Front cover – Photos taken by Wolf Monitoring Crew 2010

Top – Adam Fahnestock – Scat Crew

Center – Caitlin Jacobs – Trapping Crew

Bottom – David Ausband – Research Associate, Supervisor

Montana Cooperative Wildlife Research Unit

Report of Activities
October 2009 – September 2010

Cooperating Agencies
U. S. Geological Survey, Biological Resources Division
Montana Fish, Wildlife and Parks
The University of Montana
Wildlife Management Institute
U. S. Fish and Wildlife Service

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Mark Hurley, Ph.D. Candidate
Ben Jimenez, M.Sc. Candidate
Lindsey Rich, M.Sc. Candidate
Jeff Stetz, Ph.D. Candidate

Tom Martin

Dan Barton, Ph.D. Candidate
Amy Johnson, M.Sc. Candidate
Ania Majewska, M.Sc. Candidate
Juan Carlos Oteyza, M.Sc. Candidate
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Jami Belt, M.Sc. Candidate
Julie Beston, Ph.D. Candidate
Jonathan Derbridge, M.Sc. Candidate*
Bruce Hitch, Ph.D. Candidate (Auburn)
Heather Johnson, Ph.D. Candidate*
Jerod Merkle, M.Sc. Candidate
Clay Miller, M.Sc. Candidate
Allison Moody, Ph.D. Candidate (Auburn)
Jesse Newby, M.Sc. Candidate
Leslie Nyce, M.Sc. Candidate
Juan Oteyza, M.Sc. Candidate
Jean Polfus, M.Sc. Candidate*
Ruth Shortbull, M.Sc. Candidate*
Sonja Smith, M.Sc. Candidate
Jason Tack, M.Sc. Candidate*
Jody Tucker, Ph.D. Candidate
Tshewang Wangchuk, Ph.D. Candidate

Tom Martin

Ashley King, M. SC. Candidate*
Elliott Parsons, Ph.D. Candidate
Steve Patterson, Ph. D. Candidate
Rachel Sprague, Ph.D. Candidate*
Paula A. Trillo, Ph.D. Candidate*
Ashley Heers, Ph. D. Candidate

*Graduated

DIRECTION STATEMENT

The Montana Cooperative Wildlife Research Unit performs research designed to address the needs of cooperators, bridging the gap between applied and basic wildlife science. Our studies provide new insights useful to management and conservation, based on understanding the ecological mechanisms that underlie habitat requirements and demography of individual and coexisting wildlife species. Research emphases within the Unit include ecology and management of carnivores, applied landscape ecology, management of large game, interactions between forest management and wildlife, environmental influences (predators, habitat, ungulates) on demography and diversity of birds, habitat requirements and community ecology of birds, and comparative demography and life history strategies of birds in differing environmental and geographical contexts. Other research topics are addressed as needed, in keeping with the Cooperative Research Program's mission to best meet the needs of the Cooperators by remaining flexible and open to new areas of inquiry. When Cooperator's needs occur outside Unit expertise, the assistance of appropriate University faculty will be recruited.

Unit staff will advance the training and education of graduate students at the University of Montana by teaching up to one graduate-level course per year in wildlife science, chairing graduate committees of Unit students, and serving on graduate committees of non-Unit students. Technical support and training will be provided to Cooperators and other agencies as the need exists.

Unit and Administrative Operating Funds		
U.S.G.S. – Cooperative Research Units – Administrative Funds	20,000	
Foreign Travel	8,000	
Vehicle Safety	7,500	
University of Montana		
Full-time Administrative Associate - Salary/Benefits	50,500	
SPABA – FY 09 IDC returned to Unit in FY10	48,512	
Subtotal		134,512
FY 2010 – Research Projects Funded		
Montana Fish, Wildlife and Parks		
Operating Funds	20,000	
WBIO/MTCWRU Research Projects (FY10)	314,595	
T. Martin - PI		
RWO 92 - USGS Climate Change	227,759	
NSF – Tropical vs. Temperate Birds	150,445	
NSF - Student Fellowship	41,690	
The Bair Ranch Foundation – Aspen Study	56,908	
UM Research Administration – Graduate Support	46,000	
M. Mitchell – PI or Co-PI		
RWO 96 - BLM – Sage-grouse – Migratory Populations	155,659	
RWO 91 – BLM – Sage-grouse – Population Viability	207,719	
RWO 93 – USGS NRMSC – Bear Research and Management	25,569	
RWO 94 – USGS SERDP	37,986	
RWO 95 – USGS Climate Change/Camouflage adaptation	69,589	
RWO 97 – USGS Rocky Mountain Elk	153,000	
RWO 98 – USGS Long-term population monitoring of Columbia Spotted Frogs	8,050	
Bernice Barbour Foundation – Bio-fences/wolves	3,341	
Bosack and Kruger Foundation –Rocky Mountain Gray Wolves	16,058	
Bureau of Indian Affairs – Wolf Monitoring	15,097	
Alberta Sustainable Resources – Gray Wolf Monitoring	6,095	
Montana Department of Transportation	1,500	
Idaho Fish & Game – Wolf, Bear, Mule Deer Research	174,904	
U.S. Fish and Wildlife Service – Surveying wolves Selkirk Mtns	13,882	
U.S. National Park Service – Denali Park	1,828	
Wolf Recovery Foundation – Bio-fences	4,086	
California Department of Fish and Game – Bighorn Sheep	40,925	
Gift/UM Foundation Funding for Wolf Research	100,708	
Subtotal		1,893,393
Total Budget		**$2,027,905**

Description	Tag number	8/30/10
1987 Chevy Custom Deluxe 20 Pickup, 4x4 3/4 ton	FED 261577	145,538
1991 Dodge Ram Pickup 4x4	FED 430733	*To be surplused*
1993 Chevrolet Fleetside Pickup, 4x4	FED 261122	115,898
1995 Ford Styleside Pickup, 4x4, 8cyl	FED 261124	130,486
1996 Dodge Ram Pickup, 4x4	FED 261125	*To be surplused*
1999 Ford Truck, Extended Cab Pickup 4 x 2	FED 252524	95,075
2003 Chevy Suburban 1500	FED 430256	70,590
2006 Ford F250 Crew Cab Pickup, 4 x 4,	FED 430965	64,250
2010 Ford Expedition 4 x 4	FED 433441	2112
2010 Ford F250 Crew Cab Pickup, 4 x 4	FED 433440	10
1997 Chevy Suburban, 3/4 ton, 2wd	UM 7787	141,756
1998 Ford Taurus 4 Door Sedan	UM 7623	115,879
1999 Chevy Tahoe Suburban	UM 6992	164,208
2001 Dodge Van - 15 passenger	UM 7495	*To be sold*

Wolf monitoring protocols

Total funds obligated: $439,200

Research Associate: **David Ausband**

Funding Source(s): Regina B. Frankenberg Foundation for Animal Welfare, Leonard X. Bosack & Bette M. Kruger Foundation, Bernice Barbour Foundation, Nez Perce Tribe – Idaho, Idaho Department of Fish and Game, Alberta Sustainable Resources Development, U.S. Fish and Wildlife Service, Defenders of Wildlife, Wolf Recovery Foundation, Wilburforce Foundation, MT Department of Natural Resources & Conservation, MT Fish Wildlife and Parks, Safari Club – Spokane, The Oregon Zoo Future for Wildlife Grants, The Mountaineers Foundation

Project Duration: 2006 – 2011

Objectives:

As Endangered Species Act protections are removed for gray wolves in the northern Rockies so too are federal monitoring dollars used to gauge overall wolf population health. States and tribes in the northern Rockies will be faced with the task of monitoring wolf populations to ensure their conservation with much limited budgets. Radio telemetry has been the primary tool for monitoring wolves in the northern Rockies, requiring intensive trapping and handling of wolves. Maintaining radio collared wolves dispersed widely across the landscape is an expensive and logistically difficult monitoring approach and its efficacy as the sole method for monitoring will wane as federal funding declines. The Nez Perce Tribe, Idaho Fish and Game, and the Montana Cooperative Wildlife Research Unit began a research project to develop cost effective yet accurate methods for monitoring wolves in Idaho.

Progress:

We used logistic regression and data collected from wolves in the northern Rockies over the last 20 years to estimate the probability a pack of a given size contains a Breeding Pair. Our results indicate that if pack size is known then the probability that the pack contains a Breeding Pair can be accurately estimated. We have VHF and GPS collared wolves in study areas to determine wolf density and to allow comparisons of wolf abundance estimates from new methods to estimates obtained from radio telemetry. From 2007-2010 we surveyed predicted rendezvous sites annually and collected several thousand genetic samples. Population estimates derived from DNA encompass the true number of wolves inhabiting our study areas. We also surveyed hunters over the last 4 years to ascertain the accuracy of their wolf observations. Results show the public is largely truthful in their reporting and that public observations may be one tool for monitoring wolves in the future. Working with the Computer Sciences Department at UM we developed an automated tool called a "howlbox" which can remotely survey an area by broadcasting a wolf howl, recording responses, and then shutting down until the next scheduled broadcast. In addition, we have developed a tool to actively solicit hair samples from wolves using rub stations. We surveyed 5 study areas across Idaho in 2010 and a Masters student in beginning in fall 2010 to begin work analyzing these samples. All of these methods are designed to also feed a patch occupancy model which can then be used to generate statewide metrics of wolf abundance and distribution.

Western elk research collaborative

Total funds obligated: $153,000

Post-doctoral Researcher: **Jedediah Brodie**

Data Technician: Matthew Nordhagen

Funding Source(s): U.S. Geological Survey

Project Duration: 2010 - 2011

Objectives:

The challenges facing elk management in Western landscapes are increasing at a rapid pace as modifications to predator communities, habitat and climate influence the demography and behavior of elk populations. Uncertainty about the influence of predation in the context of other limiting and regulating factors on elk populations initiated communication among wildlife researchers in the northwestern states of Idaho, Montana, Wyoming, Oregon, Washington, Utah, and Colorado about shared management challenges and research needs. While some individual states are conducting their own research projects on how these factors influence elk, the collaborators recognize the benefits of a region-wide analysis for informing local ecological processes. A region-wide analysis would allow collaborators to assess greater spatial and temporal variation in these drivers than could be achieved within any single study site or state, and gain a more general understanding of factors influencing elk populations to inform future management strategies (i.e., harvest, predator management, habitat management, etc). Furthermore, collaborative analyses would increase and add value to pre-existing local data sets, maximizing their utility in guiding elk and carnivore management beyond individual jurisdictions. Therefore, the Western Elk Research Collaborative (WERC) will pool data on elk (and other covariates) from populations across the Northwest to assess the relative influence of predation, habitat quality, weather, and their interactions on elk survival.

The fundamental objective of this collaborative is to increase our understanding of the major drivers of elk survival at regional scales to inform elk management at all scales.

Progress:

We have created an Access database that is user-friendly, menu-driven, and designed to easily integrate potential future data types. This database will store all demographic data, along with summary statistics on weather, habitat, predation, etc, for each population. It has been designed with pre-written reports and queries to facilitate data cleaning and analysis, and includes plenty of explanatory documentation and data dictionaries for ease-of-use. We have downloaded and processed PRISM spatial weather data. In total, ~650 grids were processed that display monthly total precipitation, average minimum temperature, and average maximum temperature for the entire US (4km pixel size) from 1984 through 2009. We have acquired basic ArcGIS coverages for the study area including state/county boundaries, land ownership, and elevation (DEMs). We have acquired and cleaned survival/population data on a 2,140 collared female elk from 41 populations.

Linking mule deer recruitment to habitat quality

Total funds obligated: $11,091

Student: **Mark Hurley**

Degree: Ph. D. Candidate

Advisor: Mike Mitchell /Mark Hebblewhite

Funding source: Idaho Department of Fish and Game

Project Duration: 2010 – 2013

Objectives:

I will test the overall hypothesis that mule deer population productivity (fitness) is related to resource selection, and to understand the mechanisms of how the trade-off between nutritional quality of habitat and predation risk determines population growth rate and carrying capacity of a landscape.

Preliminary objectives will be addressed in the following research questions:

1. What is the population productivity of mule deer in different habitats in Idaho? Can mule deer modify resource selection in different habitats to achieve the same nutritional result?

2. How do individual traits of adult female mule deer influence their own survival, fawn survival, or measures of density dependence?

3. Mule deer have mixed strategies for migration likely due to phenology of vegetation on summer range, but little is known about the potential effects of migration on population performance. Therefore, we will ask what is the effect of migration after parturition on population performance.

Progress and Status:

This project will capitalize on mule deer research conducted by the IDFG research biologist and project staff in 52 fawn survival study sites and 6 permanent study sites across Idaho. From 1998 to date, >3,000 mule deer fawns and > 650 adult females have been radio collared with VHF transmitters to monitor survival. Another 70 adult females were collared with GPS transmitters from 2003 to 2010 to estimate resource selection.

Progress since beginning of this project in January 2010: I have completed a resource selection model for summer range in eastern Idaho and have gathered data necessary to complete a resource selection model for winter range for all of Idaho from aerial survey locations. These preliminary models will be used to evaluate data needs for the linked habitat-survival models required to answer research questions. I have also completed an analysis of spatial predation risk on neonate fawn survival in varying fawn rearing habitats. Next year will be dedicated to research proposal development, compiling population and survival data, and redeploying radio collars for survival and resource use monitoring.

Northern river otter population size and habitat assessment in the Upper Clark Fork River

Total funds obligated: $14,000

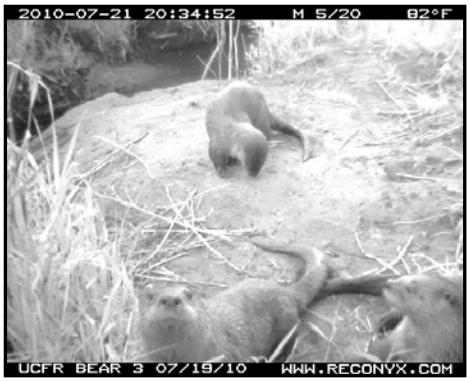
Student: Darin Newton

Degree: M. Sc. Candidate

Advisor: Kerry Foresman

Funding Sources: Montana Natural Resource Damage Program, River Otter Alliance, Society for Ecological Restoration NW Chapter

Project Duration: 2010 – 2011



Objectives:

Northern river otters in the Upper Clark Fork River were negatively impacted by decades of mining activity near Butte, MT. With recent restoration efforts and increasing fish populations, otters have returned to this stretch of the Clark Fork River. Although otters are know no occur there, little is known about the population size or potential for population growth. To better understand this recovering population, this project aims to answer the following questions using non-invasive techniques:

1. How many otters are in the Upper Clark Fork River? How are otters in the Upper Clark Fork River connected to otter populations in other river systems?

2. Are the habitat characteristics in the Upper Clark Fork River conducive to otter population growth?

Progress and Status:

To date we have identified 8 otters in the Upper Clark Fork River using non-invasive techniques, with one having been trapped during the 2009-2010 trapping season. Three individuals were detected using spraints (scat), 3 individuals were detected using hair, and 2 were detected with both methods. Also, we obtained genetic material from 58 trapped river otters in the Blackfoot River, Bitterroot River, and Clark Fork River drainages to look at otter movements and connectivity. Finally, we measured habitat characteristics at 310 locations along the Upper Clark Fork River. We are in the process of running a principle component analysis to look at otter movements, as well as analyzing our habitat data. We are also developing new techniques to efficiently collect otter hair. I am defending my project proposal fall 2010, and plan on defending my thesis fall 2011.

Evaluation of risks and benefits of population augmentation for peninsular Bighorn Sheep

Total funds obligated: $77,000

Post-Doc Researcher:	**Richard Fredrickson**
Principal Investigator:	L. Scott Mills
Funding Source:	U.S. Fish and Wildlife Service Grant to the California Department of Fish and Game
Project Duration:	2008 – 2010

Objectives:

Bighorn sheep in the Peninsular Ranges of California were federally listed as endangered in 1998 (USFWS 1998) following large reductions in numbers from the late 1970's to the mid 1990's. Evidence available during the period of decline suggested that bronchopneumonia and perhaps pathogens associated with other types of disease may have played a large role in reducing bighorn sheep numbers in these mountains. Other factors may also have contributed to the declines including lion predation, habitat modification, and human activities. Since the mid 1990's bighorn numbers have increased substantially, but some of the eight subpopulations have remained small and have not met numerical thresholds for recovery.

The goal of this project was to provide a basis for weighing the potential demographic benefits of two types of augmentations, release of captive-born sheep and translocation of wild-born sheep, against the demographic costs due to transmission of infectious disease among bighorn sheep of the Peninsular Ranges.

Progress:

The final report was submitted August 7, 2010. We are currently developing a plan for publication along with the data owners. We used multi-model analyses to explore the effects of precipitation, the El Niño Southern Oscillation Index (SOI), infectious disease, lion predation and other factors on reproduction, survival, and population growth rate; at the same time this step allowed us to estimate from field data the parameters to be used in simulations. We searched for statistical signatures of disease in the vital rate data using seroprevalence and titer data on pathogens associated with bronchopneumonia and hemorrhagic disease. These field-based parameter estimates along with management-driven scenarios formed the basis of the simulation models we developed. The stochastic, stage-based transition matrix population model incorporated within and between subpopulation dynamics of the eight sheep subpopulations as well as realistic bronchopneumonia dynamics driven by the detected signature of bovine respiratory syncytial virus on recruitment rates. The simulation program also allowed augmentation by releases of captive-born bighorn sheep or by translocation of wild-born sheep from within the Peninsular Ranges. We developed a decision framework that as the first step identifies subpopulations that should be considered for augmentation based on biological parameters. The framework provides means for prioritizing subpopulations for receiving augmentations if more than one qualifies, determining the types and numbers of sheep to be moved, identifying sources for these sheep, determining when augmentations to a given subpopulation should stop, and recommendations for evaluating the effectiveness of augmentations.

Multiscale effects of forest roads on Black Bears

Total funds obligated: $53,929

Student:	**Ben Jimenez**
Degree:	M. Sc. Candidate
Advisor:	Mike Mitchell
Funding Sources:	Idaho Department of Fish and Game Montana Cooperative Wildlife Research Unit University of Montana
Project Duration:	2007 – 2010

Objectives:

Black bears (*Ursus americanus*), are a highly adaptable landscape species with few natural predators. With high road densities and increasing traffic volumes throughout much of their range however, the potential effects of roads on bears as well as the habitat which they rely upon are of growing concern (IUCN Bear Specialist Group 2007). The black bear population within the Coeur d'Alene (CDA) river watershed of Northern Idaho is exposed to high road densities and moderately high hunting pressure. Hunting regulations allow for the use of bait and dogs in both spring and fall hunting seasons, and dogs are permitted for non-lethal pursuit during the summer pursuit season. In an effort to better understand the effects of these pressures on black bears, the objectives of this study are as follows:

1. Provide a fine scale analysis of habitat selection of black bears (2^{nd} and 3^{rd} order habitat selection).
2. Assess the effects of road density and traffic volume on this multi-scale habitat selection.
3. Assess alterations to activity patterns due to seasonal shifts in traffic volumes.

Progress and Status:

Between June 1, 2007, and July 25, 2008, we captured 43 individual black bears, and instrumented 28 adults with Global Positioning Systems (GPS) collars. Collars were set to acquire positions at 20 minute intervals from April 10 - November 10. During the winters of 2008 and 2009, we visited 32 dens to collect and redeploy collars. All dropped collars were retrieved, and all collars were collected from harvested animals.

Analysis of wildlife movements in relation to Denali Park road traffic

Total funds obligated: $97,325

Research Biologist:	**Rick Mace**
Cooperator:	Bureau of Land Management/CESU
Project Duration:	2007 – 2011
UM Project Affiliation:	MTCWRU

Objectives:

The study's purposes are first, to provide for the preservation of the physical, biological and social environment of Denali National Park; second, to promote the enjoyment of the park by the public and the economic activity associated with public use, and third; to support the research and educational mission of the cooperating universities.

Using GPS radio telemetry, this project will quantify the distribution, movement patterns, and daily activity patterns of grizzly bears and Dall sheep along the park road corridor. Spatio-temporal relationships among these ecological parameters and traffic flow along the road corridor will be investigated. Results will be combined with traffic flow studies, visitor and driver surveys and logistical analyses to create a traffic model for the Denali Park Road. A comprehensive model that evaluates the impacts of road traffic will allow wise decisions about traffic volume and timing, in order to maximize opportunities to view wildlife in Denali without degrading resources or visitor experiences.

Using patch occupancy models to estimate wolf population trends in Montana and Idaho

Total funds obligated: $61,318

Post-doctoral Researcher: **Betsy Glenn**

Principal Investigator: Mike Mitchell

Funding Source: Montana Fish, Wildlife and Parks, Idaho Department of Fish and Game, Nez Perce Tribe, US Fish and Wildlife Service, The Frankenberg Foundation

Project Duration: 2009 - 2010

Objectives:

Working closely with collaborators, we will develop monitoring protocols for wolves in the northern Rocky Mountains based on patch occupancy modeling. We will develop the potential for population and harvest modeling that is present conceptually in patch occupancy modeling but has yet to be realized. Specifically, we will incorporate trends in distribution, reproduction, and the distribution of pack sizes to estimate population size and distribution, with confidence intervals, for each state in the northern Rockies. Further, understanding population dynamics by integrating our monitoring with insights derived from empirical exploration of historical data and results of highly focused simulations could lay the groundwork for follow-on or complementary research estimating sustainable harvests of wolves in the northern Rockies. Such an approach would allow geographically targeted planning and refinement of management practices (e.g., control actions, harvest quotas, etc.) to meet local, state-wide, and regional objectives.

Progress and Status:

Montana

During 2010, I developed both multi-year and single year patch occupancy models for estimating numbers of wolf packs and numbers of wolves in Montana for 2007, 2008, and 2009 based on hunter survey data. Hunter survey data provide information on when and where hunters sighted wolves as well as the total number of wolves seen. For Montana, a large number of hunters (80,000+/year) are surveyed, providing statewide survey coverage. Hunter observations of wolves in specifically-defined areas form the input data used to estimate the probability that the area of interest contains a wolf pack. We use the POMS to estimate the probability of wolf pack occupancy on 250 mi^2 grid cells spanning the state. These 250 mi^2 grid cells are approximately equal in size to an average wolf pack territory size. The sum of occupancy probabilities across all grid cells in the state therefore provides an estimate of numbers of wolf packs. These models also provide upper and lower confidence intervals for each cell, providing us with confidence intervals for our estimates of numbers of packs on statewide and regional areas.

To estimate the total number of wolves, we have developed a model that uses occupancy estimates from the patch occupancy models in combination with the mean number of wolves seen by hunters to obtain estimates of total numbers of wolves. For each 250 mi^2 grid cell, we calculate (occupancy*mean # wolves observed) and sum these values across all cells to get a statewide (or regional) estimate of numbers of wolves. While the individual grid cell estimates should not be interpreted to reflect actual pack sizes, this approach appears to accuracy represent the known distributions of wolves and wolf packs in the state for 2007-2009. Confidence intervals for these estimates are obtained through a bootstrapping approach.

We have also developed models to estimate the distribution of pack sizes and the number of breeding pairs. To determine the distribution of pack sizes, we are using the distribution of known pack sizes from 2005-2009 to

estimate the distribution of pack sizes based on POM estimates. With a pack size distribution, we are able to estimate the number of breeding pairs using methods described in Mitchell et al. (2008). We are also examining applying the Mitchell et al. (2008) methodology directly to the grid cell-specific estimates of numbers wolves.

In addition to single-year patch occupancy models, we have also developed a multi-year occupancy model that enables us to examine local colonization and local extinction rates using the hunter survey data. Both the single-year and multi-year models provide comparable estimates of numbers of wolf packs and numbers of wolves. While the multi-year model provides useful estimates of colonization/extinction rates, our ability to obtain bootstrapped confidence intervals of numbers of wolves is limited in the multi-year model framework.

Idaho

In order to develop a similar patch occupancy modeling approach for the state of Idaho, we developed and implemented a statewide hunter survey program in 2010. Idaho deer and elk hunters were randomly selected by Game Management Unit (GMU), and were mailed a short questionnaire asking if, when, and where they saw wolves during the 2009 hunting season. We also recorded how many wolves were observed. Approximately 13,000 surveys were mailed in May 2010 and approximately 4000-5000 were returned. We are currently in the process of entering these survey data into a database which can be used to develop a patch occupancy model for Idaho similar to the one we developed for Montana. In the future, an on-line reporting system may be available in Idaho which has potential to greatly reduce labor for compiling survey data.

Our goal is to develop a patch occupancy modeling approach for Idaho similar to the one we have developed for Montana. In addition, Idaho has several wolf study areas where rendezvous site surveys, track surveys, and genetic sampling (hair/scat) have been conducted since 200x. We hope to integrate these different survey methods (hunter surveys, hair/scat, etc.) into the patch occupancy modeling framework. These field data can also help validate our assumptions about average territory size and pack size.

Effects of Rocky Mountain Elk on small mammals and nutrient cycling in Arizona

Student: **Elliott Parsons**

Degree: Ph.D. Candidate

Advisor: John Maron

Funding Source: USDA CREES Managed Ecosystems Program

Project Duration: 2006 - 2010

Objectives:
My research examines how impacts of ungulate herbivory on plant community structure affect both small mammal abundance and litter and nutrient dynamics. To explore these questions I am using three ungulate exclosures erected in fall 2004 in northern Arizona, and three paired non-fenced plots. We have been using live-trapping since 2004 to determine how small mammal species abundance and community compsition change as a result of ungulate browsing. Furthermore, we are examining how browsing by ungulates impacts deciduous tree recruitment and whether subsequent changes in litter quantity or quality impacts available nitrogen in the soil, and understory plant growth.

Progress and Status:
Abundant Rocky Mountain elk (*Cervus canadensis*) in our study system are currently having a significant impact on vegetation and small mammal populations as revealed by our exclosure study. We have seen a significant increase in maple and aspen recruitment and overall shrub cover inside of exclosures as compared to non-fenced plots since 2004. These changes in vegetation have paralleled changes in small mammal populations. Voles (*Microtus mexicanus*), woodrats (*Neotoma mexicana*), and mice (*Peromyscus maniculatus* and *P. boylii*) have increased inside of the exclosures relative to the non-fenced drainages since 2004. In addition, yearly line transect surveys have revealed increased red squirrel (*Tamiasciurus hudsonicus*) middens on exclosures relative to non-fenced plots indicating potentially higher red squirrel density. We studied habitat use of both species of *Peromyscus* and found that mice select habitat high in shrub cover, which is increasing inside the exclosures.

Significant increases in deciduous tree recruitment and height since 2005 have also led to higher quantities of high quality leaf litter being deposited within exclosure plots. However, the changes in deciduous tree litter quantity may not yet be affecting nitrogen availability in the soils; we found that aspen and maple litter (both high in nitrogen) did not influence the mineralization of nitrogen underneath bags of litter of both species.

Combining hunter surveys and territorial dynamics to monitor wolf pack abundance and distribution in Montana

Total funds obligated: $172,867

Student:	**Lindsey Rich**
Degree:	M. Sc. Candidate
Advisor:	Mike Mitchell
Funding source:	Montana Fish, Wildlife, and Parks
Project Duration:	2008 – 2010

Objectives:

My overall objective is to develop a patch occupancy model (POM) using hunter surveys as my sampling method to monitor wolves in the Northern Rocky Mountains. I am developing a POM which provides an estimate of the number of wolf packs and their distribution in Montana. To develop a POM that is robust to variation in wolf territory size, however, an ecological understanding of factors influencing territory size is required. To address this, I am answering the following questions:

1. What factors drive the spatial and temporal variation in wolf territory size?

2. How does a POM developed using hunter surveys compare to known abundance and distribution of wolf packs in Montana?

Progress and Status:

In 2008 I purchased 15 GPS collars with Argos capabilities. I programmed them to collect 8 locations a day and to transmit these locations via Argos satellites to an internet accessible database once every 10 – 14 days. Montana Fish, Wildlife, and Parks deployed 9 of these GPS collars in 2008 and 5 in 2009. Six of these wolves dispersed from the packs in which they were collared, 7 died of human-related causes, and 5 had collar failures. Wolves from 9 packs did not disperse for ≥8 months and provided ≥8 months of GPS location data. I used data from these 9 GPS-collared wolves and from the 67 wolf packs that contained ≥1 VHF-collared wolf in 2008 or 2009 to estimate mean territory size for the state of Montana.

For the years 2007 – 2009 I plotted all hunter sightings of ≥2 wolves during my 5-week sampling period. This data will be used as the repeated sampling necessary for my POM. I put together GIS layers containing information about my covariates for the probability of occupancy (e.g., elevation, forest cover, elk density) and the probability of detection (e.g., hunter effort, road density). I developed an all-inclusive set of candidate POMs comprising different hypotheses about how covariates affect the probability of a wolf occupying an area or being detected by a hunter. I restricted models to non-correlated first-order terms that had a significant univariate effect on the probability of occupancy or detection. For each model AIC was calculated and ΔAIC was used to determine the best approximating model. The best approximating model was used to estimate the abundance and distribution of wolf packs in Montana. I will present and defend my thesis this November 2010.

Linking resource selection and mortality modeling for population estimation of mountain lions in Montana

Total funds obligated: $146,843

Post-doctoral Researcher:	**Hugh Robinson**
Principal Investigators:	Mike Mitchell and Mark Hebbelwhite
Funding Source:	Montana Department of Fish, Wildlife and Parks
Project Duration:	2009 - 2011

Objectives:

In Montana a combination of limited entry and quotas are used by the Department of Fish Wildlife and Parks (MTFWP) to allow recreational opportunities for the public, while maintaining viable mountain lion populations, thus creating a need for accurate and defensible population estimates. Advances in generalized linear modeling and geographical information systems (GIS) have made available new techniques to quantify and spatially represent resource selection, mortality risk, and population dynamics. Using data provided by MTFWP, I propose to produce spatially explicit models of mountain lion resource selection, survival, densities, and population dynamics. This research will be directed towards aiding MTFWP personnel in developing local harvest strategies and a statewide mountain lion management plan.

Progress and Status:

This project began in September 2009. The first fall was spent obtaining data sharing agreements with collaborators, data acquisition and management. In January 2010 Montana Fish Wildlife and Parks (FWP) added a second component to this project; the completion of a final report for Garnet cougar study conducted by FWP staff from 1997 to 2007. I am currently finishing preparation of this manuscript entitled “The Garnet Mountain Lion Study: characteristics of a hunted population in west-central Montana Final Report: August, 2010”.

Exploring noninvasive genetic sampling methods for long-term, multi-species monitoring

Total funds obligated: $56,230

Student:	**Jeff Stetz**
Degree:	Ph.D. Candidate
Advisor:	Mike Mitchell
Funding Source(s):	U.S. Forest Service, U.S. Geological Survey
Project Duration:	2009-2013

Objectives:
My primary interests are in investigating habitat selection, genetic population structure, and population growth rates across the sympatric grizzly and black bear populations in the Northern Continental Divide Ecosystem (NCDE) in the Northern Rocky Mountains of Montana. I am also interested in evaluating the ability of noninvasive genetic sampling (NGS) to detect fine-scale demographic processes in these populations. The ability to combine inferences from multiple tests to these two species may provide greater insights into population processes. The specific objectives that I am currently exploring include:

1. Compare habitat selection of grizzly and black bears using either standard (e.g., RSF) models or approaches similar to what we are currently developing with our grizzly bear data (hierarchical Bayesian abundance-based habitat modeling).
2. Use simulations based on empirical data to evaluate the performance of regional population growth rate (λ) estimates made using the Pradel (1996) model and NGS data.
3. Compare λ estimates derived from the Pradel model using NGS data to asymptotic projection matrices made with telemetry data. Evaluate the strengths and weaknesses of each approach with respect to precision, bias, and confidence interval coverage.
4. Develop a regional approach to modeling bear habitat selection by breaking the NCDE into logical geographical units, which may shed light on the variables of regional interest, not just the dominant, population-wide variables.

Progress and Status:

The bulk of the data to be used in my dissertation research was collected in 2004 during the Northern Divide Grizzly Bear Project, where I was the assistant project leader. Our ongoing research is in year 2 of at 3, with approximately 30 field technicians conducting repeated surveys of over 5,400 sampling sites across nearly 3.6 million ha in the Northern Rockies. In 2009, our start-up year, 9,200 hair samples were collected, with 258 grizzly bears detected. This year we anticipate >20,000 samples to be collected and >300 grizzlies detected. These data will improve simulation modeling for my dissertation, as well as provide a robust estimate of population growth rate for this population.

During summer 2010 I conducted the first density estimate for black bears in the Glacier National Park area using data collected during the 2004 grizzly bear study. I am currently exploring newer methods to estimate density (spatially explicit capture-recapture) to contrast with 'traditional' buffer methods. I am also working with Gordon Luikart to investigate genetic population structure of black bears in Glacier. We extended the genotypes of a subset of known black bears to 15 loci, and are working with other researchers on a meta-analysis across the northern Rockies.

BIRDS

Which environmental factors explain differences among species in parent and offspring responses to brood size variation?

Total funds obligated: $163,190

Student:	**Daniel Barton**
Degree:	Ph.D. Candidate
Advisor:	Thomas E. Martin
Funding Source(s):	National Science Foundation, Montana EPSCoR, U.S. Geological Survey
	U.S.Department of Agriculture
Project Duration:	2005-2010

Objectives:

Life history theory explains variation in age-specific fecundity and mortality, which is enigmatically arranged along a 'slow-fast' gradient. Species at the 'slow' end express long life span, low fecundity, and low reproductive effort, while species at the 'fast' end express the converse. Understanding how ecological factors explain this pattern is key to understanding evolution of life history traits and demography of wildlife populations. Food limitation, age-specific mortality, and offspring quality are advanced to explain this variation. We test the predictions of each of these alternatives by examining variation among species in their responses to natural and experimental perturbations. For example, rate of feeding offspring is a key life history trait. It varies substantially among species and incurs energetic costs to parents (reproductive effort) and fitness benefits to offspring (e.g. increased growth, survival). Simultaneously, variation in offspring number and quality strongly influences parental fitness. Comparisons among species of the responses of parents to natural and experimentally induced variation in offspring number allows for tests of alternative explanations for life history diversity. Predictions for within- and among-species variation in responses are generated under alternative hypotheses and we test them using brood size manipulations. This approach of testing life history theory by comparing plasticity responses among species yields tests that are unattainable with traditional single or multiple species studies.

Progress and Status:

Field work for this research began in 2007 and completed in this year (2010). We manipulated clutch size and measured parental and offspring responses at 250 nests of 20 species in Arizona and Venezuela. Over natural variation in brood size, we tested whether food limitation or age-specific mortality explain variation in parental feeding behavior among 29 songbird species from Arizona, Argentina, South Africa, and Venezuela. Our results supported the age-specific mortality hypothesis and suggested species with high adult mortality increase feeding rate proportionately with increasing brood size, while species with low adult mortality do not. In contrast, food limitation theory predicts proportional adjustment of feeding rate across species and this was not the case. This suggests an important role for adult mortality in the evolution of provisioning strategies, which are a key component of life histories. However, alternatives remain and experimentally induced variation in brood size will provide stronger inference. I am currently writing my disseration for defense in fall 2010.

Identification of aspen habitat features that affect reproductive success and diversity of birds

Total funds obligated: $330,000

Student: **Amy Johnson**

Degree: M.Sc. Candidate

Advisor: Thomas E. Martin

Funding Source(s): Montana Fish, Wildlife and Parks, The Bair Foundation

Project Duration: 2008-2010

Objectives:

Aspen forests are biodiversity hotspots in North America, and declining area of aspen may be associated with population declines of a variety of organisms dependent on this community type, including many species of birds. Understanding the aspen stand features that enhance bird diversity and reproductive success is of great interest to wildlife management and conservation because aspen forests are declining in western North America. Conifer trees are being removed from some aspen stands as one management treatment that can increase aspen survival and recruitment. However, the effects of such forest treatments on wildlife populations, such as breeding birds, are unknown. Conifer removal greatly alters vegetation structure, which may strongly affect bird populations within the treated aspen stands. Therefore, I am interested in understanding how bird communities utilize aspen forests before treatments to improve management decisions. More specifically, I want to know how the habitat structure of aspen stands (i.e., stand size, amount of conifers, understory density) influences songbird diversity and nest survival. In addition, I will be looking at predator abundance in relation to the amount of conifers present to better explain nest survival.

Progress and Status:

The second and final season of fieldwork was completed August 2010. Bird diversity, predator abundance, nest survival, and vegetation structure were surveyed during the 2009 and 2010 songbird breeding seasons. Bird diversity was measured using intensive point counts in all study plots across both seasons. A total of 38 nesting songbird and woodpecker species were surveyed across all study plots. Predators were surveyed during point counts and also throughout the season during daily nest searches. Red Squirrels, chipmunks, Gray Jays, and Common Ravens are common nest predators. Initial results show that bird diversity and squirrel abundance increase with the amount of conifer trees present in and around aspen stands, as well as with aspen stand size.

A total of 820 nests were found and monitored during the two field seasons. Open-cup nest survival data will be used in conjunction with vegetation surveys that were conducted within 11 meters of each nest to estimate vegetation influences on nest survival using logistic exposure modeling. Systematic vegetation survey points in each aspen stand will be used to answer questions about habitat preferences for nest placement, availability of nest sites, and overall aspen stand structure.

Data analyses and thesis writing are underway and will be completed and defended during the fall 2010 semester.

The importance of embryonic development for offspring and adult immune function

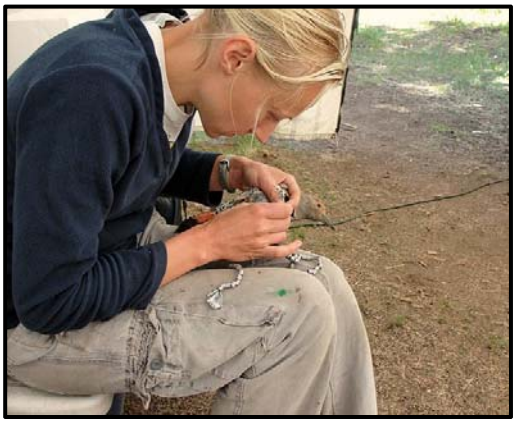
Student: **Ania Majewska**

Degree: M.Sc. Candidate, WBIO

Advisor: Thomas E. Martin

Funding Source: U.S. Geological Survey, National Science Foundation

Project Duration: 2008-2010



Objectives:

Rate of development varies broadly within and among taxa and is an integral component of life history strategies that has important consequences for offspring phenotype, survival and fecundity. Although accepted as a standard measure of development, the length of the embryonic period is not necessarily representative of embryonic development rate. In birds, development rate is a function of temperature which greatly fluctuates as incubating parents leave the nest to forage. Indeed, colder average incubation temperatures result in slower development and extended embryonic periods as well as decreased offspring quality (measured as offspring size and immune function). Interestingly, colder egg temperatures also result in embryos that hatch with reduced yolk reserves, a key nutritional source that aids hatchling survival. Previous studies primarily focused on length of the embryonic period and a single measure of immune function, while overlooking the nestling stage and the possible influence of parasites and of parental effects on offspring phenotypes. I am testing alternative hypotheses in a rigorous design in two developmental stages and at multiple levels of immune function. In the 2009 field season I began to examine two major hypotheses that explain variation in immune function and developmental rates of passerine birds. In the summer of 2010 I carried out an egg content reduction experiment to test whether reduced egg contents affect offspring quality.

Progress and Status:

Analyses of the 2009 data revealed length of the embryonic period does not correlate with increased immune function of adult and nestling passerines. Cavity nesting birds such as House Wrens showed increased levels of natural antibodies. Field work continued during the summer of 2010 in Coconino National Forest, Arizona and an additional 609 blood samples were collected from adult and nestling birds representing 26 species. In the 2010 season I performed an egg content reduction experiment on two common species. I reduced egg contents (yolk or Albumin) to determine the effect of reduced parental resources on nestling quality. Data and laboratory analyses of the 2010 samples are underway.

Understanding the environmental causes of a major global divergence in life history strategies of tropical birds

Total funds obligated: $393,627

Principal Investigator: **Thomas E. Martin**

Funding Source: National Science Foundation

Project Duration: 2009-2012

Objectives:

Measure demographic and life history strategies (clutch size, nest predation, development rates, parental care, adult survival rates) of bird species in montane Malaysian Borneo (Kinabalu Park) to compare with related bird species in Arizona and previous work in tropical Venezuela at similar elevations. Examine the relative importance of nest predation, food limitation, and adult mortality on variation in demography and life history strategies.

Progress and Status:

Life history strategies are comprised of age-specific fecundity and mortality, plus parental care behaviors and developmental rates influencing these fitness components. Altogether these traits determine demography of populations in ecological time and influence evolution of phenotypes to provide critical insight into environmental selection pressures. By examining geographic variation in life history strategies and the selection pressures favoring differing strategies, new insights are gained into the environmental influences on population regulation. Tropical Asia has a major life history divergence that has gone un-noticed: clutch sizes are larger and more variable for some species, development rates of embryos are faster, and yet adult mortality remains low compared to other tropical regions. This combination of traits is thought to be impossible under current theory, but detailed studies of these traits across species do not exist.

We completed our second year studying these traits t in tropical Borneo because it retains large blocks of pristine forest at mid-elevation. In the past two seasons, just over 900 nests were found and monitored, nestling growth measured, parental care video-taped, and egg temperatures quantified. In addition, some 1,000 birds were banded to aid in estimating adult survival and renesting efforts. Data are in the process of being entered into the database and videos are being transcribed to allow initial analyses later in the year. Impressions from the field suggest that nest predation rates are high, but recapture rates of birds are higher than anywhere else that I have worked. This indicates that birds are very sedentary and potentially have quite high adult survival, but many more years are needed.

This work includes an important training component for young US and Malaysian scientists. The perception that reproduction cannot be studied in the field is corrected by training young scientists in the conduct of this field work. In addition, the most motivated are invited to the lab in Montana where they are taught to write their first publications on the life history of some species that is previously undescribed.

Effect of climate change and elk browsing on population trajectories and trophic Interactions in a high elevation riparian ecosystem

Total funds obligated: $439,015

Principal Investigator: **Thomas E Martin**

Funding Source(s): U.S. Geological Survey, U.S. Department of Agriculture

Project Duration: 1985-ongoing

Objectives:

Measure and examine annual variation in avian nest success and predation, adult survival, population size, habitat selection, and parental care behaviors, as well as small mammal density and species composition, vegetation density and species composition in a high-elevation riparian ecosystem in north-central Arizona relative to climate variation and elk browsing.

Progress and Status:

Climate has had large consequences for 32 bird species by affecting trophic levels below (plants) and above (predators) them based on study of their populations and >15,000 nests over the past 25 years. Winter snowfall has declined strongly across the 25 years of study, as typical throughout western North America, which has increased over-winter densities of elk in the study area. This decline in snowfall and increase in overwinter elk was strongly associated with the loss of deciduous vegetation (aspen, canyon maple, New Mexican locust) that represents preferred bird habitat, and birds have declined in abundance associated with the decline in preferred habitat. In addition, summer precipitation has also declined over the 25 years of study and drier summers have yielded greater predation on offspring.

The direct effects of climate on differing trophic levels together with indirect effects arising from altered interactions among trophic levels substantially change ecosystem structure. An exclosure experiment was initiated in the fall of 2004 to test the effects of elk and winter snow on plant, bird and small mammal communities. Three large (10 ha) exclosures were established on three different canyons. Results through 2010 show a large effect on aspen recruitment and ground cover, and a slower but increasing effect on maple and locust recruitment; plant abundance and diversity (e.g., increased perennial flower diversity) have increased in the 6 years since fence establishment. In addition, several bird species increased in abundance compared with adjacent controls. Small mammal species also show responses, with some species (deer mice, wood rats) increasing and others (chipmunks) decreasing on fenced areas compared with controls.

Continuation of this project will help to differentiate the interacting effects of elk browsing and climate on plant reproduction and growth, and subsequent effects on higher trophic levels (birds, small mammals), as well as the interaction among these trophic groups.

Understanding life history strategies that influence offspring size.

Student:	**Juan C. Oteyza**
Degree:	M. Sc. Candidate
Advisor:	Thomas E. Martin
Funding source:	National Science Foundation, The University of Montana
Project Duration:	2009 – 2011

Objectives:

Offspring size is a critical trait because it has important consequences for survival and reproductive success. Traditionally one of the main factors thought to influence size of dependent offspring (i.e., those that depend on parents for care) is parental food delivery rates. The ability of parents to deliver food is thought to be limited by food abundance. Therefore, number of adults contributing to care may influence food delivery rates. Number of adults contributing to care is particularly variable in cooperatively breeding birds, where parents may be aided in parental duties by helpers. However, many studies have failed to detect an increase in offspring size with an increase in number of helpers. To understand this paradox where number of helpers seem to have no effect on offspring size, I am studying traditional ideas involving feeding rates and alternative hypotheses related to female condition and incubation temperature.

I am studying the breeding behavior of two cooperatively breeding passerine birds in the family Timaliidae: Chestnut-crested Yuhina (*Yuhina everetti*) and Mountain Wren-babbler (*Napothera crassa*). These two species represent opposing ends of the slow-fast life history gradient. Their differences in developmental speed, egg size, and parental care provide a basis for examining how offspring size is related to life history strategies. Number of adults helping the main pair varies from one to eight individuals for these species. The first season of field work took place in 2010 at Kinabalu National Park in Malaysian Borneo. A second season of work will take place in 2011.

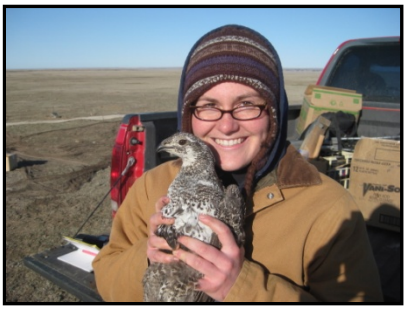
Progress and Status:

The 2010 field season in Malaysia was very fruitful with a total of 112 nests found for both species of interest. A total of 143 adult birds were uniquely color banded to be able to identify individuals at their nests. 334 egg masses and 377 nestling measurement were recorded, hundreds of hours of videos data, as well as egg temperature data (13 nests) and incubation attentiveness data (47 nests), all of which I am currently analyzing.

Sage-grouse stepping stones: Identifying habitat pathways in migratory populations

Total funds obligated: $155,659

Student:	**Rebecca Smith**
Degree:	M. Sc. Candidate
Advisor:	Dave Naugle
Funding source:	U.S. Geological Survey, Bureau of Land Management, World Wildlife Fund, Parks Canada
Project Duration:	2010 – 2013



Objectives:

While much work has been done looking at brood-rearing, summer, and winter habitat requirements of greater sage-grouse (*Centrocercus urophasianus*), migratory pathways are only just now receiving attention. I am using solar-powered GPS transmitters to track a migratory population of sage-grouse at the northeastern extreme of their current and shrinking range in Valley County, MT and Grasslands National Park (GNP), Saskatchewan. GPS technology allows me to remotely track the movements of this sage-grouse population, providing insight on their use of the landscape and movement corridors as they travel up to 120 km between summer and winter habitats.

My research is focused on answering the following questions:

1. How do sage-grouse move across a landscape as they migrate?
2. What is the time frame for their seasonal movements?
3. How frequently and for how long do sage-grouse use stopover locations as they migrate?
4. How do habitat characteristics at stopover locations compare with those at summer and winter habitats?

Progress and Status:

This spring I deployed 24 GPS transmitters, four on grouse caught in GNP, and 20 on grouse caught in north Valley County, MT. An additional 5 VHF transmitters were deployed to aid in relocation and capture of birds in case of summer mortalities. Blood samples taken from caught birds have been sent to the University of Wyoming to be tested for West Nile virus.

The GPS transmitters are programmed to collect four points per day, and I access the locations from the Argos internet database at least once a week. To date I have had seven confirmed mortalities, all apparently depredations, and one unit that appears to have fallen off a juvenile bird. I have been able to recover all but two of the GPS units, one of which is currently in a golden eagle's nest. I suspect that the other unrecovered unit has been swept down a creek and is buried in sediment.

This September I will spotlight for more sage-grouse, re-deploy the units I've retrieved, and collect more blood samples. I will begin vegetation assessments at used and random locations after the grouse have begun their fall migration.

Population viability analysis for Greater Sage-grouse in select areas of the Miles City Field Office

Total funds obligated: $207,719

Post-Doctoral Researcher:	**Rebecca Taylor**
Principal Investigators:	David Naugle and L. Scott Mills
Funding Source:	Bureau of Land Management
Project Duration:	2008 – 2011

Objectives:
Greater sage-grouse (*Centrocercus urophasianus*) have experienced a four decade decline, during which their range has contracted to half its historic area. The Bureau of Land Management (BLM) manages large acreages of sage-grouse habitat, and must decide what levels of human use are compatible with sage-grouse conservation. In particular, the BLM issues grazing permits and oil and gas drilling permits on its own lands, and permitting levels must be set in light of the effects of other stressors on sage-grouse populations. Two such stressors are agricultural tillage on neighboring private lands and West Nile virus. Our research links sage-grouse counts and population dynamics with stressors and management actions to evaluate the viability of populations under future land use scenarios. Our objectives were to use lek count data and demographic information from marked birds to

1. evaluate current viability of sage-grouse populations in eastern Montana,
2. formulate potential and realistic future management scenarios for populations and simulate these management scenarios to evaluate future viability of populations to provide decision support to BLM officials at field office, state and national levels

Progress:
We analyzed the effects of different levels of oil and gas development and different levels of agricultural tillage on sage grouse lek counts, for years with West Nile virus (WNv) outbreaks and for years without. We also assessed the potential of grazing as a sage-grouse management tool by quantifying the relationships between grass height, nest success and population growth.

Land use planning must be geared toward preserving sage-grouse in WNv outbreak years, as the disease causes extreme mortality events in this species. Lek counts in relatively intact landscapes are predicted to drop by approximately 25% when birds are subject to an outbreak. The negative, synergistic effect of WNv and oil and gas development is evident in the 62% decline that is predicted with an outbreak in areas with already high energy development. Should an area be developed to 1 well pad per 160 acres throughout, we predict the increased level of development combined with a WNv outbreak to precipitate a 95% drop in lek counts. West Nile virus also exacerbates the effects of tillage on sage-grouse. An increase to 10% tillage, combined with a disease outbreak is predicted to result in a 40-50% decrease in lek counts; while an increase to 20% tillage is expected to result in 60-70% declines. Furthermore, the presence of large leks (> 25 males) is a leading indicator of population status. Loss of large leks is associated with population declines of 42-76%, and loss of medium sized leks (11-25 males) is associated with declines of 77-94%.

Correlations between grass height and nest success suggest that grazing may be one of the few tools available to managers to enhance sage-grouse populations. For instance, a 2 inch increase in grass height could result in a 10% increase in nest success, which our analyses translate to an 8% increase in population growth rate. Managing grass height in otherwise intact sagebrush habitat deserves further research; however, grazing management holds little promise in highly impacted landscapes, because research to date suggests that benefits of grass structure at nest sites are secondary to other habitat features.

FISHERIES AND BIODIVERSITY

Dynamics of hybridization between sauger and introduced walleye

Total funds obligated: $104,236

Student: **Daniel Bingham**

Degree: M.Sc. Candidate

Advisor: Fred Allendorf and Robb Leary

Funding Source: Montana Fish, Wildlife and Parks

Project Duration: 2009 – 2011

Objectives:
The objective of my project is to assess the threat that hybridization with nonnative walleye poses to sauger by addressing the following questions:

1. How is genetic variation distributed within and among nonhybrid sauger populations?
2. What is the power of hybrid detection using microsatellites?
3. Do samples from introgressed populations appear to come from hybrid swarms?
4. If populations are not hybrid swarms, what are the patterns of individual and population admixture?

Progress and Status
During the fall and spring semesters of 2009 and 2010, I worked on completing my thesis proposal and identifying informative microsatellites between sauger and walleye. My graduate committee approved my proposal in spring 2010. I then optimized multiplexes for eleven microsatellites, and I began screening samples collected from the Missouri and Yellowstone River drainages. In July, I presented a poster at the ICCB (International Congress for Conservation Biology), Edmonton, Canada: Dynamics of hybridization between introduced walleye and sauger: 2010. Currently, I am working on double-checking data entry and finishing final rounds of PCR on recently-arrived and troublesome samples. I expect to begin writing my thesis by the end of September.

The eleven microsatellites chosen are highly divergent between sauger and walleye (F_{ST} = 0.22, R_{ST} = 0.58). Three are *diagnostic* (non-overlapping allele sizes) and two are partially diagnostic allowing for hybrid index analysis. The remaining six are *informative* with substantial allele frequency differences. To quantify the power of hybrid detection, we have used the software package STRUCTURE to estimate the amount of admixture in simulated individuals by Bayesian analysis of the multiple locus genotypes. 100% of sauger and walleye and 100% of F_1, F_2, and first generation backcrosses are correctly identified at q_i=0.95 and 0.05 (q_i is the posterior proportion of an individual's genome with walleye ancestry).

Our preliminary results from the Yellowstone and Tongue Rivers suggest that hybridization may be widespread as two of four populations are hybridized. However, results from this, and our previous allozyme study, indicate that populations are not hybrid swarms. This is somewhat surprising as walleye have been stocked extensively in Montana for over 60 years. The apparent absence of hybrid swarms suggests there are barriers to complete introgression (e.g., assortative mating, reduced hybrid fitness, or temporal/spatial separation in spawning).

Long-term population monitoring of Columbia spotted frogs

Total funds obligated: $8,050

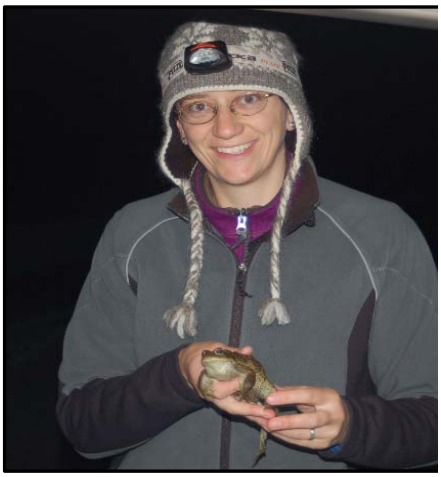
Principal Investigator: Lisa Eby

Project Coordinator: Rebecca McCaffery

Funding Source(s): USGS; ARMI

Project Duration: 2010-2011

UM Project Affiliation: MTCWRU



Objectives:

The worldwide decline of amphibian populations has been well documented (Houlahan et al. 2000). A significant proportion of the amphibian species native to the western United States has suffered declines or may be declining, often with no obvious cause (Corn 2000). We seldom have a complete understanding of the reproductive ecology and population dynamics of species purported to be in decline, both of which are essential prerequisites to understanding trends and designing informed conservation and management plans.

In order to begin to determine how montane amphibian populations will be impacted by climate change in the Rocky Mountain west, we need a better understanding of their demography, the variance in their vital rates, and the climate drivers of those vital rates. Long-term studies of amphibian populations are rare (Salvidio 2009) but provide data on variation in demographic variables and responses to environmental influences that are impossible to obtain in any other manner. Initial analyses of the existing data set suggest that such populations have negative population growth in most years (McCaffery and Maxell 2010), but that predicted less severe winters, particularly lower snowpack, may benefit some high elevation populations (McCaffery 2010).

The objectives of this study are to continue this long-term data set to allow us to address the following questions:

How well do regional climate variables (from weather station 20km away) reflect key physical processes in the basin, such as melt out time for the ponds (tightly linked to breeding timing)? What proportion of the annual variation in survival can be explained by climate variables? Which are the most important climate variables driving variation in breeding and survival?

Progress:

In the summer of 2010, we completed another year of field work. Egg mass surveys took place in the Little Rock Creek basin, Ravalli County, Montana the end of June and through mid-July. In August, adult and juvenile spotted frogs were captured and marked as described by McCaffery (2010) and McCaffery and Maxell (2010) in the upper Little Rock Creek Basin across all water bodies. Data are currently being entered into the long-term database, shared with ARMI, and analyses will continue over the next year.

A risk assessment framework for defining scientifically-defensible recovery goals for listed species

Total funds obligated: $296,779

Post-doctoral Researcher:	**Cindy Hartway**
Principal Investigator:	L. Scott Mills (In collaboration with co-PIs at University of Idaho [Oz Garton, Michael Scott] and University of Wyoming [Matthew Kauffman]
Cooperators:	U. S. Department of Defense, University of Idaho, University of Wyoming, University of Montana
Project Duration:	2006 - 2010

Objective:

Management of sensitive species is often complicated by incomplete data on the species. An additional complication is our ability to confidently draw inference from data we do have, given uncertainty in parameter estimates and the inherent variability of natural systems. The objective of this project is to develop analyses quantifying the effect of parameter uncertainty (due to environmental variation or observer error) on estimates of population persistence and the prioritization of recovery actions. The main focus of the University of Montana portion of this collaborative grant is to determine the impact of environmental variability on the overall effectiveness of management actions to alter key population attributes such as survival and reproduction. In particular, we are focusing on determining the role of climate variables on the success of plant management actions. Climate is a major driver of plant population dynamics. Many managers attempt to increase plant growth rates by manipulating the level of competition plants face (e.g. removing or reducing invasive plants through weeding, herbicides or mowing). These efforts could be helped or hindered by climate conditions. Understanding how climate variables affect management efforts will help managers prioritize when to focus their management efforts, timing them to coincide with climactic conditions that result in largest overall increases in plant population growth rates.

Progress:

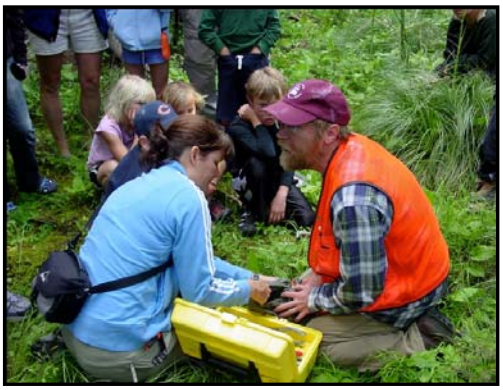
Over the past year we identified appropriate studies on the effect of competitor removal treatments on three plant vital rates: germination rate, seedling survival and reproductive output (e.g. seed or fruit set) for which concurrent climate data was also available (e.g. through NOAA). We have conducted a meta-analysis of these study results to determine how different ecologically relevant grouping variables, including climate variables such as precipitation, mediate the outcome of management. For these analyses we used generalized estimating equations (GEE), which allow us to analyze the effect of covariates on each year of each study separately, while accounting for within study temporal autocorrelation.

Our results indicate that variability in management outcome across all studies, all species and all life-history types is best explained by interactions between seasonal precipitation levels and habitat type. Increases in precipitation increased the effect of competitor removal on seed germination rates and fecundity measures across habitat types, with effects being strongest in semi-arid habitats. However, increased precipitation levels had the opposite effect on seedling survival: in all habitats, increases in rainfall led to decreases in the effectiveness of management to increase seedling survival rates. Management interventions in the wettest years actually have a negative effect on seedling survival.

Can camouflage keep up with climate change? Connecting down-scaled climate models to adaptation for a key forest species

Total funds obligated: $274,860

Faculty Member: **L. Scott Mills** and **Mike Mitchell**
Funding Source(s): U.S. Geological Survey
Project Duration: 2009 – 2012



Objectives:

This project uniquely addresses the linkage between downscaled, high-resolution climate models and the consequences of specific climate drivers on species and ecosystem-level adaptation. Snowshoe hares are critical players in forest ecosystems, because most carnivores prey on them. Like many other species in temperate ecosystems (e.g. arctic foxes, weasels, ptarmigan), hares undergo a seasonal coat color molt to match the presence or absence of snow. Because a reduced duration of snowpack is the strongest signal of climate change in temperate regions, and because mismatch (white coat on non-snowy background) is likely to lead to high predation-induced mortality, the climate factors that make this species vulnerable to rapid decline are starkly clear. On the other hand, any species may respond to climate change by adapting or moving.

This project builds off Mills' longest-running snowshoe hare study in the United States, and climate downscaling by Dr. Steve Running, UM CFC climatologist. We will use radio telemetry to determine the demographic cost of mismatch of snowshoe hares to their background, and to evaluate the scope for movement and/or adaptive responses whereby timing of coat color shifts are modified or behaviors mitigate negative effects of mismatch. Importantly, we will then connect the responses of hares to high-resolution climate models of snowpack and temperature.

Progress:

In the last year we have radio collared 70 hares in 3 different study areas: 16 in the Swan Valley, 51 in the Seeley Valley, and 3 to date outside Yellowstone National Park. These efforts are continuing. For each radio collared hare, we are collecting 3 kinds of data. First, we are photographing hares weekly to quantify the phenology of the coat color change, recording both the initial date where hares start to molt from brown to white (or vice versa) and the speed it takes to complete the molt. These photos also let us quantify 'mismatch', the degree to which hares are white against a snowless background, or brown against a snowy background. Second, at the same times that we photograph the hares we are also photographing the area around the hare, and throughout the general study area, so we can test whether hares are choosing microsites that may minimize mismatch. Finally, we are recording mortality year-round to test whether mortality is associated with the hare being mismatched. In addition, because coat color molt may be affected by temperature, we are experimenting with I-button thermocrons on the radio-collars to try to track ambient temperatures used by the hares, and throughout the sites. Our collaborator Steve Running has begun working on the climate downscaling models, and has begun to produce preliminary projections of %snow on the ground at our study areas each month, projected 30 years into the past and 100 years into the future. This will allow us to link fitness costs of being mismatched to predictions of how mismatch will change in the future with decreased snow cover.

Genetic population structure and conservation of Bull Trout (Salvelinus confluentus) in the East Fork Bitterroot River, Montana

Total funds obligated: $65,053

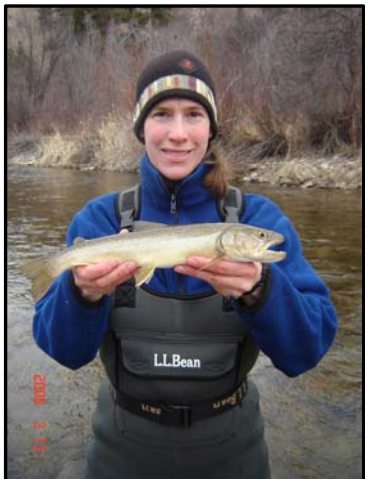
Student: **Leslie Nyce**

Degree: M.Sc. Candidate

Advisor: Lisa Eby

Funding Source(s): Montana Fish, Wildlife and Parks through Sec. 6 and SWIG funds

Project Duration: 2008-2010



Objectives:

1. Determine the genetic population structure of bull trout in the East Fork Bitterroot River.
2. Determine which tributaries are important for fluvial fish.
3. Re-evaluate the current monitoring plan to determine if it captures the status and trends of fluvial fish.

Progress and Status:

To determine genetic population structure, we sampled all East Fork tributaries with known bull trout presence to collect non-lethal tissue samples during the summers of 2008 and 2009. Analysis of the tissue samples has included DNA extraction, polymerase chain reaction and fragment analysis using 16 microsatellite loci with allelic diversity. Seven of the loci are diagnostic allowing examination of hybridization with brook trout. DNA extraction has been completed on all samples along with fragment analysis. A total of 399 samples have been genotyped with three samples showing hybridization. Initial analyses show an allelic diversity between 2-22 alleles. In addition to analyses to describe population structure, I will test for relatedness among individual samples within tributaries as well as examine whether there is evidence of population bottlenecks. To examine which tributaries are important for fluvial fish, I implanted six fluvial bull trout with radio transmitters in order to identify spawning tributaries. Three of the six fish were tracked to spawning tributaries and a fourth to the East Fork Wilderness area. In addition, we collected tissue samples from the East Fork mainstem and Bitterroot River to assign to a tributary of origin. Between the different approaches (following fluvial fish and assigning fluvial fish to natal tributaries), I hope to be able to highlight the key tributaries producing fluvial fish. Once I have a better understanding of the distribution and sources of fluvial fish, I will evaluate the current monitoring plan and existing data to examine whether it has captured the trends in the fluvial component and make recommendations for future monitoring approaches. The field components of this project were completed by fall of 2009 with final data analyses and thesis writing occurring in 2010.

PUBLICATIONS AND REPORTS

Ausband, D.E., **M.S. Mitchell**, K., Doherty, P. Zager, C.M. Mack, and J. Holyan. 2010. Surveying predicted rendezvous sites to monitor gray wolf populations. Journal of Wildlife Management 74:1043-1049.

Beyer, H. L., D. T. Haydon, J. M. Morales, J. L. Frair, M. Hebblewhite, **M. S. Mitchell**, and J. Matthiopoulos. 2010. The interpretation of habitat preference metrics under use-availability designs. Philosophical Transactions of the Royal Society B 365:2245-2254.

Biancucci, L. and **T.E. Martin**. Can selection on nest size from nest predation explain the latitudinal gradient in clutch size? Journal of Animal Ecology 79:1086-1092.

Chalfoun, A. D. and **T. E. Martin.** 2009. Habitat structure mediates predation risk for sedentary prey: experimental tests of alternative hypotheses. Journal of Animal Ecology 78, 497-503.

Chalfoun, A.D. and **T.E. Martin**. 2010. Facultative nest patch shifts in response to nest predation risk in the Brewer's sparrow: a "win-stay, lose-switch" strategy? Oecologia 163:885-892.

Fedy, B. C. and **T. E. Martin**. 2009. Male songbirds provide indirect parental care by guarding females during incubation. Behavioral Ecology 20:1034-1038.

Forsman, J. T. and **T. E. Martin.** 2009. Habitat selection for parasite-free space by hosts of parasitic cowbirds. Oikos 118: 464-470.

Fredrickson, R., and **L. S. Mills**. 2010. Final Report for "Evaluation of Risks and Benefits of Population Augmentation Options to Facilitate Recovery of Bighorn Sheep in the Peninsular Ranges, California". Submitted to CA Fish and Game.

Gude, J. A., **M. S. Mitchell**, **D. E. Ausband**, C. A. Sime, and E. E. Bands. 2009. Internal validation of predictive logistic regression models for decision-making in wildlife management. Wildlife Biology 15:1-18.

Hanson, L. B., **M. S. Mitchell**, J. B. Grand, D. B. Jolley, B. D. Sparklin, and S. S. Ditchkoff. 2009. Effect of experimental manipulation on survival and recruitment of feral pigs. Wildlife Research 36:185-191.

Hartway, C. 2010. A risk assessment framework for defining scientifically defensible recovery goals for listed species. (SI-1477)

Jolley, D. B., S. S. Ditchkoff, B. D. Sparklin, L. B. Hanson, **M. S. Mitchell**, and J. B. Grand. 2010. Estimate of herpetofauna depredation by a population of wild pigs. Journal of Mammalogy 91:519-524.

Kie, J. G., J. Matthiopoulis, J. Fieberg, R. A. Powell, F. Cagnacci, **M. S. Mitchell**, J. Gaillard, and P. R. Moorcroft. 2010. The home range concept: are traditional estimators still relevant with modern telemetry technology? Philosophical Transactions of the Royal Society B 365:2221-2231.

Laikre, L., F.W. Allendorf, L.C. Aroner, C.S. Baker, D.P. Gregovich, M.M. Hansen, J.A. Jackson, K.C. Kendall, K. McKelvey, M.C. Neel, I. Olivieri, N. Ryman, M.K. Schwartz, R. Short Bull, **J.B. Stetz**, D.A. Tallmon, B.L. Taylor, C.D. Vojta, D.M. Waller, and R.S. Waples. 2009. Neglect of genetic diversity in implementation of the Convention on Biological Diversity. Conservation Biology 24:86–88.

Laikre, L., M.K. Schwartz, R.S. Waples, N. Ryman, and The GeM Working Group: C.S. Baker, D.P. Gregovich, M.M. Hansen, J.A. Jackson, K.C. Kendall, K. McKelvey, M.C. Neel, I. Olivieri, R. Short Bull, **J.B. Stetz**, D.A. Tallmon, B.L. Taylor, C.D. Vojta, D.M. Waller. 2010. Compromising genetic diversity in the wild: unmonitored release of commercial gene pools. Trends in Ecology and Evolution 25:520–529.

Lloyd, P., A. Taylor, M. A. de Plessis and **T. E. Martin**. 2009. Females increase reproductive investment in response to helper-mediated improvements in allo-feeding, nest survival, nestling provisioning and post-fledging survival in the Katoo scrub-robin *Cercotrichas coryphaeus.* J. Avian Biol. 40: 400-411.

Long, R. A., J. G. Kie, R. T. Bowyer, and **M. A. Hurley**. 2009. Resource selection and movements by female mule deer *Odocoileus hemionus*: effects of reproductive stage. Wildlife Biology 15:288-289.

Mitchell, M.S., J.A. Gude, **D.E. Ausband**, C.A. Sime, E.E. Bangs, M.D. Jimenez, C.M. Mack, T.J. Meier, S. Nadeau, and D.W. Smith. 2010. Temporal validation of an estimator for successful breeding pairs of wolves *Canis lupus* in the U.S. northern Rocky Mountains. Wildlife Biology 16:101-106.

Mitchell, M. S., L. B. Pacifici, J. B. Grand, and R. A. Powell. 2009. Contributions of vital rates to growth of a protected population of American black bears. Ursus 20:77-84.

Sawaya, M.A., T.K. Ruth, S. Creel, J.J. Rotella, **J.B. Stetz**, H.B. Quigley, and S.T. Kalinowski. Evaluation of Noninvasive Genetic Sampling Methods for Cougars Using a Radio-Collared Population in Yellowstone National Park. Journal of Wildlife Management. In Press.

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Sparklin, B. D., **M. S. Mitchell**, L. B. Hanson, D. B. Jolley, and S. S. Ditchkoff. 2009. Territoriality of feral pigs in a highly persecuted population on Fort Benning, Georgia. Journal of Wildlife Management 73:497-502.

Stenglein, J.L., L.P. Waits, **D.E. Ausband**, P. Zager, and C.M. Mack. 2010. Efficient noninvasive genetic sampling for monitoring reintroduced wolves. Journal of Wildlife Management 74:1050-1058.

Stenglein, J.L., De Barba, M., **Ausband, D.E**., Waits LP. 2010. Impacts of sampling location within a faeces on DNA quality in two carnivore species. Molecular Ecology Resources. 10:109-114.

Stetz, J.B., K.C. Kendall, and C. Servheen. 2010. Evaluation of bear rub surveys to monitor grizzly bear population trends. Journal of Wildlife Management 74:860–870.

Stewart, K. M., R. T. Bowyer, J. G. Kie, and **M. A. Hurley**. 2010. Spatial distributions of mule deer and North American elk: Resource partitioning in a sage-steppe environment. American Midland Naturalist 136:400-412.

Taylor, R. L., D. E. Naugle and L. S. Mills. 2010. Viability analyses for conservation of sage-grouse populations. Unpublished report to the Miles City Field Office, Bureau of Land Management, Miles City, Montana.

PRESENTATIONS AND POSTERS

Jimenez, B.S. 2009. *Effects of Forest Roads on Black Bears in North-Central Idaho*. 10th Annual Western Black Bear Workshop. Reno, NV.

Jimenez, B.S., M.S. Mitchell, P. Zager. 2010. *Multi-scale Effects of Forest Roads on Black Bears*. Idaho Chapter of the Wildlife Society Meetings. Boise, ID.

Mitchell, M. S. 2009. Finding a moving needle in a haystack: monitoring wolves in the northern Rockies. El Centro de Investigación y Capacitación Río Los Amigos, Peru.

Mitchell, M. S., M. Kauffman, and J. S. Bissonette. 2010. Transboundary research. All hands meeting, Cooperative Research Units. New Orleans, LA.

Mitchell, M. S. 2010. Making good decisions for conservation using structured decision making. International conference on wildlife research techniques in rugged mountainous Asian landscapes. Ugyen Wangchuck Institute for Conservation and Environment, Bhumtang, Bhutan. (*Invited*)

Mitchell, M. S., and **L. N. Rich**. 2010. Using radiotelemetry to answer habitat and population questions. International workshop on wildlife research techniques in rugged mountainous Asian landscapes. Ugyen Wangchuck Institute for Conservation and Enivronment, Bhumtang, Bhutan. (*Invited*)

Nyce, L.G. March 2010. Genetic population structure and conservation of bull trout in the East Fork Bitterroot River, Montana. Trout Unlimited, Bitterroot Chapter, Hamilton, MT (*Invited*).

Parsons, Elliott 2010. Effects of large herbivores on ecosystems in northern Arizona. La Selva Biological Station, Costa Rica.

Parsons, Elliott 2010.. Elk herbivory alters small mammal assemblages in high elevation snow melt drainages. Annual Conference, Ecological Society of America

Rich, L. and **M. S. Mitchell**. 2009. Combining hunter surveys and territorial dynamics to monitor wolf pack abundance and distribution in Montana. Northern Rocky Mountains wolf managers' meeting, West Yellowstone, Montana.

Rich, L, **M. S. Mitchell**, C. Sime, R. Russell, and J. Gude. 2010. Using hunter surveys to monitor wolf pack abundance and distribution in Montana. Montana Chapter of the Wildlife Society Annual Conference, Helena, Montana.

Rich, L. and **M. S. Mitchell**. 2009. Using hunter surveys to monitor wolf pack abundance and distribution in Montana. The Wildlife Society Annual Conference, Monterey, California.

Stetz, J., A. Macleod, and K.C. Kendall. 2009. What Do Bears Really Do in the Woods? Crown the Continent Research Learning Center Brown Bag Seminar, Community Building, Glacier NP Headquarters, MT. (*Invited*)

Stetz, J.B., K.C. Kendall, and C. Servheen. 2010. Using Noninvasive Genetic Sampling to Assess and Monitor Grizzly Bear Population Status in the Northern Continental Divide Ecosystem, Montana. Montana Chapter of The Wildlife Society Annual Meeting. Helena, MT.

Stetz, J.B., K.C. Kendall, and C. Servheen. 2010. Evaluation of bear rub surveys to monitor grizzly bear population tends. 19th Annual Conference of the International Association for Bear Research and Management. Tiblisi, Republic of Georgia.

Stetz, J.B., K.C. Kendall, and C. Servheen. 2010. Using Noninvasive Genetic Sampling to Assess and Monitor Grizzly Bear Population Status in the Northern Continental Divide Ecosystem, Montana. Society for Conservation Biology conference. Edmonton, AB.

Stetz, J.B., K.C. Kendall, and A. Macleod. 2010. Black bear density in Glacier National Park, Montana. 19th Annual Conference of the International Association for Bear Research and Management. Tiblisi, Republic of Georgia.

Stetz, J.B. , K.C. Kendall, and A.C. Macleod. 2010. Using Genetics to Assess Status & Trends of a Threatened Grizzly Bear Population. US Geological Survey Genetics and Genomics Showcase. Washington DC.

Stetz, J., K.C. Kendall, and A. Macleod. 2010. Black bear density in Glacier National Park, Montana. Society for Conservation Biology conference. Edmonton, AB.

Taylor, R. L., B. L. Walker, D. E. Naugle and L. S. Mills. 2009. Sage-grouse population dynamics: using vital rates and lek counts to explore management options. Powder River Basin Interagency Working Group Research Meeting. Sheridan, Wyoming.

Taylor, R. L., B. L. Walker, D. E. Naugle and L. S. Mills. 2010. Managing multiple vital rates to maximize greater sage-grouse population growth. Western Agencies Sage and Columbian Sharp-tailed Grouse Workshop. Twin Falls, Idaho.

AWARDS AND RECOGNITIONS

Elliott W. R. Parsons

- Outstanding Teaching Assistant Award, Wildlife Biology Program, spring 2010

Thomas E. Martin

- Elected Honorary Member – Cooper Ornithological Society – 2010
- Edwards Prize – for best paper published in Wilson Journal of Ornithology in prior year - coauthor
- Elected Fellow – AAAS (American Advancement for the Association of Science) - 2009

Jeff Stetz

- 2010 Wildlife Society wildlife paper of the year (2007-2009). Kendall, K. C., **J. B. Stetz**, J. Boulanger, A. C. Macleod, D. Paetkau, and G. C. White. 2009. Demography and genetic structure of a recovering brown bear population. Journal of Wildlife Management 73:3–17.
- Best Ph.D. Student Presentation – Montana Chapter of The Wildlife Society Annual Meeting. Helena, MT. 25 Feb 2010.
- Student Finalist – Society for Conservation Biology conference. Edmonton, AB. 05 July 2010.
- Les Pengelly Scholarship, 2010
- Bertha Morton Scholarship, 2010