MONTANA COOPERATIVE

Wildlife

RESEARCH UNIT

Report for the

Coordinating Committee

Meeting

25 April 2012

Montana State University

Bozeman, Montana

Cover Photos

Tom Martin, P.I. – Understanding the environmental causes of a major global divergence in life history strategies of tropical birds

Funded by the National Science Foundation

Location - Borneo

Top	**Andrew Boyce, Ph.D. Candidate – Reviewing Project Goals**
Middle	**Female Whitebrowed Shortwings**
Bottom	**Outlook at Mount Kinabalu, Borneo**

Montana Cooperative Wildlife Research Unit

Report of Activities for the Coordinating Committee Meeting
April 2012

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

Project and fiscal information included in this report:
1 July 2010 through 31 December 2011

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Rebecca Taylor, Post Doc

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Barbara Fannin, M.Sc. Candidate
Charles Henderson, M. Sc. Candidate
Mark Hurley, Ph.D. Candidate
Ben Jimenez, M.Sc. Candidate
Lindsey Rich, M.Sc. Candidate *
Sarah Sells, M.Sc. Candidate
Jeff Stetz, Ph.D. Candidate

Tom Martin

Dan Barton, Ph.D. Candidate
Andrew Boyce, M.Sc. Candidate
Karolina Fierro-Calderon, M.Sc. Candidate
Ross Crandall, M.Sc. Candidate
Amy Johnson, M.Sc. Candidate*
Joseph LaManna, Ph.D. Candidate
Ania Majewska, M.Sc. Candidate *
Juan Carlos Oteyza, Ph.D. Candidate
Riccardo Ton, Ph.D. Candidate

* Graduated

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Mike Mitchell

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Sonja Christensen, Ph.D. Candidate
Daniella Dekalaita , M.Sc. Candidate
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Allison Moody, Ph.D. Candidate (Auburn)
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Leslie Nyce, M.Sc. Candidate *
Juan Oteyza, M.Sc. Candidate
Keith Slauson, Ph.D. Candidate
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Sonja Smith, M.Sc. Candidate *
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Ashley Heers, Ph. D. Candidate
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Margaret Riordan, M. S. Candidate
Joseph Smith, 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.

OPERATING BUDGET 2011

Unit and Administrative Operating Funds		
U.S.G.S. – Cooperative Research Units – Administrative Funds	20,000	
Travel – Mitchell to Auburn	2,762	
USFWS/NCTC – Structured Management MTFWP Personnel	8,531	
University of Montana		
Full-time Administrative Associate - Salary/Benefits	53,447	
SPABA – FY10 IDC returned to Unit in FY11	64,405	
Subtotal		**149,145**
FY 2011 – Research Projects Funded		
Montana Fish, Wildlife and Parks		
Operating Funds	20,000	
WBIO/MTCWRU Research Projects (FY11)	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		**$2,042,538**

Completed Projects – 1 July 2010 – 31 December 2011

End Date	Principal Investigator	Funding Agency	Title
December 2010	Dave Ausband	Alberta Sustainable Resources	Canada support for gray wolf monitoring
	L. Scott Mills	USGS – RWO 94	Linking conservation actions: A risk assessment framework for defining scientifically defensible recovery goals for listed species
	Mike Mitchell	IDFG	Influence of home range patterns of black bears on capture-mark-recapture estimates based on hair snaring
April 2011	Lisa Eby	MTFWP	Investigations on the fluvial life history of bull trout in the Bitterroot River
June 2011	Dave Ausband	Nez Perce Tribe	Wolf monitoring protocols
	Mike Mitchell	IDFG	Ungulate ecology in Idaho: Understanding predator/prey interactions
September 2011	Dave Ausband	Bureau of Indian Affairs	Wolf monitoring protocols
	Mike Mitchell	MTFWP	Linking resource selection and mortality modeling for population estimation of cougars in Montana
	Mike Mitchell	USGS – RWO 93	Bear research and management
	L. Scott Mills Dave Naugle	USGS – RWO 91	Population viability analysis for greater sage-grouse in select areas of the Miles City Field Office
October 2011	Dave Ausband	USFWS	Surveying for wolves in the Selkirk Mountains
	Mike Mitchell	National Park Service	Analysis of wildlife movements in relation to Denali Park Road Traffic
November 2011	Dave Ausband	Oregon Zoo Foundation	Developing non-invasive population techniques for gray wolves
December 2011	Dave Ausband	Mountaineers Foundation	Wolf monitoring-howlbox surveys
	Dave Ausband	Wolf Recovery Foundation	Wolf biofence project

MTCWRU – Federal and State Vehicles

Description	Tag number	Odometer as of 4/17/12
1993 Chevrolet Fleetside Pickup, 4x4	FED 261122	119,834
1999 Ford Truck, Extended Cab Pickup 4 x 2	FED 252524	97,344
2003 Chevy Suburban 1500	FED 430256	78,354
2006 Ford F250 Crew Cab Pickup, 4 x 4,	FED 430965	78,742
2010 Ford Expedition 4 x 4	FED 433441	13,218
2011 Ford F250 Crew Cab Pickup, 4 x 4	FED 433440	6,364
2011 Ford F250 Crew Cab Pickup, 4 x 4	FED 433610	500
2012 Dodge 1500 Crew Cab 4 x 4	FED 433621	10
1997 Chevy Suburban, 3/4 ton, 2wd	UM 7787	144,693
1998 Ford Taurus 4 Door Sedan	UM 7623	118,962
2005 Ford Explorer 4 x 4	UM 3787	108,885

AMPHIBIANS AND FISH

Conservation genetics of Sauger in the upper Missouri River

Obligated funding: $104,236

Student: Daniel Bingham

Degree: M.Sc. Wildlife Biology
Completed spring 2011

Advisor: Fred W. Allendorf
Co-Advisor: Robb F. Leary

Project Duration: 2009 – 2011

UM Affiliation: DBS - Wildlife Biology

Funding Source:

- Montana Fish, Wildlife and Parks

Abstract

Hybridization with nonnative walleye may play a substantial role in sauger declines throughout the upper Missouri River drainage of Montana and Wyoming. I identified 11 microsatellite loci to detect interspecific hybridization and describe the genetic population structure of sauger. Two major population groupings of sauger were revealed by principal component analysis. The first consisted of samples from the Missouri and lower Yellowstone River drainages, which showed no evidence for genetic divergence among each other. The second major grouping contained samples from the Bighorn River drainage and the upper Yellowstone River. Samples from the upper Bighorn River drainage were genetically distinct from downstream samples. The Bighorn and upper Yellowstone River samples had substantially lower heterozygosity and allelic richness than the lower Yellowstone and Missouri River samples. Analysis of simulated data sets suggested that 100% of sauger and walleye and 100% of first and second generation hybrids could be correctly identified using these 11 loci. This indicates that my analysis method has the power to discriminate sauger and walleye and to detect hybridization and introgression. I detected only eighteen hybrids out of 925 individuals analyzed. Hybridization appeared recent, as nearly 50% of the hybrids showed significant evidence for having a non-hybrid ancestor within two generations. Only one hybrid was detected in the Missouri River. All others were found in the Yellowstone River drainage, despite a substantially higher rate of walleye stocking in the Missouri River drainage. Environmental conditions in the Yellowstone River drainage may be more conducive to hybridization, or hybrid and walleye survival. The rarity of hybrids, despite massive walleye stocking, is unexpected.

Introgression of walleye genes into native sauger does not appear to be an immediate threat. Nevertheless, the presence of hybrids could still be harmful because their production represents wasted reproductive effort. Given my results, I recommend that (1) the transfer of genetically distinct stocks of sauger not take place; (2) historical levels of gene flow among populations be restored; and (3) the walleye fishery in the upper Missouri River drainage be replaced with a sauger or sterile walleye fishery.

Analyses of restoration projects in the Blackfoot River Basin, MT

Obligated funding: $10,000

Student: Kellie Carim

Degree: Ph.D. Candidate

Advisor: Lisa Eby

UM Affiliation: CFC - Wildlife Biology

Project Duration: 2010-2012

Funding Sources:

- Montana Fish Wildlife and Parks (2010-2011)

Objectives

Use existing monitoring data to evaluate the habitat restoration work in the Blackfoot River Basin.

Progress and Status

Over the past century, anthropogenic habitat degradation and exotic species interactions have led to range-wide salmonid declines. We examined the response of wild trout to reach-scale restoration projects from the past 20 years on private ranchlands in Blackfoot River Basin, Montana. We used a single-pass electrofishing catch statistic to examine the population response of age 1+ native and nonnative trout on 16 streams. Across all projects, total trout abundance increased 56% from pre-treatment to four years post-treatment and was not statistically distinct from reference streams approximately 10 years post-treatment. Ten of the sixteen streams were defined as successful because they displayed sustained population increases of trout from pre-project numbers. Across individual streams, population responses varied between native and non-native groups and among restored sites based on environmental and ecological factors, and the degree of human mediated impacts, particularly grazing practices. Results indicate that our restoration strategies are contributing to expanding populations of native fish within the lower basin. The Blackfoot River Basin restoration work is exceptional in its landscape conservation, scientific evaluation to find the source of population declines, community based, collaborative approaches to all aspects of the restoration process to ensure sustained project success. In addition, this study is unique in its long-term monitoring dataset to evaluate a variety of projects and influence management and conservation strategies. Our successful experiences and failures provide valuable insight for restoration planning across aquatic and other ecosystems.

In addition, we have collected tissue samples of restored populations and at spawning tributaries within 15km around restored areas for population structure and assignment tests. We are examining where individuals that are founding these newly restored populations are coming from. The overarching goal is to think about how we may be able to prioritize restoration sites to promote the expansion of metapopulations of native fish on the landscape.

Long-term population monitoring of Columbia spotted frogs

Obligated funding: $ 12,050

Principal Investigator: Lisa Eby

Project Duration: 2010-2012

UM Project Affiliation: CFC – Wildlife Biology
Montana Cooperative Wildlife Research Unit

Funding Source:

- U.S. Geological Survey – Research Work Order 98

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. Analyses of the data set suggests 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:

1. 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)?
2. What proportion of the annual variation in survival can be explained by climate variables?
3. Which are the most important climate variables driving variation in breeding and survival?

Progress and Status

In the summer of 2011, we completed another year of field work. 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.

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

Obligated funding: $65,053

Student: Leslie Nyce

Degree: M. Sc. Wildlife Biology
Completed spring 2011

Advisor: Lisa Eby

Project Duration: 2008 - 2011

UM Affiliation: CFC - Wildlife Biology
Montana Cooperative Wildlife Research Unit

Funding Sources:

- Montana Fish, Wildlife and Parks

Abstract

Bull trout *Salvelinus confluentus* are a species of conservation interest and are currently listed as threatened by the U.S. Fish and Wildlife Service. Understanding and conserving the genetic and life history diversity of bull trout populations across their range is critical as conservation, management, and recovery plans are developed. Numerous studies in different regions have shown that local bull trout populations in close geographic proximity are typically very genetically different and evidence for dispersal among neighboring tributary populations is weak.

In addition to genetic diversity, maintenance of life history diversity may increase resilience of bull trout populations. The larger migratory forms have been linked to high reproductive potential and increased population persistence in unstable environments as the distribution of adults across multiple habitats may buffer them against stochastic events. Ensuring the persistence of both genetic and life history diversity are important conservation priorities.

I evaluated the genetic population structure of bull trout in the East Fork Bitterroot River, Montana and identified which tributaries produced the majority of fluvial fish using genetic assignment. My data showed that populations in tributaries are genetically distinct from each other and fish in the main stem East Fork; however, dispersal of individuals among populations was apparent suggesting a metapopulation structure. My results indicate that the scale of management for bull trout in the East Fork is the basin and that migratory fish may be important for maintaining gene flow among small populations and genetic variation within them.

Given the importance of migratory fish, I examined how well we are tracking migratory bull trout populations and threats to their existence. The evaluation of the current monitoring protocol revealed that redd count (spawning beds of salmonid fishes) surveys are not useful. Even though mark-recapture surveys are common, there are few locations where population estimates are obtained. Improving the protocols and combining approaches may improve our inference, specifically, conducting redd counts and electrofishing population estimates in areas identified as supporting migratory fish.

In general, threats such as roads, grazing allotments, and wildfire have been well tracked, although future threats to river habitat conditions (e.g., temperature and degradation) and invasions of brown trout are yet to be fully evaluated.

BIRDS

Ecological causes of life history variation tested by meta-analysis, comparison, and experimental approaches

Student: Dan Barton

Degree: Ph.D. Candidate

Advisor: Tom Martin

UM Affiliation: Division of Biological Sciences –OBE
Montana Cooperative Wildlife Research Unit

Project Duration: 2005 – 2012

Funding Source:

- National Science Foundation
- Montana EPSCoR
- U.S.Geological Survey
- U.S. Department of Agriculture

Dissertation Abstract

The ecological causes of life history variation among taxa and the arrangement of such variation along geographic gradients is enigmatic despite the proximity of life history traits to fitness and implications for understanding basic and applied population ecology. One classic explanation for the arrangement of avian life histories along a 'slow-fast' gradient, where species at low latitudes have 'slow' life history traits (low fecundity and mortality) and species at high latitudes have 'fast' life history traits (high fecundity and mortality), is the increase in seasonality of resources with increasing latitude (Ashmole's hypothesis). Despite broad acceptance, this hypothesis has been supported only indirectly. I tested two key predictions of this hypothesis – that most mortality occurs in winter and that most mortality is caused by starvation – using meta-analysis. Surprisingly, in many populations, the season of greatest mortality was summer, and most mortality was caused by predation. These results suggest alternative explanations for life history variation should remain under consideration despite support for Ashmole's hypothesis.

The relationship between provisioning behavior and offspring number was long recognized to integrate key life history tradeoffs between number and quality of offspring and between current and future reproductive success. Studies of the response of parental provisioning behavior to brood size variation played a formative role in the development of life history theory. Yet, the inference of such experiments for explaining among-species differences has always been limited by lack of comparative context. I expanded predictions of alternative ecological explanations (food limitation, nest predation, adult mortality) for life history variation to an among-species context and test these predictions using a comparative-experimental design across a broad range of bird species from three continents. I found resource limitation and adult mortality risk interact to explain variation among species in responses to natural and experimental variation in brood size, with the degree of food limitation appearing to vary across a gradient of adult mortality risk. This result helps to explain the potentially conflicting results of previous studies and suggests a pluralistic approach to understanding what factors explain life history variation may be fruitful.

Understanding variation among species in mortality rates may thus be pivotal to understanding ecological causes of life history variation. To this end, I compared differences in spatiotemporal variance in survival among three temperate-breeding species with differing migratory strategy. I found that migratory behavior may be associated with reduced spatial variance in annual survival because resident species disperse less, reducing population connectivity. I also found that migratory behavior is associated with increased temporal variance in survival, counter to expectations of general theory. Given the potential importance of mortality risk in life history evolution, expanded geographic comparisons of annual and within-year patterns of variance in survival rates is likely key to understanding variation among species in life history traits.

Progress and Status

Defending Ph.D. on April 26,2012.

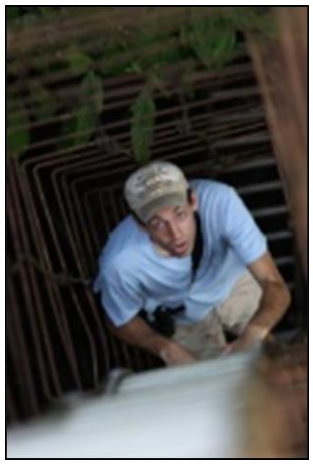
The fight for space: Exploring the role of competition and environmental filtering in limiting elevational distributions and structuring communities in tropical birds

Student: Andrew Boyce

Degree: Ph.D. Candidate

Advisor: Tom Martin

UM Affiliation: Wildlife Biology
Montana Cooperative Wildlife Research Unit



Project Duration: 2011 – 2016

Funding Source:

- National Science Foundation
- The University of Montana
- Montana Cooperative Wildlife Research Unit

Objectives

I propose an observational and experimental study to investigate the importance of competition and environmental filtering in limiting species distributions in clades of birds with parapatric elevational distributions. This pattern of abutting, non-overlapping, elevational ranges of close relatives is a key component of biodiversity and endemism in the tropics and has been documented across taxa (Cadena et al. 2011). However, the mechanisms underlying this pattern are poorly understood. I will perform playback experiments at congener interaction zones to determine the ecological mechanisms determining distributional limits. Additionally, I propose to examine phylogenetic community structure in elevationally stratified bird communities. Phylogenetic community structure, or the degree to which species in a community are related to one another, is thought to reflect the relative importance of interspecific competition and environmental filtering in a given community (Losos 1996, Webb 2000, Graham 2009).

Progress and Status

I am conducting my fieldwork in Kinabalu National Park, Sabah, Malaysia.This reserve consists of intact tropical forest from 400 to 4,100 m.a.s.l., with definitive elevational zonation of forest types, suggesting stable bands of environmental conditions across an elevational gradient (Kitayama 1992). Surveys will be conducted on two distinct mountains within the park, Mt. Tambuyukon and Mt. Kinabalu. Mt. Tambuyukon has undisturbed primary forest from 400-2,600 m.a.s.l, whereas protected forest on Mt. Kinabalu occurs only from 1,450-4,100 m.a.s.l. . This limited elevational range on Mt. Kinabalu results in the absence of many low elevation species. This allows for a natural congener removal experiment to be done by contrasting elevational ranges of focal species at both study sites. Kinabalu Park is also a reserve with tremendous conservation importance; it is at the heart of the Bornean Mountain Endemic Bird Area, which contains 29 endemic bird species including 1 Vulnerable and 6 Near Threatened species (Birdlife Intl. 2011). These species include several montane endemics whose mountain-top ranges are thought to put them at the highest risk of extirpation/extinction assuming upward range shifts due to climate change (Colwell et al. 2008). Understanding the mechanisms that underpin species' elevational distributions and community composition in these threatened areas is vitally important to conservation efforts.

Determining the influence of landscape change on a breeding Golden Eagle population: 1962-Present

Student: Ross Crandall **Obligated funding: $17,993**

Degree: M.Sc. Candidate

Advisor: Tom Martin
Erick Greene

UM Affiliation: Wildlife Biology
Montana Cooperative Wildlife Research Unit

Project Duration: 2011 – 2013

Funding Source:

- Craighead Beringia South

Objectives

Declining populations of native plant and animal species is a major problem threatening global biodiversity. Causes for declining populations have primarily been attributed to human-related impacts such as habitat loss or degradation, direct persecution and over exploitation of resources. Predicting and mitigating impacts is often a primary goal of conservation biologists and ecological research. Before efforts focus on determining causes for declining population, it is first necessary to collect information on the abundance, distribution and productivity of the species and monitor it over an appropriate time period so trends can be properly identified. Once a trend has been established, efforts can expand to determine factors influencing change in the population of interest. My project examines the influence of landscape change on a breeding population of an apex avian predator, the golden eagle (*Aquila chyrsaetos*), in an area of increased breeding density since the 1960's despite increased human presence and a population-level decrease of golden eagles. I am interested in determining the landscape and environmental factors necessary to support the current population and testing differences in identified factors between both time periods. This information will shed light on the role that landscape change has on ecosystem processes, provide information on factors influencing a species of conservation concern and provide tools managers can use to effectively create plans and implement guidelines or management action based on sound scientific evidence.

Progress and Status

In 2010 and 2011, data were collected on occupancy rates of historic territories, 13 new territories were located within the study site and nest success and productivity rates for all territories were documented. In addition, 13 adult breeding golden eagles were captured and outfitted with GPS tracking transmitters to aid in estimating territory sizes, identifying seasonal movements and landscape utilization within established territories. I will be continuing the documentation of occupancy and productivity rates within all known territories in 2012 and 2013 to supplement the information collected in 2010 and 2011. In addition, beginning in 2012 nest sites will be visited to collect prey remains and pellets to analyze prey selection. I will use a combination of these data to assess the factors influencing occupancy and productivity by comparing landscape and environmental variables within a robust occupancy modeling framework. This will be done by testing site-specific and period-specific covariates on occupancy and productivity within each territory between both time periods to identify which factors are most influential in predicting presence and breeding success. A finalized research proposal will be defended during the spring semester of 2012.

Greater Sage-Grouse genetic connectivity across the species' eastern range

Obligated Funds: $175,000

Student: Todd Cross

Degree: Ph. D. Candidate

Advisors: David Naugle & Michael Schwartz

Project Duration: 2011-2016

UM Affiliation: CFC – Wildlife Biology
Montana Cooperative Wildlife Research Unit

Funding sources:

- Bureau of Land Management,
- USDA NRCS – Sage Grouse Initiative
- Montana Fish, Wildlife & Parks
- U.S. Geological Survey – Research Work Order 99

Objectives

The greater sage-grouse (*Centrocercus urophasianus*) is a charismatic icon of the western sagebrush landscape, ranging across 11 Western states and 2 Canadian provinces. Sage-grouse are sagebrush obligates. They rely on sagebrush habitat for food, nesting, and spring breeding congregations known as leks (the male lek display can be viewed here: http://www.youtube.com/watch?v=m0M8pZnNlnI). Sagebrush habitat is rapidly being fragmented and lost due to anthropogenic impacts including subdivision, agricultural tillage, energy development, and invasive species. Sage-grouse currently occupy only 56% of potential pre-western settlement habitat and are warranted but precluded from the Endangered Species Act due to higher priority actions.

Habitat loss and fragmentation, and overall range contraction have heightened concerns regarding the risk of local population extinction due to the severing of genetic connectivity. Therefore, the conservation and management of sage grouse requires a detailed understanding of how landscape change influences gene flow, genetic dispersal, and genetic population structure.

I am partnered with the Bureau of Land Management, Montana Fish, Wildlife and Parks, the National Resource Conservation Service, and the University of Montana to gain a more comprehensive understanding of greater sage-grouse genetic connectivity across Montana, North Dakota, South Dakota, and Wyoming. I am using non-invasive collecting techniques, and molecular genetics monitoring tools in a landscape genetics framework to:

1. Assess the relative importance of individual leks in the network of leks in Montana, North Dakota, South Dakota, and the Powder River Basin of Wyoming.
2. Assign management importance to the persistence of individual leks as it relates to the population as a whole.
3. Test multiple hypotheses about which landscape and environmental features are critical to maintain connectivity, and which features hinder bird movement among leks and Montana and the surrounding states.
4. Model connectivity between and within the thirteen recently designated Montana Fish, Wildlife & Parks core breeding areas.
5. Identify corridors of conservation priority to be included in updating resource management plans.

Progress and Status

To date, I have determined genotypes for over 500 birds representing over 300 leks across Montana and into North Dakota and South Dakota. I am pursuing the development and application of more powerful molecular genetic tools, and have been expanding sampling extent and resolution in collaboration with other state and federal agencies. Additionally, I have begun to identify statewide population substructure as well as landscape and anthropogenic factors influencing these patterns.

Sandhill Crane and Long-Billed Curlew breeding season occupancy in response to habitat structure at multiple scales

Student: Stephanie Couture **Obligated funding: $56,424**

Degree: M.Sc. Candidate beginning fall 2012

Advisor: Mike Mitchell

Project Duration: 2012 -

UM Affiliation: Wildlife Biology Program
Montana Cooperative Wildlife Research Unit

Funding Sources:

- U.S. Fish and Wildlife Service

Objectives

The primary objective of this study is to examine the response of breeding season occupancy to habitat attributes affected by cattle grazing. However, birds select habitats at multiple scales and in response to habitat attributes independent of grazing. Landscape-scale attributes (e.g., distance to emergent marsh) will be included in the study design and occupancy modeling efforts. Explicitly accounting for habitat selection at the landscape scale will provide a better understanding of the relative role grazing has in breeding season occupancy of curlews and cranes. Moreover, modeling the response of curlew and crane breeding season occupancy to landscape-scale habitat attributes provides predictive models that can be used in conjunction with remotely-sensed data to target conservation efforts in other Intermountain West valleys.

The Red Rocks Wildlife Refuge conducted a pilot study in 2009 exploring the response of cranes and curlews to grazing (Stadum 2010). Data collection continued in 2010 and will be expanded onto recently acquired refuge lands in 2011. We propose to conduct a final field season in 2012 and complete analysis and synthesis of all 4 years of data. Preliminary analysis has already provided important insights into the response of crane and curlew breeding season occupancy to vegetation structure influenced by grazing (Stadum 2010).

Finalizing this work will:

1. provide further information on curlew and crane response to habitat attributes affected by grazing,
2. assist in developing an adaptive management plan for the current grazing program, and
3. provide a predictive model based on landscape–scale habitat attributes for curlew and crane occupancy during the breeding season.

Which environmental factors influence territory selection in coexisting species and why?

Student: Karolina Fierro

Degree: Ph.D. Candidate

Advisor: Thomas E. Martin

UM affiliation: Wildlife Biology

Project duration: 2012 - 2015

Funding source:

- Montana Cooperative Wildlife Research Unit
- University of Montana
- Departamento Administrativo de Ciencia, Tecnología e Innovación de Colombia - Colciencias Fulbright

Objectives

Habitat selection has direct consequences for population dynamics and community structure. This process involves behavioral responses by organisms and is considered complex and hierarchical. Within each level of choice, resource partitioning among different species must occur in order for them to coexist in the same geographic area. However, when phylogenetically-related species occur in the same area, they tend to overlap in their requirements because they are ecologically similar. Therefore, in order to minimize competition and predation risk and thus increase reproductive success, ecologically-similar species partition resources temporally, spatially, or by exploiting resources in different ways related to species-specific morphology or behavior. Interspecific territorial behavior allows ecologically similar species to divide space; but, in absence of territoriality, other factors mediate the division of resources between species.

The goal of my research is to explore which environmental factors influence habitat selection of coexisting species and why those factors are important. I will specifically address the following questions: which environmental factors influence territory selection of four ground-nesting birds in Arizona, and why are those factors important in overlapping vs. non-overlapping situations? First, I will determine if vegetation density explains the distribution of territories, considering the degree of territory overlap between species. Then, I will evaluate nest predation, competition, and vegetation density to determine which variable is more influential concerning distribution of territories and why. Moreover, I will identify which are the dominant and subordinate species among three warbler species and determine how dominance behavior affects resource partitioning. Finally, I will identify foraging plasticity of species in situations of spatial overlap vs. non-overlap.

Progress and Status

I will start my first field season on the Mogollon Rim, Arizona, in 2012. From May to July, I will collect data about distribution of territories, behavior in interspecific interactions, and foraging strategies of my four focal bird species: Red-faced Warbler, Orange-crowned Warbler, Virginia´s Warbler, and Dark-eyed Junco. Also, I will explore the possibility of developing experiments that will involve temporal removal of individuals to evaluate changes in behavior and foraging strategies in overlap situations.

Effects of aspen forest restoration on songbird diversity, habitat selection, and reproductive strategies and success

Student: Joseph LaManna **Obligated funding: $240,000**

Degree: Ph.D. Candidate

Advisor: Thomas E. Martin

Project Duration: 2009-2016

UM Affiliation: Wildlife Biology Program
Montana Cooperative Wildlife Research Unit

Funding Sources:

- The Bair Foundation
- Montana Fish, Wildlife and Parks

Objectives

Understanding features that enhance bird diversity and determine reproductive strategies and success is of great interest to science and conservation, especially in Aspen because these forests are declining across western North America. 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. Conifer trees are being removed from some aspen stands as one management treatment that can increase aspen survival and recruitment, and similar treatments are being planned and executed across western North America. 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 and after treatments to improve management decisions and to test hypotheses regarding habitat selection and reproductive strategies. More specifically, we want to know how changes in predator and plant community assemblages influence songbird diversity, habitat selection, and reproductive strategies and success.

Progress and Status

The third season of fieldwork was completed August 2011. Bird diversity, predator abundance, various measurements of reproductive success, and vegetation structure were surveyed during the 2009, 2010, and 2011 songbird breeding seasons. Bird diversity was measured using intensive point counts in all study plots for all seasons, and separate point count plots were added in pure conifer stands adjacent to our aspen study plots to measure the difference in diversity and density among the two vegetation types. 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. However, whereas 37 species were detected within aspen and aspen-conifer mix, only 20 species were detected in pure conifer. A total of 1,230 nests were found and monitored during the three field seasons. Reproductive success data will be used in conjunction with vegetation surveys and the conifer removal treatment to examine the bird community and reproductive response to changing habitat conditions. 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 proposal writing are underway and a complete dissertation proposal will be completed and defended during the spring 2012 semester.

The importance of embryonic development for offspring and adult immune function

Student: Ania Majewska

Degree: M.Sc. Wildlife Biology
Completed fall 2010

Chairperson: Thomas E. Martin

Project Duration: 2008-2010

UM Affiliation: Wildlife Biology
Montana Cooperative Wildlife Research Unit
M-EID Montana Ecology of Infectious Disease

Funding Source:

- National Science Foundation

Thesis Abstract

Why species differ in rate of development and quality of offspring is a central question in life history theory. A physiological trade-off is thought to occur between the rate of development and enhancement of internal systems, such as immune function, which determine high offspring quality. For example, in birds, slow rate of embryonic development is thought to enhance immune function; however, tests of the trade-off show mixed results for adult and nestling birds. A problematic assumption of previous tests is that the length of the embryonic period represents the intrinsic rate of embryonic development. Evidence indicates that temperature experienced by the avian embryo influences rate of development such that cool temperatures slow development, extend development period and may even compromise offspring quality. We studied coexisting species of passerines to test predictions that species with slower embryonic development have higher measures of immune function. We used the absolute length of embryonic period and temperature-corrected embryonic period as measures of rate of development. We also tested the prediction that species with higher parasite attack evolved stronger immune function. We found that among species, measures of adult immune function are positively related to the absolute length of embryonic period but not to temperature-corrected embryonic period. One measure of adult immune function was explained by intestinal parasite intensity suggesting these parasites may exert a selection pressure on certain components of immune function. Nestling immune function was not related to the absolute length of embryonic period while one component of nestling immune function was positively associated with temperature-corrected embryonic period. The discord between nestling versus adult immune function and their relationship with absolute length of embryonic periods raises questions about the importance of embryonic development in determining adult immune function. Our results suggest that a physiological trade-off may be occurring between rate of development and certain aspects of the immune function.

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

Obligated funding: $600,000

Principal Investigator: Thomas E. Martin

Project Duration: 2009-2013

UM Affiliation: Montana Cooperative Wildlife Research Unit

Funding Sources:

- National Science Foundation

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 U.S. and tropical Venezuelan birds studied 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. 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 appears to remain 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 third year studying these traits in tropical Borneo because it retains large blocks of pristine forest at mid-elevation from 1450 to 1900 m elevation. In the past three seasons, 1,576 nests were found and monitored (the largest sample size ever accrued for tropical Asia), nestling growth measured, parental care video-taped, and egg temperatures quantified. In addition, 1,703 new individuals were banded, and a total of 3,757 capture/recapture/resight events were accrued 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. Nest predation rates are high, as common in many tropical areas, but show an elevational gradient where predation increases with elevation in the range we are working. Recapture rates of birds are reasonable, and higher than any other tropical locale that I have worked. This suggests that birds are relatively sedentary and potentially have quite high adult survival, but many more years are needed. As one example, the Chestnut-capped Yuhina (pictured above) has an annual survival estimate of 69% and recapture rate of 60% based on only 3 years and an effective sample size of 176.

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

Obligated Funds: $915,015

Principal Investigator: Thomas E. Martin

Project Duration: 1985-ongoing

UM Affiliation: Montana Cooperative Wildlife Research Unit

Funding Source:

- U.S. Geological Survey – Research Work Order 92

Objectives

Measure and examine: 1) annual variation in avian nest success and predation, adult survival, population size, habitat selection, parental care behaviors, and physiological metrics, 2) small mammal density and species composition, and 3) 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 >17,000 nests over the past 26 years. Winter snowfall has declined strongly across the 26 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. The results will have important implications for elk and ecosystem management in this vulnerable habitat type. This project also has a strong training component, training up to 20 students each year in a diversity of field techniques and conduct of hypothesis-testing science.

Understanding life history strategies that influence offspring size

Student: Juan C. Oteyza

Degree: Ph.D. Candidate

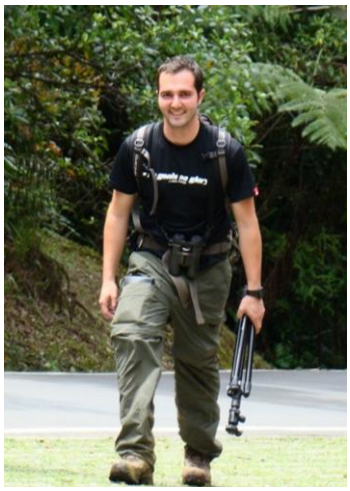
Advisor: Thomas E. Martin

Project Duration: 2009 – 2014

UM Affiliation: Wildlife Biology
Montana Cooperative Wildlife Research Unit

Funding Source:

- National Science Foundation
- Montana Cooperative Wildlife Research Unit
- The University of Montana



In 2011 I transitioned from the M.Sc. to the Ph.D. program. I will continue studying life history strategies that influence offspring size (see below).

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 seems to have no effect on offspring size, I am testing alternative hypotheses related to feeding rates, female condition and incubation temperature.

I am studying the breeding behavior of four passerine birds in the family Timaliidae: Chestnut-crested Yuhina (*Yuhina everetti*), Grey-throated Babbler (*Stachyris nigriceps*) and Temminck's Babbler (*Pellorneum pyrrogenys*) and Mountain Wren-babbler (*Napothera crassa*). These cover a broad range of parental care strategies, including "obligate" cooperative breeders, facultative cooperative breeders and non-cooperative breeding (bi-parental care). These species also include variation from slow to fast life history strategies. Their differences in parental care behaviors, developmental speed, egg size, etc. provide a basis for examining how offspring size is related to life history strategies. The first two seasons of field work took place at Kinabalu National Park in Malaysian Borneo. A third season of work will take place in 2012.

Progress and Status

The 2010 and 2011 field seasons in Malaysia were very fruitful with a total of 313 nests found for all four species of interest. 772 egg masses and 954 nestling measurement were recorded, hundreds of hours of videos data, as well as egg temperature data (38 nests of all four species) and incubation attentiveness data (83 nests of all four species). In the period 2009-2011 a total of 511 adult birds were uniquely color banded to be able to identify individuals at their nests. Furthermore, 187 nestlings have been banded at the nest.

Factors influencing survival of mountain plover chicks in Eastern Colorado

Obligated Funds: $90,110

Student: Maggie Riordan

Degree: M. Sc. Candidate

Principal Investigator: Mike Mitchell and Victoria Dreitz

Project Duration: 2011 – 2013

UM Affiliation: CFC – Wildlife Biology
Montana Cooperative Wildlife Research Unit

Funding source:

- State of Colorado

Objectives

- To investigate differences in and causes of mortality of Mountain Plover chicks among different habitat types – grassland with prairie dogs, grassland without prairie dogs, and agricultural fields.
- To provide information to assist in developing management actions for mountain plovers on public and private lands in eastern Colorado

This project is in year two of field research study that will provide information on the vulnerability of mountain plover reproductive performance on different types of habitats within the species range.

Progress and Status

The Mountain Plover (*Charadrius montanus*) is a neotropical, upland shorebird found on the xeric tablelands from Mexico to northern Montana. In both 1999 and 2010, the United States Fish and Wildlife Service (USFWS) petitioned to list the mountain plover as 'threatened' under the Endangered Species Act. The listing was considered unwarranted subsequent to the proposals in 2003 and 2011 (USFWS 2003, 2011). Regardless of the current conservation status, data are needed to address questions concerning potential factors contributing to population declines.

The preliminary results of this field study suggest that the causes of mountain plover chick mortality do differ amongst habitats but may be consistent within particular habitat types across the species' range. Conservation and management efforts will be difficult and controversial given that the main avian predator of mountain plover chicks, a species of conservation concern, is another species of conservation concern, the burrowing owl. Additional years of field data collection are needed to strengthen the emerging patterns in chick mortality across different habitat types. Such information will contribute to developing conservation efforts, that will:

1. provide sound scientific information to establish an understanding of factors affecting reproductive output for Mountain Plovers;
2. advance existing knowledge on the factors limiting Mountain Plover populations and the factors operating on plover chick survival; and,
3. refine conservation and management efforts for the Mountain Plover and its primary breeding habitats.

Connecting the dots: Identifying migratory pathways for sage-grouse conservation

Obligated Funds: $185,848

Student: Rebecca Smith

Degree: M. Sc. Candidate

Advisor: Dave Naugle

Project Duration: 2010 – 2013

UM Affiliation: CFC – Wildlife Biology
Montana Cooperative Wildlife Research Unit

Funding source:

- Bureau of Land Management
- World Wildlife Fund
- Parks Canada
- U.S. Geological Survey – Research Work Order - 96

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 seasonal movements of individuals from this population, providing insight on their use of the landscape and movement corridors as they travel up to 160 km between summer and winter habitats and revealing unexpected responses to extreme weather events. My research is focused on answering the following questions:

1. Where do migrating sage-grouse travel and spend time between seasonal habitats?
2. What environmental variables predict where grouse are likely to stop en route, and what variables drive where grouse move during periods of abnormal snow-depths?
3. Why do grouse leave a given seasonal habitat?

Progress and Status

I initially deployed 24 GPS transmitters on sage-grouse in spring 2010 and tracked the fall and spring migrations of surviving individuals through 2010-2011. The transmitters are programmed to collect 4 points per day and I can view and download locations via Argos online database. Record snow depths in winter 2010-2011 caused unexpected movements of sage-grouse into the C.M. Russell National Wildlife Refuge (CMR NWR) and raised additional questions about critical sage-grouse winter habitat during extreme weather events. Fall 2011 I will trap again with a goal of deploying 12 additional GPS transmitters.

I wrote my Masters Proposal in fall 2010 and defended my proposal to my committee in spring 2011. I worked with a field crew in summer 2011 collecting shrub cover data from used and available locations within the migratory pathway. We also collected shrub cover data in the CMR NWR and will continue sampling there through October.

Sage-grouse population viability

Obligated Funds: $204,719

Post-doc Researcher: Rebecca Taylor

Principle Investigators: L. Scott Mills and David Naugle

Project Duration: 2009-2011

UM Affiliation: Montana Cooperative Wildlife Research Unit

Funding Source:

- Bureau of Land Management
- U.S. Geological Survey – Research Work Order 94

Objectives

Greater sage-grouse (*Centrocercus urophasianus*) have experienced a four decade decline, during which their range has contracted to half its historic area. While extensive research has been conducted on sage-grouse, specific links between their biology, population dynamics and management are missing. Our research goal was to fill this void by 1) incorporating 70 years of demographic data into a model that projects populations into the future and 2) evaluating the effects of different stressors and management actions on lek counts across a 30 million hectare area of Montana and Wyoming.
Progress:

Progress and Status

Despite decades of field research on greater sage-grouse, range-wide demographic data has yet to be synthesized into a sensitivity analysis to guide management actions. We reviewed range-wide demographic rates for greater sage-grouse from 1938–2011 and used data from 50 studies to parameterize a 2-stage, female-based population matrix model. Three rates were demonstrably important for population growth: female survival, chick survival and nest success. In lieu of quantitative data on specific mortality factors driving local populations, we recommend that management efforts for greater sage-grouse first focus on increasing juvenile, yearling, and adult female survival by restoring large, intact sagebrush-steppe landscapes, reducing persistent sources of human-caused mortality, and eliminating anthropogenic habitat features that subsidize predator species. Our analysis also supports efforts to increase chick survival and nest success by managing shrub, forb, and grass cover, height, and composition to meet local brood-rearing and nesting habitat guidelines, but not at the expense of reducing sagebrush cover or height below that required for female survival in other seasons. The success or failure of management actions for sage-grouse should be assessed by measuring changes in vital rates over long time periods to avoid confounding with natural, annual variation.

Species of conservation concern are increasingly threatened by multiple, anthropogenic stressors which are outside their evolutionary experience. Greater sage-grouse are highly susceptible to the impacts of two such stressors: oil and gas (energy) development and West Nile virus (WNv). We used lek counts across a landscape encompassing extensive local and regional variation in the intensity of energy development to identify the spatial extent at which impacts of development on sage-grouse are best detected. Energy development and WNv each strongly impact sage-grouse, and they interact synergistically. The effect of an outbreak year can cut a population in half, which is roughly equivalent to the 42% reduction that accompanies drilling an undeveloped landscape at the permitting level of 1.5 wells/km^2. The negative, synergistic effect of WNv and energy development is evidenced by a more than doubling of the effect of drilling to 1.5 wells/km^2 in the presence of an outbreak year (96% population reduction instead of 42%). In addition, the effect of energy development on sage-grouse was best detected by measuring well density at a large scale: within a 15 km radius of each lek (707 km^2). Conservation measures should be geared toward conserving sage-grouse in outbreak years and maintaining landscapes large enough to buffer against the far reaching impacts of energy development.

Effects of heat in passerine birds: Physiological, life history and behavioural responses during the ectothermic life stages

Student: Riccardo Ton

Degree: Ph. D. Candidate

Advisor: Thomas E. Martin

Project Duration: 2011 – 2014

UM Affiliation: Division of Biological Sciences –OBE
Montana Cooperative Wildlife
Research Unit

Funding Source:

- National Science Foundation
- The University of Montana

Objectives

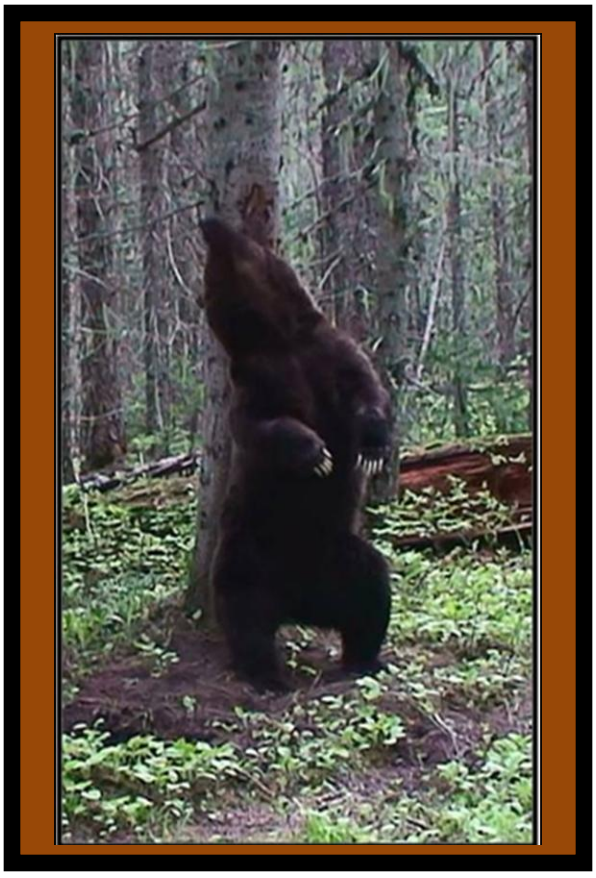
Temperature is a major driver of biological processes and it has significant effects on the physiology, life history and behavior of organisms. In passerine birds, however, the way in which temperature influences development is not always clear and direct. The temperature that embryos and nestlings experience is driven by the behavior of the parents, which is determined proximately by their reaction to ecological factors and ultimately by the life history strategy of each species.

I am interested in understanding the role that temperature plays during the egg and nestling stage, in explaining embryonic and nestling variation in metabolism, sensitivity to temperature, rate of development, growth, and parental care. My goal is to answer the following questions:

1. Do embryos and nestlings of different species metabolically react differently to higher temperatures during development?
2. Is their sensitivity to temperature going to change, and are these changes permanent across developmental stages?
3. Do higher than normal temperatures lead to faster development? With what consequences?
4. How do the adults of different species change behavior in response to an extra source of heat at the nest? Why?
5. How does temperature interact with other factors to constrain the life history strategies of embryos, nestlings and adults?

Progress and Status

From the beginning of May until the end of July of 2011, I spent my first field season of data collection in a high altitude riparian system in Arizona. Supported by a crew of 12 field assistants, I collected data from 62 nests for 3 target species: western bluebird (*Sialia mexicana*), cordilleran flycatcher (*Empidonax occidentalis*) and red-faced warbler (*Cardellina rubrifrons*). I chose these 3 species, because they have significantly different life history strategies and are under different predation regimes. I experimentally heated some of these nests, and videotaped more than 700 hours of parental behavior at heated and control nests. Additionally, I measured the metabolic rate of 62 embryos and 51 nestlings of these and other species. I also measured embryos and nestlings at regular intervals to determine growth rate. Data and laboratory analyses of the 2011 samples are underway.



Wolf monitoring protocols

Research Associate: **David Ausband**

Project Duration: 2006 - 2012

UM Affiliation: Montana Cooperative Wildlife Research Unit

Funding Sources:

- Regina B. Frankenberg Foundation for Animal Welfare - $200,000
- Leonard X. Bosack & Bette M. Kruger Foundation - $160,000
- Bernice Barbour Foundation - $10,060
- Nez Perce Tribe – Idaho - $176,939
- Idaho Department of Fish and Game $45,000
- Alberta Sustainable Resources Development - $6,095
- U.S. Fish and Wildlife Service - $11,701
- MT Department of Natural Resources & Conservation - $1,500
- The Oregon Zoo Future for Wildlife Grants - $11,450
- Rocky Mountain Canada Support - $9,926
- Wilburforce Foundation - $5,000
- Montana Fish Wildlife & Parks
- Safari Club – Spokane
- Animal Welfare Institute – $10,000
- Wolf Recovery Foundation - $2,500
- Mountaineers Foundation - $5,500
- Defenders of Wildlife - $2,500

This report documents our efforts from 2010-11. For full information on previous years' results and detailed descriptions of survey methodology please visit: http://www.umt.edu/mcwru/personnel/ausband/default.aspx

Objectives

We have devised a wolf population monitoring program rooted in patch occupancy modeling, a statistical technique that can integrate data from multiple sampling methods. To populate a patch occupancy model, we are evaluating a variety of survey methods that have demonstrated strong relationships to wolf abundance and distribution. The survey methods we are testing are hunter surveys, rendezvous site surveys, howlboxes, and rub stations.

Progress and Status

We conducted a statewide survey of 13,000 hunters in Idaho in 2010 and again in 2011 to generate data for use in an occupancy model. Data are currently being analyzed and we will use these data to populate a statewide occupancy model that can generate wolf abundance estimates for Idaho. We worked with the University of Montana's Computer Sciences Department to improve the howlbox and tested its efficacy under field conditions in 2011. We found the device lasts 5-6 days and broadcasts > 3 km and records >2 km. Each of the survey methods we have designed over the course of this project (hunter surveys, rendezvous site surveys, howlboxes, and rub stations) can provide the data needed to populate a patch occupancy model; further, some of the methods can yield highly detailed information on wolves in focal areas, providing biologists with unprecedented tools for understanding wolves in areas where management interest is high. We suggest a monitoring framework based on patch occupancy modeling, using observations available from a variety of sampling techniques, can provide reliable statewide estimates of wolf population size.

Biofence for manipulating wolf movements

Research Associate: **David Ausband**

Project Duration: 2010 - 2012

UM Affiliation: Montana Cooperative Wildlife Research Unit

Funding Sources:

- Regina B. Frankenberg Foundation for Animal Welfare
- Leonard X. Bosack & Bette M. Kruger Foundation
- Bernice Barbour Foundation - $20,550
- Nez Perce Tribe – Idaho
- Idaho Department of Fish and Game
- Kampe Foundation - $5,000
- Wilburforce Foundation
- Wolf Recovery Foundation - $7,500
- Animal Welfare Institute

Objectives

Gray wolves (*Canis lupus*) can conflict with livestock production throughout Idaho, Montana, and Wyoming. Generally, wolves that prey on domestic livestock are killed by management agencies or private landowners. These actions typically stop depredations for producers in the short-term but are not a lasting solution because wolf packs generally fill the recently vacated territory within 1 year and livestock predation often continues. Most tools currently available for non-lethal control of wolves are short-lived in their effectiveness or require constant human presence. Wolves, like most canids worldwide, use scent-marking (deposits of urine, scat, and scratches at conspicuous locations) to establish territories on the landscape and avoid intraspecific conflict. We hypothesized that human-deployed scent-marks consisting of scat and urine (i.e., "biofence") could be used to manipulate wolf pack movements in Idaho.

Project and Status

We deployed 64.7 km of biofence within 3 wolf pack territories in central Idaho during summer 2010. Location data provided by satellite collared wolves in 2 of the packs showed little to no trespass of the biofence even though the excluded areas were used by the pack (> 75% kernel level) in previous summers. Sign surveys at predicted rendezvous sites in areas excluded by our biofence yielded little to no recent wolf use of those areas. Lastly, we opportunistically deployed a biofence in between a resident wolf pack's rendezvous site and a nearby (< 1.6 km) active sheep grazing allotment totaling 2,400 animals. This pack was not implicated in any depredations even though their rendezvous site was in close proximity to sheep. Our pilot test provides preliminary evidence that wolf movements can be manipulated using human-distributed scent-marks. We satellite-collared additional wolves in these 3 packs in January 2011, and repeated biofence testing in the summer of 2011. Data analyses are currently underway.

Movements, gene flow, and relatedness of Bighorn Sheep in Central Idaho

Obligated Funds: $69,090

Student: Nathan Borg

Degree: M. Sc. Candidate

Advisor: Mike Mitchell

Project Duration: 2010-2012

UM Affiliation: CFC – Wildlife Biology
Montana Cooperative Wildlife Research Unit

Funding Source:

- Idaho Department of Fish and Game

Objectives

The primary objective of my project is to assess connectivity of bighorn sheep populations at different scales in order to understand the potential for disease transmission and spread between these populations. At a broad scale, I am using landscape genetic techniques to measure levels of gene flow between populations and to assess factors that regulate connectivity. To understand disease transmission at a local scale, I am combining telemetry and genetic data to evaluate bighorn group size, as well as interactions among and between groups. From these data, I will test a range of covariates in predictive models of disease spread within the lower Salmon River drainage. In addition, I will explore measures of genetic diversity in bighorn sheep across central Idaho to determine if there is a relationship between genetic diversity and recruitment or lamb survival.

Progress and Status

In November 2010, we captured and collared 1 ram and 2 ewes and re-collared 1 ram, all with VHF collars. This brought the total number of radio-collared bighorn to 34. Locations are collected bi-weekly during the majority of the year except from April to September when they are flown weekly. During the fall of 2010, I began extracting DNA from 241 bighorn blood or horn samples. In January of 2011, I finished DNA extraction and began analysis of nDNA. I presented preliminary results at both the ID and the MTTWS meetings. From late May through early July, we conduct lamb counts to assess productivity in the lower Salmon study area. I collected 50 fecal samples for DNA analysis from the South Fork of the Salmon River. During summer 2011, 151 samples were processed for mtDNA analysis.

Western elk research collaborative

Obligated Funds: $181,799

Post-Doc Researchers: Heather Johnson/Jedediah Brodie

Principal Investigator: Mike Mitchell

Data Technician: Matthew Nordhagen

Project Duration: 2010 - 2013

UM Affiliation: Montana Cooperative Wildlife Research Unit

Funding Source:

- U.S. Geological Survey – Research Work Order 97
- Idaho Department of Fish and Game
- State of Colorado

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 and Status

We completed the analysis of factors affecting the survival of adult female elk across seven western states. This is one of the largest survival datasets analyzed for any large mammal. In May 2011 we hosted a meeting of members of the Western Elk Research Collaborative (WERC) in Missoula, Montana, where we discussed preliminary results and outlined a plan for finalizing the analysis and disseminating the information. Since then, we revised the analysis and drafted a manuscript presenting the results, which will be submitted to a peer-reviewed journal. We circulated the first draft of this manuscript to the WERC participants in August, and are now revising the manuscript based on the comments we received. We hope to submit a final version of the manuscript by the middle of October, 2011. We have also initiated discussion amongst the WERC collaborators as to the future directions and strategies for the collaborative to take to better understand the ecology and management of elk across the western U.S.

Noninvasive genetic sampling and landscape genetics of Idaho gray wolves

Student: Barbara Fannin

Degree: M.Sc. Candidate

Advisor: Mike Mitchell

Project Duration: 2010-2012

UM Affiliation: CFC - Wildlife Biology
Montana Cooperative Wildlife Research Unit

Funding sources:

- Bosack & Kruger Charitable Funds for Gray Wolf Research
- CFC-WBIO, University of Montana
- Regina B. Frankenberg Foundation for Animal Welfare
- Idaho Department of Fish and Game
- Montana Fish, Wildlife and Parks
- U. S. Fish and Wildlife Service
- Wolf Recovery Foundation

Objectives

My overall objective is to use a landscape genetic approach to investigate population structure and model dispersal in Idaho gray wolves. Wolves in Idaho and Montana were recently removed from the Endangered Species list based on fulfillment of the 3 removal criteria set out in the Northern Rocky Mountain Wolf Recovery Plan. One of those criteria was effective gene flow between the 3 recovery areas. While an earlier study showed that there was effective migration between the 3 recovery areas in the first 10 years after reintroduction, little is known about the current genetic status of wolves within and between states. A baseline understanding of current wolf population structure and probable dispersal corridors in Idaho would allow managers to easily track changes over the years and adjust management actions accordingly. To address this, I am answering the following questions:

1. Are Idaho gray wolves one panmictic population, and if not, are there physical/environmental barriers to geneflow within the state?
2. What is the best (most useful) model for predicting gray wolf dispersal routes within Idaho?

Progress and Status

I chose 5 geographically distinct study areas in Idaho ranging from the Panhandle in the north to Island Park in the southeast corner of the state. During the summer of 2010, rub stations were deployed in each study area to noninvasively collect gray wolf hairs. Each station was left out for 4 nights, and then hairs were collected in 10-hair increments. Between May and September, over 2300 samples were collected and stored in silica desiccant beads until extraction at the University of Idaho Conservation Genetics lab. Preliminary results indicate that individual wolves can be identified using nuclear DNA genotyping. Other carnivores including coyotes, foxes, and black bears have also been detected.

As of fall 2011, I am continuing genetic data analysis and working in ArcMap to plot my data and begin modeling dispersal using the least-cost pathway and circuitscape add-ons for that software. I am also working on completing my master's thesis proposal.

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

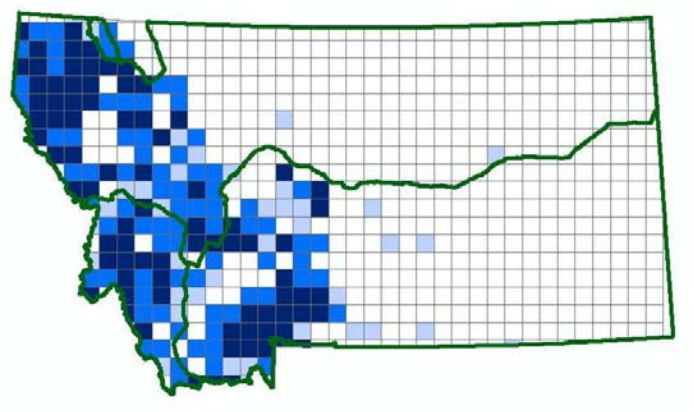
Obligated Funds: $51,886

Post-Doctoral Researcher: Betsy Glenn

Principal Investigator: Mike Mitchell

Project Duration: 2009 - 2011

UM Affiliation: Montana Cooperative Wildlife Research Unit



Funding Sources:

- U.S. Geological Survey – Research Work Order 90
- Montana Fish, Wildlife and Parks
- Idaho Department of Fish and Game
- Nez Perce Tribe
- US Fish and Wildlife Service
- The Frankenberg Foundation

Objectives

We will develop monitoring protocols for wolves in the northern Rocky Mountains based on patch occupancy modeling. We will develop patch occupancy models based on hunter survey data (and other survey data) to estimate numbers of wolf packs, numbers of wolves, pack size distribution, and numbers of breeding pairs. Such an approach would allow geographically targeted planning of management practices (e.g., control actions, harvest quotas, etc.) to meet local, statewide, and regional objectives.

Progress and Status

Montana

During 2010, we developed 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. We used parch occupancy models to estimate the probability of 600 km^2 grid cells containing a wolf pack. These grid cells are approximately equal in size to an average wolf pack territory size, and allowed us to estimate numbers of wolf packs directly from occupancy estimates. Given that hunter surveys also recorded numbers of wolves seen, we were also able to estimate total numbers of wolves. Additionally, our multi-year models provide estimates of local colonization and extinction rates. We were also able to estimate the distribution of pack sizes and the number of breeding pairs for Montana based on the patch occupancy models and other research on gray wolves in the Northern Rockies.

Idaho

We developed and implemented a new statewide hunter survey program for Idaho in 2010. Idaho deer and elk hunters were randomly selected by Game Management Unit (GMU), and were mailed a short questionnaire asking if, when, where, and how many wolves they saw during the 2009 hunting season. We are currently in the process of entering these survey data into a database which can be used to develop a patch occupancy modeling framework for Idaho similar to the one we developed for Montana.

Linking resource selection with survival in female white-tailed deer

Obligated Funds: $70,000

Student: Charles R. Henderson, Jr.

Degree: M.Sc. Candidate

Advisor: Mike Mitchell

Project Duration: 2011 – 2013

UM Affiliation: CFC – Wildlife Biology Program
Montana Cooperative Wildlife Research Unit

Funding Source:

- Washington Department of Fish and Wildlife

Objectives

The main goal of this project is to use survival as a measure of habitat quality and to link portions of the landscape that have a high probability of use with area specific survival rates. I will also identify local population sources and sinks using movement and survival information. Finally, I will be examining what portion of the white-tailed deer population in the study area migrates and how this affects survival rates. I will address these questions by calculating resource selection probabilities, estimating survival rates for various age classes, and quantifying winter severity. The information generated from the study will result in seasonal maps that combine probability of use and survival data. These maps will allow agency personnel to more effectively manage the white-tailed deer population in this region. I will also provide information to managers that will increase the accuracy of local population estimates and identify migration patterns. On a broader scale, the resource selection information will increase scientific knowledge on a common species near the edge of its geographic distribution. The use of survival as a way to measure habitat quality will not only increase the understanding of habitat requirements for white-tailed deer but can also be used for a better understanding of the habitat needs of other species.

Progress and Status

In January 2012, we began capturing and outfitting white-tailed deer with radio telemetry devices. Currently, we have 38 individuals outfitted with radio collars or ear tags. I will begin field work in mid-May 2012. During the field season I will be tracking adult females to determine if they reproduce and if so to track the survival of their offspring. I will also be ground truthing GIS data to ensure the accuracy of resource selection probabilities calculated from this information.

Linking resource selection to population dynamics of mule deer

Obligated Funds: $48,326

Student: Mark Hurley

Degree: Ph. D. Candidate

Advisors: Mike Mitchell
Mark Hebblewhite

Project Duration: 2010 – 2013

UM Affiliation: CFC – Wildlife Biology
Montana Cooperative Wildlife Research Unit

Funding Source:

- Idaho Department of Fish and Game

Objectives

The broad goal of my Dissertation will be to answer the question: how does forage quality, predation risk and weather interact to determine habitat quality and, subsequently, how is habitat quality modified by mule deer behavior and local density to influence vital rates and population size? I will answer this question by investigating the interactive influence of weather patterns, resource selection, and predation risk on mule deer survival and population growth rate. I will integrate measures of population growth and fecundity with fine-scale resource selection and predator-caused mortality to estimate population dynamics and rank habitat components (vegetation type and quality, weather, density and predation) by their importance to population growth rate. These models will then enable wildlife managers to combine population data collected within climate and broad vegetation biomes with fine-scale habitat models to predict the potential mule deer population productivity in different habitats, weather patterns, and management regimes.

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 8 permanent study sites across Idaho. From 1998 to date, >3,000 mule deer fawns and > 1500 adult females have been radio collared with VHF transmitters to monitor survival. Another 79 adult females were collared with GPS transmitters from 2003 to 2011 to estimate resource selection. I have compiled spatial data layers need to complete preliminary resource models.

This year I have developed a research proposal to be defended in October. I have completed resource selection models for summer range in eastern Idaho using GPS locations and 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 estimated survival by population management units and compiled data files and weather variables to begin Proportional Hazards modeling of survival and cause specific mortality. We have collected preliminary vegetation and food habits data for mule deer living in 3 primary ecotypes in southern Idaho. This year I will deploy 200 VHF radio collars on 6-month-old fawns and 30 GPS collars on adult females.

Multiscale effects of forest roads on Black Bears

Obligated funding: $31,000

Student: Ben Jimenez

Degree: M.Sc. Candidate - WBIO

Advisor: Mike Mitchell

Project Duration: 2007 - 2011

UM Affiliation: Wildlife Biology

Montana Cooperative Wildlife Research Unit

Funding Sources:

- Idaho Department of Fish and Game
- Montana Cooperative Wildlife Research Unit

Thesis Abstract

As the vast network of roads associated with resource extraction, recreation and general transport continues to expand, so too does the necessity to understand the associated ecological effects. In order appropriately assess the impacts of these roads on wildlife, it is necessary to view ecological processes at multiple spatial and temporal scales. I assessed the effects of forest roads on habitat selection and activity patterns of a population of black bears (*Ursus americanus*) in the Coeur d'Alene Mountains of northern Idaho. From 1 June 2007 through the winter of 2008, I instrumented 33 adult black bears with Global Positioning System (GPS) collars. I used locations acquired at 20 minute intervals to test hypotheses on annual home range selection, as well selection of resources within home ranges and activity patterns of black bears by month and activity period. I found that annual home range selection of neither male nor female bears were affected by road density. Habitat selection within home ranges varied by sex as well as by month, but selection for moderate slopes, relatively high elevation, and areas close to water was consistent throughout. Whereas habitat selection varied by sex and by month as well, selection for features presumably associated with risk (canopy cover and distance to roads) and activity patterns in proximity to roads illuminated an apparent trade-off between the costs and benefits associated spending time in areas adjacent to roads: throughout the entire study any time bears selected for areas close to roads, they were also selecting dense canopy cover. Similarly, within a buffered area around roads, bears remained further from roads and spent proportionally less time near roads during daylight hours throughout fall hunting seasons. This was especially true for older adult males, which was contrary to previous assessments and information used in management strategies.

My findings suggest that although areas adjacent to roads likely contain resources desirable to bears, the risks associated with these areas require them adjust their use of and activity patterns within these areas so as to minimize mortality risk. My findings indicate that seasonal road closures in areas of productive food resources for bears may be beneficial. In areas where bears are hunted, adjusting season dates so that they do not overlap with periods of vital weight gain (i.e. spring and late summer-early fall hyperphagia). Refining age classes in harvest data on male black bears may provide a more accurate assessment of actual population age structure.

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

Obligated Funds: $412,290

Faculty Members: **L. Scott Mills** and **Mike Mitchell**

Project Duration: 2009 – 2012

Funding Source:

- U.S. Geological Survey Climate Change Research Work Order 95

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 and Status

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.

Grizzly bear population status in the Cabinet-Yaak ecosystem

Obligated Funds: $1,260,000

Principal Investigator: Mike Mitchell

Project Duration: 2011 - 2015

UM Affiliation: Montana Cooperative Wildlife Research Unit

Funding Sources:

- Lincoln County
- U.S. D.A. Forest Service Northern Region

Objectives

This project will provide/identify:

- Baseline data on grizzly bear population size, distribution, and genetic structure
- An index of black bear relative density
- Landscape variables important in explaining bear abundance, gene flow, and dispersal patterns.
- Genetic library of grizzly bears in region and further insight into their connection to neighboring populations/jurisdictions.
- Integrated relational database of grizzly bear spatial and genetic information from all sources in the ecosystem willing to share data

The goal of this project is to acquire precise and accurate data on the status of the endangered (listed as warranted but precluded) grizzly bear population in northern Montana and Idaho using noninvasive genetic sampling. Data generated will provide

1) baseline information on total and local population abundance,
2) level of gene flow within the ecosystem and with other recovery zones / Canada,
3) environmental and anthropogenic landscape characteristics influencing bear abundance,
4) insight to bear dispersal mechanisms,
5) integrated database of grizzly bear spatial and genetic information.

The results will provide information needed to design and assess a conservation strategy to recover and adaptively manage this population in the face of altered landscape conditions due to climate change, resource extraction, habitat manipulation designed to enhance bear habitat values, and expanding human presence.

Data on grizzly bear abundance will provide feedback on the effectiveness of population recovery efforts. The study will provide baseline data useful for monitoring population trend in the future. By identifying the most important landscape drivers of bear abundance, distribution and gene flow, this information will support resource conservation by informing which variables to monitor and what actions require mitigation to ensure a viable, unfragmented population.

Understanding what landscape variables influence grizzly bear abundance, distribution and gene flow is vital to managers seeking to enhance habitat and mitigate factors negatively affecting recovery. A monitoring program targeting these variables should provide early insight into changes in population status due to climate change and more direct human activities such as mining and increasing human settlement. Knowledge derived from this project of how bears are distributed across the landscape and degree of genetic fragmentation within and among populations is fundamental to this understanding.

Ungulate ecology in Idaho: Understanding predator/prey interactions

Obligated Funds- $219,946

Principal Investigator: Mike Mitchell

Project Duration: 2010 – 2012

Fund Source:

- Idaho Department of Fish and Game

Project summary

In 2005, we launched the Ungulate Ecology Project. An important initial objective was to simply take a demographic and ecological "snapshot" of representative mule deer and elk populations in 12 study areas across Idaho. Results have provided wildlife managers with important background information, including adult female survival rates and cause-specific mortality, pregnancy rates, body condition, and general movement patterns.

More recently, the emphasis has shifted to 2 contrasting focal areas (Lowman, GMUs 33, 34, 35; and North Fork, GMUs 10, 12) where the objective is to understand the dynamics and mechanics of the elk/ wolf system. The goal is to develop predictive models to estimate elk populations based on elk/wolf ratios and covariates such as topography, habitat, alternate prey species and density, and weather. These models will reduce the need for intensive radio-collaring and monitoring efforts in each GMU of interest, resulting in significant efficiencies. This project requires intensively monitoring elk, moose, and wolves in study areas, investigating mortalities, and significant data management challenges.

Furthermore, there is a strong link between the Ungulate Ecology Project and the Wolf Monitoring Project (Nez Perce Tribe is an additional collaborator). The primary initial funding for the Wolf Monitoring Project was provided through the Nez Perce Tribe, though UM has played a leadership role in that research effort via the Coop Unit. Results and techniques from this work are integrated into the Ungulate Ecology Project and management programs as they become available. The UEP provides logistical support and continual feedback.

These projects will provide decision tools to wildlife managers that strive to balance natural processes with social and economic realities.

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

Student: Elliott Parsons

Degree: Ph.D. Wildlife Biology
Completed spring 2011

Chair: John Maron

Project Duration: 2006-2010

UM Affiliation: DBS - Wildlife Biology
Montana Cooperative Wildlife Research Unit

Funding Source:

- USDA CREES Managed Ecosystems Program

Dissertation Abstract

Large herbivores are major drivers of community structure and function in many terrestrial systems. Through their direct effects on plants, large herbivores can influence the structure and complexity of habitats, the population abundance of animals that rely on those habitats, and the rates of ecosystem processes within those systems. These manifold impacts on systems are potentially magnifying, as removal of top predators and changes in land use have triggered large increases in large herbivore populations. Although increasing evidence suggests that large herbivores can critically shape the structure and function of the ecosystems they inhabit, few studies have detailed the direct and indirect effects of large herbivores on vegetation, animal populations, and ecosystem processes in the same system. Typically these varied impacts are studied in isolation and it is often unclear what the magnitude or sources of spatio-temporal variation in these effects might be. I used a large-scale replicated elk-exclusion experiment to determine the effects of elk on small mammal communities, plants, and ecosystem processes.

I found that five years of elk exclusion led to noticeable changes in small mammal communities; some small mammals increased in the exclosure while others declined on controls. These changes were likely due to increasing habitat quality inside the fences and declining habitat quality outside. Elk browsing also decreased the recruitment of two dominant deciduous species and the quantity of litter of both of these species deposited on the forest floor during the peak in litter fall. Elk similarly reduced the cover of nitrogen fixing forb species, and the decomposition rates of both aspen and maple litter were more rapid inside the fences after 2 years of decomposition. These results indicate that elk are influencing the quantity and quality of litter inputs into this system as well as the decomposition environment. Finally, I found that mixtures of deciduous and evergreen litter influenced decomposition dynamics, the net mineralization of nitrogen, and plant growth. These results suggest that shifts in litter quantity and quality from browsing ungulates could have important indirect effects on plant growth. Overall, this work indicates that elk can have effects on multiple components of the community and ecosystem in only a short five year time period.

An assessment of factors influencing territory size and the use of hunter surveys for monitoring wolves in Montana

Obligated Funds: $186,150

Student: Lindsey Rich

Degree: M.Sc. – Wildlife Biology
Completed December 2010

Chairperson: Mike Mitchell

Project Duration: 2008 – 2011

UM Affiliation: Wildlife Biology
Montana Cooperative Wildlife Research Unit

Funding Sources:

- Montana Fish, Wildlife, and Parks
- Montana Cooperative Wildlife Research Unit
- The University of Montana

Thesis Abstract

Reliable knowledge on the status and trend of carnivore populations is critical to their conservation. Direct and indirect methods of monitoring carnivores, however, are time consuming and expensive to conduct across large spatial scales. In the Northern Rocky Mountains, wildlife managers need a time- and cost-efficient method for monitoring the growing population of gray wolves (*Canis lupus*). I evaluated whether a multi-season patch occupancy model (POM) could be used to accurately estimate the abundance and distribution of wolf packs in Montana from 2007 to 2009. I evaluated hunter sightings of wolves as an index of occupancy and assessed model accuracy by comparing POM estimates to Montana Fish, Wildlife and Parks minimum wolf pack counts (N_{min}). To develop a POM robust to variation in territory size, I investigated how territory sizes of wolf packs were affected by ecological factors. In the future, when territory sizes cannot be estimated directly, these ecological factors can be used to predict and monitor changes in territory sizes. I estimated territories for 38 wolf packs in Montana using 90% adaptive kernels, created generalized linear models (GLM) representing combinations of ecological factors hypothesized to effect territory size, and evaluated the predictive power of the top GLM using a jack-knife approach. I estimated 82 (SE = 31; N_{min} = 82), 124 (SE = 28; N_{min} = 102), and145 (SE = 28; N_{min} = 118) wolf packs in Montana in 2007, 2008, and 2009, respectively. I found territory size was positively related to terrain ruggedness, lethal controls, and human density and negatively related to number of surrounding packs relative to the size of the territory. The top GLM had good model fit (R^2 = 0.68, P < 0.0005, df = 37) and successfully predicted territory sizes (β_1 = 0.88, SE = 0.14, P < 0.0005). Patch occupancy models, using hunter surveys as the sampling method, combined with an understanding of territory size, offers promise as a method for accurately monitoring elusive carnivores at state-wide scales in a time- and cost-efficient manner.

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

Obligated Funds: $165,843

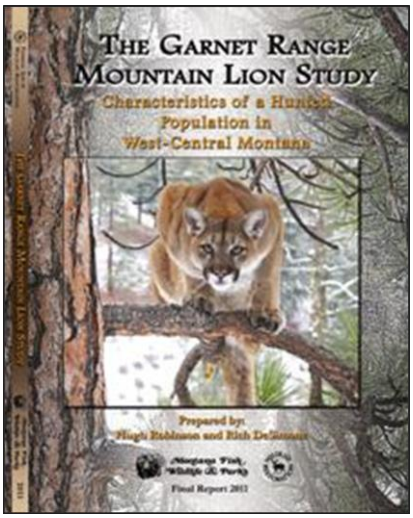
Post Doc Researcher: Hugh Robinson

Project Duration: 2009 - 2011

UM Affiliation: Montana Cooperative Wildlife Research Unit

Funding Source:

- Montana Fish, Wildlife and Parks



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. The Garnet final report was completed in December 2010 and published by the State. Currently 2 manuscripts stemming from the work are in review by Wildlife Monographs and the Journal of Applied Ecology.

Progress on the metapopulation project includes completion of resource selection modeling, population and vital rate estimation as well as deterministic growth rate calculation. Work is currently focused on completion of the stochastic, statewide metapopulation model.

Proactive management of disease outbreak in bighorn sheep in Montana

Obligated Funds: $24,532

Student: Sarah Sells

Degree: M.Sc. – Wildlife Biology Candidate

Advisor: Mike Mitchell

Project Duration: 2011 – 2013

UM Affiliation: Wildlife Biology
Montana Cooperative Wildlife Research Unit

Funding Sources:

- Montana Fish, Wildlife, and Parks
- Montana Cooperative Wildlife Research Unit

Objectives

Bighorn sheep (*Ovis canadensis*) have declined dramatically from the millions present prior to European settlement (Valdez and Krausman 1999). Pneumonia epizootics have been of great importance in the decline. After an outbreak occurs, which can quickly decimate a population, a herd may require costly and extensive management such as culling and herd augmentations to recover, and in fact may never fully recover. Lamb recruitment in particular can remain chronically low for years after an initial pneumonia epizootic event, with major effects on population structure and recovery (Cassirer and Sinclair 2007).

Comingling between domestic sheep and goats and bighorn sheep is considered a significant risk factor in disease transmission to bighorn sheep (WSWG 2010). Why pneumonia epizootics occur when they do is unclear, however, because some bighorn herds coexist near domestic sheep for years without evidence of disease. Conditions that cause stress may trigger epizootics by increasing susceptibility to infection, though rarely can an exact stressor be identified and usually more than one is involved (Valdez and Krausman 1999). Identifying triggers of epizootics and common conditions prior to their occurrence would be of great value in knowing how to better manage and protect bighorn sheep from future pneumonia epizootics.

Without an understanding of triggers to epizootics and associated levels of risk, current pneumonia management practices are generally reactive rather than proactive. Reactive management, such as augmenting a herd in attempt to increase numbers in a decimated population post-epizootic, can be less effective than proactive management. Proactive management could allow prevention of an epizootic, such as through addressing and mitigating stressors that may contribute to increased epizootic risk. This thesis project will center on the challenge of predicting pneumonia risk and appropriate proactive management of pneumonia epizootics in bighorn sheep in Montana. My main objectives will be two-fold: to design a model to predict relative risk of pneumonia outbreak for bighorn herds and to design a decision model to aid bighorn managers in making appropriate proactive decisions based on each herd's estimated risk of pneumonia outbreak. I will collaborate with the Montana Fish, Wildlife and Parks (FWP) Health Lab and other FWP managers and biologists to develop the models. In addition to aiding biologists in managing risk and occurrence of bighorn pneumonia epizootics and best allocating limited resources, the goal of this project is to create a case study for wildlife management agencies in the development and application of risk and decision models for statewide, proactive programs for managing wildlife health.

Spatial and temporal scales of population performance in grizzly and black bears in the Northern Continental Divide Ecosystem, Montana

Obligated Funds: $56,230

Student: Jeff Stetz

Degree: Ph.D. Candidate

Advisor: Mike Mitchell

Project Duration: 2009-2013

UM Affiliation: Wildlife Biology
Montana Cooperative Wildlife Research Unit

Funding Sources:

- U.S. Forest Service
- U.S. Geological Survey

Objectives

My primary interests are in investigating habitat selection and population performance 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 specific questions that I am currently exploring include:

1. How does habitat selection vary in space and time for grizzly and black bears in this region? To answer this, I will use a combination of occupancy modeling and spatial interpolation methods using detection data from noninvasive genetic sampling projects.
2. How do habitat selection patterns vary between the sympatric grizzly and black bear populations in the NCDE? I will use the results of Question 1 to identify habitat factors that are shared versus specific to each species. This answer could inform grizzly bear reintroduction/augmentation programs if we determine that, for example, high black bear densities may lead to reduced grizzly bear density.
3. Why do we see such dramatic differences in capture probabilities of grizzly bears in certain NGS methods across populations? I will use detection data from 3-4 distinct populations to model capture probabilities in a meta-analysis framework. These results could be useful in designing future monitoring programs.
4. How can we use NGS methods to detect fine scale population performance (i.e., population growth rates)? I will use simulations with spatially-explicit mark-recapture methods to explore the conditions under which intra-population (e.g., source-sink) dynamics can be identified.

Progress and Status

The bulk of the data to be used in my dissertation research was collected in 1998-2000 and 2004 during our two research projects. I have obtained access to datasets from the Russian Far East, Banff National Park, and Greece for Question 3. Ongoing research in Montana is in year 3 of 4, with approximately 30 field technicians conducting repeated surveys of over 5,900 sampling sites across nearly 3.6 million ha in the Northern Rockies. For example, In 2009, our start-up year, 9,200 hair samples were collected, with 258 grizzly bears detected; these numbers will increase each year as more sampling sites are activated.

POPULATIONS

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

Post-doc 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]

Project Duration: 2006 - 2011

UM Affiliation: Montana Cooperative Wildlife Research Unit

Funding Sources:

- U.S. Geological Survey – Research Work Order 94
- U. S. Department of Defense
- University of Montana

Objectives

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 and Status

Final report to DoD SERDP Program was completed in summer 2011.

Research to inform Chronic Wasting Disease management in Montana

Obligated Funds: $24,564

Data Analyst: Matthew Nordhagen

Principal Investigator: Mike Mitchell

UM Affiliation: Montana Cooperative Wildlife Research Unit

Funding Source:
Montana Fish, Wildlife and Parks

Objectives

1. Use available deer research and survey data, including movement and distribution data from individually-marked deer, population surveys, and genetic data to define and/or refine maps depicting the connectivity between populations in Montana. Based on connectivity, density, and proximity to infected deer populations outside Montana, populations most at risk of contracting CWD will be identified. Results from this project will help to focus surveillance efforts to detect CWD as well as potential management actions aimed at reducing the risk of CWD in Montana and/or its spread between populations.

2. Place CWD management and planning in the context of the Montana wildlife health program, where actions aimed at affecting CWD are aligned with objectives related to ungulate conservation and public enjoyment of ungulates in Montana. Results from this project will help in efforts to revise the CWD management plan by collecting input from agency deer and CWD experts, making CWD management actions and the rationale for them transparent and explainable, and integrating existing knowledge and data from Montana and elsewhere into CWD management in Montana.

Specifically, the research associate will work closely with State staff to collect available and relevant data from statewide and regional FWP offices. Dr. Mitchell will work closely with FWP staff to plan and facilitate a workshop with FWP staff at which CWD management and planning efforts will be placed in the context of the Montana wildlife health program, as well as ungulate conservation and public enjoyment of ungulates in Montana.

Progress and Status

Over the past six months, all available deer survey, distribution and movement data have been collected from statewide and regional FWP offices. All deer survey data was recently synthesized into a single database while deer distribution and movement data are currently being intersected with covariates such as temperature, precipitation, land cover, NDVI, elevation and distance to road using ArcGIS Desktop 10. Data extraction of deer distribution and movement data will be completed by the end of April.

AWARDS AND RECOGNITIONS

Dave Ausband

- Idaho Chapter of The Wildlife Society – Best Professional Paper 2011
- Oregon Chapter of The Wildlife Society – Best Technical Paper 2011

Thomas E. Martin

- Keynote Lecture – XX Spanish Congress of Ornithology (meets every 4 years); Tremp, Spain, 2010.
- Provost Outstanding Faculty Lecture – University of Montana , 2010.
- Plenary Lecture – IX Neotropical Ornithological Congress (meets every 4 years); Peru, 2011.

Michael S. Mitchell

- Wildlife Publication Award: Article of the Year, The Wildlife Society, 2011.

Juan Oteyza

- Stufdent Travel Award to present at the IX Neotropical Ornithological Congress, 2011.

Riccardo Ton

- Dave Nicholas Student Award, 2011
- Philip l. Wright Award, from the Five Valley Audubon Society, 2011

USGS – Cooperative Research Unit Award – Science Excellence, 2011

PRESENTATIONS AND POSTERS

Ausband, D. E., and **M. S. Mitchell**. 2011. How to trick a wolf: manipulating pack movements with biofencing. Annual Meeting, Idaho Chapter, The Wildlife Society.

Ausband, D. E., **M. S. Mitchell**, C. Mack, and P. Zager. 2011. Needle in the hay: developing wolf population monitoring techniques. Annual Meeting, Idaho Chapter, The Wildlife Society.

Ausband, D. E., J. Skrivseth and **M. S. Mitchell**. 2011. How to trick a wolf. Annual meeting, Montana Chapter, The Wildlife Society, Missoula, MT.

Brodie, J. and M. S. Mitchell, et al. 2011. Female elk survival. Annual meeting, Montana Chapter, The Wildlife Society. Missoula, MT.

Glenn, E., L. Rich, D. Ausband, M. Mitchell, J. Gude, C. Sime, C. Mack, and P. Zager. 2011. Using hunter survey data to estimate wolf population sizes in the Northern Rocky Mountains. Annual Meeting, Idaho Chapter, The Wildlife Society.

Jimenez, B. S., M. S. Mitchell, and P. Zager. 2011. Multi-scale effects of forest roads on black bears. Annual Meeting, Idaho Chapter, The Wildlife Society.

Martin, Thomas E. XX Spanish Ornithological Congress (meets every 2 years) – December 2010 – Climate change impacts in a high elevation riparian system. (invited Keynote)

Rich, L. N., E. Glenn, M. S. Mitchell, R. Russell, J. A. Gude, and C. A. Sime. 2011. Using hunter surveys to estimation wolf abundance. Annual meeting, Montana Chapter, The Wildlife Society.

Robinson, H. S., N. DeCesare, M. Hebblewhite, and M. Musiani. 2010. Predator-mediated indirect effects of fire on caribou habitat in Banff and Jasper National Park. 24th International Congress for Conservation Biology. Edmonton, Alberta.

Stansbury, C., **D. Ausband**, C. Mack, P. Zager, **M. Mitchell**, and L. Waits. 2011. A noninvasive genetic sampling approach for monitoring gray wolves in Idaho. Annual Meeting, Idaho Chapter, The Wildlife Society.

Taylor, R. L. 2011. Embracing variation in wildlife population dynamics and data. USGS Alaska Science Center, Anchorage, AK.

Taylor, R. L. 2011. Sensitive Species: making the most of available information. University of Montana Wildlife Biology Seminars, Missoula, MT.

Taylor, R. L., B. L. Walker, **D. E. Naugle** and **L. S. Mills**. 2011. Managing multiple vital rates to maximize greater sage-grouse population growth. The Wildlife Society Montana Chapter Annual Conference. Missoula, MT.

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 Association of Fish and Wildlife Agencies Biennial Meeting. Twin Falls, ID.

Taylor, R. L., D. E. Naugle and **L. S. Mills**. 2010. Viability analyses for conservation of sage-grouse populations. Bureau of Land Management/Montana Department of Fish and Game. Miles City, MT.

Taylor, R. L., B. L. Walker, **D. E. Naugle** and **L. S. Mills**. 2010. Sage grouse population dynamics: using vital rates and lek counts to explore management options. University of Montana Statistics Seminars, Missoula, MT.

Taylor, R. L., B. L. Walker, **D. E. Naugle** and **L. S. Mills**. 2010. Sage grouse population dynamics: using vital rates and lek counts to explore management options. University of Montana Wildlife Biology Seminars, Missoula, MT.

Ton, R., and **T.E. Martin**. 2011. Influence of Metabolism, Size and Temperature on Incubation Length Variation in Passerines Among Latitudes. XVI Italian Ornithological meeting. Cervia, Italy.

SCIENTIFIC PAPERS AND REPORTS

Ausband, D.E., J.Young, **B. Fannin, M.S. Mitchell**, J.L. Stenglein, L.P. Waits, and J.A. Shivik. 2011. Hair of the dog: obtaining samples from coyotes and wolves noninvasively. Wildlife Society Bulletin 35:105-111.

Ausband, D. E., J. Skrivseth, and **M. S. Mitchell**. 2011. An automated device for provoking and capturing wildlife calls. Wildlife Society Bulletin 35:498-503.

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 metric s under use-availability designs. Philosophical Transactions of the Royal Society B 365:2245-2254.

Biancucci, L. and **T.E. Martin**. 2010. 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.** 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.

Chalfoun, A.D. and **T.E. Martin**. 2010. Parental investment decisions in response to ambient nest-predation risk versus actual predation on the prior nest. The Condor 112:701-710.

Cheng, Y., and **T. E. Martin**. 2012. Nest predation risk and growth strategies of Passerine species: Grow fast or develop traits to escape risk? American Naturalist, in press.

Fontaine, J.J., E. Arriero, H. Schwabl and **T.E. Martin**. 2011. Nest predation and circulating coricosterone levels within and among species. The Condor 113:825-833.

Graves, T.A., K.C. Kendall, J.A. Royle, **J.B. Stetz**, and A.C. Macleod. In press. Road density and percent mesic habitat as best descriptors of variation in grizzly bear abundance. Animal Conservation.

Gude, J. A., **M. S. Mitchell**, R. E. Russell, C. A. Sime, E. E. Bangs, L. D. Mech, and R. R. Ream. 2012. Wolf populations dynamics in U.S. northern Rocky Mountains are affected by recruitment and human-caused mortality. Journal of Wildlife Management 76:108-118.

Hammond, C. A. M., **M. S. Mitchell**, and G. N. Bissell. 2012. Territory occupancy by common loons in response to disturbance, habitat, and intraspecific relationships. Journal of Wildlife Management 76:645-651.

Hurley, M. A., J. W. Unsworth, P. Zager, M. Hebblewhite, E. O. Garton, D. M. Montgomery, J. R. Skalski, C. L. Maycock. 2011. Demographic response of mule deer to experimental reduction of coyotes and mountain lions in southeastern Idaho. Wildlife Monographs 178:1-33.

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.

Lomascolo, S.B., A.C. Monmany, A. Malizia, and **T.E. Martin**. 2010. Flexibility in nest-site choice and nesting success of *Turdus rufiventris* (Turdidae) in a montane forest in northwestern Argentina. The Wilson Journal of Ornithology 122:674-680.

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Martin, T.E. 2011. The cost of fear. Science 34:1353-1354.

Martin, T.E., **E. Arriero** and **A. Majewska**. 2011. A trade-off between embryonic development rate and immune function of avian offspring is revealed by considering embryonic temperature. Biology Letters 7:425-428.

Martin, T.E., P. Lloyd, C. Bosque, **D. C. Barton**, **A.L. Biancucci**, **Y.R. Cheng**, and **R. Ton**. 2011. Growth rate variation among passerine species in tropical and temperate sites: An antagonistic interaction between parental food provisioning and nest predation risk. Evolution 65-6: 1607-1622.

Mitchell, M. S., and **M. Hebblewhite**. In press. Carnivore habitat ecology: integrating theory and application. In L. Boitani and R. A. Powell (editors), Carnivore ecology and conservation: a handbook of techniques. Oxford University Press, London, UK.

Mitchell, M. S., L. N. Rich, et al. In press. Using radiotelemetry to answer habitat and population questions. In T. Tshering and L. S. Mills (editors), Wildlife Research Techniques in Rugged Mountainous Asian Landscapes. Ugyen Wangchuk Institute for Conservation and Environment, Bhumtang, Bhutan.

Robinson, H. R. and R. DeSimone. 2011. The Garnet range mountain lion study. Final Report. Montana Fish, Wildlife and Parks, Wildlife Division, Helena, MT.

Taylor, R. L., B. W. Walker, **D. E. Naugle** and **L. S. Mills**. In press. Managing Multiple Vital Rates to Maximize Greater Sage-grouse Population Growth. Journal of Wildlife Management.

Taylor, R. L., **D. E. Naugle** and **L. S. Mills**. 2011. Viability analyses for conservation of sage-grouse populations. Unpublished report to the Buffalo Field Office, Bureau of Land Management, Buffalo, Wyoming.

Taylor, R.L., B.L. Walker, **D.E. Naugle**, and **L.S. Mills**. In Press. Managing multiple vital rates to maximize greater sage-grouse population growth. *Journal of Wildlife Management*.

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