Montana Cooperative Wildlife Research Unit

Coordinating Committee Report

May 14, 2019

MONTANA COOPERATIVE Wildlife RESEARCH UNIT

Montana Cooperative Wildlife Research Unit

Report of Activities for the Coordinating Committee Meeting

May 14, 2019

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:
01 April 2018 through 30 April 2019

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Cover photos by Linz Strickland (mammals) and Elise Zarri (bird)

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Birds

Mammals

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Allison Keever, PhD Candidate
Kenneth Loonam, MSc Candidate **
Collin Peterson, MSc Candidate **
Sarah Sells, PhD Candidate
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Andrew Boyce, PhD Candidate *
Timothy Forrester, PhD Candidate
Adam Mitchell, PhD Candidate
James Mouton, PhD Candidate
Sarah Straughan, MCc Candidate
Elise Zarri, MSc Candidate

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Jennifer Feltner, PhD Candidate
Charlie Henderson, PhD Candidate*
William Janousek, PhD Candidate*
Ellen Pero, PhD Candidate
Hans Martin, PhD Candidate
Kaitlyn Reintsma, PhD Candidate
Tshering Tempa, PhD Candidate*
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Hannah Beyl, MSc Candidate
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* Graduated
** Co-Advised

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Sarah Straughan
Lee Sutcliff
Charles White
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Violet Arnold
Nathan Barton
Kelly Benson
Sarah Bonnington
Logan Brauer
Madeline Broom
Jacob Cohen
Ella Dohrmann
Kenley Fields
Fritz Cain
Nicolas Hall-Skank
Dustin Johnson
Susan Kieser
Stephanie Klein
Rhys McKinstry
Aileen Oldstone-Moore
William Rook
Justice Root
Chelsea Scheirer
Ashley Sinclair
Ashley Skartved
McKenzie Stager
Kaitlyn Strickfaden
Shelby Weigand
Jennifer Welsh
Randall Wilson
Holly Womack
Audria Yoachum

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 2018

Unit and Administrative Operating Funds		
University of Montana - Full-time Accounting Manager	$ 43,800	
SPABA – returned to Unit in FY18/FY19	107,000	
Subtotal		**$ 150,800**
FY 2019 – Research Projects Funding		
Montana Fish, Wildlife and Parks - Operating Funds		**$ 20,000**
T. Martin – PI		
New Funding:		
NSF – Quantifying the response of sagebrush obligate birds to fence-modifications and encroaching conifer removal	$181,198	
NSF – Effects of conifer removal on songbirds in Sage-grouse habitat	465,110	
NSF – Dimensions US-South Africa	1,474,999	
UM Research Administration – Graduate Support	46,000	
Subtotal		**$ 2,167,307**
Continued Funding:		
USDI – Effects conifer removal – songbirds	$ 45,967	
NSF – Songbirds in Tropical Rainforests	824,336	
USGS – Climate and Habitat Change	465,433	
Subtotal		**$1,335,736**
M. Mitchell – PI or Co-PI		
New Funding:		
US FWS – Structuring Governance	$ 60,500	
MTFWP – North Sapphire Research	108,939	
MTFWP – Blackfoot Clearwater elk project	,220,300	
MTFWP – Bat Roost Survey	10,440	
MTFWP – HD Bear	25,164	
MTFWP – FWP invert sampling & mapping	300,033	
Panthera – Preventing predation	152,876	
US FWS – Beaver dam analogs	49,537	
Subtotal		**$ 927,789**
Continued Funding:		
IDFG – Sandhill Cranes	$ 79,790	
IDFG – Mule Deer Population Dynamics and Modeling	328,832	
IDFG – Cougars	52,952	
USDI – Linking Exposure to Sub-Lethal Stressors	92,299	
IDFG – Population dynamics FY19	157,407	
State of Colorado Moose Study	39,532	
USDI – Reliability of Management recommend	33,694	
MTFWP – Migratory songbirds – grazing	408,535	
State of Colorado – Colorado moose ecology	39,532	
MTFWP – Elk Distribution Sapphire Mountains	67,389	
USDI - Linking Exposure to Sub-Lethal Stressors to Vital Rates	129,997	
USDI – Grizzly IPM	25,000	
MTFWP - Montana Wolf Monitoring	274,003	
MTFWP – Statewide mule deer study	241,537	
MTFWP – Sage grouse & grazing study FY18-19	68,568	
MTFWP – Kootenai river trout study	10,000	

MTFWP – Sage grouse grazing	169,278	
MTFWP – Fisher occupancy habitat needs	245,955	
MTFWP – Non-game indicator species	181,153	
MTFWP – MT SCORP 2019	29,422	
NSF Fellowship	146,000	
WDFG - Moose Demography	195,500	
Subtotal		**$ 3,016,375**
Total Budget		**$7,648,007**

Completed Projects – 1 January 2019 – 31 December 2019

End Date	Student	Funding Agency	Title
June 2019	Forest Hayes	State of Colorado	Moose Ecology: Nutrition, habitat, space use and life history
June 2019	Kaitlyn Strickfaden	Idaho Fish and Game Dept.	Boom, bust: linking patterns of rural land-use change and wetland condition to trends in greater sandhill crane demographics
June 2019	James Nowak	USDI Fish and Wildlife Service	Grizzly bear integrated population modeling and interface development
November 2019	Charles Henderson, Molly McDevitt, James Nowak	Idaho Fish and Game Dept.	Ungulate and predator population dynamics, modeling and data quality advancements
December 2019	Sarah Sells, Allison Keever	Montana Fish Wildlife and Parks	Montana wolf monitoring study
December 2019	Rachel Shouse	Montana Fish Wildlife and Parks	Montana State comprehensive outdoor recreation plan 2019
May 2019	James Goerz	NSF	Fellowship

MTCWRU – Federal and State Vehicles

Description	Tag number	Odometer as of 4/19/2019
1999 Ford Truck, Extended Cab Pickup 4 x 2	FED 252524	105,054
2006 Ford F250 Crew Cab Pickup, 4 x 4	FED 430965	103,383
2010 Ford Expedition 4 x 4	FED 433441	76,689
2011 Ford F250 Crew Cab Pickup, 4 x 4	FED 433440	50,264
2011 Ford F250 Crew Cab Pickup, 4 x 4	FED 433610	62,079
2012 Dodge 1500 Crew Cab 4 x 4	FED 433621	56,592
2017 Ford F150 Crew Cab Pickup, 4 x 4	FED 434302	2,813
2005 Ford Explorer, 4 x 4	UM 3787	155,047

BIRDS

Photo by Elise Zarri

Photo by Elise Zarri

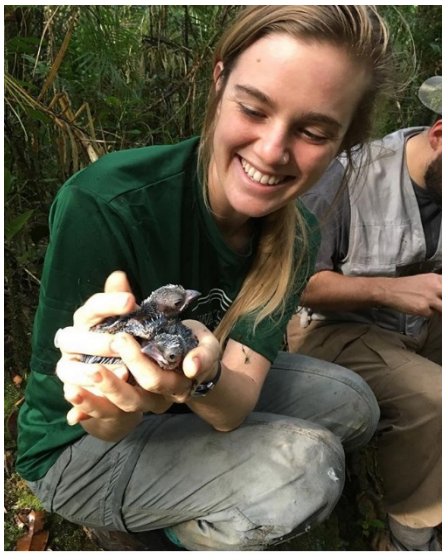
Understanding Variation in Juvenile Heat Loss and the Costs to Growth and Development

Student: **Sarah Marie Straughan**

Degree: MS Student

Advisor: Tom Martin

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



Project Duration: 2018 – 2019

Funding Sources:

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

Objectives

Parental effort and growth rates vary extensively within and across species, with critical consequences for offspring quality that impact fitness and demography. Yet, the causes of this variation remain unclear. Traditionally, studies in birds have focused on relative energy input based on parental provisioning rates. Yet, net energy (input – loss) is the actual determinant of energy available to offspring for growth and development. The 'loss' side of the equation has received little attention, but may vary extensively among species due to differences in rates of heat loss as a function of nest structure, parental effort (i.e., brooding young), and the number of offspring huddling together per brood.

My research will focus on these three factors in order to better understand variation in heat loss as an energetic cost for offspring. I will manipulate brood size and measure offspring cooling rates across nest types in order to quantify variation in heat loss and its potential costs. Additionally, I will examine parental behavior, such as provisioning and brooding rates, in order to understand how adults may reduce the energetic cost of heat loss to their young.

Progress and Status

I am currently a Master's student in Tom Martin's Lab at The University of Montana. I am about to embark upon my second field season in Kinabalu National Park in the state of Sabah, Malaysia where I will continue to investigate the variation in offspring heat loss across species. During my first field season I focused on examining the impacts of huddling as a function of brood size on the cooling rate of young nestlings. This season I will turn my attention to monitoring offspring temperature over the length of the day to determine the impacts of parental brooding behavior on juvenile heat loss. Although the tropics are generally thought of as warm, temperatures range from 15-22 oC, well outside of the thermoneutral zone of birds. Therefore, our mid-elevation tropical site provides a great study area to examine the role that heat plays in the development of offspring and adult behavior during reproduction.

Impacts of conifer removal on sagebrush songbirds

Student: **Elise Zarri**

Degree: MS Candidate

Advisor: Thomas Martin

Project Duration: 2018 – 2020

UM Affiliation: Wildlife Biology Program
Montana Cooperative Wildlife Research Unit

Funding Sources:

- Montana Cooperative Wildlife Research Unit
- U.S. Fish and Wildlife Service
- Bureau of Land Management

Objectives

Across the western United States, conifers have encroached into sagebrush habitats due to fire suppression, grazing practices and climate change. Sagebrush is one of the most imperiled ecosystems in North America and many sagebrush-obligate species are in decline. Removal of conifers is a common restoration practice that has been shown to benefit Greater Sage-grouse. However, impacts to other sagebrush species are not well understood. Sagebrush songbirds, such as Brewer's Sparrow and Sage Thrasher have shown positive correlations with reduced conifer cover, but reproductive responses of these species to conifer removal have not been quantified. I will be studying the habitat selection, abundance and fitness responses of sagebrush songbirds to conifer removal.

Removal of conifers on the leading edge of encroachment results in an abrupt edge between dense conifer forest and open sagebrush habitat. Abrupt edges often result in increased abundance and diversity of organisms, but can also lead to high predation and parasitism rates close the edge. Conifer removal and the creation of abrupt edges could lead to ecological traps, where sagebrush songbird abundance is high, but reproductive success is low. Although edge effects have been studied extensively, no studies have compared gradient and abrupt edges between the same habitat types. High abundances of nest predators in conifer forests in combination with increased abundance of sagebrush songbirds when conifers are removed could lead to an ecological trap close to conifer edges. However, no studies have investigated songbird reproductive responses to conifer removal. This study will examine the impacts of abrupt and gradient edges on sagebrush songbird habitat selection and fitness. Additionally, this study will examine sagebrush songbird abundance and reproductive success in response to conifer removal.

Progress and status

I defended my MS research proposal in April and data collection will begin in May. This work will be conducted in the Medicine Lodge Valley in Beaverhead County, Montana. I am working at a high elevation sagebrush site, where conifer removal has been conducted over the last two years. I will be setting up plots in areas where conifers have been removed and where conifers still remain. Four technicians will assist with nest searching for sagebrush songbirds, as well as territory mapping and vegetation monitoring.

I will quantify territory and nest site use in relation to shrub cover, height and density, as well as distance to conifer edge, density, and distance to nearest tree. This will allow me to understand habitat use in conifer removal and non-removal sites. I will also quantify successful nest sites using the same vegetation characteristics to understand how fitness correlates with habitat use.

Effects of conifer invasion and removal on sagebrush and conifer songbird demography in Montana

Obligated funding: $541,743

Principal Investigator: Thomas E. Martin

Project Duration: 2019-2024

UM Affiliation: Montana Cooperative Wildlife Resea

Graduate Students: Elise Zarri, M.S.

Collaborators: Anna Noson, University of Montana Bird Ecology

Funding Sources:

- US Fish and Wildlife Service
- Bureau of Land Management
- Montana Fish, Wildlife, and Parks

Objectives

Conifer removal is a core practice in sage-steppe restoration, with potential to benefit Greater Sage-grouse (*Centrocercus urophasianus*) as well as other sagebrush species of management concern. The impacts of conifer encroachment on Sage-grouse is well documented, but research to identify the demographic impacts on sagebrush obligate birds, as well as conifer-dependent species, is lacking. Demographic impacts of habitat change are particularly poorly known in the sagebrush communities where conifer encroachment is occurring in Montana. Previous studies have focused on sagebrush habitats dominated by stands of Wyoming big sagebrush, and invaded by juniper (*Juniperus spp*.), while in Montana conifer encroachment is primarily occurring at higher elevations in stands dominated by mountain big sagebrush invaded by Douglas fir (*Pseudotsuga menziesii*). The latter habitat includes bird species of management concern, including Brewer's sparrow (*Spizella breweri*) and Sage Thrasher (*Oreoscoptes montanus*) in sage habitat, and Green-tailed Towhee (*Pipilo chlorurus*), Cassin's Finch (*Haemorhous cassinii*), and Clark's Nutcracker (*Nucifraga Columbiana*) in the conifer habitat.

Understanding the consequences of conifer removal for abundance and reproductive output of songbirds using both conifer and sagebrush habitats in high elevation Montana is needed to understand best practices for enhancing populations. Mountain sagebrush landscapes include other woody habitat like riparian stringers and denser conifer stands at the periphery of conifer removal areas. Conifer removal can create artificial 'hard' edges that might yield high predation near the edges both inside and outside the conifer. This could even create ecological traps, where abundances are high but breeding productivity creates population sinks that yield declining populations near the edges in both habitats.

Collaborative projects spearheaded by Montana Conservation Corps, Red Rock Lakes National Wildlife Refuge, The Nature Conservancy of Montana, Bureau of Land Management-Dillon, Montana Fish, Wildlife, & Parks, and Montana Department of Natural Resources and Conservation are underway to remove encroaching conifers from up to 10,000 acres of mountain big sagebrush habitat on state and federally-owned lands through 2019. We request research funds to evaluate effects of these removals on songbird populations.

We will examine: 1) abundance and reproductive output of sagebrush-obligate songbirds in sagebrush habitat in Sage-grouse core areas and including some active leks without versus with conifer removal, 2) abundance and reproductive output of conifer-dependent songbirds in adjacent conifer stands, 3) the change in songbird species composition from conifer to sagebrush habitats, and 4) impacts of distance from woody vegetation on nesting success and population trajectories (i.e., lambda) of songbirds. This information will inform the management removal of conifer trees located in stands of mountain big sagebrush habitats, and provide specific recommendations on the landscape contexts and distances from woody cover that will benefit songbirds the most.

Quantifying the response of sagebrush obligate birds to fence-modifications and encroaching conifer removal in Montana

Obligated funding: $181,198

Principal Investigator: Thomas E. Martin

Project Duration: 2019-2021

UM Affiliation: Montana Cooperative Wild

Graduate Students: in process

Collaborators: Anna Noson, University of Montana Bird Ecology
Kyle Cutting, US Fish and Wildlife Service

Funding Sources:

- US Fish and Wildlife Service

Objectives

One aspect of this project focuses on the ecology of sagebrush obligate songbirds in relation to conifer encroachment, as described in the preceding associated project. Conifer encroachment is one of the most pervasive and ubiquitous threats to the quality of high-elevation mountain big sagebrush habitats in Montana. Encroaching conifers reduce soil moisture and native plant species diversity, and facilitate increased habitat use by avian predators, often functioning as artificial perches for these predators. Conifer removal is a core practice in sage-steppe restoration, and has been extensively implemented across important habitats of sagebrush songbirds. Research is lacking to identify the abundance responses of sagebrush obligate birds in higher elevation habitats dominated by stands of mountain big sagebrush invaded by Douglas fir (Pseudotsuga menziesii). This habitat supports the highest levels of plant species diversity than does any other type of sagebrush type. This work will expand point-count surveys of sagebrush songbirds in conifer-invaded and conifer-removal areas over a broader geographic scope than the prior study.

A second aspect of this research project focuses on greater sage-grouse (*Centrocercus urophasianus*) nest and brood survival in relation to livestock grazing infrastructure. Recent data from sage-grouse research in the Centennial Valley, Montana found lower nest survival rates for females nesting in close proximity to fences than females nesting further from fences (K. Cutting and B. Sowell, unpublished data). This research suggests that fencelines may be facilitating avian and/or ground predators to prey upon sage-grouse nests. However, these results are from an observational study, which precludes cause-and-effect conclusions. To more thoroughly investigate this potential issue, land managers including Red Rock Lakes NWR, The Nature Conservancy, Montana Department of Natural Resources Conservation, U.S. Bureau of Land Management, and a private landowner collaborated to implement a large-scale experiment in the spring of 2018, where fences were modified to reduce perches for avian predators and allow facilitated movements under fences by ground predators. We will monitor sage-grouse in areas of fence modifications to evaluate effects of these modifications on nest and brood survival. These data will inform the management of grazing infrastructure, especially fences, to avoid negative impacts on breeding greater sage-grouse.

Environmental influences on elevational distributions and biodiversity tested in tropical Asia & Effects of drought on survival, reproduction and population change across tropical songbird species that differ in average survival rates

Obligated funding: $1,524,030

Principal Investigator: Thomas E. Martin

Project Duration: 2013-2020

UM Affiliation: Montana Cooperative Wildlife Res

Graduate Students: Adam Mitchell, James Mouton, Sarah Straughan, Timothy Forrester

Funding Sources:

- National Science Foundation

Objectives

This project examines environmental influences on demography (clutch size, nest predation, development rates, parental care, adult survival rates) of bird species in montane Malaysian Borneo (Kinabalu Park) to compare tropical versus U.S. birds. Tropical birds are often longer-lived and slower developing than north temperate birds in the U.S. and extend the range of variation in demographic strategies which provides critical new insight into environmental influences on demography. We are also measuring metabolic sensitivity of adults and offspring to temperature variation, possible role of competition in constraining elevational ranges, measuring dispersal through both capture/recapture and gene flow, and measuring genetic differentiation across elevations. We are examining the relative importance of nest predation, food limitation, and adult mortality on variation in demography and life history strategies. Ultimately, this work provides critical information on environmental determinants of demography and how it varies among tropical compared with north temperate species.

As part of this continuing work, we examine the effects of drought on demographic consequences. Drought has become an increasing issue of concern to demography and, yet, a predictive framework for the relative demographic sensitivity of species to drought is lacking. I hypothesized that sensitivity of species may be related to adult survival probability. Thus, we are examining differences in survival and reproduction during and following the drought among species that differ in their average annual survival probabilities.

Results

I work in tropical Borneo because it retains large blocks of pristine forest at mid-elevation from 1450 to 1950 m elevation. Large numbers of nests were found and monitored, nestling metabolism and nestling growth measured, parental care video-taped, and egg temperatures quantified. In addition, a very large number of capture/recapture/resight events were accrued to aid in estimating adult survival. Adult survival and nest predation interact to strongly influence reproductive strategies and demography not only in Borneo but also in North America. This integration of adult and offspring survival data across suites of species have never been available previously and has yielded critical new insight into environmental influences on demography. In addition, data collected on both adult and nestling metabolism shows that species vary strongly in their sensitivities to temperature. The importance of temperature suggests that global warming may be particularly important to long-term reproductive success of tropical birds. Modeling of apparent adult survival rates based on multiple field methods demonstrates that standard-effort netting programs produce flawed estimates that obscure biological relationships. Resighting of marked birds demonstrate strong net avoidance among tropical birds that cannot be modeled due to life-long avoidance. This work has potentially important ramifications for local and national programs based on standard-effort netting alone.

Responses of tropical rainforest songbirds to drought yielded surprising behavioral adjustments whereby reproductive activity was reduced and longer-lived species (those with higher adult survival rates) reduced reproductive activity the most. Species with large reductions in reproduction exhibited increased survival in the

drought, likely due to reduced costs of reproduction. Shorter-lived species maintained reproductive activity and experienced lower survival in drought than non-drought years. These differing behavioral adjustments can minimize the population impacts of drought, except in species that rely on the wettest habitat.

This work continues to include 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.

Understanding demographic adaptations to recurring drought in dry-habitat songbirds

Obligated funding: None yet

Principal Investigator: Thomas E. Martin

Project Duration: 2020-2027

UM Affiliation: Montana Cooperative Wildlife Research Unit

Funding Sources:

Objectives

Drought is an increasing problem in North America associated with climate change. Seasonality of climate, and particularly severity of the lean season (period of lowest productivity), are thought to play a strong role in affecting adult and juvenile mortality. Yet, comparisons of demography and causes of life history evolution among groups of related species in contrasting seasonality and climate conditions are lacking. Songbirds occupying the dry tropics exhibit clutch sizes that are about 50% larger than related species in wet tropical forest, indicating a role for climate seasonality in demographic evolution. I propose to examine the environmental causes and demographic responses to contrasting seasonality and drought intensity in the dry versus wet tropics among related species of songbirds.

I propose to examine a traditional seasonality hypothesis along with two alternative hypotheses. The larger clutch sizes in the dry tropics could reflect higher adult and juvenile mortality during the severe (drought) lean season, as predicted by the traditional seasonality hypothesis. However, various pieces of evidence among taxa from trees to birds suggest that severe drought may favor slow growth and high survival, conflicting with the long-standing traditional hypothesis. I propose an alternative hypothesis whereby species evolve low annual reproductive effort (annual fecundity) through few nesting attempts per year to enhance adult survival to increase iteroparity across years and chances of breeding in good years. Alternatively, predation on offspring (i.e., nest predation) may be reduced in dry habitats through reduced abundance and diversity of predators. Reduced nest predation can favor larger clutch sizes by allowing lower feeding rates via slower growth and longer development periods. The latter in turn can enhance offspring developmental state when they leave the nest to thereby increase juvenile survival. I will take advantage of already-collected demographic data from 40 to 50 songbird species in the wet tropics and use the same methods in the dry tropics to conduct observational and experimental tests of the alternative hypotheses. I will use telemetry to measure annual fecundity and juvenile survival, along with stringent measurement of adult survival in the breeding vs lean seasons, offspring growth rates, and parental effort in raising young among ca. 20 species in the dry tropics to compare with already measured data in the wet tropics.

This work has important conservation implications because it informs demographic sensitivities of endemic species in a biodiversity hotspot, where many species are at risk or already threatened. I will explicitly test hypotheses of population vulnerability among species as a function of their evolved life history strategies. This work also provides important training opportunities for students.

How and why do species differ in within-year reproductive effort?

Student: **Timothy R. Forrester**

Degree: PhD Candidate

Advisor: Thomas Martin

Project Duration: 2018 – Current

UM Affiliation: Organismal Biology, Ecology, & Evolution Program
Montana Cooperative Wildlife Research Unit

Funding Sources:

- Montana Cooperative Wildlife Research Unit
- National Science Foundation (NSF)

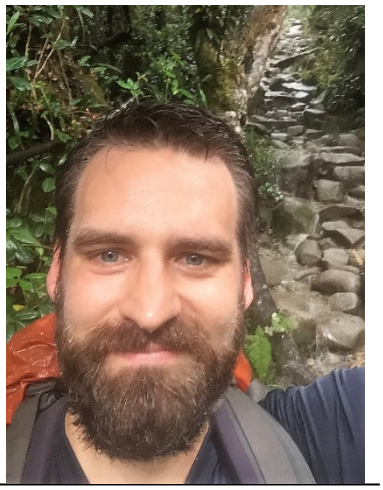
Objectives

A central tenet of life history theory is that natural selection maximizes lifetime reproductive success by favoring the optimal strategy for partitioning energy between reproduction and survival. Because species occupy areas of varying climate, habitat, and latitude, they are exposed to different selective pressures that result in different life-history solutions to optimize fitness. Theory predicts that long-lived species with high probability of future reproduction should invest relatively greater effort in survival than reproduction and therefore have lower annual fecundity than short-lived species, which should invest more annual effort in reproduction than survival. For some taxa such as birds, however, different combinations of brood sizes and numbers of breeding attempts can achieve the same annual fecundity. Thus, what determines how annual fecundity is achieved? How selection influences different strategies for achieving annual fecundity is poorly understood. Differential age-specific mortality rates may influence the optimal within-year reproductive strategy. For example, higher ratios of adult-to-juvenile survival may favor increased liftime iteroparity (i.e., decreased within-year reproductive effort achieved through lower brood sizes and/or fewer breeding attempts) to save energy for future reproduction and to maximize the chances of at least some reproductive attempts being successful. Alternatively, harsh non-breeding seasons have been theorized to yield high adult mortality accompanied by high resource availability and low competition, which should favor decreased lifetime iteroparity (i.e., increased within-year reproductive effort achieved through increased brood sizes and/or more breeding attempts. Yet, we lack a basic understanding of the range of variation among species in the annual number of reproductive attempts and the time between attempts. Understanding how these traits vary among species is critical for testing key predictions of life history theory (e.g., how age-specific mortality influences within- and among-year reproductive effort) and making robust predictions about population trajectories (e.g., how reproductive responses to climate change and habitat disturbances will differ across species). Therefore, my objective is to (1) describe the variation in within-year reproductive effort in two tropical systems that differ in seasonality and (2) examine how age-specific mortality and seasonality contribute to the evolution of reproductive strategies.

Progress and status

I recently completed my first committee meeting, where I presented my dissertation pre-proposal, which outlined my plan for data collection and the relevant theoretical background. I also completed my coursework form to plan the classes that I will take. Currently, I am in the middle of my first field season at Kinabalu National Park, Malaysian Borneo. I am working in a mid-elevation (~1500-1900m) tropical montane rainforest. My research aims to address a major gap in our understanding of tropical avian life history: how many breeding attempts species make, and how long they take between those attempts. I am using radio-telemetry to track individuals of eight passerine bird species, which span a diverse phylogeny, for 3-4 months each. Using radio-telemetry, I follow the species regularly and attempt to find every nesting attempt. If differences in life-history traits (e.g., adult and juvenile survival) influence reproductive strategies, I expect to find differences among species in number of breeding attempts and the time between those attempts. Understanding these traits will help to reduce the pervasive reliance on brood size for describing reproductive strategies, which continues to obscure our understanding of both demography and how selective forces influence the evolution of life history strategies.

Effects of rainfall on nestling bird energetics



Student: **Adam E. Mitchell**

Degree: PhD Candidate

Advisor: Thomas Martin

Project Duration: 2014 – 2019

UM Affiliation: Wildlife Biology Program
Montana Cooperative Wildlife Research Unit

Funding Sources:

- Montana Cooperative Wildlife Research Unit
- National Science Foundation (NSF)

Objectives

Organisms living at higher elevations typically have slower life histories, but the causes of this shift are not fully understood. Ambient climatic conditions (e.g. temperature, rainfall, humidity, etc.) can be very different between elevations (often harsher at higher elevations), and can also have significant effects on the growth, development, and survival of organisms. This is particularly true in birds, but few studies directly test the effects of harsh, high elevation climate on avian life histories. I am experimentally testing a hypothesis that the harsh weather at high elevations constrains avian life histories.

Rainfall can be a harsh weather condition, even in tropical mid-elevation rainforests, where birds may be particularly adapted to heavy rain. This selection pressure may explain the increased prevalence of enclosed nests in these habitats, despite literature favoring protection from predation as the primary driver of enclosed nests. My research explores the effects of rainfall on the energetics of nestling birds in the tropical mountain forests of Borneo. The effects of rainfall variation on nestling energetics are almost entirely unknown, despite predictions of shifting rainfall patterns due to climate change. This limits our understanding of nest success, which can affect demographic rates, as well as ecosystem stability. Furthermore, many tropical montane birds are vulnerable due to habitat loss, and these effects are likely to be exacerbated as mountains warm, allowing lower-elevation species to displace those in the highlands. Wildlife watching creates strong economies with high conservation value in many developing tropical communities, but this is threatened as species decline and ecosystems degrade. Through my research, I hope to improve our understanding of the basic processes that influence wildlife, helping us predict changes and protect our fragile resources.

Progress and status

I am currently amid my last field season in Malaysian Borneo. I have finished collecting data on the high elevation portion of my dissertation and am in the process of writing the results up for peer-reviewed publication. My current work has now fully shifted to Dr. Martin's mid-elevation field site, where I am collecting data to answer my remaining questions. Here, I will continue using the doubly-labeled water technique to estimate field metabolic rates (FMR) of wild nestling birds across 20+ species. On a subset of these species I am experimentally increasing the amount of rainfall at the nests with a makeshift bamboo shower to directly test the effects of rain on nestling FMR. I am predicting that nestling energetics will increase with increasing rainfall, or parental attentiveness will increase, or some combination of the two.

Museum exhibit

During the 2018 field season I organized the creation of a museum exhibit cataloging and displaying the unique nests of 38 different species found at our field site in Malaysian Borneo. Our team collected, dried, and preserved the nests as well as mounted them in 3 different display cases for public outreach. This project was done with support from and in collaboration with the local management of Kinabalu Park and will hopefully raise interest in the unique diversity of nest types in the park.

Plastic reproductive strategies in response to nest predation risk.

Student: **James C. Mouton**

Degree: PhD Student

Advisor: Thomas E. Martin

Project Duration: 2013 – 2019

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

Funding Source:

- National Science Foundation
- MT Institute on Ecosystems
- Toelle-Bekken Family Fund
- Drollinger-Dial Foundation
- Montana Cooperative Wildlife Research Unit
- The University of Montana

James in Arizona in 2012

Objectives

Life history theory predicts that organisms will allocate limited time and energy between current and future reproduction to maximize lifetime fitness. Age specific mortality can affect this allocation such that increased risk of offspring predation is expected to reduce reproductive value of current broods and decrease reproductive effort. Studies examining mortality patterns and evolved levels of reproductive effort across taxa support theory. Organisms may also plastically adjust overall reproductive effort and the expression of different life history traits (e.g. clutch size, food provisioning behaviors, growth and developmental rates) in response to variation in offspring mortality risk. Such plasticity can have important consequences for the rate of evolution and the persistence of populations in ecological time. However, we know little about plastic responses of life histories to changes in current brood reproductive value caused by offspring predation risk.

My research will examine how reduced brood value caused by nest predation risk affects reproductive effort expended by parents and growth and development in offspring in four songbird species. I will test the effect of nest predation risk on parental effort by manipulating the perceived level of risk and measuring parental energy expenditure. I will examine how nest predation risk affects offspring growth and development and test how responses in these traits affect performance and survival during the fledgling stage. Additionally, I will be examining how predation risk influences offspring begging and how parents respond to it by using playback experiments at nests across species. Understanding the plastic responses of organisms to important sources of selection, such as offspring predation, is vital for a full understanding of life history evolution and can help explain ecological differences between populations.

Progress and Status

I have manipulated the perceived level of predation risk at bird nests by playing recorded vocalizations from nest predators (i.e. Red Squirrels) and a songbird species that does not pose any threat to the study species. I am finished with the field work for this project and have started working on a paper examining how nest predation risk can influence survival later in life which was funded by an NSF Dissertation Improvement Grant. I will soon begin work on several other papers from this project. I finished my final field season in Kinabalu Park in Malaysian Borneo last spring (2018) and have begun drafting a manuscript about why species differ in how responsive they are to the begging calls of their young.

MAMMALS

Photo by James Goerz

Photo by Linz Strickland

Analyzing Conflict of Grizzly Bears with Agricultural Attractants Using Electric Fencing

Student: Kari Eneas

Degree: MSc Candidate

Advisors: Mike Mitchell
Chad Bishop

Project Duration: 2017-2020

UM Affiliation: Wildlife Biology Program
Montana Cooperative Wildlife Research Unit

Funding Sources: Confederated Salish Kootenai Tribes
Alfred P. Sloan Foundation
Vital Grounds
University of Montana – Wildlife Biology Program

Objectives

My passion for wildlife and the complexities of natural ecosystems began for me at an early age. I grew up within the heart of the Flathead Indian Reservation, and today I am employed as a wildlife biologist with the Confederated Salish and Kootenai Tribes Wildlife Management Program. After starting as a wildlife trainee in 2008, I completed my Bachelor of Science Degree in Wildlife Biology in 2013 while establishing a barn owl survey protocol for the Mission Valley and conducting a dietary analysis between barn owls and short eared owls. I have since then conducted breeding bird surveys and worked on the monitoring of long-billed curlew populations and interagency planning efforts for sharp-tailed grouse restoration in western Montana.

Project

To better understand how agricultural attractants such as chickens, pigs, goats and lamas affect bear behavior we are using iridium GPS collars to observe fine scale movements of grizzly bears. We worked with landowners throughout the valley to install electric fences and equipped selected sites with stealth cameras to assess bear presence and behavior. Entering into our second field season we will continue to collect data and begin analyzing the resource selection of these Mission Valley grizzly bears. As both human and grizzly bear populations continue to increase and expand within the Northern continental Divide Ecosystem, addressing the increasing management conflicts and human concerns has become a management priority. This study aims to address this priority by quantifying the effectiveness of electric fencing in reducing depredation conflicts between grizzly bears and small scale poultry and livestock producers in the Mission Valley. Homeowner sites with livestock will be monitored during the study and compared with collar data to determine the success and effectiveness of the fencing in preventing further conflict.

Effects of summer foraging strategy on reproduction and survival of moose in northeast Washington

Student: James Goerz

Degree: PhD Student

Advisor: Mike Mitchell

Project Duration: Fall 2014 – Spring 2020

UM Affiliation: Wildlife Biology Program
Montana Cooperative Wildlife Research Unit

Funding Source:

- Washington Department of Fish and Wildlife
- UM College of Forestry and Conservation
- National Science Foundation Graduate Research Fellowship

Objectives

In North America, moose (*Alces alces*) populations are declining due in large part to the direct and indirect effects of a warming climate. These large, cold-weather adapted herbivores may have difficulty meeting the energetic demands of survival and reproduction amidst increasingly high seasonal temperatures. Late spring through early fall is a critical energy acquisition period for adult female moose when they must give birth, lactate, protect offspring, restore fat reserves, and breed again before the approaching winter. This physiological stress is compounded by the expanding presence of large carnivores across much of the Northwestern U.S. as well as changes in forest cover stemming from land-use by humans.

Because of these challenging circumstances currently facing moose, our project has two general and related objectives. First, we seek to understand the behavioral response of moose to variation in heat stress, predator activity and forest cover type as well as how these environmental features may interact to influence moose behavior. Secondly, we seek to estimate the survival and reproductive consequences of individual moose given their habitat selection strategies.

Progress and Status

Over the last four years of continuous fieldwork, we have monitored 67 GPS/VHF radio-collared adult female moose within two study areas of Northeast Washington to estimate pregnancy, calf production, and adult/calf survival. To explain variation in these vital rates, we are currently studying the spatial and temporal foraging patterns employed by these moose to meet their competing needs of energy acquisition and predator avoidance during critical but thermally-stressful summer months (May-Sept). Four years of GPS data coupled with four years of demographic data on known individuals may allow us to assess the relative success of specific behavioral strategies employed by moose given their environmental constraints. Results from this research may identify environmental features which are uniquely important to adaptive individual moose behavior, thereby influencing fitness and ultimately population persistence.

Evaluating moose (Alces alces shirasi) calving success, movement, and habitat use in Colorado

Student: **Forest Hayes**

Degree: MS Student

Advisor: Chad Bishop

Project Duration: Fall 2017 – Spring 2020

UM Affiliation: Wildlife Biology Program
Montana Cooperative Wildlife Research Unit

Funding Source:

- Colorado Parks and Wildlife

Objectives

Understanding reproduction of moose (Alces alces), habitat selection, and their ability to adapt to habitat disturbance is fundamental to successful conservation and management of the species. Breeding populations of moose in the United States are found as far south as Colorado and Utah where climates and habitats are vastly different from those of higher latitudes. Unlike many northern latitudes, the majority of moose diet in Colorado is comprised of various species of willow (Salix spp.). Over the past several years, Colorado Parks and Wildlife has detected differences in calving success between two spatially segregated populations of moose in Colorado and have funded this project to study possible explanatory differences between the two populations.

There are two overarching objectives for this project. The first is to determine the impact of willow nutrition on moose calf recruitment and to evaluate to what degree differences in nutrition between moose populations explain the observed disparity in calving success. Secondly, this project seeks to evaluate moose resource selection and the impact of large-scale disturbance, such as mountain pine beetles, at multiple scales.

Progress and Status

In collaboration with Colorado Parks and Wildlife, approximately 20 moose were captured in each of the two study areas each winter from 2015 to 2019. Each of these moose were fitted with GPS and/or VHF radio collars to aid in relocation and tracking. As of this project update, more than 300,000 GPS unique GPS locations have been recorded. During the summers of 2017 and 2018 a total of 200 samples from willows from known used locations were collected in June to compare forage quality between the two study areas. During the summer months of those years willows samples were collected weekly from 5 plants per study area to assess phenology, or the change in nutrition over time. Results from this project may help to inform future management of moose in Colorado through an enhanced understanding of factors limiting moose populations in Colorado and by determining how habitat selection by moose is influenced by large scale disturbance.

Mule Deer Habitat Selection of Disturbance in Conifer Forests of Northwest Montana

Student: **Teagan Hayes**

Degree: M.S.– Wildlife Biology

Advisors: Mike Mitchell
Chad Bishop

Project Duration: 2017 – 2020

UM Affiliation: Wildlife Biology Program
Montana Cooperative Wildlife Research Unit

Funding Sources:

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

Objectives

In many western forests, anthropogenic disturbance has increasingly replaced wildfire as the predominant source of landscape alteration. Recent declines in mule deer (Odocoileus hemionus) population estimates and hunter harvests have been linked to changes in the availability and distribution of nutritional resources in many western states. However, the relationship between the spatial configuration of disturbances and resource selection is not fully understood, particularly for lesser studied mule deer populations in the northern forests of the Rocky Mountains. My objectives for this research are to: 1) quantify the effects of disturbance on the spatio-temporal distribution of forage nutrition in each of three study areas; and 2) quantify selection of mule deer for forest disturbances from wildfire and logging in three study areas in northwest Montana.

Progress & Status

As of March 2019, MFWP field staff has completed the final winter capture for the project. We currently have 32 collared mule deer does in the Whitefish Range, 34 does in the Cabinet-Salish Mountains, and 34 does in the Rocky Mountain Front using a combination of clover traps and helicopter netgunning. The project is approaching the third and final summer of field data collection which is headed jointly by my project and research partner Collin Peterson and me. Last summer, we hired six technicians to conduct vegetation and habitat monitoring in all three study areas. I will use this data to compare the plant community composition and forage nutrition available to mule deer in each study area. During the upcoming summer of 2019, we will employ an additional 2 technicians to improve the number and geographic spread of fecal sample collections. Fecal samples inform our understanding of mule deer diets and the importance of forage plants for nutrition. I will use the knowledge of mule deer diets and plant responses to disturbances from fire and logging to evaluate mule deer migration and use of habitat. This project will ultimately help to inform forest management decisions, treatment sizes, and configurations.

Optimizing the use of wildlife monitoring resources

Obligated funding: $68,620

Student: **Charles R. Henderson, Jr.**

Degree: PhD Candidate

Advisor: Paul Lukacs

Project Duration: 2014 – 2018

UM Affiliation: Wildlife Biology Program
Montana Cooperative Wildlife Research Unit

Funding Source: Idaho Department of Fish and Game

Objectives

The main goal of this project is to provide the Idaho Department of Fish and Game (IDFG) with information and tools to more efficiently monitor wildlife populations. The study system being used to quantify monitoring effectiveness and develop tools to optimize the use of monitoring resources is IDFG's statewide monitoring program for mule deer. This project is split into 5 lines of research. The first line of research is a cost-effectiveness analysis of the current methods used by IDFG to monitor mule deer abundance. The next research line is the development of a method for weighting different types of data included in the current IDFG population model. The development of a weighting method will facilitate the appropriate use of different data types and suggest how to prioritize the collection of data. The third line of investigation will focus on improving survival estimates from data gathered using radio collars. Specifically, this research will address differences in data generation between GPS and VHF radio tracking devices and the impact of these differences on missing data points. The fourth line of research will focus on the efficiency of monitoring conditional mule deer habitat to inform the frequency of winter aerial surveys. Monitoring conditional habitats via less expensive and less risky methods, i.e. camera traps or driving transects, has the potential to reduce the frequency of winter aerial surveys thereby reducing cost and the risk to personnel. The overarching goal of this project will be to develop a tool for managers that simultaneously optimizes over cost and abundance estimate precision using information generated by the previous lines of research. The expected result of the optimization process is to produce a set of potential monitoring strategies that are tailored to specific budgets and management requirements. This optimization process is also expected to be flexible enough for application to other game and non-game species management scenarios.

Progress and Status

Data for this analysis is being provided by IDFG and is the product of their mule deer monitoring from the past 20 years. Research pertaining to the development of a method for weighting data within the population model has diverged into 3 separate courses of research. These include estimating the influence that biases in ratio data have on estimates of abundance, how changes in the quality and quantity of different data types impact abundance estimates, and estimating the amount of information gained with changes in the cost of gathering various data types. Research on optimization that incorporates the results from the previous analyses will begin in April 2018. All aspects of the project are expected to be completed by December 2018.

Adaptive harvest management and estimation of recruitment for wolves in Montana

Obligated Funding: $181,488

Student: **Allison Keever**

Degree: PhD Student

Advisor: Mike Mitchell

Project Duration: Spring 2015 – Fall 2019

UM Affiliation: Wildlife Biology Program
Montana Cooperative Wildlife Research Unit

Funding Source: Montana Fish, Wildlife and Parks
Montana Cooperative Wildlife Research Unit

Objectives

Harvest is an important management tool for gray wolves (Canis lupus) in Montana. Harvest regulations for wolves are evaluated biennially and can be updated as needed dependent on the status of the population and objectives for management. Decisions on harvest regulations for wolves can be challenging, however, due to conflicting objectives from various stakeholder groups and uncertainties in the effects of harvest on wolf population dynamics. Despite uncertainty and conflicting objectives and values of stakeholders harvest regulation decisions must still be made. This can be challenging, however, without a formal process. Further, existing monitoring efforts yield insufficient data to estimate recruitment using traditional methods because the limited time and funding for monitoring. Recruitment is an important vital rate for wolf population dynamics and harvest management, therefore a new approach is needed to estimate recruitment.

Our objectives are to 1) develop approach to estimate recruitment that is cost-effective; 2) develop framework for adaptive harvest management to help guide harvest decisions while learning about effects of harvest on wolves to improve future decisions; and 3) design a targeted monitoring program.

Progress and Status

We have developed and tested an empirical model to estimate recruitment of wolves and evaluate factors that cause variation. We found that density dependence, pack size, and harvest were the primary factors causing variation in recruitment of wolves. This method relies on abundance estimates, group counts, and GPS collars to estimate recruitment. Although abundance estimates will be available in the future, group counts and GPS collars are relatively more expensive and may not be available. Therefore we will also develop a theoretical model of recruitment which may require fewer data to predict recruitment of wolves across Montana. For the adaptive harvest management model we will collaborate with Montana Fish, Wildlife and Parks to finalize objectives for management and alternative harvest strategies to evaluate. We will also evaluate the relationship between harvest regulations, environmental conditions and harvest rate to improve understanding of variation in harvest rate. We will then be able to determine optimal harvest strategies and reduce uncertainty over time via management and monitoring.

Estimating cougar abundance with remote camera surveys

Student: **Kenneth Loonam**

Degree: M.Sc. Candidate

Advisors: Hugh Robinson

Project Duration: 2017-2019

UM Affiliation: Wildlife Biology Program
Montana Cooperative Wildlife Research Unit

Funding Sources: Idaho Department of Fish and Game

Objectives

Wildlife management relies on accurate estimates of abundance, but these estimates can be difficult to obtain for low density, cryptic animals, such as cougars. Current methods for measuring cougar populations range from high intensity efforts that are limited spatially by the availability of resources, such as mark saturation and genetic capture recapture, to a variety of indices that can be broadly applied but have limited accuracy. We are working with Idaho Fish and Game (IDFG) to test a method of estimating abundance using remote cameras and time-to-event modelling on cougars to evaluate its utility for low density species. Remote cameras can lower the costs of abundance monitoring, allowing accurate measurements to be made across broad spatial extents or in multiple locations. To understand how the time-to-event approach compares to established methods, we are applying it alongside genetic spatial capture-recapture to estimate the abundance of two cougar populations in Idaho.

Progress and Status

The final winter of data collection is in progress, with two winters already completed. From the two winters of camera surveys, we have collected and scored approximately 1,000,000 pictures. From those, we have observed 186 unique events of cougars on camera. From two winters of genetic capture-recapture surveys, we have collected 164 potential samples, and genetic analysis has identified 29 unique individuals from the first winter of sampling. The final winter of genetic sampling wrapped up at the end of February, and the final winter of remote camera sampling will end in April.

Resource Selection for Nutrition and Physical Security by Mule Deer in Northwest Montana

Student: **Collin Peterson**

Degree: MSc Candidate

Advisors: Mike Mitchell and Chad Bishop

Project Duration: 2017 - 2020

UM Affiliation: Wildlife Biology Program
Montana Cooperative Wildlife Research Unit

Funding Source:

- Montana Fish Wildlife and Parks
- UM College of Forestry and Conservation

Objectives

Recently, Mule deer (Odocoileus hemionus) populations in the Intermountain West have undergone unpredictable bouts of decline, largely due to habitat degradation and changing food availability. In Northwest Montana, public and scientific perception suggest that mule deer populations are declining or stabilizing below historic levels. However, mule deer movement patterns, resource selection behaviors, and the environmental factors driving those behaviors in this region are poorly understood. I aim to determine how mule deer select for nutritional resources and avoid predation risk, and how they make tradeoffs between food and security. I will be studying 3 mule deer populations in 3 separate study areas comprising a range of forage and predation risk conditions. I will compare how selection for forage and security varies at multiple spatial scales, and will assess how resource selection patterns are influenced by migratory strategy in partially migratory populations. I will conduct this analysis using Resource Selection Functions (RSFs). My research will help indicate the factors limiting mule deer populations in the northern forest ecoregion, and will broaden our understanding of how resource selection and tradeoffs by mule deer vary with environmental conditions.

Progress

I am working in tandem with Teagan Hayes on this project. Currently, we have ~90 mule deer does GPS-collared in the Whitefish Range, the Cabinet and Salish Mountains, and the Rocky Mountain Front. We are quantifying summer forage quality and abundance by sampling at transects throughout these study areas to create a landscape forage model, and are entering our 3rd season of forage data collection. So far, we've found that forage biomass varies significantly with landcover type. We are also using mountain lion RSFs to represent predation risk for mule deer, and are hoping to develop wolf RSFs for our study areas.

Carnivore Territoriality and Sociality: Optimal Behavior for Gray Wolves in the Northern Rocky Mountains

Student: **Sarah Sells**

Degree: Ph.D.– Wildlife Biology

Advisor: Mike Mitchell

Project Duration: 2015 – 2020

UM Affiliation: Wildlife Biology Program
Montana Cooperative Wildlife Research Unit

Funding Sources:

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

Objectives

Abundance estimates are a key component of monitoring gray wolves (Canis lupus) in Montana and Idaho. In Montana, abundance is estimated using 3 parameters. Area occupied is estimated with a Patch Occupancy Model (POM) based on hunter observations and field surveys. Average territory size is assumed to be 600 km2 with minimal overlap, and annual average pack size is estimated from field surveys. Total abundance is then calculated as area occupied ÷ $\bar{x}$ territory size × $\bar{x}$ pack size.

Although estimates of area occupied from POM are reliable, development of accurate methods to estimate territory size, territory overlap, and pack size is critical for accurate estimates of abundance. Assumptions of fixed territory size and minimal overlap are simplistic; in reality, territories vary spatiotemporally, and this variability is likely even greater under harvest. Meanwhile, estimating pack size requires packs to be located and accurately counted each year, which is increasingly difficult due to the number of packs and declining funding for monitoring. Furthermore, our understanding of territories and pack sizes are based on abundant data collected prior to delisting and implementation of harvest in 2009. Data collected post-delisting and concurrent with harvest are comparatively sparse; meanwhile, those data that do exist show behaviors of wolves have changed. Abundance estimates may therefore become increasingly inaccurate.

My objectives are to develop territory and group size models based on mechanisms hypothesized to drive wolf behavior. The models will yield biologically based, spatially explicit predictions for territory size, location, and overlap and group size at any spatiotemporal scale, in absence of abundant empirical data. Alongside POM, the models will help accurately estimate abundance of wolves in the northern US Rocky Mountains. Results of this work will negate need for intensive monitoring efforts and aid in decision-making for wolf management.

Progress & Status

In Year 4, I finalized the first-generation theoretical territory model, prepared drafts of the related manuscript for future publication, and presented results at a national conference. I completed several steps towards building empirical territory models by preparing data, writing code, estimating territory sizes and locations for GPS-collared wolves from 2008 – 2018, and running univariate analyses. I also completed work towards parameterizing the theoretical territory model; the outcome of this stage will be used to calibrate POM. I continued managing and adding to Montana wolf database (including all GPS locations and their attributes), which will be sent to MFWP upon project completion. As in earlier years, I continued to serve as the point person for collar-related tasks, and spent 2 weeks assisting MFWP wolf specialists with trapping. I also completed my teaching requirements at the University by independently teaching an undergraduate course.

AWARDS AND RECOGNITIONS

Forrester, T. Drollinger-Dial Research Travel Award - $1500

Goerz,J. Shikar Safari Club International Scholarship - $4000

Mitchell, A. Wesley M. Dixon Graduate Fellowship - $30,376

Mitchell, A. Bertha Morton Scholarship - $2,500

Mitchell, A. Carl and Camilla Reitman Scholarship - $2,500

Mouton, J. Toelle-Bekken Family Fund - $2,500

Mouton, J. Drollinger-Dial Foundation Travel Grant - $990

Mouton, J. NSF Doctoral Dissertation Improvement Grant - $13,000

Mouton, J. MT Institute on Ecosystems Graduate Enhancement Award - $5,000

Mouton, J. UMT Research and Creative Scholarship - $450

Mouton, J. Drollinger-Dial Foundation Travel Grant 2016 - $1200

Mouton, J. Drollinger-Dial Foundation Travel Grant 2015 - $1000

Mouton, J. Drollinger-Dial Foundation Travel Grant 2014 - $849

Mouton, J. American Ornithologist Union Research Grant - $1000

Mouton, J. NSF Graduate Research Fellowship

Sells, S. Research and Creative Scholarship Fund Travel Grant, University of Montana

Sells, S. PoND Fund Travel Grant, University of Montana.

Sells, S. John Richard Seiver Scholarship Award, University of Montana

Sells, S. George and Mildred Cirica Graduate Student Support Fund, University of Montana

Zarri, E. Montana Audubon Society - $500

PRESENTATIONS AND POSTERS

Barker, K., M. Mitchell, and K. Proffitt. Quality and predictability of native forage mediate influence of irrigated agriculture on elk migration. 2018. Tracking the Human Footprint: Biennial Scientific Conference on the Greater Yellowstone Ecosystem.

Barker, K., M. Mitchell, K. Proffitt, and J. DeVoe. Effects of fire on elk forage and migratory behavior: Estimation methods and management implications. 2018. Stakeholder and management agency meeting, Missoula, MT.

Goerz, James, Effects of Summer Foraging on Survival and Reproduction of Moose in Northeast Washington. May 2018.52nd Annual North American Moose Conference and Symposium in Spokane Washington.

Hayes, T., C. Peterson, C. Bishop, M. Mitchell, and N. DeCesare. Approaches to diet composition: interpreting DNA metabarcoding and comparing results. 2019 Conference of the Montana Chapter of the Wildlife Society. Helena, MT.

Hayes, T. Arctic Wild Life: Flora, Fauna, and Research in Greenland. 2019 Native Plant Society and Audubon Society.

Keever, A. C., M. S. Mitchell, K. M. Podruzny, and B. Inman. 2019. Methods to estimate recruitment for social species with limited data. Annual Meeting, Montana Chapter of the Wildlife Society.

Keever, A. C., M. S. Mitchell, K. M. Podruzny, and B. Inman. 2019. Variable recruitment of gray wolves in Montana. Annual Meeting, Montana Chapter of the Wildlife Society.

Mitchell, Adam E., Martin, T.E. Patterns and Causes of Tropical Montane Life Histories: An Observational and Experimental Study in Malaysian Borneo. International Ornithological Congress (IOC).

Mitchell, Adam E. Pros and Cons of Tropical Research, and Results from a Montane Avian Life History Experiment. Field Course Guest Lecturer, Anglia Ruskin University.

Peterson, C., T. Hayes, N. DeCesare**, C. Bishop, and M. Mitchell.** Mule deer resource selection for forage and security in a partially migratory population in Northwest Montana. 2019. Montana Chapter of The Wildlife Society Conference.

Sells, S. N., M. S. Mitchell, K. M. Podruzny, R. M. Inman, and J. A. Gude. 2019. Improving Estimates of Wolf Abundance in Montana. Annual Conference, Montana Chapter of The Wildlife Society.

Sells, S. N., M. S. Mitchell, and K. M. Podruzny. 2018. Carnivore territoriality: emergence of population-level patterns from individual behaviors. Annual Conference, The Wildlife Society.

Sells, S. N., M. S. Mitchell, and J. A. Gude. 2018. Structured decision making: integrating the science and art of wildlife management. Invited presentation, Alberta Environment and Parks.

SCIENTIFIC PAPERS AND REPORTS

Barker, K. J., M. S. Mitchell, and K. Proffitt. In press. Native forage mediates influence of irrigated agriculture on migratory behavior of elk. Journal of Animal Ecology.

Stetz, J. B., M. S. Mitchell, and K. C. Kendall. 2019. Using spatially-explicit capture–recapture models to explain variation in seasonal density patterns of sympatric ursids. Ecography 42: 237–248, 2019 doi: 10.1111/ecog.03556.

DeVoe, J. D., K. M. Proffitt, M. S. Mitchell, C. S. Jourdonnais, and **K. J. Barker**. 2019. Elk forage and risk tradeoffs during the fall archery season. Journal of Wildlife Management. DOI: 10.1002/jwmg.21638.

Bassing, S. B., D. E. Ausband, **M. S. Mitchell**, P. Lukacs, **A. Keever**, G. Hale, and L. Waits. 2018. Stable pack abundance and distribution in a harvested wolf population. Journal of Wildlife Management; DOI: 10.1002/jwmg.21616.

Barker, K. J., M. S. Mitchell, K. M. Proffitt, and **J. D. DeVoe**. 2018. Land management alters traditional nutritional benefits of migration for elk. Journal of Wildlife Management. DOI: 10.1002:jwmg.21564.

Mitchell, M. S., S. N. Sells, K. J. Barker, S. B. Bassing, A. C. Keever, S. C. Forshee, and J. W. Goerz. 2018. Testing a priori hypotheses improves the reliability of wildlife research. Journal of Wildlife Management. DOI: 10.1002/jwmg.21568.

Cain, J.W., III, and **M. S. Mitchell**. 2018. Evaluation of key scientific issues in the report, State of the mountain lion—A call to end trophy hunting of America's lion: U.S. Geological Survey Open-File Report 2018-1128, https://doi.org/10.3133/ofr20181128.

Mitchell, M. S., S. N. Sells, S. B. Bassing, K. J. Barker, A. C. Keever, S. C. Forshee, and J. W. Goerz. 2018. Explicitly reporting tests of hypotheses improves communication of science. Journal of Wildlife Management. DOI: 10.1002/jwmg.21461.

Proffitt, K.M., DeVoe, J., Barker, K., Durham, R., Hayes, T., Hebblewhite, M., Jourdonnais, C., Ramsey, P. and Shamhart, J., 2019. A century of changing fire management alters ungulate forage in a wildfire-dominated landscape. Forestry: An International Journal of Forest Research.

Sells, S. N., M. S. Mitchell, and J. A. Gude. In press. Addressing disease risk to develop a health program for bighorn sheep in Montana in Case Studies in Decision Analysis for Natural Resources Management, edited by M. C. Runge, S. J. Converse, J. E. Lyons, and D. R. Smith. (Invited book chapter.)

DeCesare, N., T. Chilton-Radandt, B. Lonner, T. Thier, **T. Hayes, C. Peterson, C. Bishop, and M. Mitchell**. 2018. Integrating statewide research and monitoring data for mule deer in Montana. Federal Aid in Wildlife Restoration Grant W-167-R. Annual report, December 12, 2018.

Kaiser, S., **T. E. Martin**, J. C. Oteyza, **C. E. Armstad**, and R. C. Fleischer. 2018. Direct fitness benefits and kinship of social foraging groups in an Old World tropical babbler. Behavioral Ecology 29: 468-478.

Mouton, J. C., and T. E. Martin. 2018. Fitness consequences of interspecific nesting associations among cavity nesting birds. American Naturalist 192: 389-396.

Martin, T. E., B. Tobalske, M. M. Riordan, S. Case, and K. P. Dial. 2018. Age and performance at fledging is a cause and consequence of juvenile mortality. Science Advances 4: eaar1988.

Boyce, A. J., and T. E. Martin. 2018. Interspecific aggression among parapatric and sympatric songbirds on a tropical elevational gradient. Behavioral Ecology 30: 541-547.

Şahin Arslan, N. and T. E. Martin. 2018. Reproductive biology of Grey-breasted Wood Wren (Henicorhina leucophrys): A comparative study of tropical and temperate wrens. Wilson Journal of Ornithology 131: 1-11 (with Frontispiece).

L. M. Callan, F. A. La Sorte, **T. E. Martin** and V. G. Rohwer. 2019. Higher nest predation favors rapid fledging at the cost of plumage quality in nestling birds. American Naturalist 193: 717-724.