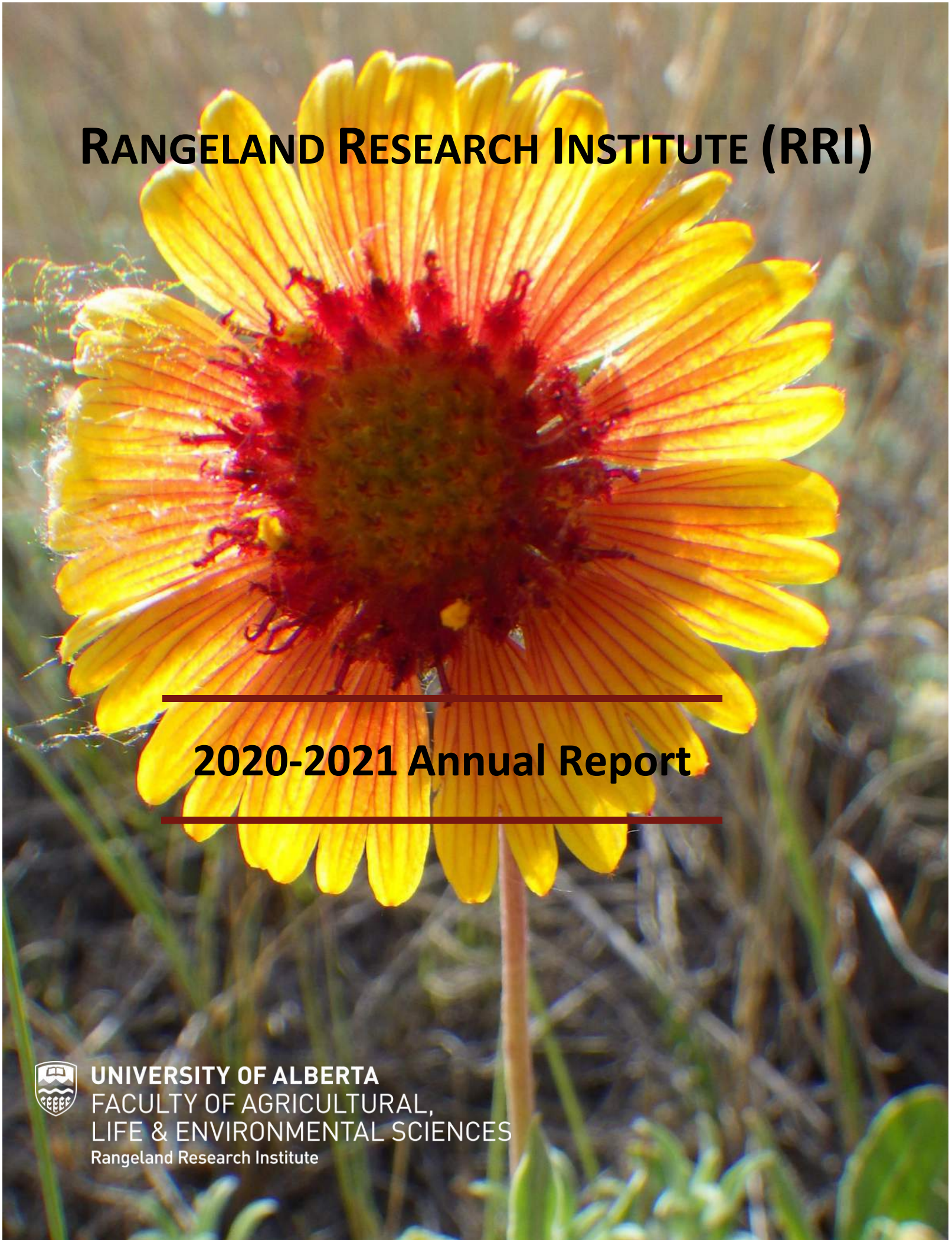
RANGELAND RESEARCH INSTITUTE (RRI)



2020-2021 Annual Report

UNIVERSITY OF ALBERTA
FACULTY OF AGRICULTURAL,
LIFE & ENVIRONMENTAL SCIENCES
Rangeland Research Institute

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Cover photo: Blanket flower (*Gaillardia aristata*) at Mattheis Research Ranch

Photo by Dr. Carol Frost

1. Introduction

The Covid-19 global pandemic emerged as a major threat in North America in early 2020 and is continuing to have far-reaching effects on human health. However, there have also been indirect effects to our natural environment, including rangelands. In Alberta, as travel and gathering restrictions were imposed to limit the spread of the virus, urban populations, in particular, used parks and public lands for recreation to a greater extent. While rangelands are important sources of forage for livestock, they also provide habitat for wildlife, are a source of biodiversity, clean water, aesthetic beauty and a desirable space for outdoor recreation, all of which reflect the many ecosystem goods and services rangelands provide. The public responded negatively to the proposed Provincial Park closures and reduction in services, and eventually led to the government re-evaluating these closures for the immediate future and updating the Alberta Environment and Parks crown land vision. Being outdoors and having the ability to hike, camp, fish, hunt, bird watch, etc. were some of the few activities that have been permitted during the tightest pandemic restrictions and many people found solace in these spaces while reconnecting to the land, and in the process gaining a new appreciation for the sprawling rangelands many of these parks and public lands consist of.

Covid-19 also indirectly put additional strain on rangeland habitats and brought significant uncertainty to the agricultural community, including the beef industry through various forms of market uncertainty. Many economies have been unstable due to declines in trade and shipment of beef to the marketplace, Covid-19 outbreaks at meat-packing plants that have led to reduced processing and shutdowns, and widespread loss of employment in Alberta that has reduced public purchasing power. All of these effects may further threaten ranching livelihoods and increase the potential for rangeland degradation or loss. For example, as

Prickly pear cactus at the Mattheis Research Ranch, June 2020.

the ownership of rangeland changes hands, there is increased risk of land conversion or fragmentation of remaining native grasslands for alternate urban, industrial, or agricultural development, in turn threatening the loss of many ecosystem goods and services.

A prairie storm at the Mattheis Research Ranch, July 2020.

In 2011, University of Alberta (U of A) alumni Edwin and Ruth Mattheis generously donated their 5000 ha ranch, which is mostly native grasslands, to their *alma mater* and from that donation, the U of A created the Rangeland Research Institute (RRI). Edwin and Ruth's love of the land is clearly communicated in their recently self-published book, The Mattheis Ranch, which recounts their family history, the community, the natural history of the ranch, as well as their vision for the land. Part of that vision was to ensure the Mattheis Ranch would be maintained as a contiguous tract of unbroken rangeland, thereby continuing to provide important habitat for wildlife as well as forage for cattle. Owing to their long-term vision, the Mattheis Research Ranch has and is becoming an important location for conducting research in the Dry Mixedgrass prairie of southeastern Alberta, joining other legacy research stations, specifically Kinsella, Onefour and Stavely, to form a strong foundation of rangeland and livestock research in western Canada.

Research activities have not been immune to the negative effects of Covid-19. For example, travel restrictions were imposed both by various governments, as well as by the University of Alberta, in order to curb the spread of virus transmission, particularly into remote areas of the province where many (if not most) rangelands occur. Thus, many research projects were either postponed (new projects), or scaled back during the past year, in order to ensure the safety of researchers, students, cooperating producers,

and the public in general. For the first time in history, classes were held almost exclusively on-line (remote learning) over the September through April academic year, which posed new challenges for instructors seeking to ensure that students continue to gain a full learning experience. Despite the challenges posed by Covid-19 restrictions in 2020-2021, the RRI and its affiliates have continued to fulfill its mandate to conduct research, teaching, and be involved in outreach activities. Several researchers affiliated with the RRI were able to continue conducting research at the Mattheis and Roy Berg Kinsella Research Ranches that investigate a wide variety of rangeland ecology and livestock questions despite provincial travel restrictions. The RRI also continued to participate in teaching and outreach, although these activities took on a very different form than it has in the past; needless to say, the academic community has made great strides in the last 12 months of finding new ways to engage students, stakeholders, ranchers and the general public. In person classes and labs were replaced with on-line learning, and in-person producer workshops were replaced with on-line webinars, often held in concert with partner organizations, and have likely changed the nature of these communications forever.

Hairy golden aster (*Heterotheca villosa*) commonly seen at the Mattheis Research Ranch

This report summarizes key activities undertaken by the RRI from April 1, 2020 through March 31, 2021. The report includes a brief summary of research activities, including three profiles of recently completed research projects; capacity building; a summary of communication and outreach activities for the RRI; current Strategic Advisory Council membership; as well as a financial summary of the previous year.

2. Research

The Rangeland Research Institute fulfills one of its primary mandates to conduct research through several methods: 1) by providing grant funding for one to several researchers each year through the Competitive Grants Program, 2) by providing in-kind support (through access to land, housing, research infrastructure) to researchers using the Mattheis and Kinsella Research Ranches, and 3) by RRI staff directly being involved in conducting research projects (e.g. Strategies to contain the invasion of introduced annual bromes into southern Alberta grasslands). While a call for Competitive Grants was not made in 2020 in order to maximize growth to the Rangeland Management and Ecology Fund (See Section 7. Financial Overview), the RRI continued to support and conduct rangeland research in other ways.

A group of curious heifers at the annual brome study in southern Alberta, June 2020.

Despite not funding new research in 2020, ongoing research has continued including researchers directly funded by RRI in previous years and those using the research ranches. Appendix 1 lists projects that are either still actively collecting field data or in the process analysis, writing, and publication. Specific RRI-funded projects are indicated with an asterisk. Covid-19 restrictions also affected the ability of many North American Universities to physically carry out research, particularly projects that are highly collaborative where staff and students are in nearby proximity. The University of Alberta has been closely following Alberta Health Services guidelines especially restrictions related to travel into rural communities. These restrictions affected all projects taking place on the Mattheis and Kinsella Research Ranches; only projects that were ongoing from previous years were approved by Faculty leadership for travel and

researchers were being encouraged to defer their 2020 field work if they were able to do so. Several RRI-affiliated researchers chose to defer their new and ongoing projects in order to limit the health risk for staff and students, as well as minimize contact with people in rural communities that have reduced capacity to provide medical services in the event of a regional outbreak.

The Mattheis Research Ranch had much reduced usage in 2020-21 reflecting the decisions by University leadership to limit travel. A total of 17 individuals spent 53 person-days at the Mattheis Ranch in 2020-21, including 3 principle scientists, 2 graduate students, 7 undergraduate students, and 5 post-doctoral researchers, senior technologists, and other staff. Researchers using the ranch and housing were those associated with the University of Alberta (or collaborating on projects with U of A researchers), from the Faculty of ALES (Agricultural, Life and Environmental Sciences; Depts. of Agricultural, Food and Nutritional Sciences & Renewable Resources), the Faculty of Science (Depts. of Biological Sciences) and the Faculty of Arts (Anthropology). External organizations were not permitted to stay at the ranch in 2020.

Overlooking Carrier Lake in the distance at the Kinsella Research Ranch

Similarly, the Roy Berg Kinsella Ranch had sharply reduced usage in 2020-21 for a total of 46 person-days. Researchers included 2 principle scientists, 3 graduate students, 1 undergraduate student, and 2 senior technicians and staff. Most researchers were from the Faculty of Science (Dept. of Biological Sciences) and Faculty of ALES (Depts of Agricultural, Food and Nutritional Sciences). Many organizations (including AAFC, AEP, Nutrien, among others) were also restricted from traveling to rural Alberta for overnight trips or experienced a much-reduced ability to conduct field research.

In spite of the disappointing reduction in the level of activity at the Mattheis and Kinsella Research Ranches, Stavely and Onefour Research Stations, as well as projects conducted on public and private land, a few projects were completed and are summarized in the following Research Profiles (Section 3). In addition, several graduate students celebrated the completion of their degrees and successfully defended their theses through online Zoom presentations (Section 5. Communications). The RRI is looking forward to welcoming back more U of A researchers and researchers from other organizations in 2022.

Researchers sampling annual brome and native grass cover at the Pinhorn Grazing Reserve – June 2020.

3. Research Profiles

Using Plant Traits to Assist Conservation and Management of Alberta's Rangelands

By Dr. James Cahill, Department of Biological Sciences, University of Alberta

Rangelands provide a wide array of environmental good and services, including forage production, carbon sequestration, recreation and biodiversity. At the heart of these services are plants, and even small changes to plant species composition can alter the benefits people receive from these services. Though many species are known to alter ecosystem function (e.g. smooth brome increases early season forage production while also suppressing native species diversity), the specific impacts of most species in Alberta's rangelands are unknown. Our knowledge of the functional value of individual species is further complicated when we consider that a single species simultaneously confers multiple ecosystem services (e.g. protection from invasive species and carbon sequestration), and species may differ in their specific contributions towards each service. Unfortunately, there is no one plant species that "does it all", and instead maintaining a diversity of native species appears to confer the greatest multi-functionality. With hundreds of species in a single community, generating a complete accounting of how every species impacts each ecosystem service is not feasible. Plant ecologists have found conservation and management success by moving focus away from a species taxonomic identity to a plant's functional ecology, with an emphasis on local collection and analysis.

Aspen parkland rolling hill topography at the Kinsella Research Ranch in May.

There are worldwide efforts to categorize species based on their chemical, physiological, and morphological traits (e.g. leaf, stem, and root characteristics), with these data serving as a critical resource for researchers and land managers. Alberta's rangelands are uniquely positioned at the northern edge of the Great Plains, and while trait data have been collected for rangelands of the United States, systematic efforts addressing this in Alberta have been limited. As many species in Alberta are at the northern edge of their continental range, the use of trait values from southerly locations is unreliable. At the same time, many Alberta species are unique to the region or rare in warmer climes, necessitating development of a unique trait database that can facilitate a functional approach to understanding and managing ecosystem services in rangelands.

Needlegrass dominated native grassland at Kinsella Research Ranch – sunset in August.

There are too many plant traits to effectively keep track of them all, and instead the current focus is on those traits viewed as "functional." More specifically, there is focus on "response traits", which are those traits associated with how plants respond to environmental stressors such as drought or intense grazing, and "effect traits" which are those traits that govern the delivery of ecosystem services of value to society. The long-term management goal of rangelands is to ensure enough biodiversity exists such that the species present provided us with the services we desire but also have the traits and characteristics needed to persist in a changing climate and in the face of land uses such as grazing. Critical to the application of this approach for conservation goals is a highly accurate database describing relevant effect and response traits. This approach does not replace field-based studies of range health and functioning, but instead adds critical information that can be incorporated into those studies to enhance management decisions.

This project involved travel throughout Alberta's rangelands, collecting a diversity of plant samples, and cataloguing both shoot and root traits of each species. Alberta's rangelands are both ecologically and economically important, and under-represented in global surveys of plant traits. Priority was given to collecting trait data on plant species most likely occur in a given community, rather than exhaustively cataloguing all grassland species. An advantage of this approach is the ability to promptly apply these trait data to ongoing studies in rangeland ecology, and because many species are found across numerous locations, this increases our ability to capture intraspecific variability. A total of 32 sites were sampled throughout Alberta, though the most intensive sampling occurred at the RRI-affiliated Mattheis and Kinsella Research Ranches. In the field, species which represented 80% of plant abundance (when combined) at each site were sampled. This approach ensured that the most common species throughout the province were sampled more intensely, and included data from multiple field sites. The most commonly measured root, leaf, and stem trait data were taken, as they are generally the most useful, yet variable across rangelands. Future researchers will add additional traits based upon project-specific needs, enabling the database to be enhanced over time.

In total, 857 samples were collected and processed from 32 locations in 2018 and 2019. Samples came from 156 species representing 36 plant families. The most heavily sampled species included Dandelion (*Taraxacum officinale*), Yarrow (*Achillea millefolium*), Smooth brome (*Bromus inermis*), American vetch (*Vicia americana*), and Kentucky Bluegrass (*Poa pratensis*). All species are commonly associated with invaded grasslands and seeded pastures, and their frequency in sampling appropriately represented their broad geographic distributions. A further 22 species, represented by at least 10 specimens each, included June grass (*Koeleria macrantha*), Blue grama grass

Common yarrow (*Achillea millefolium*)

(*Bouteloua gracilis*), Pasture sage (*Artemisia frigida*), and Needle-and-thread grass (*Hesperostipa comata*).

Blue grama grass (*Bouteloua gracilis*) at the Mattheis Research Ranch

The value of this work lies not in delivering a specific management practice to land managers, nor in a specific publication highlighting a novel finding. In fact, these data will never be published by themselves, but instead are made available for others to use. The value of this project is analogous to the value of a tractor; having a tractor is not the goal of an operation, but it makes so many more things possible. Rather than drawing particular interest in the raw values of plant traits, such as height or root and stem densities, these data are the tools that can be used to estimate broader ecosystem attributes and function, including their efficiency of delivering ecosystem goods and services. For example, by calculating "functional trait diversity", ecologists have been successful in predicting a grassland's ability to provide services such as forage production or carbon storage, as well as estimate ecosystem stability in response to environmental change (e.g. drought, warming, grazing, etc.). Doing so requires access to locally collected trait data, as there can be substantial variation in plant traits within a species throughout its geographic range. Because these data are publicly available, they will be useful to local, regional, and international researchers and managers, forever. The data and metadata are openly available at: https://doi.org/10.7939/r3-wszy-4x39. If you have questions about this project, please contact jc.cahill@ualberta.

Native pollinator communities are resilient to high honey bee densities in mixedgrass rangeland

By Dr. Carol Frost, Department of Renewable Resources, University of Alberta

Commercial honey bee densities have been rapidly increasing in Alberta relative to other parts of Canada. Studies in other locations have suggested that honey bees may threaten native pollinator population persistence, via competition between honey bees and native pollinators for nectar and pollen, or via transmission of diseases from honey bees to native pollinators. The prairie region is home to Canada's highest native bee diversity, and rangelands in particular are important for pollinators in providing food and nesting areas that are scarcer in areas of the prairies that are cropped. It is therefore important to know whether increasing honey bee densities are threatening native pollinators in these areas that are important to native pollinator conservation.

Sydney and Janelle empty insect pan traps. Photo by Carol Frost.

Sydney Worthy, an MSc student working with Dr. Carol Frost and John Acorn, recently finished a study evaluating whether adding high honey bee densities to three locations on Mattheis Ranch changed native pollinator abundance or diversity at 16 sites that were different distances from the hives (100 m to 5 km). They sampled pollinators once every two weeks, using pan traps and hand netting of insects visiting flowers during timed observation periods.

Sydney found no effect of honey bee abundance on native pollinator abundance or diversity. Honey bee colony size is largest in mid-summer, but even analyzing data from just her mid-summer collections, when honey bees should exert the greatest competitive effect on other pollinators, Sydney found no effect of honey bee abundance on native pollinator abundance or diversity, whether she considered all pollinators together, or the higher taxa of pollinators

separately (bees, flies, beetles, and butterflies). This suggests that native pollinators do not avoid areas with high honey bee abundance.

Summer assistant, Janelle, helps Sydney with data collection close to the bee hives. Photo from Carol Frost.

To investigate whether there was any indication of honey bees changing native pollinator flower visitation, Sydney compiled species-specific data on plant-pollinator interactions. She did this by counting and identifying all the flower species along a transect at each site on every visit, and also identifying all the pollinator species that visited each flower species. She then produced a plant-pollinator interaction network for each site (Figure 1). She analyzed the structure of the network for each site to look at whether the pattern of interactions across the entire plant-pollinator community is different when honey bee abundance is high.

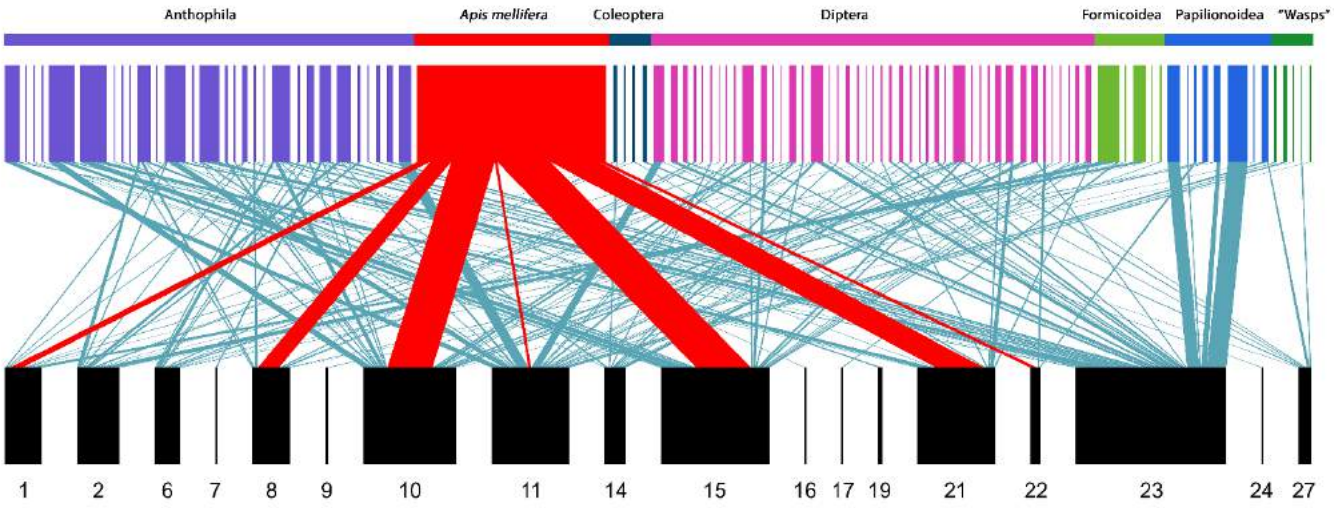


Figure 1. *Plant-pollinator interaction network created from data pooled across sites that were only 100 m from clusters of honey bee hives. Coloured rectangles (top) represent pollinator species (coloured by taxon), with rectangle width proportional to interaction frequency. Black rectangles (bottom) represent plant species. Lines connecting pollinator species and plant species represent visits between that pollinator and that plant species, with line width proportional to visit frequency. The red box represents honey bees, and the red lines represent the frequency of honey bee visits to different plant species.*

In particular, Sydney looked for changes in the extent to which native pollinator species overlapped in their use of different plant species. If honey bees were outcompeting native pollinators for the best sources of nectar and pollen, she expected to see native pollinators shifting patterns in their use of plants when sampling sites with a lot of honey bees. However, Sydney found no change to any metric of how the native pollinator community interacted with the native plant community, even at distances of only 100 m from 48 honey bee hives. Thus, although honey bees did factor in prominently into the plant-pollinator communities at Sydney's sites that were close to hives, they had no detectable effect on native pollinator visitation of native plants. As it is likely that floral resources are more limiting in drier years, this study is unable to discount the possibility of more competition occurring in other (drought) years, but nevertheless, these results suggest that Alberta's native pollinator communities appear resilient to the addition of high densities of honey bees.

Soil health improvements in native grasslands

By Mina Kiani and Guillermo Hernandez-Ramirez

Native grasslands can improve soil health, a general term used to describe the attributes that regulate biological and ecological function of soils, including their potential to support forage and crop production. However, soil health attributes can vary spatially across fields, and this variability needs to be understood to better manage these grassland ecosystems. Therefore, there is a need to examine key soil properties that help characterize soil health such as plant available water, organic carbon, and microbial biomass carbon. Our study measured the spatial variation of these important soil health attributes, and included a comparison of native grassland and an irrigated cropland located at the

Cattle grazing native grassland at the Mattheis Ranch

Rangeland Research Institute Mattheis Research Ranch, near Brooks, Alberta. We found that the native grassland had 25% greater macroporosity (large soil pores) compared with the irrigated cropland, which should favor water infiltration and storage. In contrast, soils in the irrigated cropland supported 20% greater accrual of microbial biomass, and this was probably explained by higher water and nutrient availability under irrigation. Across fields, we found strong effects of topography on soil health. Characteristics such as terrain elevation and estimated depth of water table were found to influence soil health in these native grasslands. Organic carbon stored in the soil increased with lower terrain elevation and a shallower depth to the water table. Our study developed mapping tools and parameters for the soil health attributes of plant available water, organic carbon, and microbial biomass. Collectively, this information can improve the accuracy of soil health estimations and predictions. Resulting interactions emphasize how assessing soil health can reveal not only multiple soil functions but also insight into the status of ecosystem services across land-use systems, including grazed native grasslands. Overall, these research findings on soil health can help land managers to spatially visualize field heterogeneity as well as support the scaling up and regional assessments of sustainable land use systems.

Canola under irrigation at the Mattheis Research Ranch - July

4. Capacity Building

The Rangeland Research Institute (RRI) has yet to fully understand how we will be affected by provincial government-imposed deep funding cuts to post-secondary institutions that were announced in the past two fiscal years. In response to the 33% ($216M) budget reduction, the University of Alberta, under the leadership of President Bill Flanagan, has initiated an aggressive change towards 'University of Alberta For Tomorrow' which includes a radical Academic and Administrative restructuring process and inevitable staffing reductions. Rapid changes have already taken place and the U of A is moving towards a College model similar to other learning instititions of similar size. While the Faculty of Agricultural, Life and Environmental Sciences will retain our identity as a Faculty, we will merge with the Faculty of Engineering and Faculty of Science to form one of three Colleges at the University of Alberta, becoming the College of Natural and Applied Sciences effective July 1, 2021.

In response to the budget cuts in 2020-21, the Rangeland Research Institute (RRI) did not put out a call for Competitive Grant proposals nor request targeted proposals. Budget shortfalls within the Department of Agricultural, Food and Nutritional Sciences have impacted the RRI in the past two budgets by the department transfering staff salaries from operational budgets increasingly onto the Rangeland Ecology and Management Fund, originally designated for funding research. Because of this, the RRI is investing as much of the interest that is generated by the endowment as well as funds generated from natural resource leases back into the principle in order to grow the endowment as quickly as possible. This strategy is intended to protect RRI's ability to award research grants in future years, but means that less research is being funded in the immediate short-term.

The RRI acquired two LiCor methane sensors in 2020 which will be installed at the Mattheis Research Ranch in order to capture long-term greenhouse gas data from grazed grasslands. The funding for these sensors (approximately $100K) was generously bequeathed to the RRI by an estate donation. All ruminant animals, including cattle, produce enteric methane, which increases the risk of climate change. In contrast, a little known fact is that grassland soils contain methanotrophs (methane 'eating' microbes), which slowly scrub methane from the atmosphere. What remains unclear is how much methane is produced within grazed grasslands relative to the amount of methane taken up by soil microbes in grasslands, and how this dynamic varies seasonally throughout the year. This information gap leads to uncertainty on what the net effect of cattle grazing on methane dynamics is within grasslands, with obvious implications for the ranching industry. Acquiring these sensors will allow the RRI to collect long term data in a cattle ranch setting and enable researchers to conduct rigorous scientific investigations around these questions. The new methane sensors will complement existing eddy covariance flux sensors that have been collecting long-term greenhouse gas (CO_2) data since 2012. The RRI is grateful for the continued technical support from Dr. John Gamon from the Department of Earth & Atmospheric Sciences, as well as from Dr. Sigrid Dengel from AmeriFlux. The RRI has also developed new partnerships with researchers within the Faculty of ALES (Mr. Dick Puurveen) and from other Universities in order to ensure the long-term success of this venture.

A CO_2 flux tower at the Mattheis Ranch where one methane sensor will be installed.

The Faculty of ALES, in partnership with generous funding from the Hays family in Alberta, created a new academic position within the faculty: The BCRC (Beef Cattle Research Council) – Hays Chair in Beef Production Systems. This position fills a gap within the AFNS department for a researcher working to support the beef industry, particularly in relation to extensive questions related to forage-based production systems. This position will enhance our capacity to conduct rangeland research from a

cow-calf perspective, increase activity at our Roy Berg Kinsella and Mattheis Research Ranches, and also provide critical support for student learning and outreach to the ranching community. Interviews and facility tours were conducted with several short-listed candidates in December 2020 (conducted via Zoom because candidates were restricted from traveling to Edmonton) and we are pleased that Dr. Gleise Medeiros da Silva will be joining the Faculty of ALES in 2021. The RRI is excited to partner with her as she initiates her research program.

Top: Cattle at the Roy Berg Kinsella Research Ranch.

Bottom: Cattle feeding out of the GrowSafe bunks as part of a research project at the Kinsella Ranch.

Photos by Carolynn Fitzsimmons.

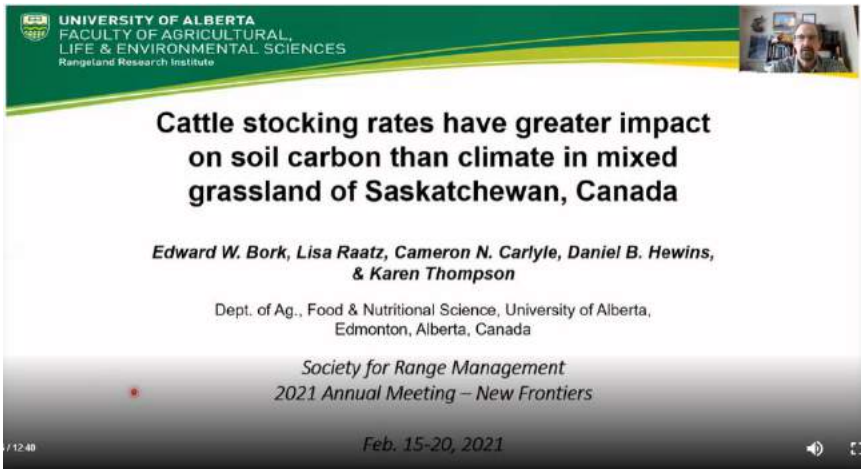
5. Communications

The world changed in early 2020 as the novel corona virus spread rapidly within and across continents. New health and safety restrictions affected every aspect of our lives including the RRI's ability to conduct field tours, teach, and extend research. For those engaged in teaching (or enrolled as a student), March 2020 was particularly memorable as instructors for U of A classes and labs responded to new health measures and a rapidly evolving crisis. In-person classes were cancelled and moved to online platforms over the span of 4 days with direction from Alberta Health Services and strong decision making by leadership at the U of A. Instructors invested time learning new online tools and transitioning their materials and teaching methods while endeavouring to ensure students still had a high quality learning experience. For example, some plant-focussed courses were able to continue in-person teaching by adding plexi-glass partitions between students and increasing the number of lab sections to minimize student density with additional teaching support and other health measures. Other lab sections rapidly catalogued their plant materials into a digital format and moved to an online format only. While not an entirely seamless transition, it did reflect our own capacity to be flexibile and resilient as students and instructors coped with all the changes.

Extension events were similarly affected. Conferences, workshops, and field tours that had been planned were cancelled, postponed, or moved to online virtual events when it became clear that travel and gathering in groups was not possible. Despite this, the RRI and RRI-affiliated researchers continued to extend research at various workshops, conferences, seminars and many discovered that the online platform allowed for a larger, wider, and more varied audience than in-person events. While connecting and meeting in person is preferred, meeting on a virtual platform had some advantages (providing there is adequate internet capacity for speakers and audience members alike). The usual barriers for people to attend events, such as travel costs or time away from work and family were removed and people could engage for a relatively short time investment to learn something new. A list of communications is provided in Appendix II, and a subset of events are described below.

The Society for Range Management Annual meeting (originally planned for Boise, ID) transitioned to an online 'New Frontiers' conference held February 2021, which proved to be an outstanding success. The conference had over 1500 people register and the

'Climate Change on Rangeland' plenary session had over 600 participants; 86% of surveyed respondants rated their online conference experience as "Good" or "Great". Three oral presentations were given by researchers from the U of A and the RRI. While meeting and networking in person would have been preferable, the online conference recordings remain on the internet as a permanent resource that registrants can refer to and view again. Many participants remarked that they enjoyed not having to choose between two talks occuring at the same time, but could "attend both". There were also several opportunities for real-time live Q&A interactions with presenters as well as networking events. For example, SRM International Mountain Section (Alberta & Montana) had a Zoom social gathering attended by some ranching members who had previously not been able to attend the in-person meetings due to the high cost of travel and need to care for overwintering animals.



Dr. Edward Bork presents research at the Annual Society for Range Management meeting in Feb 2020, held virtually from and to anywhere in the world speakers and presenters were participating.

In early March, Alberta Land Use Services (ALUS) hosted an online extension workshop largely attended by ranchers. The workshop featured the expansive Adaptive multi-paddock (AMP) grazing research project led by Dr. Mark Boyce with many research collaborators and multiple locations across western Canada, including the Mattheis Research Ranch. Many scientists affiliated with the RRI presented their research on various aspects of the project. Presentations can be viewed on YouTube AMP Grazing or available on the RRI website Presentations page https://rri.ualberta.ca/resources/presentations/.

Dr. Cameron Carlyle (University of Alberta, RRI-affiliated researcher) along with Dr. Eric Lamb (University of Saskatchewan) led a webinar highlighting several rangeland

research projects taking place at both Universities. The webinar was attended by approximately 70 people, including many of the ranching families that were involved in the Wildfire Recovery research project in Alberta and Saskatchewan (Acadia Valley and Burstall). Recent graduate, Brendan Bischoff M.Sc., presented the outcomes of his project. Rangeland Research Project presentations can be viewed on YouTube or from the RRI website Presentations page https://rri.ualberta.ca/resources/presentations/.

Additional outreach activities presented by our RRI-affiliated researchers are listed in Appendix II. Several graduate students completed their research projects and successfully defended their theses; their online seminars are also listed in Appendix II. In addition to extension and outreach events, researchers also communicated their research in peer-reviewed journals during 2020-2021. Many of these publications are listed in Table 5.1. These outreach and extension activities increases the profile of the RRI, the University of Alberta and the Research Ranches, and expands our knowledge about the importance of grasslands and rangelands to a wide audience.

Traveling the highway adjacent to the Onefour Research Station

Table 5.1. Select peer-reviewed publications authored by RRI affiliated researchers between April 2020 and March 2021

Wang, J.Y., Li, Y.M., Bork, E.W., Richter, G.M., Chen, C.C., Shah, S.H.H., Mezbahuddin, S. Mar 2021. Effects of grazing management on spatio-temporal heterogeneity of soil carbon and greenhouse gas emissions of grasslands and rangelands: Monitoring, assessment and scaling-up. Journal of Cleaner Production, 288: 125737. DOI: 10.1016/j.jclepro.2020.125737

Batbaatar, A., E.W. Bork, T. Broadbent, M.J. Alexander, J.F. Cahill, and C.N. Carlyle. 2021. Grazing alters the sensitivity of plant productivity to precipitation in northern temperate grasslands. Journal of Vegetation Science, 32:e13008. DOI: 10.111/jvs.13008.

Miller, V.S., Naeth, M.A. Mar 2021. Amendments to improve plant response under simulated water-limited conditions in diamond mine Anthroposols. Canadian Journal of Plant Science, 101(1): 91-102. DOI: 10.1139/cjss-2019-0121

Lysyk, T.J., Dergousoff, S.J., Rochon, K., Chilton, N.B., Smith, A.M. Mar 2021. Distribution of *Dermacentor andersoni* (Acari: Ixodidae) in Grassland Regions of Alberta, Canada. Journal of Medical Entomology, DOI:10.1093/jme/tjab019

Bork, E.W., Osko, T.J., Frerichs, L., Naeth, M.A. Feb 2021. Low soil disturbance during boreal forest well site development enhances vegetation recovery after 10 years. Forest Ecology & Management, 482: 118849. DOI: 10.1016/j.foreco.2020.118849

Camps-Valls, G., Campos-Taberner, M., Moreno-Martinez, A., Walther, S., Duveiller, G., Cescatti, A., Mahecha, M.D., Munoz-Mari, J., Garcia-Haro, F.J., Guanter, L., Jung, M., Gamon, J.A., Reichstein, M., Running, S.W. Feb 2021. A unified vegetation index for quantifying the terrestrial biosphere. Science Advances, 7(9): eabc7447. DOI: 10.1126/sciadv.abc7447

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*Papers from 2019-20 not listed in the previous Annual Report

'Hay's Converters' cattle at the Roy Berg Kinsella Research Ranch. Photo by Carolyn Fitzsimmons.

6. Strategic Advisory Council

There was no Strategic Advisory Council (SAC) annual meeting held in 2020, although a 2020-2021 Annual Report was prepared and shared with SAC members. The RRI continues to be active; however, changes made to the RRI funding model in the last few years have altered the ability to fulfill many goals that were included in the Draft Strategic Plan previously developed by the 2016 SAC members. Revisions to the plan are required once the transitions to Faculty structure and funding stabilize. The current composition of the SAC as of March 31, 2021 is provided in Table 6.1.

Table 6.1. Members of the RRI Strategic Advisory Council, March 2021.

Name	Position, *Agency*	Location
Barry Adams*	Head, Rangeland Resource Management Program (Retired) *Alberta Environment and Sustainable Resource Development*	Lethbridge, AB
Dr. Stan Blade	Dean, Faculty of Agricultural, Life & Environmental Sciences, *University of Alberta*	Edmonton, AB
Dr. Edward Bork	RRI Director; Professor and Mattheis Chair in Rangeland Ecology & Management, *University of Alberta*	Edmonton, AB
Dr. Cameron Carlyle	Associate Professor, *University of Alberta*	Edmonton, AB
Edwin Mattheis	Producer (Retired)	Calgary, AB
Ruth Mattheis	Producer (Retired)	Calgary, AB
Karin Schmid	Research and Production Manager, *Alberta Beef Producers*	Calgary, AB
Josie Van Lent	Dean, Agriculture Technology & Applied Research, *Lakeland College Canada*	Vermillion, AB
Dr. Walter Willms	Researcher (Emeritus), *Agriculture & Agri-Food Canada*	Lethbridge, AB
Dave Zehnder	Producer; Program Lead, *Farmland Advantage*	Invermere, BC

* Chair of RRI Strategic Advisory Council

7. Financial Overview

The RRI 2020-21 financial statement is shown in Appendix III and summarizes revenue and expenses. The majority of the RRI operational revenue continues to be generated from oil and gas extraction surface leases and utility (powerline) activity resulting from the Mattheis Research Ranch. Expenses include costs associated with outreach and extension, RRI operating and administration costs, and support for research activities and capacity building.

In 2015, the Rangeland Ecology and Management Fund (REMF) was created as an endowment and the majority of the principle is derived from revenue received following the major powerline construction at the Mattheis Ranch, a generous donation from the Alberta Beef Producers, and a large contribution from the conservation easement placed on the Mattheis Research Ranch in partnership with Western Sky Land Trust. In 2020-21, $500,000 was transferred from the RRI Operations budget to the REMF in order to build the principle as rapidly as possible thereby increasing our long-term capacity to conduct research from the interest that is generated on an annual basis. Of note, starting in 2018-19, a proportion of the spending allocation (the amount annually generated as interest received on the principle) is being used to support the salary and benefits of the Mattheis Chair in Rangeland Ecology and Management. As planned, the proportion of salary and benefits cost has increased in 2019-20 and 2020-21 and will increase further over time. The current value of the REMF as of March 31, 2021 was $8,865,505 (Appendix IV).

Appendix I. Summary of ongoing research projects led by RRI affiliates

All projects listed are being undertaken by various research affiliates associated with the RRI during 2020-2021. * Indicates projects that have received support from the RRI Competitive Grants Program.

Project Title	Principle Investigators
Mitigation of high voltage powerline construction on mixedgrass prairie	Edward Bork, Cameron Carlyle & Sylvie Quideau
Long-term monitoring of rangeland ecosystem functions on the Mattheis and Kinsella Research Ranches*	Cameron Carlyle
Differentiating and understanding the roles of soil nutrient and soil community heterogeneity on plant growth, carbon storage and biodiversity*	James Cahill
Economic and C-capture benefits of including forages in long-term crop rotations at Breton	Edward Bork, Miles Dick, Sylvie Quideau, Scott Jeffrey, & Dick Puurveen
Site specific control of Canada thistle by drone.	Markus Webber, Edward Bork, John Church, JP Pettyjohn, and 6 others.
Assessment of altered precipitation and defoliation on rangeland EG & S	Cameron Carlyle, Scott Chang, James Cahill, Ben Willing & Edward Bork
Quantifying the carbon balance and associated ecosystem properties at the Mattheis Ranch*	John Gamon
Use of plant growth regulators for enhancing forage grass seed production in NW Alberta	Nitya Khanal & Edward Bork
Precision ranching of cattle: Integrating cattle genomics, grazing behavior, and production	Edward Bork, Carolyn Fitzsimmons, Cameron Carlyle, Graham Plastow, James Cahill, Eric Lamb, John Church, John Basarab, Leluo Guan & Changxi Ling

Effect of adaptive multi-paddock grazing on carbon storage and greenhouse gases	Mark Boyce, Edward Bork, Cameron Carlyle, & others
Quantifying the effects of adaptive multi-paddock grazing on soil carbon sequestration and soil organic matter quality	Kim Schneider, Ira Mandell, James Longstaffe, Edward Bork, James Byrne & Paul Voroney
Survey of cattle rumen microbiome under different grazing systems: Linkage to grazing behavior and productivity	Leluo Guan, Graham Plastow, Edward Bork & John Basarab
Evaluation of grazing management practices that increase pollinators in Alberta's Dry Mixed Grass Prairie*	Cameron Carlyle, Carol Frost, Jessamyn Manson, & Marcus Becker
Comprehensive study of the human prehistory and history of the Mattheis Ranch*	Jack Ives & Kisha Supernant
Using plant traits to assist conservation and management of Alberta's rangelands*	James Cahill
Collaborative development of precision ranching to address climate change issues in cow-calf production*	Cameron Carlyle & John Church
Evaluating the contribution of lichens to Alberta's grassland biological soil crusts through baseline taxonomic research and manipulative grazing and drought experiments*	Cameron Carlyle, Diane Haughland, & Raquel Pino-Podas
Does defoliation affect carbon flow in rangelands? A test at two ecosites at the Mattheis Ranch*	Scott Chang, Edward Bork & Zilong Ma
Interactive impacts of managed pollinators and invasive plants on native plant-pollinator networks and native plant reproductive success*	Carol Frost
Evaluating the efficacy of herbicide indaziflam applied in fall and spring to control downy and Japanese brome in southern Alberta rangeland	Edward Bork, Lisa Raatz, Tanner Broadbent, & Darren Bruhjell

Appendix II. Select presentations by RRI affiliates in 2020-2021

Outreach and promotional activities undertaken in support of the RRI during 2020-2021.

Abbreviated title	Presenter(s)	Venue	Audience(s)	Date
Management differences between AMP and Non-AMP ranchers	Bork	Alberta Conservation Association (webinar)		April 2020
Are managed honey bees altering native pollinator diversity, or their interactions with plants in Western Canadian grasslands?	Worthy	MSc thesis defense (online oral)	Students, researchers, academics, staff	Dec 2020
Vegetation response to fall wildfire in the mixedgrass prairie of AB and SK	Bischoff	MSc thesis defense (online oral)	Students, researchers, academics, staff	Dec 2020
Patterns of non-native plants among native grasslands in AB	Zapisocki	MSc thesis defense (online oral)	Students, researchers, academics, staff	Jan 2021
Species delimitation in the lichen genus, *Cladonia* based on RadSeq data	Pino*, Lewis	British Lichen Society Annual Meeting (online oral)	Students, researchers, academics, public	Jan 2021
Wild licorice control following herbicide application at two growth stages in Mixedgrass prairie, AB	Raatz*, Bork	Society for Range Management Annual Meeting: New Frontiers (online oral)	Ranchers, researchers, resource managers, policy makers, students, government, NGOs, public	Feb 2021
Cattle stocking rates have greater impact on soil carbon than climate in Mixed grassland of SK	Bork*, Raatz, Carlyle, Hewins, Thompson			
Grazing system and legacy effects of cultivation on soil microbial diversity in the Canadian Prairie	Khatri-Chhetri*, Thompson, Quideau, Boyce, Bork, Carlyle			
Woody species control options in pasture	Bork	B.C. Forage Council Association, extension series (online oral)	Ranchers, farmers, government, NGOs	Feb 2021
Can planting trees or soil additives improve soil quality and reduce the damaging greenhouse gas emissions produced by agricultural activities?	Gross	Bentley Lecture Series, University of Alberta (online poster)	Students, academics, researchers, government, NGOs, public	Feb 2021

Linking cattle performance within diverse grazing environments to habitat and diet selection.	Bork, Fitzsimmons	Beef and Forage Research Forum: U of S, SK Stock Growers Association, Gov't of SK (online oral)	Ranchers, researchers, government, policy makers	Feb 2021
Temporal dynamics of plant-soil feedbacks and community consequences during *Bromus inermis* invasion	Salimbayeva	MSc thesis defense (online oral)	Students, researchers, academics, staff	Mar 2021
A comparison of ranch attributes and grazing management practices between AMP and neighbouring (non-AMP) ranches in western Canada	Bork*, Döbert, Grenke, Carlyle, Cahill, Boyce	Alternative Land Use Services (ALUS) Extension Workshop: Adaptive Multi-Paddock Grazing (online oral)	Researchers, ranchers, academics, students, government, NGOs	Mar 2021
Water infiltraion in grazed grasslands	Döbert			
AMP management influences on plant diversity composition and production	Grenke			
Managing grassland grazing to boost soil carbon sequestration	Sobrinho			
Adaptive multi-paddock grazing lowers soil greenhouse emission potential by altering extracellular enzyme activity	Shrestha*, Bork, Chang, Carlyle, Ma, Döbert , Kaliaskar, Boyce			
Effects of grazing management, climate and soil properties on field greenhouse gas flux within grazed grasslands of AB	Ma*, Shrestha, Bork, Chang, Carlyle, Döbert, Sobrinho, Boyce			
AMP grazing effects on soil microbial abundance, biomass and diversity in the Canadian Prairie	Upama*, Carlyle			
Cultivation and grazing impacts on extracellular enzyme activity in Alberta grasslands	Kaliaskar, Shrestha, Carlyle, Bork, Boyce, Chang*			
Alternative ranchers and scientific communication	Dlusskaya			

AMP Economics Overview	Wheeler			
Benefits from AMP grazing - panel discussion	Boyce			
Grassland forage and litter response to wildfire	Bischoff	Update on current rangeland research in AB and SK (webinar)	Ranchers, government, NGOs, researchers, students	Mar 2021
Carbon storage in rangelands of the Canadian prairie	Carlyle			
Cow/calf performance while grazing Mixed grassland varies with predicted RFI (residual feed intake) and cow age	Bork*, Lansink, Moore, Fitzsimmons, Plastow			
Assessing herbicides as a tool for managing annual brome and wild licorice in native rangelands	Raatz*, Bork, Dombro			
Integrating herbicides, fertilization and rotational grazing for weed management in pastures	Bork	BC Forage Council, Extension Series (online oral)	Ranchers, farmers, government, land managers, NGOs, public	Mar 2021
Enhancing soil organic carbon storage through forested buffers and biochar application in agricultural lands	Gross*, Bork, Carlyle, Chang	Soil and Crops Conference (online oral)	Resource managers, researchers, policy makers, government, NGOs, farmers, ranchers, students	Mar 2021
Linking rotational grazing with greenhouse gas dynamics in grassland soils	Bork*, Shrestha	SK PCAP: Prairie's Got the Goods Week (webinar)	Resource managers, ranchers, government, NGOs, researchers, public	Mar 2021
Cattle grazing effects on water infiltration in grassland soils	Döbert			
Cattle genomics & pasture management decisions for productivity, soil carbon and diversity	Carlyle*, Bischoff	Cattle herd genetics and ecosystems goods & services: recruiting study participants (online oral)	Ranchers, researchers	Mar 2021

* indicates the primary presenter where projects have multiple authors credited.

Appendix III. RRI Financial Statement of Actuals, April 1, 2020 to March 31, 2021

	Actuals
****Opening Balance**	**$0.00**
Revenue	
Lease/Utility (Powerline) Revenue	$ 527,320.90
Total Revenue	**$527,320.90**
Expenditures	
Transfer to Endowment	$500,000.00
Property Taxes	$2,617.92
Supplies	$ 3,832.75
Travel	$ 1,350.00
Communications (telephone)	$657.72
Repair and Maintenance	$1,006.33
Rentals and Leases	$500.00
Total Expenditures	**($509,964.72)**
Net Balance	**$17,356.18**

*** In 2019-2020, the closing balance for the RRI Operating Budget was $82,924.95. Due to the Government of Alberta's directive that funds could not be carried forward, the opening balance is shown as $0.00. While these funds are not lost, they remain unavailable to the RRI until this directive is lifted.*

Note: This summary excludes U of A (in-kind) support to the RRI through academic staffing, which is currently valued at over $250,000 annually

Appendix IV. Rangeland Ecology and Management Fund Financial Statement of Actuals, April 1, 2020 to March 31, 2021

	Actuals
Principal	
Opening Balance (April 1, 2020)	$ 7,412,843.85
Current Year Contributions	$500,000.00
Capitalized Investment Earnings	$952,661.38
Closing Balance (March 31, 2021)	**$8,865,505.23**
Spending Allocation (Revenue)	
Opening Balance (April 1, 2020)	$64,251.67
Current Year Endowment Spending Allocation	$305,021.47
Total Revenue	**$369,273.14**
Current Year Expenditures	
Faculty salary[1]	$71,168.76
Support staff	$95,993.80
Rental Expenses	$4,185.40
Research Projects	$17,690.00
Summer student assistant	$2,212.63
Equipment & Supplies	$27, 121.54
Total Expenditures	**($218,312.13)**
Closing Balance After Encumbrances	**$150,961.01**

[1] The faculty staff salary covered by the endowment since 2018/19 is to support the salary and benefit of the Mattheis Chair in Rangeland Ecology and Management. As expected, the proportion has increased in subsequent years and will continue to increase over time.