2020/21

Alberta Conservation Association

ACA Grants in Biodiversity
Biennial Report

Photo: Erin Low radio-tracking a little brown bat in Waterton Lakes National Park

Project: Effects of Forest Fire on Bat Communities in Southwestern Alberta

ACA Grants in Biodiversity

Message From the Chairman

Hello!

Conserving the rich natural landscape of Alberta is a journey of discovery. Such discovery builds on scientific and traditional knowledge of the past and develops with new discovery and new demands on our natural ecosystems.

Alberta Conservation Association (ACA) recognizes the importance of such knowledge and discovery, and supports it through the Grants in Biodiversity Program. This program has supported hundreds of graduate student researchers over the last 25 years and continues on this path today.

This publication is our way of sharing some of the excellent research being supported by ACA across the province. In the following pages you will learn of new and interesting research in the province, including intensive grazing of grasslands, ecosystem function in agricultural lands, bird communities finding refuge in the Cypress Hills, mating tactics of mule deer does, the impact of honeybees on native bee species, and earthworm invasion!

There are multiple people and groups that make this program possible. On behalf of ACA, I would like to thank Syncrude for their ongoing financial commitment to this program; the numerous scientific reviewers and adjudicators who are integral to the functioning and professionalism of this program; and the adjudication committee. Specifically, I would like to thank outgoing adjudicators Dr. David Goldblum (University of Calgary), Dr. Kimberley Mathot (University of Alberta), Dr. David Logue (University of Lethbridge), and Lori Neufeld (industry representative, Imperial Oil). Finally, I would like to thank Tracy Stewart for her many hours of work administering this program and compiling this biennial report.

As we emerge from the challenges posed by the COVID-19 pandemic, I trust this information will be a welcome respite and source of positive encouragement for the future.

Respectfully,

John K. Pattison-Williams, Ph.D., P.Ag.
Chair of ACA Research/Biodiversity Grants Adjudication Committee

John K. Pattison
Chair of ACA Research/Biodiversity Grants Adjudication Committee

Tracy Stewart
ACA Grants Coordinator

The ACA Grants in Biodiversity Program is sponsored by:

Syncrude

Photo: Benjamin Larue taking a break from bighorn sheep behavioral observations on Ram Mountain

Project: Causes and Consequences of Individual Heterogeneity in Bighorn Sheep

ACA Grants in Biodiversity

Program Overview

Funded by the province's anglers, hunters, and other conservationists, in partnership with Syncrude, the ACA Grants in Biodiversity Program for graduate students ultimately aims to conserve, protect, and enhance Alberta's fish, wildlife, and natural habitats.

The program provides two-year grants of up to $20,000 to master's and Ph.D. students to fund projects researching the flora, fauna, or habitats of Alberta. While most recipients are from Alberta universities, the program is open internationally to any student, from any university, whose subject of study is in Alberta.

Program Goals

The ACA Grants in Biodiversity Program supports graduate student projects to:

- Increase knowledge of Alberta's living resources, notably flora, fauna, and habitats.
- Attract excellent graduate students and their supervisors to conduct their research in Alberta.
- Promote the development of highly qualified, Alberta-based conservation biologists and managers.
- Support ACA's mission to promote conservation of Alberta's resources.

ACA's Vision

An Alberta with an abundance and diversity of wildlife, fish and their habitats; where future generations continue to use, enjoy, and value our rich outdoor heritage.

ACA's Mission

ACA conserves, protects, and enhances fish and wildlife populations and their habitats for Albertans to enjoy, value, and use.

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For more details on the ACA Grants in Biodiversity Program, applications, deadlines, and sponsors please visit:

Biodiversity Grants:
www.acabiodiversity.ca

Alberta Conservation Association:
www.ab-conservation.com

Unless otherwise noted, all photos have been provided by and are credited to the grant recipient.

Cover Photos (left to right from top):
Melissa Dergousoff; Sydney H. Worthy; Colby Whelan; Maria A. Dobbin; Melanie Mullin

ACA Grants in Biodiversity

Final Reports

(Funded in 2018/19)

Photo: Maddie Trottier searching for GPS/VHF-collared elk using radio telemetry

Project: Elk Behaviour on Sympatric Winter Ranges: Does Migratory Tactic Influence Interactions?

Assessing Stream Ecosystem Function Across an Agricultural Gradient

Emily Barrie
University of Alberta (M.Sc.)
Dr. Suzanne Tank, Supervisor
Dr. Rolf Vinebrooke, Supervisor

Stream ecosystem functioning provides an integrated metric of biological structures and processes that can respond to changes in agricultural land cover such as removal of riparian areas and nutrient enrichment. Agricultural land cover is common in the Boreal Transition, Parkland and Grassland ecoregions of Alberta, where streams are exposed to a range of land use intensities and levels of nutrient concentrations. Two key indicators of ecosystem function that respond to agriculture are stream metabolism and organic matter decomposition, which incorporate carbon cycling and community structure. The objectives of my study were to (i) describe direct and indirect drivers of stream metabolism including local stream characteristics and watershed level variation, and (ii) examine how microbial and invertebrate decomposition rates and detrital quality respond to increased concentrations of stream water nutrients. I studied 34 streams along a gradient of nutrients over three years in spring, summer and fall where I measured metabolism using diurnal oxygen concentrations and decomposition with leaf litterbags. Stream metabolism was driven primarily by water temperature and did not appear to be strongly influenced by nutrients, but was indirectly influenced by land cover. Contrary to metabolism, decomposition was directly influenced by increasing concentrations of nitrogen, which enhanced microbial activity and increased leaf litter quality. This research showcases the diverse impacts of land cover on stream function and the importance of nutrient criteria and watershed management to preserve ecological integrity.

Photo (top): Example of a coarse litterbag containing read canary grass as a substrate to measure organic matter decomposition.

Photo (bottom): Pine Creek, a stream studied in the Boreal region of Alberta, flowing through an agricultural area.

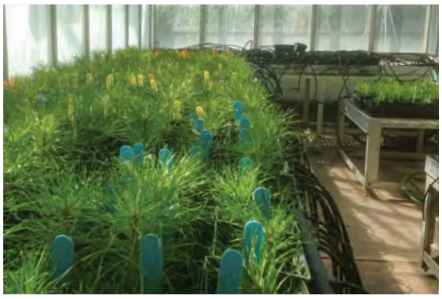
Impact of Disturbance Altered Soil Fungal Communities on Pine Regeneration

Jackson L. Beck
University of Alberta (M.Sc.)
Dr. Nadir Erbilgin, Supervisor

Disturbances are frequent events across the Canadian boreal forest and can affect both below and above ground ecosystem processes. How disturbances change belowground soil fungal communities and in turn affect pine establishment and performance is poorly understood. I used a greenhouse experiment to determine how soil inoculum collected from lodgepole pine stands undisturbed or disturbed by fire, mountain pine beetle outbreak, logging, and salvage logging affect pine seedling performance in western Canada. I first characterized whether fungal communities of seedling roots change as a function of inoculum source, and then determined whether changes in fungal community composition impact pine seedling performance. Root fungal communities of pine seedlings from logged and salvage logged disturbances differed from their respective paired controls, while soils from fire and beetle outbreak did not. Among disturbances, the pine root fungal communities of fire and salvage logged disturbances differed. In parallel to the root fungal communities, seedling performance also decreased when comparing logging and salvage logging disturbances to paired controls. Among disturbance treatments, seedlings from the salvage logged disturbance did not grow as big as seedlings inoculated with soils from burned forests. These findings indicate that logging and salvage logging can have impacts on pine seedling performance, through shifts in seedling root fungal community structure. Furthermore, the impacts of soil fungi on pine seedlings appear to be pronounced following salvage logging, stressing the importance of compound disturbance events. These findings may be of importance to land managers considering clear-cut logging or salvage logging in pine forests.

Photo (left): Lodgepole pine stand disturbed by Mountain pine beetle near Hinton, AB.

Photo (right): Lodgepole pine seedlings growing in the greenhouse at the University of Alberta.



Effects of Habitat Features on Long-toed Salamanders

Charity Blaney
University of Calgary (M.Sc.)
Dr. Steven Vamosi, Supervisor

Amphibian populations are experiencing worldwide declines, occurring at higher rates than for any other taxa. Long-toed salamanders *Ambystoma macrodactylum*, have been listed as a species of special concern in Alberta since 1999 when they were considered not at risk. I investigated the effects of potential habitat threats on long toed salamander populations by comparing historical with present day populations in 13 breeding ponds in Southwestern Alberta and assessing indicators of habitat quality as possible population predictors. My central goals were to: (1) determine if historical populations in the study area remain and update their presence/absence status, (2) identify variation between populations and habitat variables to observe relationships between the two, and (3), discover evidence for metapopulations as possible vectors for species persistence. I observed a 23% decrease in populations of the survey area over the past two decades. Increased water turbidity had a significantly negative effect on long toed salamander population abundances in breeding ponds, while the presence of other amphibians was a strong predictor of increased population abundance. Metapopulations appeared to be an important factor in the survival of long toed salamanders. This study helps to fill a gap in provincial population data for this species, and points to some variables that should be considered vital habitat characteristics, information that can be used to direct conservation policy and future research.

Photo: Charity and field assistant Heidi measuring body length of a long toed salamander larvae.

"Amphibian populations are experiencing worldwide declines, occurring at higher rates than for any other taxa"

Feral Horse Ecology in the Rocky Mountain Foothills

Paul N. Boyce
University of Saskatchewan (Ph.D.)
Dr. Philip D. McLoughlin, Supervisor

The feral horse population in the Rocky Mountain foothills of Alberta has grown in recent decades, potentially impacting native wildlife and rangeland health. Little is known about their population demographics or interactions with native species as the population has not been studied since 1978, and the relative diversity of native predators and prey in the foothills makes inference from other feral horse populations difficult. From 2017-2020, I deployed and maintained 128 trail cameras throughout the Sundre Equine Management Zone. Trail camera images allow me to assess broad patterns of species abundance and overlap, including predators and prey, throughout the foothills, and how these may relate to feral horse spatial distribution and density. Using natural markings of horses, I am also able to identify individual animals and follow them through time, building a record of encounters throughout the trail camera grid. Using capture-mark-recapture (CMR) analyses I will assess population characteristics such as age and sex structure, and reproduction and mortality rates which will directly information population models assessing current and future growth trends in the feral horse population.

Photo: Paul collecting data from a trail camera near the Ya Ha Tinda ranch.

Quantifying the Effects of Forestry Harvest Residuals on Bird Communities

Brendan G. Casey
University of Alberta (Ph.D.)
Dr Erin Bayne, Supervisor

Variation in the pattern and volume of harvest residuals provides opportunities to evaluate their impacts on bird communities. Forest Resource Inventories (FRIs) include useful harvest related disturbance metrics for most forest tenures across Canada, however, they poorly describe residual structures in recovering harvest blocks. Expanding covariates beyond the simple harvest severity classifications in most FRI to those derived directly from modern remote sensors, may reveal subtle relationships between the structure of harvest residuals and bird communities. Here, I used historical point count data, acoustics monitoring tools, LIDAR, and multispectral satellite imagery to explore the effects of harvest residuals on species richness. Objectives were: (1) Quantify the influence of harvesting on birds along a gradient of recovery, (2) examine the post-harvest structural conditions that drive community response, and (3) compare the predictive power of common sources of spatial covariates. I surveyed bird communities using autonomous recording units in harvest blocks across northern Alberta and gathered supplemental acoustic and point count data from the Boreal Avian Modeling Project and the Alberta Biodiversity Monitoring Institute LiDAR and Landsat normalized burn ratio (NBR) were used to characterize the vertical structure and spectral recovery of harvest blocks. I used generalized linear mixed models to evaluate the power of spatial covariates to predict community responses to harvesting, and the QPAD approach to accommodate the effects of differential detection error between sampling methods.

Photo: Brendan installing an autonomous recording unit in a regenerating harvest block.

Effects of Landscape on Montane Bumble Bees

Danielle J. Clake
University of Calgary (Ph.D.)
Dr. Paul Galpern, Supervisor
Dr. Sean Rogers, Supervisor

The ranges of many bumble bee species are changing globally, including shifts to higher elevation habitats. This can have consequences for populations of these pollinators, especially in mountain habitats where the varied landscapes can make populations particularly susceptible to changes. My research uses genetic methods to understand how bumble bee populations are able to move between and use mountain habitats. I set out to determine whether populations of montane bumble bees tend to specialize in either high or low elevation habitats, or whether they are able to take advantage of multiple habitats due to the close geographic proximity of different habitat types. If bumble bees are elevation specialists it could cause additional challenges when populations shift in range. To answer my question, I sampled bumble bees at 40 different sites throughout the Rocky Mountains at a variety of elevations and habitat types. I have extracted DNA from two bumble bee species found in the Alberta Rocky Mountains. I estimated genetic differences between populations from different locations and used these to estimate the likelihood that individuals were dispersing between sites. I found that populations may have been separated more by the divide between mountain and foothill habitats than by elevation itself. My future research will use models to evaluate specific landscape conditions that encourage or hinder bee dispersal. Understanding how bees move between locations, and how they utilize habitats at varying elevations will be important in evaluating their ability to respond to predicted habitat and range changes.

Photo (left): A bumble bee foraging on a mountain flower in the Alberta Rockies

Photo (right): Danielle setting up a blue vane trap to collect bumble bees

Phytoplankton Communities as Indicators of Water Quality in a Changing Climate

Jenna L. Cook
University of Alberta (M.Sc.)
Dr. Rolf Vinebrooke, Supervisor

Mountain lakes are viewed as sensitive indicators of climate change and atmospheric pollutants because they are often situated in protected areas, removed from direct human disturbance. Phytoplankton are among the first responders to environmental change because of their small sizes and fast growth rates. To determine the best suite of environmental predictors of mid-summer phytoplankton communities along an elevational gradient, I sampled 82 lakes within the Canadian Rockies in 2017 and 2018. I collected chemical and environmental data from each site, and I analyzed phytoplankton pigments to quantify the phytoplankton community. I also chose a subset of 14 alpine lakes for nutrient enrichment experiments to investigate which key nutrient, nitrogen or phosphorus, would stimulate algal growth in these chemically dilute systems. Phosphorus was identified as the key nutrient stimulating phytoplankton production in the nutrient experiments. For the 82-lake survey, statistical results revealed local features to be the most important drivers of phytoplankton community composition. Namely total phosphorus, light availability and maximum depth along with proportion of carbonate sedimentary bedrock, bare catchment and glacial coverage. These findings highlight the sensitivity of phytoplankton communities in the Canadian Rockies to the increased incidence of wildfires that fuel phosphorus deposition, and further changes involving melting glaciers which can reduce the light availability of glacially fed lakes due to the high content of glacial rock flour. The overall greater importance of local compared to regional climatic factors emphasizes a need for future research into the cumulative interactive impacts on phytoplankton communities in a changing climate.

Photo: Jenna paddling to the deepest point to sample a montane lake.

Beavers as Biomonitors of Trace Element Contamination in Northern Alberta

Melissa Dergousoff
University of Alberta (M.Sc.)
Dr. William Shotyk, Supervisor
Dr. Glynnis A. Hood, Supervisor

Development of the Athabasca Bituminous Sands in northern Alberta has led to concern about emissions of potentially toxic trace metals. Given the presence of these elements from natural sources, the challenge is to identify the degree to which wildlife are exposed to elements from anthropogenic activities. Alberta also provides ideal habitat for beavers, which are ideal bioindicators owing to their wide distribution, centralized foraging activities, well-known biology, and importance to local Indigenous communities. In collaboration with the Alberta Trappers Association, I collected tissue from 51 beavers from industrial and natural areas in northern and central Alberta. At the SWAMP Laboratory, an ultra-clean research facility at the University of Alberta, I tested for trace metal concentrations in kidney, liver, and muscle tissue from beavers in industrial areas, natural/control areas, and a subset of agricultural sites. Preliminary results suggest considerable variability in metal concentrations among the sites. For example, Cd was highest in livers and kidneys from industrial regions of central Alberta. However, willow, a staple forage species of beavers, also accumulates Cd, which might confound the results. Additionally, lead was higher in kidneys and livers of beavers from southern natural areas compared to northern natural areas, but there was no difference among industrial sites. Barium and yttrium were higher in kidneys and livers in northern industrial beavers, when compared to beavers from northern natural areas, but not to southern industrial sites. My findings reveal how a culturally and economically important semi-aquatic mammal acts as a bioindicator in anthropogenic and natural systems.

Photo: Melissa conducting trace metal analysis of beaver samples at the University of Alberta's SWAMP Laboratory.

"My findings reveal how a culturally and economically important semi-aquatic mammal acts as a bioindicator in anthropogenic and natural systems."

Influence of Wolf Predation on Wood Bison in the Alberta Oilsands Region

Lindsey T. Dewart
University of Alberta (M.Sc.)
Dr. Scott Nielsen, Supervisor
Dr. Mark Edwards, Supervisor

Prey selection by predators is a complex process, with acquisition strategies varying between generalists and specialists. Generalist predators with limited selectivity, like wolves, can temporarily specialize on a specific prey in response to increases in abundance or vulnerability. In multi-prey systems that include bison, wolves often select less dangerous prey. However, changes in environmental conditions can influence bison vulnerability and alter wolf prey selection. I evaluated temporal patterns of wolf predation on bison relative to other prey in northeast Alberta, Canada. Specifically, I used summer scat analysis and winter wolf location visits to examine the diets of wolf packs whose territories overlapped a small bison population. I found that wolf packs predominantly preyed on beaver in summer and cervids (deer and moose) in winter, which is consistent with other boreal systems. Although wolf winter diets consisted mainly of cervids, two packs began selecting for bison in late winter. I tested possible mechanisms of this trend and found wolf predation success on bison was driven in part by winter duration and snow depth. Further, I tested whether wolves modify their use of areas frequented by bison relative to the timing of bison vulnerability, and found that wolves increased their use of these areas during periods of heightened bison vulnerability. My findings suggest that bison predation risk is limited to conditions that make them vulnerable, and wolves can capitalize on the vulnerability of this profitable, but rarely obtainable, prey source.

Photo (top): Lindsey removing a GPS collar from a bison recently killed by wolves.

Photo (middle): Wolf at a recently killed bison carcass.

Photo (bottom): Lindsey finding part of a bison skull at a wolf kill site.

Analysis of Mule Deer Contacts and Transmission of Chronic Wasting Disease

Maria A. Dobbin
University of Alberta (M.Sc.)
Dr. Evelyn Merrill, Supervisor

Chronic wasting disease (CWD) is a fatal neurodegenerative disease that infects farmed and free ranging cervid populations throughout North America. Recent studies from Wyoming and Colorado now demonstrate population-level declines in deer related to CWD. Alberta is one of two Canadian provinces with CWD in wild cervids, with over 2000 cases (~85% in mule deer) in Alberta since its detection in 2005. CWD is transmissible by direct contact of infected individuals or by contact with pathogenic prions in the environment but little is known about primary routes of transmission. From 2017-2020, I captured and collared 135 (46 males, 89 females) with GPS/proximity collars. I used collar data to investigate the seasonal effects of grouping patterns and landscape heterogeneity on direct, pair-wise contacts within and between sex-specific (same or mixed sex) groups of mule deer *(Odocoileus hemionus)* in eastern Alberta. Further, I relate seasonal predictions of the spatial relative risk of contacts to the risk of deer being CWD-infected in an area based on hunter-harvest, CWD surveillance data. Preliminary results indicate contact rates varied by season and pair type with between group contacts being greater in summer whereas within-group were higher in winter. Compared to areas used in their overlapping home ranges, contacts were most likely to occur where there was woody cover, short distance to water, long distance to roads and high edge density and ruggedness. These results can be used to inform management harvest strategies that target individuals and landscapes that are most likely to transmit CWD.

Photo (left): Johanna listening for collared mule deer out on the Cresthill Grazing Lease.

Photo (right): Maria posing with a newly collared, adult female mule deer.

Impact of Sulfur Dioxide Emissions on Lodgepole Pine Growth in Alberta, Canada

Devon Earl
University of Calgary (M.Sc.)
Dr. Mary Reid, Supervisor
Dr. Ann-Lise Norman, Supervisor

It is important to understand the factors that affect tree growth to predict how the growth response of trees will be affected by changing climate. Emissions of sulfur dioxide (SO_2) are one such factor that may affect tree growth and alter the growth response of trees to climate. Sulfur dioxide may affect tree growth and climate-growth relationships directly by entering through stomata and altering photosynthetic rate, or indirectly by causing soil acidification. I used dendrochronological methods to assess how the growth and climate-growth relationships of lodgepole pine *(Pinus contorta)* changed with varying emissions intensity and distance from a source of emissions in Alberta, Canada. Tree growth response to key climate variables was stronger in a period of high SO_2 emissions compared to the periods of no emissions and reduced emissions, and farther from the source of emissions compared to near. Liming in stands near the source of emissions likely reduced the effects of SO_2 on tree growth and climate-growth relationships in one study area. The effects of certain key climate variables, such as previous late summer precipitation, were opposite of expected in the high emissions period near the source of emissions, indicating that under heavy acidic deposition, increased precipitation may lead to soil nutrient leaching. In one study area, tree growth near the source of emissions was more strongly negatively affected by 6-year and 10-year cumulative emissions than annual emissions, indicating that soil acidification may be a more important mechanism behind the effects of SO_2 on tree growth than direct effects.

Photo: Lodgepole pine tree core.

"It is important to understand the factors that affect tree growth to predict how the growth response of trees will be affected by changing climate."

Potential Climate Change Refugia for Boreal Bird Communities

Cesar A. Estevo
University of Alberta (Ph.D.)
Dr. Erin Bayne , Supervisor
Dr. Diana Stralberg, Supervisor

Climate change will pose dramatic changes to entire ecosystems around the globe, with rather grim consequences for Canada's natural heritage and landscapes. In Alberta, the greatest impact will likely occur in the boreal forest, wherein its southern limit is predicted to be pushed further north and converted to forests dominated by deciduous trees. Recent research indicates that local topography could promote resilience to global warming and, once mapped, be used for climate change adaptation strategies. These areas are referred to as refugia, wherein vegetation transitions due to climate change are delayed, allowing wildlife to persist amidst unfavorable conditions. I am particularly interested in understanding how refugia can benefit boreal birds. To identify potential refugia areas, I set off to survey birds and climate conditions in valleys and hills in the boreal plains of Alberta, wherein previous research suggests there is high refugia potential. One of such areas is Cypress Hills, a fantastic boreal-like island within the prairies of southern Alberta, and likely an analog of how boreal hills may look in the future. I am currently processing data from valleys, and my preliminary results from boreal hills indicate that slope orientation in hilly areas and roughness may play a role in decreasing temperatures. However, I found that only a few bird species seem to benefit from these cooler local climates. Additionally, I could only find some boreal birds in Cypress Hills, thus suggesting that climate change may lead future boreal hills to contain only a subset of boreal species.

Photo: Cesar and Maia deploying data loggers to collect local climate data in central Alberta.

"Recent research indicates that local topography could promote resilience to global warming and, once mapped, be used for climate change adaptation strategies."

Fire and Forest Recovery of Seismic Lines

Angelo T. Filicetti
University of Alberta (Ph.D.)
Dr. Scott E. Nielsen, Supervisor

Alberta's forests are highly fragmented by linear disturbances, particularly seismic lines, linear features (3–12 m wide) cleared of trees for the purpose of petroleum exploration. Many seismic lines have failed to recover trees 50 years after being originally cleared, often within the preferred habitat for threatened woodland caribou. The mechanized creation of seismic lines flattens and depresses the ground surface leading to failures in tree recruitment. These open corridors can then act as pathways for animal movement including predators to caribou. Actively restoring seismic lines is expensive (more than $12,000/km) and does not account for wildfires that can destroy planted trees, yet also initiate early seral conditions that favor long-term recovery. I investigated, across multiple studies, the restoration of seismic lines through tree recovery with mechanical site preparations and wildfires. Overall, mechanical site preparation successfully recruits trees in the short-term, yet wildfires pose a cost-effective long-term solution for most forest types with the exception of fens. I also relate limitations in restoration to changes in the ground surface, water table, and life history traits of boreal trees. I demonstrate that restoration of seismic lines may not inhibit animal use and in some conditions can promote lichens on seismic lines in some ecosites thus acting as a potential attractant for caribou. I suggest that passive restoration of seismic lines can be expected post-fire and therefore active restoration, through mechanical site preparations and tree planting, should be applied strategically to save limited restoration dollars.

Photo: Angelo laying out a transect line in a severely burnt jack pine forest.

Can Fungal Communities Restore Native Trees on Reclaimed Substrates Containing Hydrocarbons?

James B. C. Franklin
University of Alberta (Ph.D.)
Dr. Justine Karst, Supervisor
Dr. Pedro M. Antunes, Supervisor

Landscapes mined for bitumen must be reclaimed and revegetated to restore self-sustaining ecosystems in the boreal forest of western Canada. However, residual hydrocarbons can be present in reclaimed landforms, and to what extent this can negatively affect the establishment of native vegetation is unclear. In parts of this region, forests occur on natural surficial bitumen deposits and some vegetation persists on abandoned ore piles. As such, these locations represent unique opportunities to investigate the factors that enable plants to persist. Interactions between soil fungi and plant roots are increasingly recognized as an important factor in primary productivity but whether this enables trees to establish on reclaimed sites is unknown. To screen fungi potentially capable of promoting seedling growth on hydrocarbon-containing substrates, I first used DNA sequencing to compare soil fungal communities in natural forests with and without bitumen. Next, in a greenhouse experiment, I grew trembling aspen and jack pine, two native tree species commonly used in revegetation, in substrates used in reclamation campaigns either inoculated or not with field soils. I found that the fungal communities present in soil from reclaimed sites contained more pathogens and unknown taxa, and fewer ectomycorrhizal fungi compared with those present in naturally occurring soils with and without bitumen. In addition, in the greenhouse experiment, while hydrocarbons reduced the growth of aspen and pine, only pine responded positively to soil inoculum from bitumen-free forests. Conversely, inoculum from forests on natural bitumen deposits and abandoned ore piles had no effect on plant growth. My results show that soil inoculation may be an effective method to promote the establishment of pines on oil-sand reclaimed areas.

Photo: James and field technician Chloe collecting soil samples in a jack pine stand established on natural bituminous soils.

Widespread Infection of the Horsehair Lichen by a Previously Unknown Fungal Pathogen

Spencer James Goyette
University of Alberta (M.Sc.)
Dr. Toby Spribille, Supervisor

Horsehair Lichens *(Bryoria spp.)* are integral to conifer ecosystems across western North America where they support the existence of a wide range of other organisms, notably as a critical winter food source for populations of critically endangered woodland caribou. In areas where *Bryoria* is abundant, a non-negligible percentage of lichen thalli stick together and form brittle dead zones, or so-called "rat-tails". Until now, the underlying cause or causes for "rat-tails" have been unknown and this phenomenon has remained undocumented. I sampled *Bryoria* thalli across western Canada and the United States monitoring thallus dieback at different times of the year. I found that this dieback phenomenon is strongly associated with the aggressive winter growth of a mold-forming basidiomycete in the genus *Athelia*, a cosmopolitan genus containing economically significant crop pathogens, and that this species is previously not known to associate with *Bryoria* or other lichens in the same family. Based on phylogenetic affinity along with its distinct morphology, I believe this mold is a new species. Whether or not this widespread infection of *Bryoria* in western North America is a recent event or simply an overlooked phenomenon is difficult to determine with certainty. Most of my collections of this new *Athelia* and the rattailed *Bryoria* will be housed in the University of Alberta Cryptogam Herbarium. This research will serve as a benchmark for documenting the pathogenic outbreak affecting an ecologically significant lichen genus.

Photo: Horsehair Lichen (Bryoria sp.) *visibly infected with the undescribed species of mold* (Athelia sp. nov.) *is still attached to its host tree.*

Grassland Plant Species and Functional Diversity Response to Intensive Grazing

Jessica Grenke
University of Alberta (Ph.D.)
Dr. James F. Cahill Jr., Supervisor

Though ungulate grazing is the most spatially extensive land-use on earth, the response of plant communities to managed grazing is not well understood. By comparing plant diversity and species assemblage between paired intensively and less-intensively managed ranches across Western-Canada I am able to understand how land-management impacts plant communities in a way suitable for direct application to land-management and policy development. I compared diversity (alpha, gamma, beta, large scale homogenization), species composition, evenness, and proportion of introduced species between 18 intensively and less intensively managed ranch pairs across the northern great plains. Management systems, both statistically derived and self-identified, were equally as powerful in explaining plant community metrics as more traditionally used individual management factors and are worthy of ongoing scientific attention. However, the usefulness of management metrics within an ecological application context will depend on the aspect of plant community composition under review. My work demonstrates that plant community variability was better explained by precipitation while absolute measures of plant communities were equally well explained by precipitation and management factors.

Photo (top): Collecting plant diversity data from an actively grazed pasture.

Photo (bottom): Jessica measuring plant diversity and biomass at an aspen-parkland region ranch.

Individual Variation in the Energetics of Reproduction in Columbian Ground Squirrels

Adriana L. Guerrero-Chacón
University of Saskatchewan (Ph.D.)
Dr. Jeffrey Lane, Supervisor

Understanding the energy allocation strategies of wild organisms is relevant for understanding both its fitness (how are some individuals able to allocate more to survival and reproductive success) and population dynamics. In my research, I evaluated how the availability of food resources influence the energetics of reproduction in Columbian ground squirrels. To do this, I measured the body composition and minimum and maximum energy requirements of females during their reproductive season during the springs and summers of 2018-2019. Additionally, I increased the food resources for a group of adult females before hibernation during the summers of 2018-2019 and during their lactation period in 2019. My preliminary results suggest that reproductive success was influenced by the amount of on-body resources available before reproduction, and that fed females were able to increase the total weight of their litters by 10 to 280 g during the food addition year, compared to the control year. Overall, the information obtained from this project will be crucial not only to predict how Columbian ground squirrels may respond to anthropogenic shifts in energy availability but also to anticipate the responses of associated species (predators), such as badgers, red-tailed and ferruginous hawks and goshawks.

Photo (left): A female ground squirrel with its pup. Female ground squirrels can face challenges to meet the energy requirements needed for survival and reproduction. (Photo credit: Maria Alejandra Hurtado)

Photo (right): Columbian ground squirrel using a pet feeder. Pet feeders were used to provide with additional food resources to a sample of females and evaluate how the surplus food will influence their energy allocation strategies. (Photo credit: Maria Alejandra Hurtado)

Nutritional Carrying Capacity of the Ronald Lake Wood Bison Herd

Lee Joseph Hecker
University of Alberta (Ph.D.)
Dr. Scott E. Nielsen, Supervisor
Dr. Mark A. Edwards, Supervisor

Central to the successful management of any population of animals relies on an accurate measure of how many animals the landscape can support. Models of carrying capacity provide the means to make these estimations. For herbivores, carrying capacity can be measured as a function of quality and quantity of foraged plants. The overall goal of my research is to provide an accurate estimation of the nutritional carrying capacity for the Ronald Lake wood bison *(Bison bison athabascae)* herd in the Alberta oilsands. The herd is comprised of about 200 animals that are unaffected by diseases that plague other herds in the province. Additionally, the herd is genetically distinct as the wood bison subspecies. To estimate nutritional carrying capacity, I first need to understand what the herd's diet is composed of and how that changes throughout the year. Next, I go into the herd's home range and measure habitat characteristics to understand how the herd's habitat selection is related to their foraging preferences. Because the herd is located in the oilsands region, I put a particular focus on how disturbances generated from logging and oil exploration influence habitat selection. With this information I can generate nutritional carrying capacity models that reflect the dietary and habitat preferences exhibited by the Ronald Lake wood bison.

Photo (left): Wood bison (Bison bison athabascae) *calf.*

Photo (right): Lee dragging the field crew of a sandbar in the Athabasca River en route to the field sites.

Nutrient Limitation of Stream Algae in Alberta's Agricultural Regions

Sydney R. Huculak
University of Alberta (M.Sc.)
Dr. Rolf Vinebrooke, Supervisor
Dr. Suzanne Tank, Supervisor

Anthropogenic land-use, such as agricultural developments, can threaten stream health through intensified nutrient loading. Since algal growth can be limited by nitrogen (N), phosphorus (P), or co-limited by both (N+P), increases in the supply of these nutrients can stimulate algal production, leading to eutrophication. Identifying the limiting nutrients of algae is critical for understanding how nutrient loading may promote stream eutrophication. Nutrient limitation is poorly understood in streams within Alberta's agricultural regions and provincial nutrient management efforts focus primarily on controlling inputs of P, despite lack of empirical evidence that P is the primary limiting nutrient. I performed nutrient diffusing substrate (NDS) bioassays to experimentally identify the drivers of nutrient limitation (i.e., N, P, or N+P) and nutrient-driven shifts in algal community composition in small streams across the agricultural region of Alberta. NDSs were deployed in each of 30 streams, which were chosen to span three ecoregions, a gradient of land-use intensity, and ambient stream nutrient concentrations. I found that nitrogen, rather than phosphorus, was identified as the limiting nutrient driving algal growth. Yet, nutrient-driven shifts in algal community composition from diatoms to green algae occurred with P enrichment. I also found a lack of regional variation in nutrient limitation dynamics across ecoregions, suggesting that broad nutrient management efforts can be applied across Alberta's agricultural regions. Overall, a dual-nutrient management approach at controlling inputs of both N and P will likely be the most ecologically effective at averting eutrophication of streams within the agricultural regions of Alberta.

Photo: Sydney deploying nutrient diffusing substrate bioassays in a stream within the Grassland ecoregion of Alberta.

How do Small Owls Call in the Presence of Predation Threat?

Jeremiah Kennedy
University of Alberta (M.Sc.)
Dr. Erin Bayne, Supervisor

Very little is known about the impacts of avian top predators on the daily vocal behaviour of smaller avian mesopredators, especially in nocturnal systems. The little research that has focused on this topic has explored the degree to which the mesopredator will reduce singing in response to artificial predator cues, ignoring how this response may change with time of year, time of night and distance to predator. Here I use Autonomous Recording Units to track how the much smaller Boreal Owl varies acoustic behaviour in response to naturally occurring Great Horned Owl vocalizations and how these responses change across time of night and year. Preliminary analysis suggests that Boreal Owls begin singing later on nights when Great Horned Owls are active and sing slower when Great Horned Owls are vocalizing. The next steps are to investigate their spatial response to Great Horned Owl vocalizations. Understanding these behavioural changes will help us manage avian communities with invasive predators for which avoidance behaviour has not yet been evolved/learned. It will also inform on survey data interpretation where avian top predators and mesopredators overlap.

Photo: A small Aegolius *owl staying quiet in response to a predator.*

Causes and Consequences of Individual Heterogeneity in Bighorn Sheep

Benjamin Larue
Université de Sherbrooke (Ph.D.)
Dr. Marco Festa-Bianchet, Supervisor
Dr. Fanie Pelletier, Supervisor

Why do some animals grow quickly, other slowly? Why do some have lots of young, others die leaving no descendants? Understanding individual heterogeneity in life-history trajectories and the effect of this heterogeneity on population dynamics has recently become a central objective in animal ecology. Individual differences can have major implications in conservation and management. To better understand the causes and consequences of individual heterogeneity in morphological, behavioral, and life-history traits, I am analyzing long-term data on bighorn sheep and mountain goat growth, survival and reproductive success. My research has highlighted strong heterogeneity in growth patterns between reproductive and non-reproductive female sheep and goats. I found that because growth decreases in years when females reproduce, annual horn growth increments provide insights on reproductive history of young females and could be used to assist conservation and management. I also found strong correlations between resource acquisition behaviors in bighorn sheep and resource allocation to growth and reproduction. This later result indicates that individual differences in life-history traits could partially originate from differences in foraging behaviour. I am now investigating the causes and consequences of individual heterogeneity in long-term costs of reproduction and in intra-seasonal growth patterns. Altogether, my study will make major contributions to our fundamental knowledge in animal ecology, evolution, and demography. It will also have a strong impact on species management and conservation as it could change the way demographers understand the influence of individual heterogeneity on population vital rates.

Photo: Benjamin taking a break from bighorn sheep behavioral observations on Ram Mountain.

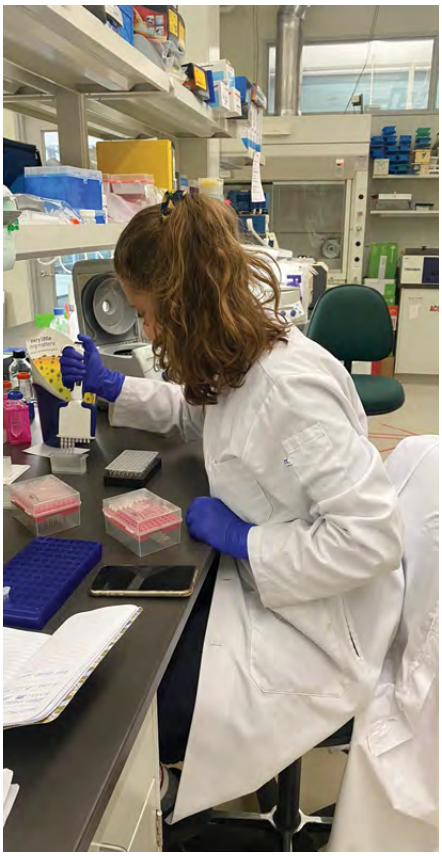
Earthworm Invasion in the Boreal Forest and Soil Carbon Dynamics

Justine Lejoly
University of Alberta (Ph.D.)
Dr. Sylvie Quideau, Supervisor

Exotic species of earthworms are invading the North American boreal forest, which had been developing in their absence since the last glaciation. Compared to temperate forests, earthworm invasion in boreal forests is more recent and remains understudied. By mixing of surface organic soil with mineral soil, earthworms can greatly affect organic matter decomposition, governed by microorganisms, and thus soil carbon storage. My study focuses on understanding the implications of earthworm invasion in northern Alberta for (1) soil carbon stocks, (2) soil carbon dynamics and (3) soil microbial communities. I sampled three forest sites with similar Luvisolic soils dominated by trembling aspen canopy and corresponding to different levels of earthworm invasion. My results show that 94% of the carbon found in the surface organic layer was lost at the most advanced stage of invasion. Although the total carbon did not change in the underlying mineral soil, the latter was reworked by earthworms and its structure drastically changed. Moreover, the carbon found in the mineral soil became more available for microbial decomposition in the presence of earthworms. The composition of microbial communities also changed, earthworms favouring fungi over bacteria. These observations suggest that the ongoing invasion of exotic earthworms in the boreal is putting in jeopardy the large carbon reservoir found in the boreal forest soils of northern Alberta.

Photo (left): Litter-dwelling earthworms found in the forest floor at Wolf Lake Provincial Recreation Area.

Photo (right): Justine cleaning bacterial and fungal DNA extracted from the soil, after amplification by PCR.



Effects of Forest Fire on Bat Communities in Southwestern Alberta

Erin B. Low
University of Calgary (M.Sc.)
Dr. Robert Barclay, Supervisor

Fire is arguably one of the most important natural disturbances shaping the landscape. However, it is unknown what the effects of rapidly changing fire regimes will be on forest biodiversity. Bats are diverse and play important roles in forest ecosystems. Past studies have suggested that most bat species respond positively to fires, as fires increase roosting and foraging opportunities. The Kenow Wildfire occurred in Waterton Lakes National Park in southwestern Alberta in September 2017. For my M.Sc. I am testing predictions regarding the effect of forest fire on bat communities by examining if fire alters species distribution and relative abundance, and if fire promotes roosting and foraging opportunities. From 2015 – 2020 bat acoustic surveys were conducted by Parks Canada staff, providing data from before and after the fire, as well as from burned and unburned sites. These data are still being analyzed. In 2019 and 2020 I radio-tracked little brown bats to their roosts. My results indicate that reproductive females show a strong preference for building roosts in the Waterton townsite and males are generalists, roosting in both burned and unburned trees as well as rock crevices. As the townsite was not burned, and males will roost in both burned and unburned areas, it suggests that roosting habitat has not become limited following the fire. Climate change is causing the size, duration, and severity of wildfires to increase globally. My findings can inform management decisions and provide a better understanding and preparedness for the effects of wildfires on bats.

Photo (left): A little brown bat being released with a radio-transmitter attached in Waterton Lakes National Park.

Photo: (right) Erin radio-tracking a little brown bat in Waterton Lakes National Park.

Gene Flow and Climate-Associated Genetic Variation in a Habitat Specialist Butterfly

Zachary G. MacDonald
University of Alberta (Ph.D.)
Dr. Scott Nielsen, Supervisor
Mr. John Acorn, Supervisor

Previous work in landscape genetics suggests that geographic isolation, measured as geographic distances accounting for barriers to dispersal, is more likely to affect species' genetic diversity than ecological isolation, measured as variation in environmental conditions. However, this has not been thoroughly examined for invertebrate habitat specialists with strong dispersal capability. In this study, I evaluate the effects of geographic and ecological isolation for a charismatic Albertan butterfly, Dod's Old World swallowtail. In southern Alberta, occurrences of these butterflies are generally restricted to eroding habitat along major river valleys where their larval host plant occurs. Despite considerable study, this species has not been observed between river valleys, suggesting they cannot disperse between them. I was curious whether their genetics told a different story.

My series of analyses indicate that divergence of thousands of genetic markers was better explained by Euclidean ('as-the-crow-flies') distance between individuals than by distances along river valleys. This suggests that, although observations of dispersal between river valleys are lacking, these butterflies are indeed capable of long-distance dispersal through unsuitable habitat. Genetic divergence was also strongly related to variation in summer temperatures—a unique finding in landscape genetics. I infer that local adaptation to environmental conditions has produced two distinct genetic clusters (north and south) that differ in their numbers of annual generations and diapause propensities. Within the next century, temperatures are predicted to rise by amounts greater than the current mean difference between the regions of the genetic clusters, potentially endangering the persistence of the northern cluster under continued climate change.

Note: Dr. Felix Sperling and Dr. Julian Dupuis were Zachary's project supervisors.

Photo (top): An adult Dod's Old World swallowtail butterfly sunning itself atop a river valley prominence in southern Alberta.

Photo (middle): Zac sneaks up on an unsuspecting swallowtail butterfly sunning itself on the eroding slopes of the Milk River in southern Alberta.

Photo (bottom): Zac and Felix in search of swallowtail butterflies along river valley edges near Drumheller, Alberta.

Assessing the Utility of Stable Isotopes as Biotracers to Estimate Diet in Sharp-tailed Grouse

Sejer D. Meyhoff
University of Lethbridge (M.Sc.)
Dr. Dan Johnson, Supervisor

Sharp-tailed grouse and other grassland birds rely on insects and spiders as a high-protein food source during the summer months. Changes to weather and climate, and the influence of agricultural pest management, have the potential to alter the timing and availability of this important food resource. I investigated the relationship between plains sharp-tailed grouse and their arthropod prey using stable isotopes as biotracers to estimate diet. The isotope signal of an animal's tissue reflects the food that it eats and can be used as chemical tracer to estimate diet proportions. I used hunter harvested grouse to analyse the isotope signals of primary feathers that were grown sequentially over the summer to assess their summer diet. I then compared the results to previous diets studies using esophageal crop contents. I found that the isotope signals from the feathers reflected a much higher consumption of insect prey, mostly grasshoppers, than found in crop studies. I believe the reason for this was that the nutrients gained from consuming insect prey, which are higher in protein than plant foods, are important for growing feathers. So even though the grouse were consuming mostly plant foods (shown from crop studies), the insects they consumed were providing grouse with the important nutrients needed to grow their feathers. Since I analysed feathers, and protein from insects was used to grow the feathers, the signal I got reflected insects more than plants. Compound specific stable isotope analysis, which is more expensive, would be needed to definitively prove this hypothesis.

Photo: A strip of feather material was sampled from each primary grouse feather in order to account for potential diet change as the feather was growing, and to establish an average isotope value for the diet during feather growth.

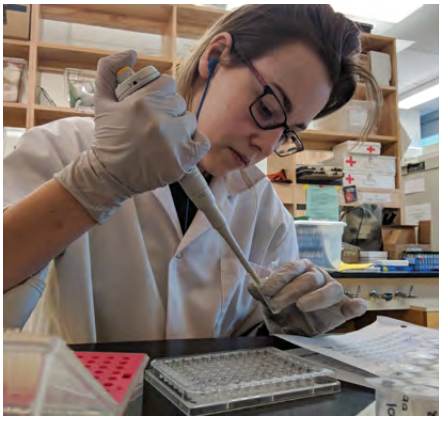
"I investigated the relationship between plains sharp-tailed grouse and their arthropod prey using stable isotopes as biotracers to estimate diet."

The Effect of Honey Bees on Alberta Native Bee Success

Ron Miksha
University of Calgary (M.Sc)
Dr. Lawrence Harder, Supervisor

Honey bees, *Apis mellifera,* are efficient non-native foragers owing to their large colonies and ability to communicate the location of floral resources. As introduced livestock, their densities are determined by human intentions, rather than ecological processes, and can impose diverse effects on the local flora and populations of flower-visiting insects. Concern has intensified with the ten-fold expansion of urban beekeeping in Calgary during the past ten years. To assess the impact of urban honey bees on native bees in Calgary, I mapped the distribution of honey-bee hives, measured density variation, and compared that with diversity of other pollinators and the reproductive success of solitary bees and bumble bees. The abundance of trapped native bees varied positively with honey-bee density, but negatively with the extent of landscape urbanization. The 1433 captured specimens comprised 44 bee species, including 13 bumble-bee species. At 73 urban citizen-scientist locations, nest establishment and reproductive success by bumble bees and solitary bees varied negatively with honey-bee density. Based on pollen from adjacent honey-bee and bumble-bee nests, honey bees largely foraged on different plant species than two common bumble bee species, *Bombus perplexus* and *B. rufocinctus,* during the peak foraging season of July and August. Specifically, nearly all pollen retrieved from honey-bee nests derived from non-native clovers and canola, likely from agricultural landscape adjacent to the city, whereas the bumble bees collected from urban wild and exotic flora. My observations indicate only weak resource competition by urban honey bees on native bees in Calgary.

Photo: Ron collecting pollen from honey bee colony.



Reaching New Heights: Chemical Signatures of Lodgepole Pine Trees Change With Elevation, But Not With Latitude

Melanie Mullin
University of Alberta (M.Sc.)
Dr. Nadir Erbilgin, Supervisor

Climate change has a high impact on plant functional and phenotypic traits including defences. One well-established approach to investigating the differences in plant defences involves studying different plant populations along elevation and latitude gradients. Despite frequent invasion of coniferous forests by insect herbivores, and the fact that host susceptibility to bark beetles is usually assessed via tree defenses few studies have evaluated conifer defences along geographical gradients. The primary defenses of lodgepole pine against bark beetles are the constitutive concentration of oleoresin terpenoids. Production of these defense chemicals relies in part on tree reserves, and non-structural carbohydrates (sum of total sugars and starch). Therefore, I investigated whether the concentration of monoterpenes, diterpene resin acids, and non-structural carbohydrates of lodgepole pine trees change as a function of elevation or latitude. I found that only elevation had a strong influence on the expression of both terpene defences and carbohydrates of trees. Specifically, as elevation increased, concentrations of monoterpenes and diterpene resin acids generally increased and concentrations of soluble sugars (glucose, sucrose, total sugars) decreased. In contrast, latitude had no impact on either of terpene or carbohydrate concentrations. I found no correlation between the higher concentrations of terpenes and lower concentration of soluble sugars. Overall, these results support that both biotic and abiotic factors likely drive the patterns of conifer chemical defences along geographical gradients. Also, absence of a relationship between defence chemicals and carbohydrate reserves suggests a nonlinear interaction between these two phenotypic traits.

Photos (left): Melanie checking the coordinates for a sample site in Jasper National Park, where some of the project fieldwork took place. Summer 2018.

Photo (top right): Melanie collecting an increment core from a lodgepole pine tree, in order to determine the tree's age and growth rate. Photo taken in Jasper National Park, where some of the project fieldwork took place. Summer 2018.

Photo (bottom right): Melanie preparing a sample for chemical analysis in the laboratory. Photo taken at the University of Alberta. Fall 2018.

"I found that only elevation had a strong influence on the expression of both terpene defences and carbohydrates of trees."

Tailoring Wildflowers for Wild Bee Restoration in the Prairies

Emily E. N. Purvis
University of Calgary (M.Sc.)
Dr. Paul Galpern, Supervisor

Global wild bee declines have been well documented in recent decades, with a regularly cited driver being habitat loss and the associated reduction of food and nesting resources. In North America's Prairie Pothole Region (PPR), habitat loss is largely attributed to agricultural intensification, resulting in the loss of once common native grasslands surrounding wetlands. Although restoration of these grassland-wetland complexes has been implemented across the region, wild bees are not often the primary target for recovery. Restoration efforts may better support wild bee recovery by including specific flowering plants (i.e. bee food resources) intended to provision the highest diversity of taxa. However, very little information is available specific to this region, which covers over 700,000 km^2 in Canada and the United States. I observed bee-plant interactions in remnant PPR grassland-wetland complexes and used a model-based approach to select top plants. I identified 16 key flowering plants that are highly visited by diverse wild bee species, as well as by *Bombus terricola* Kirby (the yellow-banded bumble bee), which is a species of conservation concern in this region. The key plants represented eight families and supported approximately 82% of all visits from 69 out of the 75 observed bee species. By reinstating targeted food resources in the PPR, or more broadly throughout the Great Plains, restoration practitioners can more efficiently mitigate the habitat loss that is thought to be a major driver of wild bee decline.

Photo: Emily walked the line (i.e. the transect) to sample bees feeding from wild flowers in grassland-wetland complexes.

Female Mating Tactics in Mule Deer

Cora Anne Romanow
University of Winnipeg (M.Sc.)
Dr. Susan Lingle, Supervisor

When picturing the breeding season of deer, we typically imagine large-antlered males intensely battling for access to receptive females. Consistent with this image, most research has focused on male mating tactics, even though several researchers have suggested that female deer play a more active role in courtship than the current dogma implies. During the breeding season, mule deer form tending bonds, with one estrous female engaged in courtship with a single male at a time. To investigate female tactics, I observed and recorded videos of courtship in mule deer living on an open grassland habitat in southern Alberta. These data are being used to test the hypotheses that (1) females use specific tactics to solicit attention from males; (2) females respond differently to different sizes of males; and (3) females drive the movement of tending pairs. This study will help fill a substantial gap in our knowledge of the mating strategies of mule deer. A more complete understanding of these mating systems that includes the role of female deer will allow managers to properly assess the effects of management strategies and hunting pressures placed on these species.

Photo (left): Mule deer courtship: A mule deer male courts a mule deer female at the McIntyre Ranch in Alberta.

Photo (right): Cora in the field getting covered in snow while trying to view slowly vanishing mule deer in a haze.

"A more complete understanding of these mating systems that includes the role of female deer will allow managers to properly assess the effects of management strategies and hunting pressures placed on these species."

Home-range and Habitat Use of Cougars in West-central Alberta

Corey A Smereka
University of Alberta (M.Sc.)
Dr. Andrew Derocher, Supervisor
Dr. Mark Edwards, Supervisor

The choices animals make such as what habitat to use or where to live are influenced by individual behavior and life history traits. For large solitary carnivores, such as cougars, prey, mates, and safe habitat to raise offspring are resources that influence space use and habitat selection. In Alberta, human-cougar conflict has increased since the mid 1990s and management actions need to be taken to reduce conflict with people while maintaining a viable population. Information on cougar space-use patterns and habitat selection should be considered before management actions are prescribed. I used GPS location data to 1) define space use patterns and 2) determine habitat selection by reproductive state and season for cougars in west-central Alberta, Canada. For my first objective, I found that cougar home ranges were dynamic, with space use changing over time for many individuals. Four space use patterns were identified: dispersers, residents, seasonal home range shifters, and individuals that shifted to a new area during the study period. For my second objective, I determined that cougars of all reproductive states used similar habitat types including close proximity to water, sloped terrain, forested habitats, and avoided roads, however there are some differences in habitat preference seasonally. The results of my research can assist in understanding the social structure of a population and whether cougar harvest levels need to be altered, and provide information on where higher-quality habitats occur seasonally for males, females, and females with kittens.

Photo: Corey looking at an abandoned cougar nursery site.

Vegetation Community Dynamics on Soil Islands in Oil Sands Reclamation

Kaitlyn E. Trepanier
University of Alberta (M.Sc.)
Dr. Brad Pinno, Supervisor

Oil sand mining is a large-scale disturbance on Alberta's landscape. One objective in reclamation is to create a self-sustaining ecosystem, which includes native vegetation. I investigated different mechanisms of plant establishment, including soil seed bank, seed rain, vegetative expansion, and competition, on a new reclamation design known as "Islands". This technique integrates islands of rich plant diversity forest floor mineral mix (FFMM) within a matrix of poor plant diversity peat mineral mix (PMM). The initial vegetation community had greater cover on the FFMM compared to PMM but was dominated by non-native forbs. Initial differences were linked to the seed bank, with 5x more seeds in the FFMM than the PMM. Over time, the vegetation community shifted towards native species and similar cover across soil types. This shift was due mainly to seed rain and biotic dispersal resulting in continuing plant establishment on both soil types. There is also some evidence of limited vegetative expansion out to 2 m of native forbs from FFMM into PMM. Finally, indirect competition is emerging with a decrease in non-native forbs over time associated with increasing total cover. Overall, it is clear that multiple factors are involved in structuring vegetation communities on reclamation sites and all of these should be considered when developing reclamation plans.

Photo (left): Brea completing a plant survey.

Photo (right): Kaitlyn taking soil volumetric water content readings.

Elk Behaviour on Sympatric Winter Ranges: Does Migratory Tactic Influence Interactions?

Madeline Trottier
University of Alberta (M.Sc.)
Dr. Evelyn Merrill, Supervisor

The Ya Ha Tinda elk herd *(Cervus canadensis)* is a partially-migratory population that winters on a sympatric range adjacent to Banff National Park in Alberta. Historically, the majority of elk migrated west into Banff National Park during the summer, with a small portion of the herd remaining on the ranch lands year-round. Over the past two decades, there has been a shift in the summer distribution of elk, with a decline in migrants and an increase in resident elk. Although migrants are exposed to higher forage quality in the summer, and thus return to the winter range in better condition than residents, small-scale behavioural trade-offs on the winter range may put residents at an advantage and play a role in the observed shift in migratory behaviour. Specifically, I looked at interaction and vigilance behaviour among elk on the winter range following different migratory tactics. From GPS collar location data and behavioural observations of individual female elk during the winters of 2019-2020, I compared home range overlap, interaction rates, and vigilance patterns among tactics. My results suggest that despite high overlap among all migratory tactics during the winter, differences in interaction rates and vigilance patterns may influence forage acquisition and exposure to predation risk on the winter range. Globally, ungulate migration is in decline, thus my study looking at small-scale trade-offs on a sympatric range contributes to our understanding of factors influencing shifts in migratory patterns in this partially-migratory elk herd.

Photo (top): Elk on the Ya Ha Tinda Ranch looking out across the grasslands in winter 2020.

Photo (bottom): Maddie searches for GPS/VHF-collared elk using radio telemetry as part of winter fieldwork studying elk behaviour on the Ya Ha Tinda grassland.

Assessing Algal Communities and Nutrient Uptake in Albertan Agricultural Streams

Nikki E. van Klaveren
University of Alberta (M.Sc.)
Dr. Suzanne Tank, Supervisor

Streams provide important ecosystem services, such as the transformation of organic matter and water purification, while transporting water from headwaters to larger receiving waterbodies downstream. Excess nutrients introduced through human land use can put stress on aquatic ecosystems and disrupts the ecosystem services we rely on. Current ecosystem health can be determined through structural and functional stream assessments to identify environmental criteria required to maintain ecosystem services. Algal communities occupy a key position in stream ecosystems through coupling the abiotic environment with food web and are therefore a strong candidate for structural assessment. Nutrient cycling is both a critical ecosystem service and a dynamic functional indicator of stream health as uptake saturation indicates the limit of the system to take up nutrients through biotic and abiotic processes. I explored both these structural and functional metrics along a nutrient concentration gradient created by 55 agriculturally-impacted streams to determine current stream health in the Grassland and Parkland ecoregions found in Alberta, Canada. Nitrogen was determined to be the limiting nutrient in this region, but no significant change was identified in either algal community structure or nutrient uptake along nutrient concentration gradients. Instead, algal communities appear to be resilient to the nutrient gradient sampled in this study, and continue to contribute to nutrient uptake even at the highest nutrient concentrations.

Photo (left): Nikki and Wiebe setting up the nutrient injection at Ray Creek.

Photo (right): Geared up to take water samples with a landscape view.

Correcting Survival Estimates to Account for Dispersal in Migratory Burrowing Owls

Morganne Wall
University of Alberta (M.Sc.)
Dr. Erin Bayne, Supervisor
Dr. Troy Wellicome, Supervisor

The migratory population of burrowing owl in Canada has undergone significant declines over the past three decades. Annual survival estimates are obtained using capture-mark-recapture data where survival is calculated according to banded individuals resighted each year within study areas; however, such survival estimates do not differentiate emigration from mortality and any individuals that disperse outside of the study area are considered dead. To better estimate survival I compiled historical and recent records of dispersal distances observed by wild burrowing owls across Alberta and Saskatchewan. I used these distances to simulate dispersal events at known nest burrow locations within historical study areas. The simulations showed how many individuals were likely dispersing outside of these areas resulting in low survival estimates. The estimates were then corrected to account for those missed owls and compared to estimates obtained when using dispersal data from owls fitted with satellite trackers. I found that while simulating these events using observed dispersal distance from the banded owls did increase the estimates, survival remained unrealistically low and were likely still confounding mortality with long-distance dispersals. I compared these estimates to those produced from another commonly used model known as the Cormack-Jolly-Seber ('CJS') model which provided higher survival estimates and included a method to account for dispersal in the CJS model. While survival estimates remained low when accounting for observed dispersal in both methods, the CJS method provided more likely estimates while accounting for dispersal. I concluded that a better understanding of long-distance dispersal is needed to use the simulation technique to correct for burrowing owl survival. In studies where dispersal is well understood, these methods could prove very informative and realistic estimates to wildlife managers.

Photo (left): Dr. Wellicome instructing Morganne how to view the nest burrow of a burrowing owl using an underground scope AKA "peeper" to determine if the owl nesting inside has a leg band on it from a previous year. Photo Credit: Ted Nanninga.

Photo (right): A photo of a breeding pair of burrowing owls. The male (right) was previously captured and marked using 2 leg bands. These bands allow us to track where the owl goes each year if recaptured. Photograph obtained using a trail camera set up near the burrow to determine the band status of the pair.

The Distribution of *T. tubifex* in Banff National Park as a Predictor of the Spread of Whirling Disease

Colby Whelan
University of Calgary (M.Sc.)
Dr. Leland Jackson, Supervisor

Banff National Park is a refuge to several populations of native westlope cutthroat trout and bull trout. Recently the parasite whirling disease was found in Banff. The parasite has caused trout population collapse in Colorado and Montana, and a worst-case scenario would be a similar result in Banff. The parasite requires the presence of an intermediate oligochaete host called *Tubifex tubifex* and the presence of *T. tubifex* is the best predictor of whether an area is susceptible to whirling disease invasion. The goal of my research was to determine whether occupancy modelling was an appropriate method to survey a water body for *T. tubifex*. I began with a study at Johnson Lake in Banff National Park and determined that *T. tubifex* were present. Furthermore, they seemed to prefer water shallower than 2m, and sediment low in inorganic carbon. I also surveyed two river systems in Banff National Park to determine the potential for whirling disease to spread into those systems. I found no *T. tubifex* in the Cascade watershed, which is positive news for an area considered core habitat for westslope cutthroat trout. I did find *T. tubifex* in low numbers in the lower Spray River below Canyon Dam. In a river environment, the *T. tubifex* were associated with slow slopes and distributed in the part of the river closest to the dam. Overall the results indicate that the spread of whirling disease into the Cascade is improbable without the presence of *T. tubifex*. In the Spray watershed *T. tubifex* will allow for whirling disease spread, but by studying the habits of this population, managers are able to refine future searches for *T. tubifex*.

Photo (top): Colby collects a kicknet sample by disturbing the sediment and allowing any invertebrates to be washed down into the net.

Photo (bottom): Colby collects data.

"Overall the results indicate that the spread of whirling disease into the Cascade is improbable without the presence of *T. tubifex*."

How Do Managed Pollinators Impact Native Plant-Pollinator Network Interactions?

Sydney H. Worthy
University of Alberta (M.Sc.)
Mr. John Acorn, Supervisor
Dr. Carol Frost, Supervisor

Evidence has suggested that honey bees may alter wild pollinator diversity and abundance, and the structure and function of plant-pollinator network interactions in a wild pollinator community. Therefore, honey bees may be of conservation concern for Alberta's native pollinator communities. For this reason, I examined the effects of honey bee abundance on native grassland pollinator communities by experimentally introducing honey bee hives to grassland prairie near Brooks, Alberta. I measured pollinator and flower abundance and diversity, and compiled flower visitor interactions into plant-pollinator networks, from which network metrics related to network stability, structure, and resource use overlap, were analyzed. Findings indicate that honey bees did not affect wild pollinator abundance or diversity. Honey bees impacted network structure by decreasing interaction evenness, and affected resource use overlap by increasing plant and pollinator functional complementarity. However, these network structural changes were due to the added honey bee-plant interactions, and not to honey bees causing changes in native pollinator interactions with plants. I demonstrated that honey bees may not negatively impact native plant-pollinator communities in all contexts, and that, despite influencing interaction network structure by visiting so many flower species themselves, honey bees may not affect the diversity of wild insect pollinators or their interactions with plants.

Photo (top): Sydney holding a male leafcutter bee.

Photo (bottom): Honey bee hives that were experimentally added to the research sites on the prairies.

Patterns of Non-native Plants Among Native Grasslands in Alberta, Canada

Zoey M. Zapisocki
University of Alberta (M.Sc.)
Dr. Viktoria Wagner, Supervisor

Non-native plant invasions are a prominent threat to the integrity of native grasslands. My research aim was to identify patterns of non-native plants among Alberta's native grasslands. I collected and analyzed species composition, environmental, and anthropogenic data from 86 plots across the Dry Mixedgrass, Central Parkland, and Peace River Parkland Natural Subregions of Alberta. Non-native plants were strongly associated with moisture and nutrient availability. Mesic grasslands on nutrient-rich soils had higher levels of invasion than dry grasslands on less fertile soils. Within the mesic grasslands, loamy soil and gentle slopes had higher levels of invasion than sandy soil and steep slopes, respectively. Kentucky bluegrass *(Poa pratensis)* was the most frequent and abundant non-native plant. Other common species include crested wheatgrass *(Agropyron cristatum)*, smooth brome *(Bromus inermis)*, dandelion *(Taraxacum officinale)* and goat's beard *(Tragopogon dubius)*. My results suggest that environmental conditions, agricultural history, and individual species adaptations may all explain patterns of non-native plants among Alberta grasslands. Future avenues of research include exploring soil fertility, topography, and soil texture effects. The patterns identified in this study could be beneficial for prioritizing conservation efforts on grassland landscapes.

Photo: Zoey recording plant species in a native grassland.

ACA Grants in Biodiversity

Progress Reports

(Funded in 2020)

Photo: A curious Columbian ground squirrel just before the start of the hibernation season

Project: Disentangling the Causes of Population Variation in Columbian Ground Squirrel Hibernation

The Effects of Artificial Light at Night on Habitat Use by Aerial Insectivores in Alberta

Carrie Ann Adams
University of Alberta (Ph.D.)
Erin Bayne, Supervisor

I am studying how light pollution impacts birds that eat flying insects, called aerial insectivores, which are experiencing population declines throughout North America. Fewer aerial insectivores in light polluted areas could indicate that artificial light is contributing to this decline.

Photo: An acoustic recording unit captures birdsong along a rural road in Southern Alberta where light pollution has increased in recent years.

Division of Labour among Trematode Populations in Alberta

Mónica Ayala-Díaz
University of Alberta (Ph.D.)
Clément Lagrue, Supervisor
Heather Proctor, Supervisor

Albertan trematode populations have been recently described and many of their ecological aspects remain unknown, despite the importance of parasites in food webs and their recent focus as conservation targets. I study trematode species parasitic in freshwater snails and aim to gather enough evidence to support the existence of a two caste system (i.e. reproductive and soldier castes), which so far, has only been described in marine environments. My project is the first one to explore division of labour and its potential effects in freshwater trematode communities as a whole.

Photo: Mónica holding a bag of freshwater snails after a successful field trip.

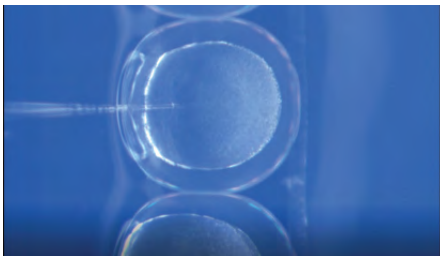
Aspen Clone Size and Gender Distribution in Alberta

Raiany Dias de Andrade Silva
University of Alberta (Ph.D.)
Barb Thomas, Supervisor

The results of my study will be important to help guiding decisions for future maintenance of aspen forests in face of the uncertain conditions resultant from climate change. Such information can be used on the improvement of policies for clonal deployment and associated regulatory standards for aspen, and for the general management of aspen forests by the government and industry.

Photo: Raiany collecting cambium samples from aspen trees for DNA analyses (clonal fingerprinting and sex screening).

The Toxicity of Polycyclic Aromatic Hydrocarbons in Model and Native Fish Species



Justin Dubiel
University of Lethbridge (M.Sc.)
Steve Wiseman, Supervisor

Polycyclic aromatic hydrocarbons (PAHs) are a chemical class of interest due to their widespread environmental presence and potential to cause toxicity in wildlife. However, there is limited data currently available for PAH toxicities, and what data is available primarily focuses on laboratory model species which may not be representative of the fishes inhabiting Alberta's waterways. This work aims to characterize the sensitivity of several fish species to PAHs and develop a predictive model of toxicity to aid in risk-assessment for species of interest in Alberta and elsewhere.

Photo: A zebrafish embryo being exposed to the PAH benz[a]anthracene through the process of embryo microinjection.

Survival Consequences of Sampling Strategies in Black-capped Chickadees *(Poecile atricapillus)*

Elène Haave Audet
University of Alberta (M.Sc.)
Kimberley Mathot, Supervisor

Little is known about how sampling potential resources affects survival in animal populations. Using chickadees as a model, my study is the first to investigate whether individual differences in sampling affect survival probability in a harsh environment, giving us a look at whether sampling behaviour is a trait that might mediate survival in a rapidly changing environment.

Photo: Elène extracting a chickadee from the mist-nests installed at experimental bird feeders.

Disentangling the Causes of Population Variation in Columbian Ground Squirrel Hibernation

Gabriela Heyer
University of Saskatchewan (M.Sc.)
Jeffrey E. Lane, Supervisor

Understanding the roles of genetic variation and plasticity in hibernation traits can be crucial to predicting population resiliency of hibernators in our changing climate. I am using a combination of field data and a common garden experimental design to partition the sources of variation in the hibernation phenotypes of Columbian ground squirrel populations across elevations, providing important insight into the potential responses of different hibernating populations to climatic changes.

Photo: A curious Columbian ground squirrel just before the start of the hibernation season.

Causes and Consequences of Mutliparasitism in Populations of Fathead Minnows

Sarah V. Hirtle
University of Lethbridge M.Sc.
Cameron Goater, Supervisor

Parasites are ubiquitous in nature and individual hosts are regularly infected by multiple parasite species or strains simultaneously. These co-occurring parasites can interact (often through the host immune system), resulting in profound impacts on each other and their hosts. My project furthers our understanding of the phenomenon of co-infection in wild hosts by characterizing the parasite community hosted by fathead minnows and testing whether co-infections have greater effects on hosts and parasites than mono-infections in an experimentally tractable model system.

Photo (left): Sarah sampling fathead minnows pond-side.

Photo (right): Trematode metacercariae encysted near the liver and spleen in a fathead minnow.

Trait Similarity's Impacts on Plant Performance: General Effects Among Communities

Emily M. Holden
University of Alberta (Ph.D.)
J.C. Cahill, Supervisor

My research examines contrasting theories on the role of trait similarity in plant coexistence, and will clarify how similarity to neighbouring plants affects focal individuals' performance. This has special relevance to limiting the spread of invasive species and their negative impacts on ecosystems.

Photo: An aerial view of a pot used in the mesocosm experiment. Turf circles of plants were cut from the field and brought back to Edmonton, where they were grown in pots. A focal seedling was added in the centre of each pot.

Adaptation, Movement, or Extinction: Will Alpine Plant Survive Climate Change?

Jared D. Huxley
University of California, Riverside (Ph.D.)
Marko J. Spasojevic, Supervisor

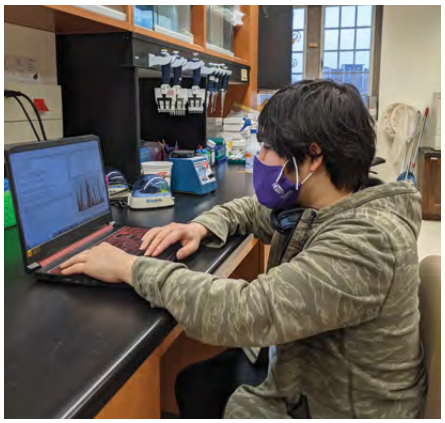
Species have three options for responding to climate change: 1) Adapt - stay in place and genetically adapt to new climatic conditions, 2) disperse - track suitable climatic conditions via dispersal or 3) go extinct. The goal of my project is to infer the dispersal ability and adaptive potential of alpine plant species from patterns of genetic diversity, to improve our predictions of which species are likely to be threatened with extinction due to climate change.

Note: Due to ongoing COVID related international border closures, ACA gave Jared permission to complete his project in the USA.

Photo (top): Extremely large individual of one of my target species (Silene acaulis, a gravity dispersed species) species that I am about to harvest tissue from. This individual's large size indicates that it is likely several hundred years old!

Photo (bottom): Jared harvesting tissue from one of his target species (Geum rossi, a gravity dispersed species) with his dog.

Characterizing a Genetic Basis of Recolonization in an Alpine Butterfly



Keon Young Park
University of Western Ontario (M.Sc.)
Nusha Keyghobadi, Supervisor

In the face of increasing habitat fragmentation across the globe, my work provides further insight into meta-population level processes that underlie the persistence of species within fragmented patches, as well as documents the genetic effects of local extinctions/bottlenecks that occurred within a natural system.

Photo: Kevin working on analysis of the genotype data.

Winter Responses in Wood Bison *(Bison bison athabascae)* to Seasonal Dynamics in Water and Factors Influencing Forage Availability in Wetlands

Garrett Rawleigh
University of Alberta (M.Sc.)
Scott Nielsen, Supervisor
Mark Edwards, Supervisor

My project is important because it is quantifying the behaviour and identifying areas of significant importance for the Ronald Lake Bison Herd. This information will inform protection and management of this herd, which holds historical cultural significance to local First Nations and Metis groups, and is threatened by potential oil sands development.

Photo: Garrett measuring snow characteristics in a bison crater.

Glacial Melt Impact on Freshwater Quality and Riverine Food Webs

Jessica Serbu
University of Alberta (Ph.D.)
Vincent St.Louis, Supervisor

Water quality is essential to the health of the riverine food web – from microbial and algal communities to higher trophic organisms like invertebrates and fish – but both the quantity and quality of glacial-fed freshwater systems are at risk due to climate change impacts. Thus, assessing water quality parameters and food web dynamics evolving from changing glacial melt inputs will help us understand the system's future capacity for ecosystem functions and services.

Photo (top) Sydney processing water quality samples in a temporary field laboratory after a day of collecting them in the mountains.

Photo (bottom) Sydney and Janelle collecting mercury samples, which are sensitive to contamination, using the standard two-person protocol.

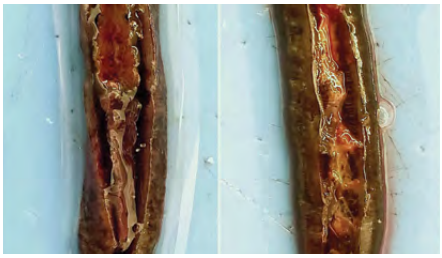
Effects of an Emerging New Species of Myxozoan Parasite of Minnows

Molly Tilley
University of Lethbridge (M.Sc.)
Cameron Goater, Supervisor

Emerging diseases can devastate populations of animals. Instances of disease emergence appear to be on the rise, including into populations of Alberta wildlife. My study is the first to document the consequences of the emergence of a new pathogenic myxozoan (the same group of parasites that causes whirling disease in trout) in a species of fish that plays a key role within aquatic ecosystems in Alberta.

Photo: Fathead minnow infected with the new emerging myxozoan parasite.

Combined Effects of Microplastics and Cadmium on the Freshwater Leech



Lauren Zink
University of Lethbridge (M.Sc.)
Gregory G. Pyle, Supervisor

The interactions of microplastics with other contaminants including cadmium, a toxic metal, poses potential threats to the health of aquatic organisms. My research works to understand what factors govern the interaction of cadmium and microplastics as well as how cadmium-microplastic complexes impact important freshwater species in Alberta.

Photo (left): Starved leech with cleared digestive tract.

Photo (right): microplastic accumulation within the leech digestive system following acute (96 hour) exposure to microplastics.

ACA Grants in Biodiversity

Reviewer Appreciation

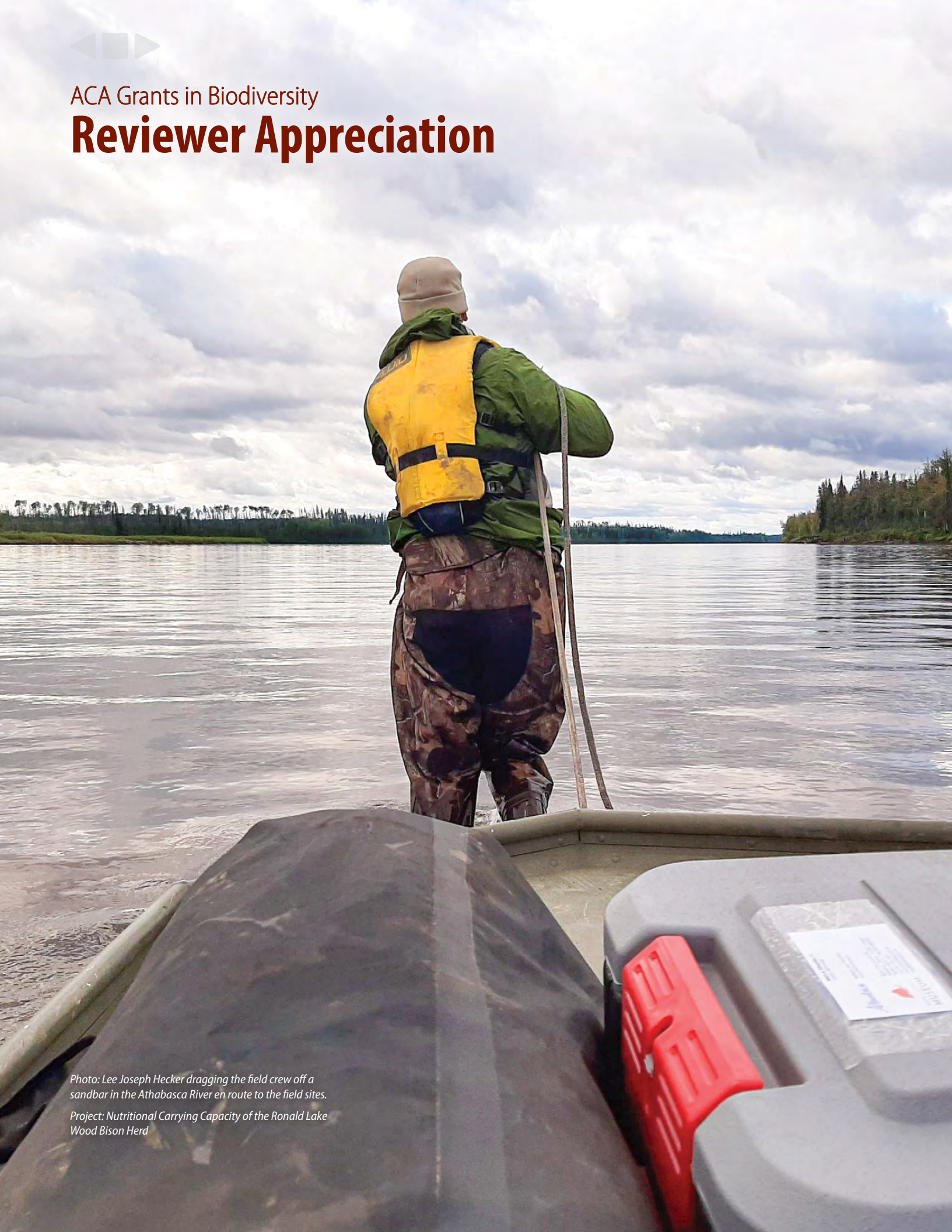


Photo: Lee Joseph Hecker dragging the field crew off a sandbar in the Athabasca River en route to the field sites.

Project: Nutritional Carrying Capacity of the Ronald Lake Wood Bison Herd

Every application received for an ACA Grants in Biodiversity competition is sent to at least three volunteer reviewers. We appreciate the time, expertise, and effort of our reviewers for the last two years:

S. Acharya
A. Achim
B. Adams
R. Al-Chokhachy
S. Alexander
B. Allen
N. Aluru
N. Anderson
D. Ausband
P. Badiou
Y. Bai
J. Ball
M. Ball
C. Barber
A. Bath
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S. Bayley
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T. Benfey
J. Bennett
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G.Goss
E. Gow
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A. Kraemer
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J. Lee-Yaw
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S. Liccioli
D. Locky
R. Longair
R. Łopucki
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C. Molina
M. Mora
C. Morrissey
J. Muenier
M. Musiani
A. Mysterud
A. Nair
L. Neufeld
L. Neufeld
T.B. Nguyen-Phuc
S. Nielsen
C. Nietvelt
S. Nolan
J. Northrup
F. Nwaishi
K. Orsel
T. Osko
R. Owen
A. Oxbrough
J. Paczkowski
C. Paszkowski
B. Patterson
B. Pauli
M. Pegg
S. Philpott
D. Pilliod
B. Pinno
J. Pinzon
G. Piorkowski
K. Poole
K. Pope
J. Post
L. Powell
M. Preston
R. Prosser
S. Pruss
M. Pruvot
B. Purdy
G. Pyle
S. Quideau
D. Reale
M. Reid
M. Richards
T. Ripley
S. Riyahi
S. Robertson
B. Robinson
S. Robinson
C. Robinson
A. Rodgers
M. Rodtka
M-P. Rogeau
S. Rogers
J. Roland
L. Ross
J. Roth
A. Russell
T. Ruth
W. Samuel
E. Sanchez
G. Schisler
J. Schoenau
A. Schulte-Hostedde
M. Schwarzfeld
C. Scobie
C. Servheen
J. Sevigny
J. Smits
C. Somers
R. Soolanavakanahally
C. Soos
C. Sponarski
T. Spribille
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G. Strickert
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D. Tarasi
E. Taylor
K. Tierney
M. Todd
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J. Vamosi
S. Van Wilgenburg
R. Vinebrooke
D. Visscher
M. Vonhof
V. Wagner
X. Wang
J. Waterman
S. Watmough
C. White
L. White
D. Whiteside
A. Whiting
K. Wieder
L. Wilkinson
G. Wilkinson
C. Williams
G. Wilson
S. Wiseman
P. Wright
D. Wrubleski
B. Xu
Y. Yang
R. Zurawell
F. Zvomuya

Photo: Emily M. Holden consults a key book to identify plant at the University of Alberta Roy Berg Kinsella Research Ranch.

Project: Trait Similarity's Impacts on Plant Performance: General Effects Among Communities

ACA Grants in Biodiversity

Application Information

Program Mandate

The ACA Grants in Biodiversity Program for graduate students has been established to increase knowledge of the flora, fauna, and habitats of Alberta and to support Alberta-based research.

Eligibility

The ACA Grants in Biodiversity Program is open to master's and Ph.D. students working in Alberta. The location of a student's university is of no consequence, but the subject of research must be in Alberta.

Applicants must be associated with a university as a graduate student enrolled in a graduate program. Priority will be given to master's and Ph.D. students in the first two and three years of their program, respectively. Applications from students not yet in a graduate program will be considered with documentation from their prospective supervisor.

See specific limits of eligibility on our website: **www.acabiodiversity.ca**

Research Mandate

Applications should focus on enhancing the understanding of Alberta's flora, fauna, and habitat at any biological level, but research should be directly anchored in the real world. For example, an experimental laboratory study dealing with beetle chromosomes must have a direct linkage to that organism in nature. Impact-type studies, such as those involving human-induced environmental change and social science will be considered, but such manipulations must be process-oriented and related to flora, fauna, and habitat change.

Applications will be adjudicated based on:

1) research merit
2) reasonable budget
3) ability of the applicant to conduct the proposed project

Award Features

The grant term is two years, and the maximum award is $20,000. Awards are made in early April each year; mean award amounts are approximately $11,000.

Funds are to be used for direct research costs.

Serious potential applicants can find updated information and download the application form from our website: **www.acabiodiversity.ca**

Deadline:

The deadline for receipt of applications is December 1 *(or the last business day before December 1)* each year.

Check **www.acabiodiversity.ca** for deadlines, to contact the program staff, and for application information.

Alberta Conservation Association

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Alberta Conservation Association

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