis*) are capable of altering stream habitat characteristics considerably, but we do not know how beaver disturbance influences brook trout invasion success, and the consequences for native cutthroat trout. To address this, I used temperature loggers, mark-recapture, and habitat surveys to establish how beaver affect (1) brook and cutthroat trout distributions within watersheds, and (2) species interactions between cutthroat and brook trout. Distribution and temperature data show that beaver-induced stream warming sustains brook trout invasion at higher elevations, while brook trout presence acts to reduce cutthroat trout growth rates. Ongoing analyses of growth rates from scales, and examination of demographic rates of both species will lend greater insight into how beaver impact this system.

The Effect of Climate Change on Wolverines

Kevin S. McKelvey, Jeffrey P. Copeland, and Michael K. Schwartz, USDA Forest Service, 800 E. Beckwith Ave., Missoula, MT 59801

Patrick Gonzalez, The Nature Conservancy, 4245 North Fairfax Drive, Arlington, Virginia 22203-1606

Wolverines (*Gulo gulo*) are climate specialists. They obligately den in snow and their movements year-around are almost exclusively confined to areas characterized by snow that persists into mid May. This pattern occurred historically, occurs currently worldwide, and likely will occur in the future. We investigated the potential impacts of climate change on wolverine habitat by analyzing observed and projected spring snow cover. We determined the temperature threshold for different probabilities of snow cover associated with wolverine denning and range through analysis of snow cover from MODIS satellite data (See Copeland et al. talk this session) and 800 m resolution PRISM temperature data. We then used temperature projections from nine general circulation models, downscaled to 8 km spatial resolution to project. By 2050, snow cover suitable for wolverine dens could decline by up to 95 percent in the lower 48 states of the U.S. Refugia may persist in high mountain areas of Colorado and California, but wolverines have been extirpated from these areas.

The Impacts of Climate Change on Snow Dependent Mammals

Kevin S. McKelvey, Jeffrey P. Copeland, Michael K., Schwartz, and Samuel A u hman, USDA Forest Service, 800 E. Beckwith Ave., Missoula, MT 59801

Patrick Gonzalez, The Nature Conservancy, 4245 North Fairfax Drive, Arlington, Virginia 22203-1606

Keith B. Aubry, USDA Forest Service. 3625 93rd Ave. SW, Olympia, WA 98512

In the western United States, much of the strongest data demonstrating climate change during the late 20th century are related to changes in snowpack. Snowpack is a particularly sensitive to climate change; shifts from snow to rain occur in many areas with relatively modest temperature increases. Many mammals are specifically snow adapted as evidenced by changes in pelage color and a variety of snow adapted morphologies. The snowshoe hare, for example, has large feet which aid in flotation and turns white in the winter. Both morphology and pelage change are maladaptive in a snow-free environment. Timing of pelage change is particularly critical. Lynx are also morphologically highly adapted to snow, having large feet, long legs, and a light, fragile bone structure. While not as morphologically linked to snow as lynx or snowshoe hares, wolverines obligately den in deep snow. All known reproductive dens, worldwide, occur within areas persistently snow covered through May 15. Further, areas that are snow covered in May contained most (91%) of the year-around telemetry locations in 6 studies in the western U.S. We transformed areas of snowpack associated with wolverine denning and range into climatic parameters by correlating the developed MODIS snow surface with high resolution climate surfaces developed by NOAA We then used "sharpened" GCM projections developed at Oregon State University. By 2050, in three representative GCMs, virtually all persistent spring snow is gone. Unless wolverine show great plasticity, they will be gone as well. Because snow adapted organisms are adapted to very specific attributes of snow such as the period of snow coverage, snow morphology, or spring snow melt, their responses to small changes in climate can be expected to be both large and rapid.

Interactions Among Gray Wolves and Coyote in Yellowstone National Park

Jerod A. Merkle, Douglas W. Smith, and Daniel R. Stahler, Yellowstone Wolf Project, Yellowstone Center for Resources, Wolf Project, P.O. Box 168. Yellowstone ational Park, WY 82190

Few studies to date examine the effects of introduced top-carnivores on other carnivores. Interspecific interactions between competing predators can influence ecosystem function, trophic structure, and the distribution and density of sympatric predator species. The recovery of gray wolves (*Canis lupus*) in Yellowstone ational Park provides a unique opportunity to study intraguild interactions with coyotes (*Canis latrans*), which have persisted without wolves for > 60 yrs. Our objectives were to quantify observed wolf-coyote interactions and describe the context and degree of competition and coexistence. Using radio-collared wolves to observe behavioral interactions with other species, we documented 337 wolf-coyote interactions over twelve years. Most (75%) interactions occurred at ungulate carcass sites. Wolves initiated (85%), outnumbered (39%) and dominated (91%) most interactions. Wolves mostly (79%) chased coyotes without physical contact; however 25 interactions resulted in a

coyote death. Interactions decreased over time suggesting coyote adaptation and/or a decline in coyote density. In most (80%) fatal interactions, wolves outnumbered coyotes. However, wolves did not outnumber coyotes in interactions (n = 18) where coyotes chased or attacked/harassed wolves. Our data suggests that there are circumstances where coyote group size influences the outcome of interactions. Although coyote density may have decreased since the reintroduction of wolves, and wolves represent a mortality risk to coyotes, the benefits of utilizing wolf-killed carcasses outweigh the potential costs of interactions with wolves.

Wildlife Provisions in the Climate Security Act of 2007

Sterling D. Miller, Tom France, and Dave Stalling, National Wildlife Federation, 240 North Higgins, Suite 2, Missoula, MT 59847

The Climate Security Act (CSA or Warner-Lieberman) currently under consideration in Congress includes provisions for funding state and federal wildlife conservation activities on a scale unprecedented since passage of the Pittman Robertson Act of 1937. The bill establishes a cap and trade provision on carbon emissions in order to curb accumulation of greenhouse gases. The CSA devotes 18 percent of the proceeds from auction of emissions permits to adaptation measures that help U.S. wildlife and natural resources survive global warming. As currently written, about $175 billion would be allocated in this way through the initial period (to 2030) or $9.3 billion/year. The bulk of this would go to state wildlife agencies (35%), DOI wildlife programs (19%), the Land and Water Conservation Fund for habitat acquisitions (10%), COE for aquatic and estuarine ecosystems (10%), NOAA (10%), USFS (5%), EPA (5%), DOI cooperative grant program (5%), and Tribal fish and wildlife agencies (1%). Professional societies like the Montana Chapter must play an active role in helping Sen. Baucus assure that these provisions for wildlife remain in the CSA.

Mountain States Transmission Intertie 500kV, Wildlife Impacts in the Face of Energy Development

Sam Milodragovich, Northwestern Energy, Butte, MT 59701

D. Dean, POWER Engineers Inc., Boise, ID 83709

Increasing electric consumption, population growth, increasing awareness of global warming, legislation, and insufficient infrastructure are combining to drive demand for new sources of electricity. Wind, clean coal, natural gas and possibly nuclear generation are likely new sources of electric generation. Most locations for new generation are long distances from the demand/population centers, requiring construction of new transmission facilities to deliver electricity. Construction of new generation and transmission facilities has the potential to impact wildlife on many levels. With a paradigm shift in the energy business toward cleaner energy production, innovative approaches for assessing impacts to wildlife are important to minimize wildlife impacts. Northwestern Energy, formerly know as Montana Power, is an investor-owned utility, proposing to build a 500-kV transmission line from southeastern Idaho to southwestern Montana. The proposed line would: extend 350-390 mi, be constructed of lattice steel towers and tubular steel self-supporting towers with an average height of 110-130 ft, require a right-of-way width approximately 220 ft, and have an average span of approximately 1500 ft between towers. Potential wildlife impacts are being identified through

a combination on Geographic Information System analyses, field verification, per onal communication with local agencies, and existing literature. Further a e sment(s) of impact to specific species and habitats is anticipated during and after construction through field investigations. Continued input of wildlife professionals is encouraged and appreciated.

Estimating Resource Utilization Functions: Correcting for Behavior Associated with Central-Place Foraging

Brian W. Moser and Edward O. Garton, Department of Fish and Wildlife Resources, University of Idaho, Moscow, ID 83844

Most resource-selection models assume that space use is uniform. However, in the case of central-place foragers, the null utilization distribution (UD) is not uniform but rather a circular-normal distribution centered about the central place. Estimating resource selection without correcting for the behavior associated with central-place foraging will result in models biased towards habitats closest to the central place. We present a method for estimating a resource-utilization function (RUF) that explicitly accounts for central-place-foraging behavior and provides a more accurate picture of resource use when using UDs to measure resource use. The bias-corrected RUF uses a fixed-kernel-density estimator to calculate a UD, and then uses the difference between the surface of this UD and the surface of a circular-normal UD to calculate corrected space-use probabilities. The individual UD cell probabilities are then used as a response variable in a modeling framework to identify explanatory variables that best explain space use. We demonstrate the use of bias-corrected RUFs using telemetry data from northern goshawks (*Accipiter gentilis*) breeding in Idaho. Advantages of the bias-corrected RUF include a less-biased picture of habitat selection by central-place foragers and the ability to map habitat selection using the resulting model without first needing to know nest-site locations.

Quantifying Ecological Process Using Landscape Genetics: A Study of Boreal Toad Connectivity in Yellowstone National Park

Melanie Murphy and Andrew Storfer, School of Biological Sciences, Washington State University, Pullman, WA 99164, mamurphy@wsu.edu

Jeffrey Evans, USDA Forest Service Rocky Mountain Research Station, Moscow, ID 83843

The boreal toad (*Bufo boreas boreas*) is a locally abundant, patchily distributed species thought to be in decline throughout most of its range. Recapture rates tend to be low, making demographically based estimates of non-breeding habitat use and population connectivity unreliable. Therefore we used a landscape genetics approach, which quantifies the impact of landscape composition, configuration and matrix quality on population connectivity using genetic markers. We surveyed boreal toad breeding sites throughout Yellowstone National Park and collected microsatellite genotype data (15 loci, $n = 953$). We used an algorithmic approach (Random Forests) to build multi-scale models of boreal toad connectivity. We found 1) boreal toad connectivity is a function of three ecological processes (habitat permeability, topographic morphology, and temperature-moisture regimes), 2) these ecological processes

operate at multiple scales, and 3) boreal toad connectivity is hierarchical with metrics operating at coarser spatial and temporal scales driving connectivity between genetic clusters; while metrics operating at finer spatial and temporal scales drive connectivity within a genetic cluster. In addition, we found heterozygosity based metrics of genetic connectivity (F_{ST}) explained more variation in coarse processes versus fine scale processes. Conversely, allele frequency based metrics (D_{ps}) of genetic connectivity explained the most variation in fine-scale processes detected recent landscape change (fire, drought, impervious surfaces). In the future, the approach we developed can be used to predict the impact of landscape change on Boreal Toad connectivity. Additionally, the analytical methods developed can be applied in any species or system with appropriate landscape and genetic data.

Wildlife-Friendly Practices on Montana's Private Lands

Carolyn M. Nistler, Ecologic, P.O. Box 11710, Bozeman, MT 59719

Donald R. Leal, PERC, 2048 Analysis Drive, Bozeman, MT 59718

The majority of Montana is privately held, maintained for agricultural production, and provides much of Montana's wildlife habitat. Landowners utilize different wildlife habitat management strategies according to location, type of agriculture production, and adjacent land value and use. In December 2007 Montana farmers and ranchers received a questionnaire included in the Montana Farm Bureau Federation newsletter to address trade-offs landowners consider when choosing wildlife-related land management practices. Within the first month, 77 questionnaires were returned (8% response rate). Preliminary results indicate about half (49%) of respondents do not participate in a natural resource conservation program, 17% participate in NRCS Environmental Quality Incentive Program (EQUIP), and 14 percent participate in Montana FWP's Block Management Program. Of those who participate in an economic incentive program or enterprise, 60 percent derive < 5 percent of annual ranch income from participation in these programs. Nearly half (43%) of respondents who participate in an economically motivated conservation program feel that the income they receive offsets wildlife damage to their land/crops. Regardless of economic benefit, most farmers and ranchers (63%) practice wildlife tolerance on their lands and 58 percent provide water for wildlife throughout the year. Some improve wildlife habitat by planting food plots (18%), fencing riparian corridors (14%) and delay mowing for nesting birds (8%). These preliminary results indicate that landowners who receive some compensation for providing wildlife habitat may be more likely to tolerate wildlife abundance, and place emphasis on creating and maintaining wildlife habitat on their lands.

Relationships Among Ungulate Browse, Willow Community Structure, and Migratory Landbirds at Red Rock Lakes National Wildlife Refuge

Megan O'Reilly, Department of Ecology, Montana State University, P.O. Box 173460, Bozeman, MT 59717

Jeffrey M. Warren and Karen R. Newlon, Red Rock Lakes National Wildlife Refuge, USDA Fish and Wildlife Service, Lima, MT 59739

Critical relationships exist between vegetation structure and avian diversity and abundance. Browsing by herbivores can lead to changes in the structural heterogeneity and species composition of plant communities, resulting in decreased use of heavily browsed habitats by avian species. We assessed the current levels of browse by native ungulates and resulting effects on composition and structure of willow communities on Red Rock Lakes National Wildlife Refuge in southwestern Montana. We also determined abundance and community composition of breeding land birds in these habitats and related these to willow structure. Bird counts and vegetation sampling were conducted along two riparian corridors and one fen habitat during the summers of 2006-2007. Our results indicate current levels of ungulate browsing on the Refuge are low to moderate. Species composition of willow communities varied between riparian and fen habitats and contributed to differences in willow volume and structural heterogeneity. Five species of birds (Yellow Warbler, Common Yellowthroat, Lincoln's Sparrow, White-crowned Sparrow and Song Sparrow) were used for examining relationships between avian abundance and willow vegetation characteristics. Additional vegetation sampling in conjunction with improved monitoring of ungulate populations utilizing the Refuge will allow managers to make informed decisions concerning ungulate harvest limits and conservation of willow communities.

Auditing a Monitoring Program: Can Citizen Science Represent Wildlife Activity along Highways?

Kylie Paul, University of Montana and Western Transportation Institute, 1721 Phillips St, Missoula, MT 59802

Len Broberg, Environmental Studies Program, University of Montana, Missoula, MT 59812-4320

Mike Quinn, University of Calgary and Miistakis Institute for the Rockies, 2500 University Drive NW, Calgary, Alberta, Canada T2N 1N4

Chris Servheen, USDA Fish and Wildlife Service and University of Montana, College of Forestry and Conservation, University Hall 309, Missoula, MT 59812

Mitigating wildlife barriers caused by transportation corridors requires data on wildlife activity to effectively locate sites for mitigation measures. *Road Watch in the Pass* (RW) is a pioneering citizen science monitoring program that engages citizens in documenting wildlife activity along a highway in Crowsnest Pass, Alberta, Canada. There are plans to upgrade Highway 3 to four lanes, with resulting increased traffic volume and speed. The information RW collects is intended to assist mitigation efforts. This study evaluates the ability of RW to represent visible wildlife activity along Highway 3. A systematic driving survey was

created to accurately document visible wildlife within 100 m of the highway. This was used to compare its spatial, temporal, and species composition wildlife observation distributions to the information gathered by RW using various analyses. Due to its unsystematic nature and lack of sampling effort documentation, RW is limited in its ability to make some statistical conclusions, limiting some analyses and conclusions of this study. Despite these problems, the spatial distribution of RW wildlife observations corresponded with the systematic dataset. Differences in observation rates by time of day and season were displayed by the systematic dataset, while RW cannot provide unbiased temporal information. Both datasets documented high levels of deer observations and low levels of non-deer observations, indicating they are effective at documenting deer but not effective at observing non-deer species. Several modifications are recommended to enhance the scientific rigor of RW and provide guidance for groups aiming to use a similar volunteer highway wildlife monitoring program.

Identifying Linkage Zones for Grizzly Bears Across a Section of Highway 3 in Southeast British Columbia

Michael Proctor, University of Alberta, Department. of Biological Sciences, Edmonton, T6G 2EN Canada

Christopher Servheen, USDA Fish and Wildlife Service, College of Forestry and Conservation, 309 University Hall, University of Montana, Missoula, MT 59812

Wayne F. Kasworm, USDA Fish and Wildlife Service, 475 Fish Hatchery Road, Libby, MT 59923

Mark Boyce, University of Alberta, Department. of Biological Sciences, Edmonton, T6G 2EN Canada

As part of recovery efforts for a small, fragmented, and threatened brown bear (*Ursus arctos*) population in North America shared by Canada and the USA, we used DNA and radio telemetry based methods to identify linkage zones in a fragmented habitat. A human settlement and transportation corridor fragments the international south Purcell-Yaak population (population ~ 50 animals) and consequently threatens its long-term persistence. Because bears are relatively sparse in this population, and sample sizes consequently low, we used two complementary methods -- ecological modeling from hair-snag DNA surveys and Geographic Positioning System (GPS) radio telemetry—to identify "linkage zones" to facilitate improving natural inter-population exchange of animals with adjacent populations, a requirement for recovery. We genetically sampled wild brown bears at 170 hair-snag sites on both sides of the human corridor in 2004 and 2005. Hair follicles were used as a source of DNA to develop microsatellite genotypes that identified 65 different bears at 54 sites totaling 124 capture events. We then characterized the landscape for 24 ecological and human variables (terrain ruggedness, riparian, forest cover, roads, settlement, etc). We correlated these variables to bear presence and absence in a multiple logistic regression and used Geographic Information Systems (GIS) to develop a spatially-explicit "resource selection function" model to predict bear occurrence across our 9500-km^2 study area. We used the model to predict areas of high use (core habitat) and linkage habitat that connects core areas. We also put GPS radio collars on eight brown bears that were captured adjacent to the human corridor. The radio collars acquired hourly locations throughout the non-denning seasons. These data revealed the presence of areas where bears crossed the human corridor and corroborated our predictive model. It is challenging to obtain reliable and objective results in a system with few bears, but we reached our goal of identifying linkage and core habitat

because we used both DNA-based ecological modeling and GPS radio telemetry method . Neither method on its own was sufficient, but each contributed significant information to the ecological solution and provided independent validation of our conclusions. These methods may be of use for other sparse bear populations around the world where conservation solutions are required but low bear numbers make research challenging.

Anesthesia of Grizzly and Black Bears Using Xylazine, Zolazepam, and Tiletamine and Its Reversal Using Yohimbine

Thomas G. Radandt. USDI Fish and Wildlife Service, Room 309, Main Hall, University of Montana, Missoula, MT 59812

Wildlife managers and research biologists are continuously looking to improve their field methods and reduce mortality to study animals during capture. This is especially true when handling individual bears from isolated, declining populations. Bear researchers require an anesthetic that is not dangerous to humans, provides a wide safety margin for bears, requires a low volume dose for efficient delivery, maintains physiological homeostasis, and is reversible. No one chemical can meet all these requirements. I tested the use of Xylazine, Zolazepam and Tiletamine (XZT) in combination on grizzly bears (*Ursus arctos*) and black bears (*Ursus americanus*) to determine the quality of anesthesia it produces and its potential to be reversed Bears were captured as part of on going research in western Montana, northern Idaho, and southeast British Columbia. Bears were captured in foot snares, and delivery systems varied according to capture episode. All bears were administered supplemental oxygen at 3 liter/hour. Bears anesthetized with XZT and reversed with yohimbine recovered from anesthesia faster than bears anesthetized with Tiletamine/Zolazepam combinations. They required smaller dose volume, showed similar induction rates, and were able to maintain physical parameters close to homeostasis. The XZT combination tested is a viable option for safe, effective handling of bears. The synergistic effect of these three drugs allows some of the anesthesia to be reversed allowing bears to recover faster. This permits bears to return to normal body function sooner, reduces vulnerability to predation and allows animals to resume normal behavior quicker.

Management Considerations for Designing Carnivore Highway Crossings

Bill Ruediger, Wildlife Consulting Resources, 1216 Creek Crossing, Missoula, MT 59802

There has been significant confusion conflict over appropriate highway crossings for carnivores and other species. The concepts of habitat connectivity and wildlife crossing have becoming more established, within resource agencies, highway departments, wildlife professionals and the general public. Various problems still emerge, often because wildlife biologists are not well trained in appropriate highway crossing designs for carnivores and other wildlife species and do not have experience in wildlife crossing design and implementation. State Department's of Transportation (DOT) also have concerns about wildlife crossing costs and efficacy. The result can be disagreements between biologists and engineers or transportation agencies and resource agencies. Gridlock and poor relation hips between agencies are often unexpected outcomes. The paper and presentation deals with 1) How biologist's can develop good working relationships with engineers and highway

departments, 2) How to successfully plan for wildlife crossings and wildlife habitat linkages with DOT's, 3) Selecting appropriate wildlife crossings for carnivores and other species, and 4) Wildlife crossing follow-up and learning from successes.

Wolverine Gene Flow Across a Narrow and Disappearing Climatic Envelope

Michael K. Schwartz, Jeffrey Copeland , Kevin McKelvey, Kristy Pilgrim, John Squires and Sam Cushman, USDA Forest Service, 800 E. Beckwith Ave., Missoula MT 59801

Neil Anderson and Jen Williams, Montana Fish, Wildlife and Parks, 1400 S 19th, Bozeman, MT 59718

Robert M. Inman, Wildlife Conservation Society, Field Office, 4 Trail Creek, Ennis MT 59729

Wolverines (*Gulo gulo*) are climate specialists that have components of their life history that require snow. Our research team initially investigated the potential impacts of climate change on wolverine habitat by analyzing observed and projected spring snow cover using MODIS satellite data. The spring snow cover is strongly correlated with year-round wolverine locations and wolverine dens (See Copeland et al. talk this session). In this work we investigate the degree to which spring snow influences movement and gene flow of wolverines by using genetic-based landscape resistance modeling. Using Mantel tests, we found that both Euclidean distance and landscape resistance distances were significantly correlated with genetic distances among all pairs of wolverine. However, partial Mantel tests reveal that Euclidean distance is not significant when removing the effect of landscape distance. Alternatively landscape distance is significant when removing the effect of Euclidean distance. This result supports our suggestion that the spring snow bioclimatic niche is important to the movement of wolverine; a niche that is predicted to rapidly disappear (See McKelvey et al. talk this session).

Local and Landscape-Scale Influences on the Occurrence and Density of the Idaho Giant Salamander

Adam J. Sepulveda, Division of Biological Sciences, University of Montana, 32 Campus Drive, # 4824, Missoula, MT 59812

Species distribution and abundance depend on a balance between large-scale, landscape processes and small-scale, local processes. To successfully manage populations in regions with anthropogenic disturbances and habitat fragmentation, an understanding of important processes at each spatial scale is important. We use a model selection approach to identify the appropriate spatial scale to manage a stream salamander species Idaho giant salamander (*Dicamptodon atterimus*) in the Lochsa River subbasin, Idaho. We use data from field surveys to compare evidence of support for landscape and local-scale models that explain salamander patch occurrence and relative density data. Landscape-scale models include covariates that reflect assumptions of metapopulation theory, while local-scale models include covariates that reflect patch quality. Our results suggest that landscape-scale processes are important controls on salamander occupancy. Specifically, we found that probability of salamander

occurrence was greatest in roadless drainages and lowest in isolated stream network. In addition, we found that the relative density of Idaho giant salamander was greatest in stream with a high proportion of embedded substrate and fine sediment. These results suggest that giant salamander patches are spatially structured within stream networks and that *D. attenuatus* has broad habitat requirements within a patch. We suggest that management efforts focus on protecting roadless areas and restoring stream connectivity in human-impacted areas, rather than on improving habitat quality within a stream.

Gray Wolves and Livestock in Montana: Recent History of Damage Management

Carolyn A Sime, Elizabeth Bradley Kent Landon, Mike Ross, and Jon Trapp, Montana Fish, Wildlife and Parks, Helena, MT 59620

Ed Bangs, USDI Fish and Wildlife Service, Helena MT 59601

John E. Steuber, Kraig Glazier, and Paul J. Hoover, USDA Wildlife Services, Billings, MT 59102

Val Asher, Turner Endangered Species Fund, Bozeman, MT 59718

The Montana gray wolf (*Canis lupus*)population grew from two wolves in 1979 to a minimum of 316 by late 2006. Resolving conflicts, both perceived and real, between wolves and livestock was a dominant social issue for the federal recovery program, and it remains so today. The USDI Fish and Wildlife Service and now Montana Fish, Wildlife and Parks work with USDA-APHIS-Wildlife Services to reduce depredation risks and address wolf-related conflicts through a combination of non-lethal and lethal management tools. The number of wolf complaints investigated from 1987-2006 increased as the population increased and expanded its distribution into Montana after reintroduction into Yellowstone National Park and central Idaho in 1995/96. Montana wolf packs routinely encountered livestock, though wolf depredation was a relatively rare cause of livestock death and difficult to predict or prevent. Cattle and sheep were killed most often from March to October although losses were confirmed each month. From 1987-2006, wolves killed 230 cattle, and 436 sheep. However, confirmed losses probably represent a fraction of actual wolf losses. Few other types of livestock classes were killed. Conflicts are addressed on a case-by-case basis, striving to connect the agency response to the damage in space and time and to decrease the potential for future losses. Lethal control is implemented incrementally after predation was verified, and 254 wolves were killed from 1987–2006. Only complete removal of either wolves or livestock eliminates the potential for wolf depredation. The continued presence of a viable wolf population requires that a wide variety of non-lethal and lethal tools be investigated and implemented. That combination will also be required to maintain local public tolerance of wolves where the two overlap and to foster broad public acceptance of techniques used to minimize conflicts. Resolving wolf-livestock conflicts at a local scale is but one component of a larger state wolf conservation and management program. Upon delisting, regulated public harvest will allow us to more proactively manage the population.

Lower Red Rock Lake and Adjacent Wetlands: Preliminary Understanding of Their Geohydrology

Richard S. Sojda, R. Hayes. Buxton, and Kenneth L. Pierce, Northern Rocky Mountain Science Center, USDI Geological Survey, AJM Johnson Hall, Montana State University, Bozeman, MT 59717-3492

Julia L. Sharp, Department of Applied Economics and Statistics, Barre Hall Clemson University, Clemson, SC 29634

Donald O. Rosenberry, Water Resources National Research Program, USDI-Geological Survey, Denver Federal Center, Denver, CO 80225-0046

Jeffrey M. Warren. Red Rock Lakes National Wildlife Refuge, USDI Fish and Wildlife Service, 27820 Southside Centennial Road, Lima, MT 59739

We have been studying the wetland systems at Red Rock Lakes National Wildlife Refuge in the Centennial Valley of Southwest Montana for several years. Our charge was to provide recommendations about water levels for optimum long term management of waterbirds. To do so, we recognized that we first needed to gain an understanding of the interacting role of water sources and soils in determining submergent and emergent plant communities. The Centennial Valley is tectonically active. That ultimately drives the location of wetlands and is responsible for the generally sloping elevation of wetland bottoms from North (highest) to South. Additionally, the area's geomorphology is dominated by glacial and related alluvial processes that drive soil development and shallow groundwater movement. Using standard hydrologic techniques, particularly shallow wells and piezometers, we have begun to gain an understanding of the prevalence of groundwater discharge in Lower Red Rock Lake and the adjacent semipermanent emergent sedge wetlands. We describe some of the initial patterns that have been uncovered using clustering and classification and regression tree statistical methods. Our next efforts will focus on multivariate analyses and modeling of soil parameters, near surface stratigraphy, hydrologic factors, and aquatic plant communities.

Status of Tribal Wildlife Mitigation Projects on the Flathead Indian Reservation

Art Soukkala, Confederated Salish and Kootenai Tribes, PO Box 278, Pablo MT 59855

In 2000 the Confederated Salish and Kootenai Tribes, Pennsylvania Power and Light Montana, and the Department of Interior reached a settlement agreement that was adopted by the Federal Energy Regulatory Commission to mitigate the negative impacts of the operation of Kerr dam on fish and wildlife resources on the Flathead Indian Reservation. The settlement included funds for habitat acquisition and restoration, monitoring and wildlife enhancement projects. Habitat acquisitions were to be completed within 5 yrs of completing a habitat acquisition and restoration plan. To achieve the mitigation targets, the Tribes chose to both acquire new lands and redirect the management of existing Tribal lands. Acquisitions were completed in 2007. Under Kerr mitigation the Tribes purchased and redirected management of nearly 8000 ac of land for wildlife habitat restoration and management. Additional lands were purchased to offset agricultural uses on Tribal lands that were redirected and to provide more land for the benefit of fish and wildlife resources. This presentation will summarize the

accomplishments that have been achieved and provide a statu report on various ongoing projects within the Tribal Mitigation Program.

Hierarchical Den Selection of Canada Lynx in Western Montana

John R. Squires, Nicholas J. DeCesare, USDA Forest Service, Rocky Mountain Re earch tation, 800 E. Beckwith, Missoula, MT 59801

Jay A. Kolbe, Montana Department of Fish, Wildlife, and Parks, P. O. Box 128 , Seeley Lake, MT 59868

We studied den selection of Canada lynx (*Lynx canadensis*) at multiple ecological scales based on 57 dens from 19 females located in western Montana between 1999-2006. We considered three spatial scales in this analysis including the den site (11-m radius circle surrounding dens), den area (100-m radius circle), and den environ (1-km radius surrounding dens). Lynx exhibited habitat selection at all 3 spatial scales. Based on logistic regression, den sites differed from the surrounding den areas in having higher horizontal cover and lo volume. Abundant woody debris from piled logs was the dominant habitat feature at den sites. Female lynx selected den areas with greater spruce-fir tree basal area, higher horizontal cover, and larger-diameter trees compared to random locations within their home ran e Eighty percent of dens were in mature forest stands and 13 percent in mid-seral regeneratin stands; young regenerating (5%) and thinned (either naturally sparse or mechanically thinned) stands with discontinuous canopies (2%) were seldom used. Lynx selected den environs in topographically concave or drainage-like areas, and further from forest edges than random expectation. Maintaining mature and mid-seral regenerating spruce-fir forests with high horizontal cover and abundant woody debris would provide lynx denning habitat in concave, drainage-like basins. Management actions that alter spruce-fir forests to a condition that is sparsely stocked, e.g., mechanically thinned, and with low horizontal cover would create forest conditions that are poorly suited for lynx denning.

The Relationship of Wildlife Management and Land Trasactions on Plum Creek Lands

Henning Stabins and David M. Greer, Plum Creek. P.O. Box 1990. Columbia Falls, MT 59912

Plum Creek is a large private land owner in several western counties where rapid growth is occurring. Population growth in western counties is expected to increase > 70 percent by the year 2030. This presentation will describe how Plum Creek reacts to some of that growth and associated demand for rural recreational properties. Topics of discussion will include existing land use practices that consider fish and wildlife habitats, proactive planning strategies, conservation strategies, and land sales. In 2007 Plum Creek sold ~ 30,000 ac of land in Montana. Conservation sales accounted for most of those sales, including lands associated with the Swan Valley and Blackfoot River watershed. Forest land management practices incorporate the Sustainable Forestry Initiative Standards and voluntary federal agreements such as the Native Fish Habitat Conservation Plan and the Swan Valley Grizzly Bear Conservation Agreement. By design, some conservation measures of these agreements and other land use restrictions are passed to subsequent landowners. Plum Creek's

involvement in regional planning efforts near Seeley Lake and the Thompson Chain of Lakes address issues of wildlife sustainability. New subdivisions by Plum Creek address practices to minimize impacts to wildlife resources at both the broad and site-specific scale.

Differential Habitat Use of Bats Along a Prairie Riparian Corridor in Eastern Montana

Joanne E. Stewart, Department of Geography, University of Denver, 614 7th Avenue North, Glasgow, MT 59230

Little attention is devoted to the ecology of bats inhabiting prairie landscapes. Although previous studies indicate the importance of riparian corridors as foraging habitat for prairie bats, resource partitioning within prairie riparian zones is relatively unknown. This study examined bat activity patterns among seven habitat types along the Missouri River in eastern Montana from June-August 2003 and 2004. Acoustic monitoring and mist net captures detected 12 species in the study area, including a considerable expansion of the known range for the spotted bat (*Euderma maculatum*). Acoustic monitoring revealed that bats utilize available habitats at different intensities along the Missouri River in eastern Montana. Riparian forest edge habitat accounted for the highest activity for the entire bat community and the two most common phonic groups detected, 40 kHz and EPFU/LANO/LACI. The 40 kHz phonic group spent relatively equal amounts of time in all other habitat types while the EPFU/LANO/LACI phonic group exhibited a strong bias towards all riparian forest habitats. Riparian forest edge habitat also accounted for the highest foraging attempts per hour for the bat community. This research suggests that riparian cottonwood forest, especially the ecotone between riparian forest and open vegetation, provides important habitat for bats in eastern Montana and might be a limiting factor to bat distributions and abundance on prairie landscapes. Conservation measures to maintain and regenerate cottonwood riparian forests are needed to continue providing important habitat for prairie bats along the Missouri River.

Status of the Western Fence Lizard in Montana

J. Kirwin Werner, Department of Environmental Science, Salish Kootenai College, P.O. Box 70, Pablo, MT 59855

In Aug, 2002 a biology student at Salish Kootenai College found a dead adult specimen of the Western Fence Lizard (*Sceloporus occidentalis*) along the shore of the Lower Flathead River near Perma on the Flathead Indian Reservation. The discovery represented the first time this species had been reported in Montana. The closest known locality is 240 km to the west in eastern Washington. A survey of the area shortly after its discovery revealed the presence of two adults and two young-of-the-year scattered among eroded sandstone banks along the river. The area occupied by the lizards was ~ 25 m long by 15 m wide. From 2003 to 2006, I undertook repeated surveys of the known locality and surrounding environs. Usually I saw five or fewer individuals with most sightings in the discovery area. Each year, however, a few individuals were sighted outside of the area, including one young-of-the-year in 2006 that was ~ 100 m to the west. In 2007 a September survey resulted in the sighting of seven young-of-the-year and eight juveniles/adults with about half of them in a new area to the north of the existing range. This represented the apparent first major expansion of the population since it was discovered in 2002. Management alternatives for this species are discussed.

Private Lands: Owner Sentiment Regarding Elk Population Season Options, and Hunter Access

Joe Weigand, Landowner/Sportsman Relations Unit, Montana Fish, Wildlife and Parks, 1420 East Sixth Avenue, Helena, MT 59620

Montana's private landscape has undergone considerable ownership changes in recent years. During this same time, elk (*Cervus elaphus*) populations in the state have continued to increase despite relatively steady hunting pressure and harvest rates. We assessed private landowner opinions of current elk populations, untried season options, and elk hunter access. For the purpose of this study, large contiguous tracts of land (> 640 ac) were considered to provide the greatest opportunity for elk harvest, assuming that hunters have access to it. Therefore, 3310 landowners owning ≥ 640 ac were surveyed in 43 hunting districts. These hunting districts were selected because elk populations in these districts exceeded management objectives. Questionnaires were successfully delivered to a total of 3237 landowners, with 1737 responses resulting in a 54-percent response rate. Survey results indicated that while a considerable majority (80%) of the landowners with elk typically on their property during general elk season allowed some form of elk hunter access in 2006, their opinions regarding elk populations and hunter access varied widely. Additionally, resident and nonresident landowners not only statistically differed ($P < 0.05$) in almost all of their opinions, but also varied considerably within their groups depending on the topic. Agency big game managers and decision makers should recognize that private landowner sentiments toward elk populations, management, and hunter access are not always as straightforward as many believe.

Effects of Cattle Grazing on Small Mammal Communities at Red Rock Lakes National Wildlife Refuge

Nathan Whelham, Department of Intercollege Programs for Science Education, Montana State University, P.O. Box 172805, Bozeman, MT 59717-2805

Jeffrey M. Warren, USDI Fish and Wildlife Service, Red Rock Lakes National Wildlife Refuge, Lima, MT 59739

Michael R. Frisina, Montana Fish, Wildlife and Parks, Butte, MT 59701

Cattle grazing is a common land use on public land in the Intermountain West that often has varied and complex effects on wildlife. However, many studies of wildlife response to grazing only compare grazed versus ungrazed treatments, ignoring the dynamic nature of grazing and the many levels of grazing intensity and frequency commonly utilized. We undertook the current study to better understand the response of small mammals to the frequency of cattle grazing in wet meadow habitats on Red Rock Lakes NWR. Three adjacent grazing units were selected for study that provided a wide range of grazing frequencies (1, 3, and 8 yrs of rest). Two randomly placed trapping grids were placed within the *Juncus balticus – Carex praegracilis* vegetative alliance (wet meadow) in each unit. Trapping occurred throughout July, with each unit sampled 3 days during each of 3 primary trapping sessions. We captured and marked 357 individuals, and had 174 recaptures. Voles (*Microtus* spp.) comprised nearly 99 percent of individuals captured, with 2 deer mice (*Peromyscus maniculatus*), and one common shrew (*Sorex cinereus*) captured. Our results indicated that

vole abundance increased with increasing rest from grazing. Unlike abundance, however, vole survival was lowest in the unit with 8 years of rest, highest in the unit with 3 yrs of rest, and intermediate in the unit with only 1 yr of rest. Our results indicated that the current grazing program on the refuge (2-yr rest-rotation) may not permit vole populations to reach maximum abundance, and a density-dependent response of survival.

Birds, Grazing, and Restoration in Tall-Willow Riparian Communities of Central Montana

Jock S. Young, Avian Science Center, University of Montana, Missoula, MT 59812

Using birds as a tool, the Avian Science Center has been monitoring the effects of several riparian restoration and grazing management projects in Montana. In 2001 and 2003 we surveyed bird populations in tall-willow riparian habitats, primarily east of the continental divide. The goal of this project was to collect and develop information on avian species responses to riparian conditions, to identify the most effective techniques for active riparian management and restoration and the conservation of avian habitats. Tall-willow community types are important avian habitat on east-side forests, and are strongly impacted by grazing practices. Information on changes in vertical structure and cover of shrub layers is especially beneficial in managing these important riparian community types. We surveyed 36 sites on the four participating National Forests; grazed and ungrazed tall-willow riparian sites were categorized based upon the degree of physical evidence of grazing at the site. Although an overall effect of grazing can be clearly seen, important riparian bird species reacted differently to various structural changes. These results, together with ongoing collaborative efforts aimed to enhance the condition of riparian areas, will be used to help develop habitat models, decision support tools, and facilitate adaptive management. We hope this kind of collaboration will continue in more areas in the future.

Habitat Comparisons of Historically Stable and Less Stable Bighorn Sheep Populations

Ashley C. Beyer, Tracy K. Brewer, and Jeffrey C. Mosley, Department of Animal and Range Sciences, Montana State University, 119 Linfield Hall. Bozeman, MT 59717

Management of Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*) focuses on 1) population demographics, 2) immunological state, and 3) habitat characteristics. Demographic targets have been identified for successful populations. Habitats suitable for bighorn sheep have also been identified, and bighorn sheep population response to immunological stressors has been documented. Research has identified domestic sheep (*Ovis aries*) as a potential source of pneumophilic bacteria to bighorn sheep. However, not all bighorn die-offs are attributed to contact with domestic sheep. Limited research has documented how habitat differences between stable and less stable bighorn populations influences their success. Understanding these habitat differences may help explain how habitat contributes to bighorn population stability. The purpose of this study is to evaluate differences in spatial, vegetative, and geographic habitat characteristics of summer and winter ranges between historically stable and less stable bighorn sheep populations that occupy rangeland and open forest habitats in Montana in the presence of domestic sheep. Habitat variables will

be evaluated for two summers in summer and winter ranges of two bighorn sheep populations in Montana, in both their entire seasonal ranges and areas identified as foraging habitat. Land cover, slope, aspect, elevation, solar radiation index, and distance to escape terrain will be quantified in each habitat using a Geographic Information System (GIS). Field sampling will be used to determine shrub canopy cover, frequency of graminoids and forbs, and horizontal visibility of each habitat. Habitat characteristics of historically stable and less stable populations will be compared. Preliminary results will be presented.

Influence of Climate And Density on Fluctuating Asymmetry in Elk Antlers

Scott Eggeman and Mark Hebblewhite Wildlife Biology Program, College of Forestry and Conservation, University of Montana, Missoula, MT 59812

Julie Cunningham and Ken Hamlin, Montana Fish Wildlife and Park. 1400 S 19th Ave., Bozeman, MT 59718

Antler size and symmetry can be an excellent indicator of individual fitness and social rank among North American elk (*Cervus elaphus*). When environmental conditions are favorable elk allocate resources to antler development over body weight to increase secondary sexual traits and enhance reproduction. Research indicates that size and fluctuating asymmetry (FA), the measure of random deviations from perfect bilateral symmetry, of elk antlers due to poor nutritional condition is a result of a tradeoff between body size and antler size. Using antler measurements (n = 2521), collected at the Gardiner Montana hunter check station by Montana Fish, Wildlife, and Parks (MTFWP) we tested two hypotheses expected to drive antler characteristics in elk. Our first hypothesis is that extreme climatic conditions (heavy snow and drought) in the northern Yellowstone area have altered the nutritional condition of elk, and thus FA. Second, we hypothesized that the occurrence of FA in elk antlers is associated with elk density where higher density of elk increases FA because of food-limitation. To test these hypotheses, we used mixed-effects time-series model of FA expressed as a function of climate covariates and elk density from winter aerial surveys. Our preliminary results support our hypotheses that harsh environmental conditions coupled with high elk densities influence the occurrence of FA in elk antlers. These results provide MTFWP with useful information on the effects of climate and density on antler characteristics of elk, an important big game species.

Short-Term Effects of Timber Harvest and Weather on Goshawk Reproduction

Brian W. Moser and Edward O. Garton, Department of Fish and Wildlife Resources. University of Idaho, Moscow, ID 83844

Nesting habitat of the northern goshawk (*Accipiter gentilis*) in North America has been associated with the amount of mature, closed-canopy forest in the nesting area. However, few studies have experimentally tested the effects of timber harvest on goshawk reproduction. We studied the effects of clearcutting within the 170-ha nesting territory on reoccupancy and nesting success for 2 yr following disturbance. We also examined the effects of winter and

spring weather on goshawk reoccupancy and nesting success. We used classification trees to relate goshawk reproduction to habitat and weather variables. Classification trees showed that timber harvest did not affect goshawk territory reoccupancy as long as the 170-ha area surrounding the nest contained > 39 percent potential nesting habitat following harvest. However mean (SD) proportion of habitat remaining in reoccupied territories was 0.57 (0.16) in yr 1, and 0.58 (0.19) in yr 2. Increased nesting success was related to mean April daily precipitation <0.3cm and mean January maximum daily temperature >0.7 °C. In the short term, goshawks are more likely to attempt nesting in territories after disturbance if > 39 percent of their territory is left in potential nesting habitat. However, our models suggest that once goshawks attempt nesting, nesting success is more likely to be a function of winter and spring weather. We recommend leaving >50 percent potential nesting habitat within territories to increase the probability of reoccupancy.

Estimating the Natal Origins of Migratory Golden Eagles Using Stable-Hydrogen Isotopes

Tim Pitz, Rob Domenech, and Sharon Fuller, Biologist. Raptor View Research Institute, P.O. Box 4323. Missoula, MT 59806

The difficulty in determining geographic origins of migratory birds and identifying their regional, source populations has limited researchers in better understanding the migratory ecology of many North American species. Species such as the Golden Eagle (*Aquila chrysaetos*), are widely distributed and well studied on their breeding grounds in a few areas of the lower 48, as well as in Denali National Park, Alaska. However, there is still much to be learned in the area of their migratory and wintering ecology. Currently, there is a need for more study of this species in Western North America. Recent point count analysis show a significant 10 year decline in the number returning spring migrant Golden Eagles counted annually in Alberta, Canada. In 2004 and 2005, Raptor View Research Institute (RVRI) sampled feathers from 22 fall migrant hatch-year (HY) Golden Eagles 12 and 10, respectively, captured along the Rocky Mountain Front (RMF) in west-central Montana. We analyzed feathers using stable-hydrogen isotope analysis; specifically we looked at deuterium a stable isotope found in hydrogen. Numerous researchers have recently described the use of this technique as a means of deciphering the breeding origin of many migratory avian species. By analyzing feathers collected from unknown origin migrants, we set out to answer three primary questions. First, what latitude did the eagles originate from? Second, are there distinct temporal patterns of migratory movements annually, e.g., leap-frog or chain migration? Third, could we identify regional source populations?

Effects of Residential Development on Avina Communities and Individual Species in Quaking Aspen: the Importance Of Habitat Conservation on Private and Public Land

Megan A. Smith and Douglas G. Wachob, Conservation Research Center, Teton Science School P.O. Box 8699, Jackson, WY 83002

Michael F. Strife, 2620 Bianco Drive, Fort Collins, CO 80521

It is a generally held tenet that habitat fragmentation and loss are primary threats to biodiversity. However, little is known about how residential development affects ecosystems, avian populations or individual species. Quaking aspen (*Populus tremuloides*), a species in decline, covers only 1 percent of the forested landscape in the Rocky Mountains but is nevertheless an important habitat for avian biodiversity. We studied the effects of low- and medium-density housing (< 2 houses/ ha and 2-5 houses/ ha, respectively), termed residential development, on bird communities and species using aspen habitat during the breeding season. Overall, residential development affected bird community composition at fine scales (250 -500 m spatial extents). These effects were best explained by multiple regression models containing variables from multiple spatial scales. Based on community composition results, patch size and percent aspen in the landscape were the habitat variables most influential to bird habitat selection. However, analysis of individual species abundances indicated that residential development had direct effects on individual species' abundances. This study's most important contribution to conservation efforts was the clear identification of scales relevant to land managers and residential development. These results suggest that future conservation efforts should focus on both private and public lands.

A Proposal for Studying Wetlands in The Face of Shifting Agricultural Practices, Energy Development, and Hydrologic Patterns

Richard S. Sojda, Northern Rocky Mountain Science Center, USDI Geological Survey, AJM Johnson Hall, Montana State University, Bozeman, MT 59717-3492

Karen J. Nelson, Montana Field Office, USDI Fish and Wildlife Service, 585 Shepard Way, Helena, MT 59601

Jerry Rodriguez, Medicine Lake National Wildlife Refuge, USDI Fish and Wildlife Service, 223 North Shore Road, Medicine Lake, MT 59247

Management of migratory birds in Western North America, especially those dependent on wetlands, are facing growing pressure on their habitat from increased biofuels production, oil and gas development, climate change, and especially potential shifts out of Conservation Reserve Program (CRP) grasslands. All these are affecting the hydrology of Montana wetlands, especially in the prairie pothole landscapes of the Northern and Eastern part of the state. An integrated understanding of the geohydrology and ecology of such wetlands is needed to understand, predict, and manage linkages between geohydrology and aquatic ecosystems and the response of wetland habitat to climatic and management actions. In Sheridan County, alone, there are over 1000 active and abandoned oil wells, and exploration

and production wastes from many of these wells have resulted in reduced water quality in adjacent wetlands. These issues are exceedingly complex, and we have proposed an ambitious project of interdisciplinary research to begin to understand the complexities. This project examines the following questions posed by Eastern Montana and Western North Dakota natural resource managers: 1) Are the brine plumes from oil wells in the Medicine Lake watershed affecting wetlands at Medicine Lake National Wildlife Refuge and the Northeast Montana Wetland Management District? And, are environmental effects from wells drilled in the past (using lined reserve pits) different than effects from the older, abandoned wells (that used unlined reserve pits)? 2) How will conversion of CRP lands back into crop and biofuels production affect groundwater gradients in refuge and Wetland Management District wetlands? 3) What effect will changes in hydrology due to CRP conversion have on brine plume movement? and 4) How representative are the environmental characteristics and issues of the Medicine Lake watershed compared with those at the broader regional scale? To what extent can a broader geographic context help inform management at the local scale?