Montana Cooperative Wildlife Research Unit

Annual Report 2021

Coordinating Committee Meeting

April 14, 2021

Montana Cooperative Wildlife Research Unit

Report of Activities for the Coordinating Committee Meeting

April 14, 2021

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 2020 through 30 April 2021

Montana Cooperative Wildlife Research Unit
The University of Montana
Natural Science Building – Room 205
Missoula, MT 59812
Ph: 406-243-5372
Fax: 406-243-6064
www.umt.edu/mcwru

Table of Contents

Birds

Mammals

Coordinating Committee Members

U. S. Geological Survey

Kevin Whalen, Supervisor
USGS - Cooperative Research Units Program
12201 Sunrise Valley Drive MS303
Reston, VA 20192

Wildlife Management Institute

Chris Smith
Wildlife Management Institute
5450 Tumbleweed Drive
Helena, MT 59602

U. S. Fish and Wildlife Service

Greg Watson, Regional Director
Mountain-Prairie Region
134 Union Boulevard
Lakewood, CO 80228

Montana Fish, Wildlife and Parks

Ken McDonald
Wildlife Bureau Chief
P.O. Box 200701
Helena, MT 59620-0701

Justin Gude
Wildlife Research & Technical Services Supervisor
1420 East 6th Avenue
Helena, MT 59620

The University of Montana

Scott Whittenburg, Vice President
Office of Research and Creative Scholarship
Main Hall 116
Missoula, MT 59812

Chad Bishop, Program Director
Wildlife Biology Program
Forestry 311C
Missoula, MT 59812

Unit Staff

Mike Mitchell, Unit Leader
Thomas E. Martin, Assistant Unit Leader
Debora Simmons, Accounting Manager

Graduate Students Advised by Unit Faculty

Mike Mitchell

Brandon Kittson
Kenneth Edmo
Peter Mumford
Sarah Sells, Postdoctoral Associate

Tom Martin

Timothy Forrester, PhD Candidate
Holly Jackson, MSc Candidate
Adam Mitchell, PhD Candidate
Elise Zarri, PhD Candidate

Unit Faculty on Graduate Students' Committees

Mike Mitchell

Jennifer Feltner, PhD Candidate
Ellen Pero, PhD Candidate
Hans Martin, PhD Candidate
Kaitlyn Reintsma, PhD Candidate
Michelle Kissling, PhD Candidate
Tara Meyer, PhD Candidate
Molly McDevitt, PhD Candidate
Brenna Cassidy, PhD Candidate
Daniel Bird, PhD Candidate

Tom Martin

Hannah Beyl, MSc Candidate*
Alex Kumar, PhD Candidate*
Maria Stager, PhD Candidate*

* Graduated
** Co-Advised

Research Associates

Colby Anton
James Nowak
Allison Devlin
Rachel Shouse
Jesse DeVoe
Hannah Specht

Research Assistants

Maxwell Anderson
Richard Aracil
Kristen Brush
Colter Chitwood
Christian Cormier
Ellie Cosgrove
Jonathan Erickson
Mathew Eckerson
Eliana Fierro-Calderon
Collen Flynn
Michael Forzley
Shannon Gillen
Ross Hinderer
Nate Jourdonnais
Leah Joyce
Ciera Keith
Ryan Luckadoo
Sarah Mueller
Wyatt Neilsen
Petros Platis
Nancy Ransom
Ryan Steiner
Kathleen Supynuk
Casey Swafford
Samantha Treu
Maili Waters
Trevor Weeks
Michael Wolf

Student Workers

Lane Arthur
McKayl Bailey
Ivie Carvo
Rachel Davies
Kami Diehl
Amelia Evavold
Amber Guerra
Hannah Hornyak
Isabelle Johnson
Jonathan Karlen
Katelyn Kline
Connor Kurz
Ila Makela
Nalani Oines
Mikaela Radcliff
Abimael Romero
Emily Ruta
Rose Sampson
Miles Scheuering
Jonathan Shaw
Ashley Sinclair
Emilee Smith
Jan Sostre-Cortes
Kile Stumbo
Kailie Todd
Tessa Van Ostrand
Anna Wearn
Candace Wiedemann
Morgan Wilson

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 2020

Unit and Administrative Operating Funds		
University of Montana - Full-time Accounting Manager	$ 50,524	
SPABA – returned to Unit in FY19/FY20	58,143	
Subtotal		**$ 108,667**
FY 2019 – Research Projects Funding		
Montana Fish, Wildlife and Parks - Operating Funds		**$ 20,000**
T. Martin – PI		
New Funding:		
NSF - Temp influences on parental energy expenditure and fitness in the tropics: the dry vs wet conundrum	$980,125	
Subtotal		**$ 980,125**
Continued Funding:		
USDI – Quantifying the response of sagebrush obligate birds to fence-modifications and encroaching conifer removal	$181,198	
UM Research Administration – Graduate Support	46,000	
USDI – Effects conifer removal – songbirds	103,774	
NSF – Songbirds in Tropical Rainforests	824,336	
Subtotal		**$1,155,308**
M. Mitchell – PI or Co-PI		
New Funding:		
USDI – Grizzly Bear Recovery: Modeling Movement, home ranges, Range expansion & Population Connectivity	$ 82,000	
Subtotal		**$ 82,000**
Continued Funding:		
USDI - Reliability of Management Recommend	$33,694	
USDI – Structuring Governance	60,500	
BLM - Lower Blackfoot Bear Stress Study	10,000	
USDI – Sage-grouse Synergies N. Great Plains	84,951	
MTFWP – Migratory songbirds – grazing	658,364	
State of Colorado – Colorado moose ecology	25,459	
MTFWP – Statewide mule deer study	241,537	
IDFG – Cougars - Population Dynamics and Modeling	52,952	
MTFWP – Sage grouse & grazing study FY19-20	20,657	
IDFG – Predator/prey	83,104	
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 – FWP invert sampling & mapping	300,033	
MTFWP – Grizzly Bear Social Survey: HD Bear	25,164	
MTFWP – Pronghorn Movement	1,429,530	
MTFWP – Westslope in Rock Creek Montana	48,200	
IDFG – Predator use of prey	49,966	
MTFWP – Mandatory Reporting and Harvest Surveys Evaluation	10,000	
MTFWP – Elk Recreation Study	152,876	

Panthera – Preventing predation	152,876	
Panthera – Puma Density and Distribution	47,374	
USDI – Linking Exposure to Sub-Lethal Stressors	92,299	
USDI - Linking Exposure to Sub-Lethal Stressors to Vital Rates	129,997	
MTFWP - Montana Wolf Monitoring	274,003	
MTFWP – Wolverine Monitoring	27,500	
MTFWP – North Sapphire Research	108,939	
MTFWP – State Parks Foundation	6,280	
	Subtotal	**$ 5,027,859**
	Total Budget	**$7,373,959**

Completed Projects – 1 January 2020 – 31 December 2020

End Date	Student	Funding Agency	Title
June 2020	Forest Hayes	State of Colorado	Moose Ecology: Nutrition, habitat, space use and life history
December 2020	Sarah Sells, Allison Keever	Montana Fish Wildlife and Parks	Montana wolf monitoring study

MTCWRU – Federal and State Vehicles

Description	Tag number	Odometer as of 4/05/2021
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	79,561
2011 Ford F250 Crew Cab Pickup, 4 x 4	FED 433440	59,488
2011 Ford F250 Crew Cab Pickup, 4 x 4	FED 433610	70,931
2012 Dodge 1500 Crew Cab 4 x 4	FED 433621	60,584
2017 Ford F150 Crew Cab Pickup, 4 x 4	FED 434302	5,811
2019 Ford F250 Crew Cab Pickup, 4 x 4	FED 434679	945
2005 Ford Explorer, 4 x 4	UM 3787	155,047

BIRDS

Photo by Tim Forrester

Photo by Holly Jackson

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, Ph.D., Holly Jackson, 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.

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 are examining: 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, 4) impacts of distance from woody vegetation on nesting success and population trajectories (i.e., lambda) of songbirds, and 5) temperature sensitivities and constraints on reproduction. 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.

Results

The second field season of this project was completed despite covid. The student shifted from a M.S. to a Ph.D. program and did an impressive job of managing covid and completing a full field season. We adjusted protocols for the field season by conducting a two-week quarantine at the beginning of the field season, taking daily temperature checks, and limiting contact with anyone outside of our crew. The same precautions will be in place for the 2021 field season.

Field work is being conducted at a high elevation sagebrush site, where conifers were removed in 2017-2019. Nest success and densities of songbirds are being compared on plots where conifers have been removed versus where conifers remain. Seven technicians assist with nest searching for sagebrush songbirds, as well as territory mapping and vegetation monitoring. 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 is being quantified. This is aimed at understanding habitat use in conifer removal and non-removal sites. We will also quantify successful nest sites using the same vegetation characteristics to understand how fitness correlates with habitat use.

Initial analyses show that bird abundances were greater in 2020 than 2019. We found double the number of nests in 2020 than 2019, which allowed statistically strong comparisons. Abundances and nesting success of Brewer's and Vesper Sparrows were higher in conifer-removal treatments, supporting the value of this management tool for sagebrush-obligate and grassland species. Species that typically use forest-shrub habitats (Dark-eyed Juncos, White-Crowned Sparrows, Chipping Sparrows) were naturally more abundant in control than removal areas. Sagebrush birds are notoriously variable among years and we will continue field studies for 2 more years to ensure results are robust and to obtain robust sample sizes for less-abundant species.

A total of 628 nests were found in the two field seasons. Nests were more successful in conifer removal plots for the two sagebrush-grassland species (Brewer's Sparrows, Vesper Sparrows) that were sufficiently abundant for estimates. The opposite was true for the forest-shrub White-crowned Sparrow, and sample sizes were too small for Green-tailed Towhees and other species to determine a pattern. These exciting results indicate that conifer removal is beneficial for sagebrush-obligate and sagebrush associated species. We will seek to increase sample sizes for all species and determine if these patterns are robust across years in the next two field seasons.

Impacts of conifer removal on sagebrush songbirds

Student: **Elise Zarri**

Degree: PhD Candidate

Advisor: Thomas Martin

Project Duration: 2018 – 2023

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 is home to many declining sagebrush-obligate species. 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 Sparrows and Sage Thrashers have been shown to have increased abundance with reduced conifer cover, but reproductive responses of these species to conifer removal have not been quantified. Conifer removal could lead to ecological traps, where sagebrush songbird abundance is high, but reproductive success is low in removal areas due to increased predation through predator spillover from conifer forest. If ecological traps occur when conifers are removed, then mitigating these negative impacts will be important for managing sagebrush songbird populations.

Removal of conifers significantly alters the landscape, so understanding how songbirds respond to these changes is vital in predicting responses on a population-level scale. Therefore, this work seeks to understand how songbirds select habitat and how predation rates differ relative to distance from woody vegetation. I am studying the habitat selection, abundance and fitness responses of sagebrush songbirds to conifer removal and modelling responses across broader spatial scales of conifer removal in the western United States.

Progress and status

I have completed two field seasons of this project and am preparing for the third season. I defended a dissertation proposal in April 2020 and completed the 2020 field seasons despite challenges from COVID-19. We adjusted protocols for the field season by conducting a two-week quarantine at the beginning of the field season, taking daily temperature checks, and limiting contact with anyone outside of our crew. The same precautions will be in place for the 2021 field season. I am in the process of preparing for comprehensive exams, which I will complete in late March and early April of 2021.

Field work is being conducted at a high elevation sagebrush site, where conifers were removed in 2017-2019. I am comparing plots where conifers have been removed to control plots where conifers remain. Seven technicians will assist with nest searching for sagebrush songbirds, as well as territory mapping and vegetation monitoring. I am quantifying 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.

Understanding thermal constraints on reproductive effort

Student: **Holly R. Jackson**

Degree: MS Student

Advisor: Thomas Martin

Project Duration: 2019-2021

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

Funding Sources:

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

Objectives

High body temperatures resulting from activity and exposure to warm ambient temperatures can constrain reproductive effort and negatively impact fitness in parental endotherms. Species vary in activity and climate regime such that heat impacts may differ across species. However, research of heat restrictions on reproductive effort has been confined to studies on short-lived temperate taxa that have wide thermoneutral zones and high reproductive activity. Tests are lacking in long-lived tropical endotherms that on the one hand, may be constrained by heat due to their narrower thermal tolerances, but alternatively, may avoid heat impacts due to comparatively lower activity and reproductive investment.

Heat may also differentially influence organisms across life stages. Young songbirds grow most efficiently at high ambient temperatures. On the one hand, higher ambient temperatures may directly increase nestling growth rates by providing favorable conditions for growth. Alternatively, high ambient temperatures may constrain adult provisioning and nest attentiveness and indirectly hamper nestling growth via reduced food delivery rates or reduced parent-shading from solar rays. The relative contributions of the direct and indirect effects of high ambient temperatures and greater solar radiation at the nest have seldom been explored, presenting a gap in our understanding on how temperature may influence fitness.

My first chapter examines whether improving heat dissipation capabilities, by means of a feather clipping experiment, will alter reproductive effort in a long-lived tropical songbird. I will assess the effects that my clipping treatment has on parental body temperature, nest attentiveness, provisioning rates, and consequences for offspring growth rates. My second chapter will explore the direct and indirect effects of temperature at the nest on nestling growth rates via a nest shading experiment. The quantity and quality of reproductive effort provided from parents to offspring can have large impacts on offspring growth and development, which influence survivorship and fitness as adults. Taken at a population level, these processes influence demography and population viability. Given current global warming projections, it is increasingly important to understand how temperature may limit reproductive effort and offspring growth, and if taxa in certain regions are more predisposed to temperature impingements on rearing young.

Progress and status

I completed the field work and data collection to address the question presented in my first chapter last spring (timeframe Feb. – Jun. 2020) studying nesting songbirds in tropical Borneo. I then completed the first season of field work for my second chapter (timeframe Jun. – Aug. 2020) in the sagebrush ecosystem near Dillon, MT. Since the conclusion of my second field season, I have completed data analysis on my body temperature data for my first chapter and will begin analysis on my parental behavior data shortly. I have also begun writing the results of my first chapter for peer-reviewed publication. In my remaining field season (May – Aug. 2021) I will focus on gathering nestling growth data from my nest shading experiment.

Qualifying the response of sagebrush obligated birds to fence-modifications and encroaching conifer removal

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. 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.

Results

Field work for 2020 was not possible due to covid. All aspects are on track to be completed in 2021.

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, Timothy Forrester, Holly Jackson

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 also measured metabolic sensitivity of adults and offspring to temperature variation, possible role of competition in constraining elevational ranges. We examined 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 work, we examined 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 examined differences in survival and reproduction during and following the drought among species that differ in their average annual survival probabilities.

Results

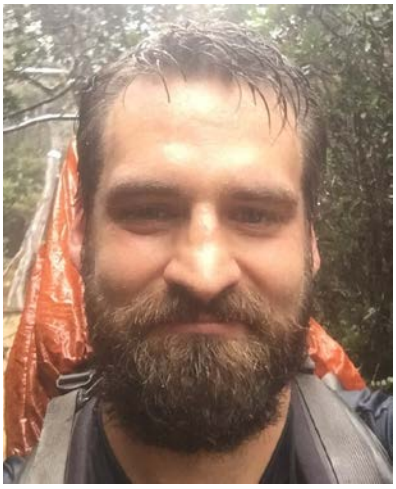
This project wrapped up last year and is now done. I worked in tropical Borneo because it retains large blocks of pristine forest at mid-elevation from 1450 to 1950 m elevation. Large numbers of nests were found and monitored, nestling metabolism and nestling growth measured, parental care video-taped, 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 included 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 and taught to write their first publications on the life history of some species that is previously undescribed.

Effects of rainfall on nestling bird energetics



Student: **Adam E. Mitchell**

Degree: PhD Candidate

Advisor: Thomas Martin

Project Duration: 2014 – 2021

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 pattern are not well 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 experimentally tested a hypothesis that the harsh weather at high elevations constrains avian life history traits, and these results are published in The American Naturalist, a peer-reviewed journal.

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 subsequent chapters explore the effects of rainfall on the energetics of nestling birds in the tropical mountain forests of Borneo, and the ability of parents to mitigate such effects. In many habitats, extreme rainfall events are predicted to increase in frequency and magnitude. Yet the direct ecological and evolutionary influences of rainfall are almost entirely unknown, limiting our ability to predict how climate change will affect bird populations, especially during their vulnerable juvenile life stage.

I collected data to answer my remaining questions at a mid-elevation tropical site in Malaysian Borneo. Here, I used 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 experimentally increased the amount of rainfall at the nests with a makeshift bamboo shower to directly test the effects of rain on nestling FMR. I predicted that nestling energetics will increase with increasing rainfall, or parental attentiveness will increase, or some combination of the two.

Progress and status

The first chapter of my dissertation has been published in the peer-reviewed journal: The American Naturalist. My second chapter has been submitted for publication and my dissertation has been submitted to my committee for defense on 30 April 2021.

Influences of abiotic factors and life histories on songbird behavior, energy expenditure, and reproduction

Student: **Timothy R. Forrester**

Degree: PhD Candidate

Advisor: Thomas Martin

Project Duration: 2018 – Current

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

Funding Sources:

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

Objectives

Examining how and why species vary in behavior, physiology, and life history strategies is a fundamental part of diverse ecological and evolutionary fields. Much effort has been focused on determining the causes of variation in energy expenditure (e.g., brood size, parental effort, metabolic rates). Yet, differences in how much energy species spend on a daily basis on tasks other than reproduction (e.g., foraging) and in time spent resting remain poorly understood. For my dissertation, I will describe and test causes of interspecific variation in behavior, energy expenditure, and reproductive strategies using diverse tropical and temperate songbirds. First, I am describing how species spend energy throughout their daily lives (e.g., foraging while flying vs. hopping, time spent active vs. inactive) by quantifying their time-energy budgets (i.e., how they partition their time and energy between different tasks). Then, I am using those time-energy budgets to estimate daily energy expenditure and test hypotheses for why interspecific variation exists. I will also examining differences in temporal patterns of parental care in response to environmental temperature across diverse temperate species using a large database of songbird provisioning behavior. Nest, I am addressing the historic question of why species lose mass during reproduction using a novel experiment with two box-nesting temperate songbirds. My research involves observational studies of avian behavior in the wild, analyzes of existing databases of avian parental care, and a novel experiment to manipulate reproductive effort in wild birds. My overriding objective is to describe and test for the causes of variation in neglected aspects of species' energy expenditure and reproductive investment to improve our understanding of how selective pressures influence behavior and life history strategies. My research also seeks to understand how environmental temperature influences behavior and reproductive strategies, which will be critical to understand as global temperatures continue to rise.

Progress and status

In the 2020-2021 academic year, I presented initial results from my dissertation at the Ecology & Evolution noon seminar. I received two internal awards from the University of Montana, Division of Biological Sciences (the David Nicholas Memorial Fund and the Clancy Gordon Environmental Scholarship). I submitted proposals for research funding to the American Museum of Natural History Frank M. Chapman Memorial Fund, the American Ornithology Society Student Research Award Program, and the Wilson Ornithological Society Research Grant program. I published one first-authored paper (from my previous masters research) in The *Condor: Ornithological Applications* and was a co-author on another manuscript published in *Ecography*. I recently completed the written portion of my comprehensive exams and will be taking the oral portion of the exam soon.

In 2020, my research during my second field season at Kinabalu Park, Malaysian Borneo was severely disrupted due to COVID-19 related shutdowns, which forced me to abandon work that I began in 2019. However, I did manage to collect sufficient time-energy budget data, which I am currently in the process of entering and

analyzing. However, initial data reveals striking differences among species in how active they are and in the forging techniques they use. Upon returning from Borneo, I initiated a new project in Montana. I designed a novel method of non-invasively measuring songbird mass across the nesting cycle, where birds land on a perch placed on top of a scale, and a camera records the mass. Using this method, I am addressing the question of why species lose mass during reproduction. I am also planning a novel nest-box heating experiment to reduce the time that parents spend brooding nesting to test effects on parental mass loss. I also wrote a comprehensive review article of this subject as part of my comprehensive exams, which I plan to publish. In 2021, I am planning a full field season in Montana and may be extending my existing work at a new site in South Africa.

Understanding demographic responses to temperature and solar radiation in dry-habitat songbirds that differ in longevities

Obligated funding: None yet

Principal Investigator: Thomas E. Martin

Project Duration: 2021-2024

UM Affiliation: Montana Cooperative Wildlife Research Unit

Funding Sources:

Objectives

Temperature and drought are an increasing problem in North America associated with climate change. Seasonality of climate is 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 arid habitat in South Africa show strong temperature sensitivity in the timing of reproduction and related to adult survival probability: data that I collected previously show that long-lived species started and stopped breeding at dates where temperatures and solar radiation were much lower, while shorter-lived species bred at later dates. I propose to examine the effects of temperatures and solar radiation on reproductive output among songbirds at my old site, a nature reserve.

Work on this issue was initially aimed at Ecuador, but was a bust due to covid and I decided to shift to South Africa due to the previous data showing clear species differences in breeding timing relative to climate conditions.

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 to temperature and solar radiation among species as a function of their evolved life history strategies. In addition, the habitat is low scrub, somewhat similar to sagebrush habitat and thereby provides an interesting contrast to our work on sagebrush habitats.

Demography and survival of songbirds in west-central Montana, with special reference to Chickadees and weather effects

Obligated funding: None

Principal Investigator: Thomas E. Martin

Project Duration: 2019-until I drop…

UM Affiliation: Montana Cooperative Wildlife life Research Unit

Graduate Students: Timothy Forrester

Funding Sources:

- None and none sought

Objectives

This work has three elements: 1) the primary study is of hybrid breakdown and demography in two chickadee species and effects of weather on reproduction, 2) adult survival among several year-round resident species for which survival has been un-estimated, and 3) demography of the two chickadee species and house wrens.

Hybridization between Black-capped (*Poecile atricapillus*) and Mountain Chickadees (*Poecile gambeli*) may impact one or both populations such that understanding the extent and population impacts of hybridization is critically needed. Population monitoring in Montana by the Integrated Monitoring in Bird Conservation Regions (IMBCR) over the four years 2010-2013 indicated that Black-capped Chickadees exhibited a significant population decline over this period (Janousek et al. 2015). In contrast, Mountain Chickadees exhibited a population increase (Janousek et al. 2015). The extent to which hybridization may influence these population trends is unknown, as are the demographies of these two species. I established 100 boxes in the Butler Creek Drainage to study their demographies and collect blood to assess hybridization. In addition, a major goal is to assess the effects of weather, particularly rain, on both reproduction and survival. Effects of rain are poorly studied on populations and growth of young.

Red-breasted Nuthatch (*Sitta canadensis*) have had limited study of their demography and no estimates of adult survival have been reported (Birds of North America Online). These nuthatches excavate cavities that can be subsequently used by chickadees (TEM, pers. obs.), but have shown strong population declines in Montana (Janousek et al. 2015). Adult survival can have a major impact on demographic trends (Clark and Martin 2007). We are capturing and banding them to study adult survival as one possible influence on their population declines. Finally, Steller's Jay (*Cyanocitta stelleri*) is an important predator of nests of songbirds, but little is reported on their demographies (Birds of North America Online). Again, no estimates of adult survival are available. We are capturing and color-band Steller's Jays visiting winter feeders to study annual adult survival to facilitate better understanding of causes of their population trends.

Progress and status

A few hundred birds have been bled and banded in the past two years and detailed data on number and growth of young were obtained from both species to assess relative to weather conditions. Rain caused mortality of young in some nests and impinged on growth in others.

MAMMALS

Photo by Brandon Kittson

Photo by Brandon Kittson

Modeling Habitat for bison on the Blackfeet Indian Reservation

Student: **Brandon Kittson**

Degree: MS Student

Advisor: Mike Mitchell

Project Duration: Fall 2020 – Spring 2022

UM Affiliation: Wildlife Biology Program
Montana Cooperative Wildlife Research Unit

Funding Sources:

- American Indian Graduate Center
- Sloan Indigenous Graduate Partnership
- University of Montana
- Hopa Mountian
- Keepseagle Grant

Objectives

Brandon is developing a project in cooperation with the Blackfeet Nation to model habitat suitability for bison on the U.S. portion of the reservation. Other work on bison has shown that models of habitat quality can be predictive of both abundance and distribution of bison. This information will be important to the Blackfeet Tribe as they reintroduce free-ranging bison to portions of their reservation.

Progress

Brandon is currently developing a Habitat Suitability Index in conjunction with the Wildlife Conservation Society. As well as working on pathway modeling using Circuitscape, in efforts to Identify how bison will traverse the reintroduction zone which will become their new home.

Grizzly bear (Ursus arctos horribilis) habitat use on the Flathead Reservation, Montana

Student: **Kenneth Edmo**

Degree: MS - Wildlife Biology

Advisor: Michael S. Mitchell

Project Duration: Fall 2021 – Spring 2023

UM Affiliation: Wildlife Biology Program
Montana Wildlife Cooperative Research Unit

Funding Sources:

- U.S. Fish and Wildlife Service
- Sloan Indigenous Graduate Partnership
- University of Montana

Objectives

Kenneth is in the process of developing a project in cooperation with the Tribal Wildlife Management Program on the Flathead Reservation. The project will be on grizzly bear habitat use on the Reservation. Grizzlies are a protected species nationally and are important cultural animals on the Flathead Reservation. By finding a better understanding of how/why grizzlies use the surrounding habitat can provide an important insight for management for grizzly protection and reduce human-grizzly conflicts.

Progress

Kenneth is currently coordinating with the Tribal Wildlife Management Program and the Montana Wildlife Cooperative Research Unit on developing a study on habitat use.

Effects of Changes in Travel Management and Hunter Access on Elk Distributions in the Northern Sapphire Mountains, Montana

Student: **Peter Mumford**

Degree: M.S. student– Wildlife Biology

Advisors: Mike Mitchell and Kelly Proffitt

Project Duration: 2019 – 2023

UM Affiliation: Wildlife Biology Program

Montana Cooperative Wildlife Research Unit

Funding Sources:

- Montana Fish, Wildlife, and Parks
- Montana Cooperative Wildlife Research Unit
- MPG Ranch
- Rocky Mountain Elk Foundation
- Backcountry Hunters and Anglers, MT Chapter
- Montana Outdoor Life Foundation

Objectives

Elk (Cervus canadensis) are a charismatic species found throughout western Montana and primarily valued for hunting and wildlife viewing opportunities. A growing concern in many parts of elk range, including the Sapphire Mountains in west-central, MT, is the trend of elk increasingly inhabiting private lands inaccessible to hunters. This is problematic for private land owners due to issues of depredation by elk, to hunters who can't access elk, and wildlife managers who use hunters to influence the abundance of elk through harvest. A study of elk population dynamics and spatial patterns in the northern Sapphires occurred from 2014 to 2016. A follow-up study was initiated in 2019 in response to large-scale changes to the access to motorized routes and land made after the conclusion the last study.

I have two main objectives. First, evaluate the effects of decreased access to motorized routes and land to hunters on the distribution of elk during the fall hunting season. Limiting access to motorized routes during hunting season is a common management practice to increase the security for elk and influence their distribution. This chapter will help understand if and how effective limiting access to motorized routes is. Second, evaluate factors that influence the fine-scale movement behavior of male elk during the hunting season. This chapter will provide information about the behavior of male elk in a free ranging population using modern analytical techniques, which is relatively scarce.

Progress & Status

I am in my third semester and successfully defended my master's proposal during my second semester. Currently, I am enrolled in coursework pertinent to my research project. I am preparing my data and setting up my analyses. I expect to run analyses for my first chapter and have initial results by the end of the semester. I have a draft of my chapter one manuscript and writing is ongoing. Field work is limited, but involves coordinating and conducting necropsies on study animals and the retrieval of dropped Global Positioning System collars.

Estimating Wolf Abundance in Montana with a Multi-Model Approach

Student: **Sarah Sells**

Degree: Postdoctoral Researcher– Wildlife Biology

Advisor: Mike Mitchell

Project Duration: 2020

UM Affiliation: Wildlife Biology Program
Montana Cooperative Wildlife Research Unit

Funding Sources:

- Montana Fish, Wildlife, and Parks

Objectives

This research aimed to provide a means to reliably estimate wolf abundance in Montana. Abundance estimates are key to management decisions, and to date have relied on challenging, costly field-based monitoring. From 2007 through 2019, MFWP estimated annual population size using a patch occupancy model-based approach. However, this approach was sensitive to sizes of packs and territories, and was developed prior to implementation of public harvest. Reliability of estimates were contingent on accurate information on territory size, overlap, and pack size. Intensive, field-based monitoring became cumbersome and less effective as the population grew. Furthermore, the cessation of federal funding for wolf monitoring required a reduction in reliance on intensive counts of the wolf population.

Progress & Status

We developed a multi-model approach known as the integrated patch occupancy model (iPOM) to estimate wolf abundance. iPOM eliminates the need for intensive field-based monitoring and introduces biological models of wolf behavior. An occupancy model first estimates annual wolf distribution, based on environmental covariates and wolf observations reported by hunters. A mechanistic territory model predicts territory sizes using simple behavioral rules and limited data for prey resources, terrain ruggedness, and human density. Together, these models predict the number of packs in a given area. Finally, a pack size model demonstrates that pack sizes are generally negatively related to terrain ruggedness, local mortalities, and intensity of harvest management. Total abundance estimates are derived by combining predicted numbers of packs and pack sizes.

We applied iPOM to estimate wolf abundance for 2007 – 2019. The population was estimated to have been smallest in 2007, with 91 packs (95% CI = 76 – 107) and 650 wolves (95% CI = 547 – 771). A peak appears in 2011, with 187 packs (95% CI = 170 – 206) and 1254 wolves (95% CI = 1136 – 1383). This coincided with the first years of harvest management, after which the population declined by 7.8% in total abundance between 2011 and 2019. From 2016 – 2019, the population appears to have largely stabilized with an average of 190 packs and 1136 wolves per year, even with an estimated annual harvest rate of >20% in this period.

Based on this new analytical method, we also provided recommendations for wolf monitoring to inform iPOM. Efficient and effective use of limited resources requires targeted monitoring. Because wolves in Montana are managed through harvest, reliable estimates of population size will help inform harvest regulations.

This project is complete as of December 2020. MFWP will continue to use iPOM to estimate wolf abundance each year. Full details of this work are provided in the Final Report for Federal Aid in Wildlife Restoration Grant W-161-R-1 by Sells et al (2020). As of March 2021, we have published two peer-reviewed manuscripts from this work (Sells & Mitchell 2020, and Sells et al. 2021), and additional manuscripts are in review and in prep.

AWARDS AND RECOGNITIONS

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

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

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.

Sells, S. N., M. S. Mitchell, K. M. Podruzny, J. J. Nowak, J. A. Gude, and R. Inman. February 2021. A multi-model approach to estimating wolf abundance in Montana. Annual Meeting, Montana Chapter of The Wildlife Society, Virtual.

Sells, S. N., M. S. Mitchell, K. M. Podruzny, J. A. Gude, and R. Inman. October 2020. Estimating wolf abundance in Montana with a multi-model approach. Annual Meeting, The Wildlife Society, Virtual.

SCIENTIFIC PAPERS AND REPORTS

Sells, S. N., M. S. Mitchell, K. M. Podruzny, J. A. Gude, A. C. Keever, D. K. Boyd, T. D. Smucker, A. A. Nelson, T. Parks, N. Lance, M. S. Ross, and R. M. Inman. 2021. Evidence of economical territory selection in a cooperative carnivore. Proceedings of the Royal Society of London B: Biological Sciences 288: 20210108.

Sells, S. N., and M. S. Mitchell. 2020. The economics of territory selection. Ecological Modelling 438: 109329.

Loonam, K. E., D. E. Ausband, P. M. Lukacs, M. S. Mitchell, and H. S. Robinson. 2020. Estimating abundance of an unmarked, low-density species using cameras. The Journal of Wildlife Management 85:87 - 96.

Bassing, S. B., D. E. Ausband, M. S. Mitchell, M. K. Schwartz, J. J. Nowak, G. C. Hale, and L. P. Waits. 2020. Immigration does not offset harvest mortality in groups of a cooperatively breeding carnivore. Animal Conservation 1 - 12. DOI: 10.1111/acv.12593.

Sells, S. N., M. S. Mitchell, and J. A. Gude. 2020. Addressing disease risk to develop a health program for bighorn sheep in Montana in Structured Decision Making: Case Studies in Natural Resource Management, edited by M. C. Runge, S. J. Converse, J. E. Lyons, and D. R. Smith.

Ausband, D. E., S. B. Bassing, and M. S. Mitchell. 2020. Environmental and social factors influencing wolf (Canis lupus) howling behavior. Ethology 1 - 10. DOI: DOI: 10.1111/eth.13041

Mouton, J. C., and T. E. Martin. 2019. Nest structure affects auditory and visual detectability, but not predation risk, in a tropical songbird community. Functional Ecology 33:1973–1981.

Khwaja, N., M. Massaro, T. E. Martin, and J. V. Briskie. 2019. Do parents synchronise nest visits as an antipredator adaptation in birds of New Zealand and Tasmania? Frontiers in Ecology and Evolution 7:389, https://doi.org/10.3389/fevo.2019.00389.

Boyce, A. J., S. Shakya, F. H. Sheldon, R. G. Moyle, and T. E. Martin. 2019. Biotic interactions are the dominant drivers of phylogenetic and functional structure in bird communities along a tropical elevational gradient. Auk 136: 1-14.

Kaiser, S. A., T. E. Martin, J. C. Oteyza, J. Danner, C. Armstad, and R. C. Fleischer. 2019. Within-group relatedness and patterns of cooperation and reproductive sharing in the tropical chestnut-crested yuhina. Animal Behavior 158: 89-99.

Burner, R. C., A. J. Boyce, S. B. Shakya, D. Bernasconi, C. Boer, M. A. Rahman, T. E. Martin, and F. H. Sheldon. 2020. Biotic interactions and temperature gradients contribute to differences in range limits of Bornean mountain birds. Journal of Biogeography 47: 760-771.

Boyce, A. J., J. C. Mouton, P. Lloyd, B. O. Wolf, and T. E. Martin. 2020. Metabolic rate is negatively linked to survival but does not explain latitudinal differences in songbirds. Ecology Letters 23: 642-652.

Mouton J. C., B. W. Tobalske, N. A. Wright, and T. E. Martin. 2020. Compensatory plasticity offsets performance and survival costs of predation risk across life stages. Functional Ecology 31: 2147-2157.

Martin, T. E., and J. C. Mouton. 2020. Longer-lived tropical songbirds reduce breeding activity as they buffer impacts of drought. Nature Climate Change 10: 953-958.

Mitchell, A. E., J. Boersma, A. Anthony, K. Kitayama, and T. E. Martin. 2020. Experimental amelioration of harsh weather speeds growth and development in a tropical montane songbird. American Naturalist 196: E110-E118.

Unzeta, M., T. E. Martin, and D. Sol. 2020. Daily nest predation rates decrease with body size in passerine birds. American Naturalist 196: 743-754.

K. Fierro-Calderón, and T. E. Martin. 2020. Does habitat change over 28 years affect habitat use and nest survival? Auk 137: 1-9.

Ton, R., and T. E. Martin. 2020. Nest predation and adult mortality relationships with post-natal metabolic rates and growth among temperate and tropical songbird species. Journal of Experimental Biology 23: doi:10.1242/jeb.226563.

Oteyza, J. C., J. C. Mouton, and T. E. Martin. 2021. Adult survival probability and body size affect parental risk-taking across latitudes. Ecology Letters 24: 20-26.

Lowe, W. H., T. E. Martin, D. K. Skelly, and H. A. Woods. 2021. Metamorphosis in an era of increasing climate variability. Trends in Ecology and Evolution https://doi.org/10.1016/j.tree.2020.11.012