MONTANA COOPERATIVE WILDLIFE RESEARCH UNIT

Annual Report 2020

Coordinating Committee Meeting
3 June 2020

Montana Cooperative Wildlife Research Unit

Report of Activities for the Coordinating Committee Meeting

3 June 2020

Cooperating Agencies
U. S. Geological Survey
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 2019 through 1 June 2020

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Cover photos by Andrew Russell (elk) and Tom Martin (mountain chickadee and roughed grouse)

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Birds

Mammals

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James Goerz, MS Student
Teagan Hayes, MS Student †*
Allison Keever, PhD candidate *
Brandon Kittson, MS Student
Kenneth Loonam, MS Student †*
Peter Mumford, MS Student
Collin Peterson, MS Student †*
Sarah Sells, PhD Candidate *

Tom Martin

Timothy Forrester, PhD Student
Adam Mitchell, PhD Candidate
James Mouton, PhD Candidate *
Sarah Straughan, MS Student
Elise Zarri, PhD Student

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Mike Mitchell

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Jennifer Feltner, PhD Candidate
Michelle Kissling, PhD Student
Jess Krohner, MS Student *
Hans Martin, PhD Candidate
Tara Meyer, PhD Student
Elizabeth Painter, PhD Student
Ellen Pero, PhD Candidate
Kaitlyn Reintsma, PhD Candidate

Tom Martin

Sara Berk, PhD Candidate *
Hannah Beyl, MS Student
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* Graduated
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John Nelson
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Christine Martin
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Christopher Lenhart
Matthew Hurley
Nikol Isakovska
Katelyn Kline
Christopher Kaminsky
Zoe Swigart
Ty Harrison

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 2019

Unit and Administrative Operating Funds

University of Montana - Full-time Accounting Manager	$ 48,480
SPABA – returned to Unit in FY19/FY20	63290
Subtotal	**$ 111,770**

FY 2020 – Research Projects Funding

Montana Fish, Wildlife and Parks - Operating Funds	**$ 20,000**

T. Martin – PI

New Funding:

Continued 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	103,774
UM Research Administration – Graduate Support	44,067
USDI – Effects conifer removal – songbirds	45,967
NSF – Songbirds in Tropical Rainforests	824,336
Subtotal	**$1,199,342**

M. Mitchell – PI or Co-PI

New Funding:

MTFWP - Pronghorn Movement	$1,429,530
MTFWP – Westslope in Rock Creek MT	48,200
IDFG – Predator use of Prey	152,876
MTFWP – Mandatory Reporting & Harvest Survey Eval	10,000
Subtotal	**$1,640,606**

Continued Funding:

BLM - Lower Blackfoot Bear Stress Study	10,000
IDFG – Cougars	52,952
IDFG – Population dynamics FY19	157,407
MTFWP – North Sapphire Elk Project Phase II	155,000
MTFWP – Blackfoot Clearwater elk project	220,300
MTFWP – Bat Roost Survey	10,440
MTFWP – HD Bear	25,164
MTFWP – Grizzly Bear Social Survey	21,652
MTFWP – FWP invert sampling & mapping	300,033
MTFWP – Migratory songbirds – grazing	408,535
MTFWP - Montana Wolf Monitoring	274,003
MTFWP – Statewide mule deer study	241,537
MTFWP – Sage grouse & grazing study FY19-20	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
Panthera – Preventing Predation	152,876
State of Colorado – Colorado moose ecology	39,532

USDI – Grizzly IPM		25,000
USDI - Linking Exposure to Sub-Lethal Stressors to Vital Rates		129,997
USDI – Reliability of Management recommend		33,694
USDI – Linking Exposure to Sub-Lethal Stressors		92,299
US FWS – Structuring Governance		60,500
US FWS – Beaver dam analogs		49,537
WDFG - Moose Demography		195,500
	Subtotal	**$3,140,034**
	Total Budget	**$6,111,752**

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
February 2020	Allison Keever	Montana Fish Wildlife and Parks	Montana wolf monitoring study
February 2020	Sarah Sells	Montana Fish Wildlife and Parks	Montana wolf monitoring study
June 2020	Kenneth Loonam	IDFG	Cougars – Population Dynamics and Modeling
June 2020	Collin Peterson	Montana Fish Wildlife and Parks	Statewide mule deer study
June 2020	Teagan Hayes	Montana Fish Wildlife and Parks	Statewide mule deer study
June 2020	Kari Eneas	Confederated Salish and Kootenai Tribes	Reducing grizzly depredation of small livestock

MTCWRU – Federal and State Vehicles

Description	Tag number	Odometer as of 5/28/2020
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	57,602
2011 Ford F250 Crew Cab Pickup, 4 x 4	FED 433610	68,000
2012 Dodge 1500 Crew Cab, 4 x 4	FED 433621	57,556
2017 Ford F150 Crew Cab Pickup, 4 x 4	FED 434302	3,245
2019 Ford F250 Crew Cab Pickup, 4 x 4	FED 434679	96
2005 Ford Explorer, 4 x 4	UM 3787	159,751

BIRDS

Photo by Elise Zarri

Photo by Elise Zarri

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

Student: **Timothy R. Forrester**

Degree: PhD Student

Advisor: Tom 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 at different life-cycle phases (e.g., breeding vs. nonbreeding) and the behavioral strategies that result in these differences 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 songbirds that occur in two contrasting tropical sites (humid aseasonal vs. dry seasonal). 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. Next, I am describing interspecific variation in seasonal fecundity and other aspects of parental reproductive care to test a historic hypothesis and a novel alternative to explain why species vary in seasonal reproductive effort. Lastly, I am examining the influences of abiotic conditions and evolved life histories on interspecific variation in the pace and persistence of reproductive attempts. The core methods for all work involves capturing diverse tropical songbirds, fitting them with radio-transmitters, and tracking them for entire breeding seasons to describe time-energy budgets through behavioral observations and quantify reproductive effort by finding repeated nesting attempts. Ultimately, robust estimates of neglected aspects of species' energy expenditure from intensive field studies are critically needed to improve our understanding of how selective pressures influence life histories, estimate species' vulnerability to climate perturbations, and to identify mechanisms which regulate population demography in diverse habitats.

Progress and status

In the 2019-2020 academic year, I completed my dissertation proposal, presented it at the Ecology & Evolution noon seminar, and defended it to my committee at my second committee meeting. In addition, I submitted a fellowship proposal to the National Defense Science & Engineering Graduate Fellowship program. I also submitted proposals for research funding to the American Museum of Natural History Frank M. Chapman Memorial Fund and the American Ornithology Society Student Research Award Program. I also submitted a first-authored manuscript to *The Condor: Ornithological Applications* and I am a co-author on another manuscript that has been submitted to *Ecography*, both of which are currently in review. I also received a Drollinger-Dial travel award to travel to the North American Ornithological Conference in Puerto Rico in August of 2020.

In 2019, I completed my first field season of PhD research at Kinabalu National Park, Malaysian Borneo. I used radio-telemetry to track individuals of 6 diverse passerine species (White-throated Fantail, Snowy-browed Flycatcher, Gray-throated Babbler, Bornean Whistler, White-browed Shortwing, Eyebrowed Jungle-Flycatcher). My initial data reveal that species vary in seasonal fecundity and renesting persistence within our Malaysia site, but that seasonal fecundity may be lower than currently thought for rainforest species. I will soon return to Malaysia for a second field season, where I will continue collecting data on nesting attempts and time-energy budgets. I will compare this to data that I will collect in dry forest of costal Ecuador in 2021-2022.

Understanding thermal constraints on reproductive effort

Student: **Holly R. Jackson**

Degree: MS Student

Advisor: Tom 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

Understanding causes of variation in reproductive effort is a major goal of life history theory. Endothermic organisms that provide parental care during offspring growth and development expend considerable amounts of energy on reproductive effort, which can generate significant amounts of excess metabolic heat. Heat accumulation above a certain body temperature threshold can have deleterious physiological effects on the parental organism and may prevent further work until the heat has been dissipated. Whether or not temperature is consistently limiting across species, which differ in life history strategy and thus work output per breeding attempt, or regions where ambient conditions vary, has not been experimentally tested in wild populations, and presents itself as a significant gap in our understanding on how temperature may constrain reproductive effort.

My research will examine how improving heat dissipation capabilities, by means of a feather clipping experiment, will alter reproductive effort across species that vary in life history strategy and climatic region. I will assess the effects that my clipping treatment has on parental body temperature upon arrival to the nest, reflective of heat generated during provisioning and foraging activities, provisioning rates, and consequences for offspring growth rates. 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 increasing important to understand how temperature may limit reproductive effort, and if certain populations or species are more predisposed to temperature impingements on rearing young.

Progress and status

I defended my MS research proposal in January and am about to begin my first field season at Kinabalu National Park in Malaysian Borneo. There I will focus on five common species that span a range of life history strategies and phylogenies, to examine if heat differentially constrains reproductive effort across species. Our mid-elevation (~1500-1900m) tropical montane forest site is quite cool (avg. 18°C) and wet (avg. 2788mm rain/yr). I plan to contrast data gathered from Malaysia with data collected from Dr. Martin's new study site in Machalilla National Park, Ecuador, during my second field season in spring 2021. I will perform identical experimental manipulations on five common species in Ecuador, where the climate is substantially different. Temperatures are quite hot during the day (28-33°C) and rainfall is limited (4-256mm/yr). Comparisons of reproductive effort and consequences for offspring growth in response to the clipping experiment will improve our understanding of whether temperature is a consistent or variable constraint on reproductive effort across species and regions.

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

Principal Investigator: **Thomas E. Martin**

Project Duration: 2019-2024

UM Affiliation: Montana Cooperative Wildlife Research Unit

Graduate Students: Elise Zarri, Holly Jackson

Collaborators: Anna Noson, University of Montana Bird Ecology Lab

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 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.

Collaborative projects by government and private groups are underway to remove encroaching conifers from up to 10,000 acres of mountain big sagebrush habitat on state and federally-owned lands. 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, 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.

Results

The first field season of this project was conducted from May-August of 2019. Twelve plots were established reflecting the conifer removal treatments. Four plots were established in sagebrush habitat with conifer removal completed and four matched control plots were established in Phase 1 and 2 habitat (sagebrush with scattered conifers). The final four plots were placed in Phase 3 conifer forest (dense forest with no remaining sagebrush). Two of the Phase 3 plots were placed in areas planned to have conifers removed in the future and two plots were controls with no conifer removal planned. Treatment and control plots were paired to match elevation, aspect and slope between them as closely as possible. Plots average 65 ha in size and the total area monitored was 775 ha.

In the first field season, 234 nests of 24 species were found, the most common being Chipping Sparrow, Brewer's Sparrow, White-crowned Sparrow, Vesper Sparrow, and Dark-eyed Junco. The sample size is lower than hoped, but a couple of key factors contributed to this number in the first year of the project, which will likely be alleviated in future years. First, since this was the first year of the project, the project supervisor and all technicians required some extra time to learn the species at the field site and how best to find their nests. In future years, the project supervisor will be more effective and efficient at training technicians and numbers of nests found will increase. Additionally, the weather in the summer of 2019 was colder and wetter than typical, which may have contributed to lower numbers of nesting birds and a later start to the breeding season. Ideally, future years will have more typical weather and longer breeding seasons, increasing nest numbers.

Due to difficulty finding nests in Phase 3 plots and the limited implementation of phase 3 removal of conifers in sagebrush systems, we have decided to drop this portion of the project to focus more effort on the conifer removal vs non-removal treatments. In future years, we will add two more conifer removal plots and two more non-removal plots to increase sample sizes.

Initial results of nest success show similar rates of nest success between conifer removal and non-removal treatments both when all passerines are combined and when the four most common species are considered separately. Since sample sizes are low and the first year was an odd weather year, we suspect these patterns may change over the coming years.

Numbers of Brewer's Sparrow (a sagebrush obligate species) nests found were substantially more abundant in conifer removal than non-removal plots, demonstrating a clear preference for conifer removal plots. Territory mapping also demonstrated that Brewer's Sparrows as well as Vesper Sparrows were much more abundant in conifer removal than non-removal plots. White-crowned Sparrows, Chipping Sparrows and Dark-eyed Juncos were significantly more abundant in non-removal plots and results for the remaining species, Green-tailed Towhee, Sage Thrasher, and Western Meadowlark were inconclusive. Similar to nest success, these patterns may change as we collect more data over the coming years.

The graduate student (Elise Zarri) leading the project switched from a M.S. to a PhD. This switch will allow us to answer more detailed questions, such as understanding how habitat quality changes with conifer removal and incorporating a broad-scale spatial analysis for sagebrush songbird populations across southwestern Montana. Additionally, retaining continuity in leadership at the field site over the duration of the project will be beneficial for allowing the project to run smoothly and keep methods the same from year to year. Finally, this longer study will allow us to understand how bird abundance and reproductive success change over four years of post-conifer removal, resulting in a more detailed and nuanced understanding of the effects of conifer removal.

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

Principal Investigator: **Thomas E. Martin**

Project Duration: 2019-2024

UM Affiliation: Montana Cooperative Wildlife Researc

Collaborators: Anna Noson, University of Montana Bird Ecology Lab
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.

Results

Thirty collared adult female sage-grouse made it through the 2018-2019 winter season. These 30 birds, along with an additional 30 captured and collared in the spring of 2019, made up the sample during the 2019 field season. Throughout the sage-grouse breeding season in 2019, 43 nests were located and monitored to determine fate. Of these, 19 were successful, and 24 were unsuccessful. Nearly all 24 unsuccessful nests were due to predation events during the incubation phase (1 nest was disturbed by an investigator and 1 nest was abandoned after ~50-days of

incubation). There were 6 re-nesting attempts included in the 43 original nests, with 2 of the re-nesting attempts successfully hatching. Chicks captured included 65 individuals from 11 of the 19 successful nests. Only 9 chicks (from 3 separate broods) survived to 30-days old. Vegetation and insect surveys were conducted at 44 brood sites and an additional 44 random sites based around the brood site locations.

During late-nesting season, 100 cameras were set-up throughout the fence modification (perch-deterrents and bottom wire removal) area in the sandhills of the Centennial Valley. In 2019, an additional 11.2 miles of fence was modified to bring the standing total to 46 miles. Each camera monitored one point along a modified/unmodified fence for three weeks. Cameras were split equally by fence type (50 along a modified and 50 along an unmodified fence). Camera-trap surveys were intending to observe potential ground predators (main targets of badgers and coyotes) of sage-grouse nests. Roughly 200,000 photos were captured from this method and 69 coyotes and 111 badgers were identified in the images. Modified fences acquired 80 ground predator observations versus 100 made along the unmodified fences. Aerial predators were also monitored throughout the fence modification area using a point count method. Total counts made were 306 during the late-nesting and early brood-rearing seasons. From these 306 surveys, 50 aerial predators were observed. Away from fence observations totaled 25. Those observations made along fences contained 4 along modified fences and 21 along unmodified fences.

Predation and climate influences on tropical songbird demography in mid-elevation rainforest

Principal Investigator: **Thomas E. Martin**

Project Duration: 2013-2020 (final year)

UM Affiliation: Montana Cooperative Wildlife Research Unit

Graduate Students: Adam Mitchell, Sarah Straughan, 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 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.

Demographic adaptations to recurring drought and heat in tropical dry-habitat songbirds

Principal Investigator: **Thomas E. Martin**

Project Duration: 2020 - 2027

UM Affiliation: Montana Cooperative Wildlife Research Unit

Graduate Students: Timothy Forrester, Holly Jackson

Funding Sources: Under development

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.

Results

I conducted an initial pilot season with a limited crew, but including local indigenous Ecuadorians. The habitat is very thick. We helped the Ecuadorians cut fifty 1km trails for seeking nests and for banding birds. We completed an initial round of netting and banding birds to establish a basis for examining adult survival over time. We also located and monitored >200 nests. Data are currently in process. My impressions were that this is a very hot environment for birds (and humans!) as I commonly observed birds gular fluttering to cool during the day. Thus, it is likely a stressful environment for survival, but data are needed to ascertain the true costs.

Effects of rainfall on nestling bird energetics

Student: **Adam E. Mitchell**

Degree: PhD Candidate

Advisor: Tom Martin

Project Duration: 2014 – 2020

UM Affiliation: Wildlife Biology Program
Montana Cooperative Wildlife Research Unit

Funding Sources:

- Montana Cooperative Wildlife Research Unit
- National Science Foundation (NSF)
- Wesley M. Dixon Graduate Fellowship

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 in revision at 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 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.

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. I am in the process of analyzing these data to write up for peer-reviewed publication.

Progress and status

I am currently finished with all data collection and my first chapter is currently in the revision stage of peer-reviewed publication. I am now focused on analyzing, writing, and formatting the remaining chapters of my dissertation for peer-reviewed publication and defense of my PhD in the fall of 2020.

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—Ecology and Evolution

Advisor: Tom 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

Dissertation Abstract

Predation is a ubiquitous ecological force that plays a major role in the evolution of phenotypes. Where the predation risk is predictable and variable, prey species are expected to evolve plasticity in traits that reduce the likelihood of being killed and eaten by predators. Such plasticity may be especially critical for the survival of dependent offspring because they are particularly vulnerable to predators and suffer high levels of predation across taxa. Yet the fitness effects of predator-induced plasticity can vary across life stages, differ between parents and offspring, or be mediated by interactions with other species in the community. The importance of each of these factors for mediating the fitness consequences of predator-induced plasticity in natural systems is poorly understood. In this dissertation, I explore these issues using experiments and observational data in a suite of songbird species.

In chapter 1, I examine how plastic responses to increased nest predation risk influence offspring morphology, flight performance and survival after they depart the nest as fledglings. When nest predation risk was elevated, young departed the nest with shorter, but more fully feathered wings. Ultimately, plastic responses to increased nest predation risk did not reduce flight performance or survival of young after they departed the nest.

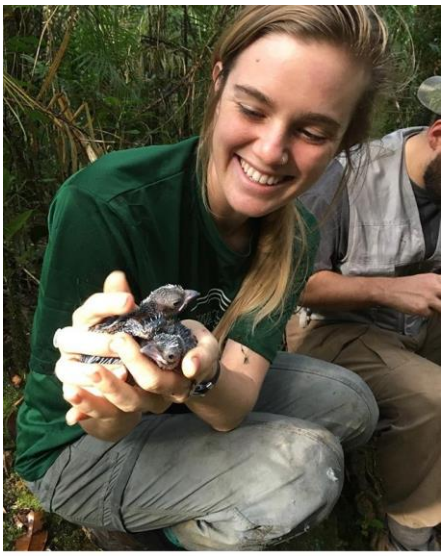
In chapter 2, I test whether parental responses to increased nest predation risk better reflect strategies to mitigate predation risk for offspring or enhance parental fitness at a cost to current offspring. I show evidence that variation in parental responses to increased nest predation risk across species better reflects adjustments in parental effort that maximize parental but not necessarily offspring fitness.

In chapter 3, I explore how species interactions vary with nest predation risk and examine the consequences for offspring survival. I show that in years with higher nest predation risk, cavity nesting birds nested together in individual trees more often and experienced greater offspring survival compared to nests in trees with only one nest.

In chapters 4-5, I examine the potential for parent-offspring communication to influence parental responses to nest predation risk. In songbirds, offspring use conspicuous, loud begging displays to solicit feeding from parents. Consequently, offspring may be able to shape parental responses to nest predation risk to favor offspring over parental fitness. Yet parental responsiveness to begging varies among species and increased offspring begging may exacerbate nest predation risk by helping predators locate nests. In chapter 4, I explore the evolutionary drivers of parental responsiveness to begging by comparing parental responsiveness across species with diverse life history and ecological traits. Parents were more responsive to offspring begging in species with smaller nestlings at greater risk of starvation on average. However, I found less evidence that annual adult survival or nest predation rates drive parental responsiveness to begging. In chapter 5, I examine whether variation in nest structure across species mediates how offspring begging affect nest predation risk. Increased offspring begging cues were associated with higher nest

predation rates in enclosed nests (with constructed walls and a roof) but had little impact on nest predation rates in open cup nests. Together, these two studies suggest that offspring may be able to influence parental responses to offspring predation risk in some species and set the stage for more in depth studies of this phenomenon.

Understanding variation in juvenile body temperature during 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 – 2020

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 measure offspring cooling rates and daily fluctuation in body temperature across five species of tropical songbirds in order to quantify variation in heat loss and its potential costs. 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 have completed my data collection over the course of two field seasons in Kinabalu National Park in the state of Sabah, Malaysia. 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. In my second season, I monitored offspring temperature over the length of the day to determine the impacts of parental brooding behavior on juvenile heat loss and body temperature. Since returning from my final field season I have analyzed my data and am currently working to complete my written thesis and prepare for my defense in summer 2020.

Impacts of conifer removal on sagebrush songbirds

Student: **Elise Zarri**

Degree: PhD Student

Advisor: Tom 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 Sparrow and Sage Thrasher 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 switched from a MS to a PhD in the fall of 2019 after defending a MS proposal and completing my first field season. I will defend a dissertation proposal in April and begin my second field season in May. This work is being 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 am comparing plots where conifers have been removed to control plots where scattered conifers are still present in sagebrush. 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.

MAMMALS

Photo by James Goerz

Photo by Linz Strickland

Influence of Small Livestock on Habitat Selection of Grizzly Bears

Student: **Kari Eneas**

Degree: MS—Wildlife Biology

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 Ground
- University of Montana – Wildlife Biology Program

Thesis Abstract

Balancing protection between livestock and carnivores has been a long-standing challenge in conservation. When encounters between carnivores and livestock or humans result in conflict or livestock depredation, the safety of both wildlife and humans are at risk. Reducing livestock depredation by grizzly bears (*Ursus arctos horribilis*) will be important as populations continue to recover and expand beyond public lands in the Northern Continental Divide Ecosystem. We used GPS locations from 8 female grizzly bears spanning 5 years in the Mission Valley, Montana, to evaluate the effect of livestock on habitat selection of grizzly bears. The Mission Valley is located on the Flathead Indian Reservation where grizzly bears have been historically revered, however modern cultural diversity complicates current management. We found a positive relationship in habitat selection for streams by grizzly bears but no relationship with wetlands. We found that bears avoided livestock, and that livestock did not have an effect on selection of streams or densities of homes or roads. The presence of livestock did have an effect on selection of wetlands by grizzly bears. Whereas electric fencing has been frequently used to protect bee apiaries from depredation by bears in North America, they have only recently been used to protect crops and livestock against grizzly bears. Maps based on our results can be used to identify how and where electric fencing efforts could be focused to reduce livestock depredation. We identified 20 sites with small livestock that had electrified fencing and 72 sites that were unfenced in 2018. We monitored 12 electric fences surrounding small livestock and recorded the presence and behaviors of grizzly bears in the Mission Valley during 2018 – 2019. No depredations occurred when livestock were inside a properly functioning electric fence, suggesting that electric fences were highly effective at reducing livestock depredations by grizzly bears. Though different attitudes about grizzly bears exist on the Flathead Indian Reservation, proactive and non-lethal actions can be implemented by residents to minimize future conflicts between livestock and grizzly bears. Securing small livestock, agricultural crops and livestock feed inside of an electric fence can prevent conflict in the Mission Valley.

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

Student: **James Goerz**

Degree: MS 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—Wildlife Biology

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

Thesis Abstract

Across much of North America, moose populations (Alces alces) are declining as a result of disease, predation, climate, and anthropogenic pressures. Despite this, populations of moose in Colorado have continued to grow well into the 21st century. Studying successful (i.e. persistent or growing) populations of moose can facilitate the continued conservation of the species by identifying habitat features critical for moose persistence.

First, I evaluate calving success of moose in Colorado and the impact of willow habitat quality and nutrition. I estimated the probability of female moose having a calf using repeated observations in a Bayesian occupancy model. I assigned values for willow covariates based on overlapping sample locations with estimated individual moose homeranges and tested the effect on calf presence. Willow height had the strongest predictive effect on calf presence and was the only covariate with credible intervals not overlapping zero. Dry matter digestibility had no effect, while browse intensity and leaf length were uninformative. Results presented here suggest that the quality (i.e. age and structure) of willow habitat are of high importance to femalemoose with calves. This work sets the stage for future research on the structure of willow habitat and the incorporation of additional remotely-sensed data.

Second, I use a resource selection function to evaluate selection by moose in Colorado and the effect of large-scale bark beetle disturbance. Bark beetles have widely impacted forests across North America, decreasing canopy cover and increasing solar radiation reaching the forest floor. These disturbances lead to an increase in ground forage but have been hypothesized to have a negative impact on thermally sensitive species such as moose. I evaluated resource selection at two scales: a large population scale and finer movement-based scale. The strongest selection by moose was for distance to willow, followed by elevation. Selection for beetle-disturbed habitat was mixed across populations and scales showing little overall effect. Undisturbed forest had moderately strong positive selection at both scales. The lack of selection for beetle disturbed habitat suggests mixed impacts, illustrating the importance of maintaining undisturbed forest habitat for moose.

Linking management for mule deer and plant communities: effects of wildfire, prescribed fire, and timber harvest in Montana's northern forests

Student: **Teagan Hayes**

Degree: MS– 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

Thesis Abstract

Mule deer (*Odocoileus hemionus*) are frequently the focus of population and habitat management in the western United States. Land and wildlife managers use disturbance to reset forests to earlier successional stages and improve the quality and quantity of forage available to mule deer. However, the effects of management practices on nutrition and selection vary widely, so the implementation of management practices raises ecological as well as management-related concerns. This work investigated how disturbance from wildfire, prescribed fire, and timber harvest influences the spatial and temporal distribution of nutritional resources in mule deer summer range, and therefore, how the nutritional landscape influences mule deer selection of disturbance. We studied changes in vegetation and habitat selection by mule deer in three areas with differing disturbance regimes during 2017-2019. We found differences in forage biomass response to disturbance that was specific to forest types, suggesting that targeted forest management within forest types would provide nutritional benefits to mule deer populations in the northern Rocky Mountains. Other vegetative responses revealed trade-offs specific to forest and disturbance types. Despite substantial variation in selection among individuals and among study areas, we found some common effects of forage quality, forest type, and disturbance type on selection at population scales. As we predicted, deer selection within home ranges was not explained well within these constraints, suggesting that deer selection may be influenced more by other factors, such as security or cover within home ranges. The age and type of disturbance also influence selection at a population scale, but do not predict selection within home ranges, where the availability of disturbances is irregular. In all study areas, we documented similar selection for more recent disturbance and avoidance of open woodland at the population scale, suggesting that these responses can be generalized to deer in other populations in the Rocky Mountains because we observed them in multiple sites under widely differing conditions. Managers accounting for local and regional frequency and availability of disturbance can identify management actions that are accessible and beneficial for mule deer. Furthermore, consideration of the likely outcomes of forest-specific vegetative responses can help managers balance potential tradeoffs of management alternatives.

Adaptive harvest management and estimation of recruitment for wolves in Montana

Student: **Allison Keever**

Degree: PhD—Wildlife Biology

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

Dissertation Abstract

Regulated public harvest became an important management tool following recovery of gray wolves (*Canis lupus*) in the U.S. Northern Rocky Mountains. Decisions on harvest regulations, however, can be contentious due to conflicting stakeholder values, uncertainties in the effects of harvest on wolves, and difficulty in monitoring wolves. We addressed challenges associated with wolf management by 1) developing methods to estimate recruitment, 2) evaluating the role of hierarchical demography in wolf population dynamics, 3) developing competing population models to address uncertainty, and 4) developing an adaptive management framework to identify harvest regulations that best meet objectives for wolf management. In Chapter 1, we developed integrated population models (IPM) with and without social structure to evaluate the role of hierarchical demography in population dynamics of wolves. We tested and compared the IPMs on simulated populations with known demographic rates. In Chapter 2, we used the IPM with hierarchical demography to estimate recruitment and population dynamics in wolves when productivity data were lacking. In Chapter 3 we developed a mechanistic model to predict recruitment based on empirical data from Idaho and then tested the model in Montana. In Chapter 4, we tested competing hypotheses of wolf population dynamics using population models and Bayesian model weight updating to compare predicted to observed abundance. Finally, in Chapter 5, we used stochastic dynamic programming and passive adaptive learning to find optimal season lengths and bag limits for wolf management in Montana. This framework accounted for uncertainty and included biological and societal objectives. We found that accounting for hierarchical demography improved estimation of demographic rates and population dynamics of wolves. Although regulated public harvest has appeared to decrease recruitment of pups and survival of adults and yearlings, the population remained relatively stationary or only slightly declined. Using passive adaptive management, we found support for the hypothesis that net immigration into Montana was positive. Additionally, we found the optimal harvest strategy became more liberal as the wolf population grew. Following the optimal harvest strategy, we found that the wolf population was maintained around 650 wolves, which suggests that maintaining the population at this size best meets objectives.

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
- Cobell Fellowship
- University of Montana

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 coordinating with the Blackfeet Tribe, Blackfeet Fish and Wildlife, and the Wildlife Conservation Society to develop a study.

Estimating cougar abundance with remote camera surveys

Student: **Kenneth Loonam**

Degree: MS—Wildlife Biology

Advisors: Hugh Robinson, Mike Mitchell

Project Duration: 2017-2019

UM Affiliation: Wildlife Biology Program
Montana Cooperative Wildlife Research Unit

Funding Sources:

- Idaho Department of Fish and Game

Thesis Abstract

Abundance estimates can inform management policies and are used to address a variety of wildlife research questions, but reliable estimates of abundance can be difficult and expensive to obtain. For low-density, difficult to detect species, such as cougars (*Puma concolor*), the costs and intensive field effort required to estimate abundance can make working at broad spatial and temporal scales impractical. Remote cameras have proven effective in detecting these species, but the widely applied methods of estimating abundance from remote cameras rely on some portion of the population being marked or uniquely identifiable, limiting their utility to populations with naturally occurring marks and populations that have been collared or tagged. Methods to estimate the abundance of unmarked populations with remote cameras have been proposed, but none have been widely adopted due, in part, to difficulties meeting the model assumptions. I examined the resilience of one model for estimating abundance of unmarked populations, the time-to-event model, to violating assumptions using walk simulations. I also tested the resilience of the time-to-event model to the low sample sizes of species that live at low densities by applying it alongside genetic spatial capture recapture on two populations of cougars in Idaho, USA. The time-to-event model is robust to many potential violations of assumptions but biased by incorrectly estimating movement speed and non-random sampling. The time-to-event model can effectively estimate the density of species living at low density and was more precise than and as reliable as genetic spatial capture recapture. Camera based abundance estimates that do not require individual identification, such as the time-to-event model, solve many of the challenges of monitoring low-density, difficult to detect species and make broad scale, multi-species monitoring more feasible.

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

Student: **Peter Mumford**

Degree: MS Student

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 mountain region in west-central, MT, is the trend of elk increasingly inhabiting private land. This is potentially problematic for private land owners due to elk depredation of fences and feed, to hunters who have limited hunting access on private land, and wildlife managers trying to employ hunters as a wildlife management tool. To better understand elk population dynamics and spatial patterns in the northern Sapphires, the North Sapphire Elk Research Project (NSERP) was conducted from 2014 to 2016. Phase two of the project (NSERP2) was initiated in 2019 in response to large scale changes to National Forest road access, land ownership, and elk hunting regulations made after the conclusion of the NSERP to study the impacts of those changes on the elk population.

I have three main objectives. First, assess the effects of changes in travel management and land ownership on the previously documented elk migratory behaviors and spatial patterns during hunting seasons. Second, examine male and female responses to changes in travel management and hunting access regulations during the fall hunting seasons. Third, elucidate ecological factors affecting specifically male elk spatial ecology. Results from the study will ideally provide wildlife managers in western MT and other areas insight regarding the impacts that significant changes to travel management, land ownership, and hunter access can have on elk spatial ecology.

Progress & Status

I am in my first semester. Currently, I am focusing on coursework, foundational reading regarding elk biology and ecology, spatial ecology and modeling, and general research design. I have met with key collaborators to establish working expectations and clarify project roles. As my first chapter is already set, I am working toward research questions that will guide my second chapter for my M.S. Additionally, I am in the process of gathering my master's committee.

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

Student: **Collin Peterson**

Degree: MS—Wildlife Biology

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

Thesis Abstract

Ungulate migration has traditionally been thought of as a strategy that increases access to forage quality or security from predators, but the benefits of migration may be waning globally. In partially migratory populations, the persistence of both migrant and resident strategies is an intriguing ecological phenomenon, for the long-term fitness consequences of each strategy must be balanced. Partial migration is common in mule deer (*Odocoileus hemionus*), a species that has experienced widespread declines across the western United States during recent decades. Mule deer seldom switch between migratory strategies throughout their lifetime, which may make them less resilient to environmental change than more behaviorally plastic ungulate species. To indicate the mechanisms maintaining partial migration, we investigated how security from predators, forage quality, and selection for these resources varied between migrant and resident mule deer. First, we developed resource selection functions (RSFs) for wolves and mountain lions to estimate predation risk. Then, we modeled forage quality throughout mule deer summer ranges and compared how the availability of forage and security varied between migrants and resident summer ranges. We then compared forage quality (kcal/m2) and predation risk in migrant and resident summer ranges of 3 partially migratory populations across Western Montana. Overall, residents had access to higher forage quality than migrants, but security did not differ predictably between the two groups. We used RSFs to assess how home range (2nd order) and within-home range (3rd order) selection varied between migrants and residents. At the 2nd order, both migrants and residents were indifferent to forage and wolf predation risk, but selected for security from mountain lions. At the 3rd order, both migrants and residents selected for forage and security from wolves and mountain lions. These results suggest that the benefits of a resident strategy outweighed those of a migrant strategy. Our findings are consistent with predictions that partial migration is maintained by either density-dependent competition or changes in the relative benefits of migration over time. Mule deer behavior was consistent across different ecosystem types and migratory strategies, suggesting a general mechanism for summer habitat selection may exist for mule deer in forested environments of the Northern Rockies.

Mechanisms Driving Territorial and Social Behavior in a Cooperative Carnivore

Student: **Sarah Sells**

Degree: PhD– 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

Dissertation Abstract

Territoriality is a fundamental and conspicuous behavior of numerous species, including many carnivores. Although relatively uncommon, carnivore sociality is likewise a conspicuous behavior where it occurs. Territorial and social behavior are of theoretical, empirical, and conservation interest because these behaviors can strongly shape demographic processes. Natural selection has likely shaped animals to make decisions that maximize benefits and minimize costs, but the mechanisms driving territory selection and social decisions remain uncertain. Our goals were to increase understanding of these mechanisms. We furthermore sought to develop reliable methods to predict outcomes of territorial and social behaviors, absent costly monitoring efforts. Gray wolves (Canis lupus) provided a case study for developing and applying mechanistic and predictive models for territory selection and group size.

Chapter 1 presents a mechanistic model for the economics of territory selection. Through simulations, we developed numerous predictions for what may be observed empirically if animals select territories economically based on the benefits of food resources and costs of competition, travel, and predation risk. A literature search demonstrated that the model's predictions matched empirical observations for many species.

Chapter 2 tests the mechanistic territory model's predictions on wolves. We analyzed territory sizes of wolf packs in Montana using wolf location data. As predicted, territory size varied inversely with prey abundance, number of nearby competitors, and group size.

Chapter 3 presents further application and tests of the mechanistic territory model. After parameterization with limited, readily-available data, the model produced spatially-explicit predictions for territory location, size, and overlap for the Montana wolf population. It reliably predicted wolf distribution and the territory sizes and locations for specific packs, without using empirical data for wolves.

Chapter 4 presents a predictive model for group size. We demonstrated that wolf pack sizes in Montana were positively related to the local abundance of prey and density of packs, and negatively related to terrain ruggedness, local mortalities, and intensity of harvest management. A predictive model for pack sizes reliably estimated the annual wolf pack sizes observed and illuminated possible underlying mechanisms influencing variation in pack sizes over space and time.

Advancing Montana's Wolf Conservation and Management Program

Postdoctoral Assoc: **Dr. Sarah Sells**

Advisor: Mike Mitchell

Project Duration: 2020

UM Affiliation: Wildlife Biology Program
Montana Cooperative Wildlife Research Unit

Funding Sources:

- Montana Fish, Wildlife and Parks

Objectives

I am working closely with FWP to advance Montana's Wolf Conservation and Management Program by transitioning the concepts and content of the two UM Wolf Project dissertations (Sells 2019 and Keever 2020) into practical application for FWP.

Abundance estimates are a key component of Montana's Wolf Conservation and Management Program. Accordingly, the first objective of this work is to finalize methodology to estimate wolf abundance. Since 2007, an approach known as the Patch Occupancy Model (POM) has been used to estimate annual wolf abundance. Earlier research developed an occupancy model that uses hunter surveys to estimate area occupied. To date, POM has relied on dividing this area occupied by a mean territory size to estimate the number of packs. The number of wolves is then estimated by multiplying the number of packs by an annual average observed pack size. This approach relied on intensive field monitoring for pack size, and assumed territory size was consistent over space and time. In reality, both parameters vary spatiotemporally, and accounting for this variation is key to reliably estimating wolf abundance at statewide and regional scales. Sells 2019 developed new models for producing biologically-based estimates for territory and pack size. For this postdoctoral work, I am finalizing the integration of these models into Montana's POM framework. Importantly, the "improved POM" methodology will enable predicting pack and wolf abundances into the future, at any spatial scales and using limited data.

The second objective of this postdoctoral research is to finalize a wolf management decision support tool for FWP based on the work completed by Keever 2020. I am working closely with UM Wolf Project collaborators as well as Dr. Mike Runge (Patuxent Wildlife Research Center, USGS) to develop a final decision tool that will enable FWP to make management decisions for wolves. These decisions will be aimed at producing optimal outcomes based on a range of competing management objectives.

Additionally, I am writing a status report of the effects of harvest on wolves in Montana. This work will also provide a final report to FWP for the UM Wolf Project, and a recommended monitoring framework for wolves.

Progress & Status

As of May 2020, I have nearly finalized the improved POM methods. Four related manuscripts are in review or revision. I am working with collaborators on completing the remaining objectives.

NEW AND POTENTIAL PROJECTS

Mike Mitchell:

Modeling Habitat for bison on the Blackfeet Indian Reservation

The Wildlife Biology program at UM has been working to develop stronger ties with Tribal Nations in the state and recruit more native students into the graduate program. Where possible, we seek to match students to research needs of their respective tribes. This project presents a unique opportunity to understand potential distribution and abundance of reintroduced bison on based on habitat quality on the Blackfeet Reservation. This will work will be of strong ecological and spiritual importance to the Blackfeet Tribe, and will be conducted in cooperation with the Blackfeet Fish and Wildlife Agency and the Innii Initiative of the Wildlife Conservation Society.

Developing Partnerships Between Private Landowners and the Public in Idaho

Interest in hiring students with nontraditional Masters degrees has grown among state and federal agencies. Such students would have broader expertise in working as part of a public agency because their degree will focus on relevant coursework instead of biological research. The student will be responsible for developing a management plan in close coordination with the agency; this plan will be used by the agency to make management decisions.

On this project, the student will work closely with IDFG leadership to conduct focus groups stakeholders invested in management of public and private lands in Idaho. The student will quantitatively assess results from the focus groups and synthesize management recommendations in a report and presentations to IDFG. At the successful completion of the project, the student will be awarded a non-thesis Masters.

Tom Martin: none.

AWARDS AND RECOGNITIONS

Eneas, Kari
Alfred P. Sloan Foundation
Vital Ground Foundation

Tim Forrester
Drollinger-Dial Foundation

Kittson, Brandon
Alfred P. Sloan Foundation
American Indian Graduate Center
Cobell Fellowship

Mitchell, Adam
Wesley M. Dixon Fellowship, UM

Mouton, James
Toelle-Bekken Family Fund
Drollinger-Dial Foundation
Bertha Morton Scholarship, UM

Sells, Sarah
Exemplary Contributions to the Wildlife Biology Program Award, UM
Bertha Morton Scholarship, UM
George and Mildred Cirica Scholarship, UM

Zarri, Elise
Montana Audubon
Non-game Fellowship, MT Fish, Wildlife and Parks

SCIENTIFIC PAPERS AND REPORTS

Ausband, D. E., S. B. Bassing, and **M. S. Mitchell**. In press. Environmental and social factors influencing wolf (*Canis lupus*) howling behavior. Ethology.

Barker, K. J., M. S. Mitchell, and K. Proffitt. 2019. Native forage mediates influence of irrigated agriculture on migratory behavior of elk. Journal of Animal Ecology DOI: 10.1111/1365-2656.12991.

Bassing , S. B., D. E. Ausband, **M. S. Mitchell**, M. K. Schwartz, J. J. Nowak, G. Hale, and L. P. Waits. In press. Immigration does not offset harvest mortality in groups of a cooperatively breeding carnivore. Animal Conservation.

Boyce, A. J., and **T. E. Martin**. 2019. Interspecific aggression among parapatric and sympatric songbirds on a tropical elevational gradient. Behavioral Ecology 30: 541-547.

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.

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 drive global variation in pace of life in songbirds. Ecology Letters 23: 642-652.

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.

Callan, L. M., 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.

Fierro-Calderón, K. and **T. E. Martin**. 2020. Does habitat change over 28 years affect habitat use and nest survival? Auk 137: https://doi.org/10.1093/auk/ukz061.

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.

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.

Merkle, J. A., N. J. Anderson, D. L. Baxley, M. Chopp, L. C. Gigliotti, J. A. Gude, T. M. Harms, H. E. Johnson, E. H. Merrill, **M. S. Mitchell**, T. W. Wong, G. P. Nelson, A. S. Norton, M. J. Sheriff, E. Tomasik, and K. R. VanBeek. 2019. A collaborative approach to bridging the gap between wildlife managers and researchers. Journal of Wildlife Management 83:1644–1651; DOI: 10.1002/jwmg.21759

Mitchell, A. E., J. Boersma, A. Anthony, K. Kitayama, and **T. E. Martin**. In press. Harsh montane weather causes slow post-natal development in a high elevation tropical songbird. American Naturalist.

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.

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.

Slevin, M., E. E. Bin Soudi, and **T. E. Martin**. In press. Breeding biology of Mountain Wren-Babbler (*Gypsophila crassus*). Wilson Journal of Ornithology.

Unzeta, M., **T. E. Martin**, and D. Sol. In press. Nest predation costs and parental defense related to body size among songbird species of the world. American Naturalist.