

RANGELAND RESEARCH INSTITUTE (RRI)

2018-2019 Annual Report



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

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Cover photo: Western Meadowlark at Mattheis Research Ranch. Photo by Caroline Martin.

1. Introduction

Native grasslands are some of the most threatened ecosystems in the world and are at risk of being lost due to land conversion for urban, industrial or agricultural uses. In 2011, Edwin and Ruth Mattheis recognized the importance of these critical landscapes and generously donated their 5000 ha ranch to the University of Alberta, of which 80% consists of native grasslands. Arising from the donation, The Faculty of Agricultural, Life and Environmental Sciences (ALES) established the Rangeland Research Institute (RRI). The Mattheis Research Ranch is located in southeastern Alberta and is a key location for contributing to our understanding of rangeland management and ecology, joining other important legacy grassland research locations: Onefour and Stavelly, as well as the U of A Roy Berg Kinsella Research Station.



Scarlet winged lichen moth rests on scarlet mallow at Mattheis Ranch, July 2018.

The mandate of the RRI is threefold and includes research, teaching, and outreach. Researchers affiliated with the RRI conduct a variety of research to improve our knowledge about major themes related to rangelands, including grazing and forage production, the environmental goods and services provided by grasslands, and industrial and human impacts. The RRI contributes to teaching of students and preparing them to engage in professions related to rangeland management, training those who will be leaders in government policy, beef production and the ranching industry, and land and resource management. Thirdly, the RRI participates in communicating science at a variety of outreach events to stakeholders, the ranching community, government, industry, researchers and the general public, thereby improving our collective understanding of rangelands and the goods and services they provide.

This report summarizes key activities undertaken by the RRI from April 1, 2018 through March 31, 2019. 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

Grasslands and rangelands are immensely resilient to drought having evolved with relatively low growing season rainfall, fire and grazing by large herbivores. In 2018, Alberta continued to experience below average growing season precipitation and areas of the province were once again affected by wildfires. The value of rangelands to the cattle industry is vital because livelihoods depend on their ability to produce forage; however, less well understood are the goods and services rangelands provide to society as a whole. While a wide array of research topics are being conducted by the RRI, one of the main focal areas being investigated is the quantification of these environmental goods and services such as wildlife habitat and biodiversity, provision of habitat for native pollinators, resilience of plant communities to entry by invasive species, among others, and determining how these link to cattle grazing.

Climate change is also a major concern for society, and governments worldwide are attempting to slow the effects of climate change at global, national, and regional levels by implementing policies and incentives to change societal behaviours responsible for greenhouse gas increases. Researchers affiliated with the RRI are determining the ability of rangelands to offset these increases, such as quantifying carbon storage in grasslands, determining greenhouse gas production under grazed and ungrazed conditions, and improving our understanding of carbon cycling and the role of underlying soil microbial communities. Additional work is examining the linkage between drought and grazing, as well as other disturbances, such as grassland recovery following wildfire, and the best management practices necessary to mitigate effects of industrial development. Many of these projects are listed in Appendix I.

In 2018-19, a total of 89 individual researchers, including 19 principle scientists, 14 graduate students, 44 undergraduate students, as well as 12 visiting scientists, post-doctoral fellows, and senior technicians, spent time on the Mattheis Research Ranch, spending 725 person-days at the facility. Researchers were mostly from the Faculty of ALES (Agricultural, Life and Environmental Sciences; Depts. of Agricultural, Food and Nutritional Sciences & Renewable Resources) as well as the Faculty of Science (Depts. of Biological Sciences & Earth and Atmospheric Sciences) and the Faculty of Arts (Anthropology). Other groups using the Mattheis Ranch included Thompson Rivers

University, Agriculture and Agri-Food Canada, Alberta Environment and Parks, the Alberta Biodiversity Monitoring Institute, and the University of Manitoba.

The Roy Berg Kinsella Ranch was used by 33 researchers for a total of 323 person days. Researchers included 9 principle scientists, 5 graduate students, 17 undergraduate students, and 2 senior technicians. Most researchers were from Faculty of ALES (Depts of Agricultural, Food and Nutritional Sciences & Renewable Resources) and Faculty of Science (Dept. of Biological Sciences). Other groups using Kinsella Ranch include the University of Calgary and Thompson Rivers University.

The Mattheis Ranch, located in the Dry Mixedgrass ecoregion, and the Roy Berg Kinsella Ranch, located in the Central Parkland region, are two vital research resources having distinct and diverse soil and plant communities, topography, climate, as well as grazing by beef cattle herds. One or both ranches are primary locations for projects being conducted by RRI-affiliated researchers or are one of several locations being assessed across western Canada. Several researchers are also continuing the historical rangeland research legacy of the Onefour and Stavely Research Stations by including them as a study location in their projects. Owing to the Memorandum of Understanding in 2016, the University of Alberta and Alberta Environment and Parks have partnered to ensure that these stations continue to be used for research. In order to test research questions under a wide variety of environments and conditions, researchers also use private and public lands widely distributed across Alberta, Saskatchewan, and Manitoba, thereby ensuring the information gathered is relevant to ranchers, industry, and stakeholders.



Mattheis Ranch. July 2018

3. Research Profiles

Effects of industrial linear landscape features on grassland songbirds

Prepared by Dr. Edward Bork, University of Alberta

One of the most threatened habitats globally is grasslands, which continue to experience widespread declines due to land use conversion and fragmentation, including through industrial development. Grassland loss, which ranges from 57% in the Dry Mixedgrass region, to nearly 90% in the Aspen Parkland of Alberta, has negatively affected many bird species that rely on these critical habitats for survival.

A research project that recently concluded at the University of Alberta Mattheis Research Ranch in southeastern Alberta assessed the impact of high voltage transmission line construction on birds in this region of the Mixedgrass Prairie. Early surveys of bird diversity from 2012 through 2013 indicated more than 100 different bird species were found across a network of 168 sample plots distributed across the 3500 hectare study area. Select sample plots from this initial investigation were resampled during the spring breeding seasons of 2016 and 2017 by Caroline Martin, an MSc student in the Department of Renewable Resources working with Drs. Scott Nielsen and Edward Bork, following the construction of two high voltage transmission lines (2014-15) built to redistribute power regionally across the province.



MSc student Caroline Martin watching birds at sunrise at Mattheis Ranch.



Baird's sparrow at Mattheis Ranch. Photo by Caroline Martin.

Field data on bird richness and composition from before and after construction were used to evaluate the effects of transmissions lines, as well as primary and secondary highways traversing the study area. Overall, bird species richness generally did not differ between the pre- and post-construction sampling periods, but tended to be greater in plots near highways. Plots in close association with transmission lines tended to have more corvids (e.g., ravens, crows and magpies), while perching songbirds

were more common in non-disturbed areas further from transmission lines. Among six focal grassland bird species examined, divergent responses were evident to the new transmission lines, with some positively affected (Baird’s sparrow, grasshopper sparrow, long-billed curlew), some negatively (Brewer’s blackbird, Eastern kingbird), and others unaffected (marbled godwits).



Collecting plant data at Mattheis Ranch. Photo by Caroline Martin.

A second component of this study examined the effects of transmission lines on bird mortality. Using search surveys of transects located directly under lines, adjacent to highways, and in control (no development) areas, a total of 47 mortalities were found under transmission lines, 9 adjacent to roads, and none in open grassland. When these results were combined with the results of concurrent detectability and scavenging trials, an estimated 1,948 birds were projected to perish during each spring migration. Given the

amount of transmission lines within the Mixedgrass Prairie (3800 linear km), and potential for mortality during both the spring and fall migrations, estimates of mortality in this region may exceed 192,000 birds. These findings highlight the need for more information on the impact of habitat loss and fragmentation, including from industrial disturbance, on bird communities across the prairie region.



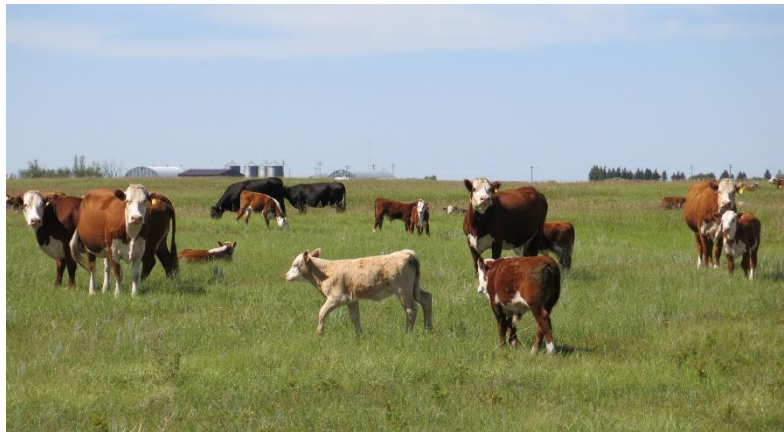
Left: Clay coloured sparrow; Right: Western Meadowlark. Photos by Caroline Martin.

Assessment of rumen microbiota in beef cattle with different feed efficiency on grazing rangeland

Prepared by Dr. Leluo Guan, University of Alberta

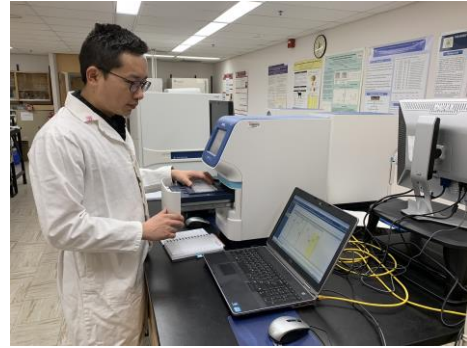
Sustainability is critical for the long-term success of the Canadian beef industry. This requires improvement in production efficiency as well as reduced environmental impact. In Canada, most cow-calf producers utilize pasture grazing during the summer to maintain favorable growth with lower costs. Recent studies from Dr. Guan's group have demonstrated a strong relationship between the rumen microbiota and both feed efficiency and methane emission of feedlot beef cattle. However, the role of the rumen microbiota when cattle are grazing on pasture has not been studied due to the challenges of collecting rumen samples and measuring performance traits (such as feed efficiency and methane emission). The objectives of this study were to characterize variation in rumen microbiota and fermentation profiles in grazing cattle and to assess whether they are associated with variation in feed efficiency measured in drylot.

Because residual feed intake (RFI, one measure of feed efficiency) is a moderately heritable trait, this project assessed rumen microbiota of 60 heifers who were selected to be divergent in terms of feed efficiency. Briefly, the high RFI (inefficient) heifers were daughters of high RFI cows that were bred with high RFI bulls, while low RFI (efficient) heifers were from low RFI cows crossed with low RFI bulls. The RFI of these 60 heifers was tested under drylot conditions with a conventional barley silage diet at the Lacombe Research Centre and rumen fluid samples were taken at the end of the RFI test. These heifers were then transferred to the Mattheis Research Ranch, where they grazed on forage oats in mid-summer. Rumen fluid was collected from 8 high RFI and 8 low RFI heifers after grazing.



Mattheis Ranch, July 2018. Photo by Lisa Raatz.

First, we compared the concentration of short chain fatty acids (volatile fatty acids (VFA)) in the rumen between the two management systems and different RFI groups. The VFA profiles showed no significant difference in total VFA or individual VFAs. However, grazing cattle had a lower acetate:propionate ratio in the rumen compared to drylot animals for both efficient and inefficient cattle. The rumen microbial populations, including bacteria, archaea, protozoa, and fungi, were also compared using a molecular based method. Briefly, microbial populations were evaluated using quantitative polymerase chain reaction (qPCR) to measure the copy number of unique marker genes for each microbial group. Results showed that inefficient cattle had fewer rumen protozoa, more rumen bacteria and a trend for more rumen methanogens when grazing on pasture compared to when they were fed in drylot (Figure 1). However, this difference was not observed within the efficient cattle. These results suggest that rumen microbiota may be more stable (and adaptable) in efficient cattle between production environments, making them more sustainable overall.



MSc student Junhong Liu measures the microbial population of cattle rumen fluid using qPCR techniques.

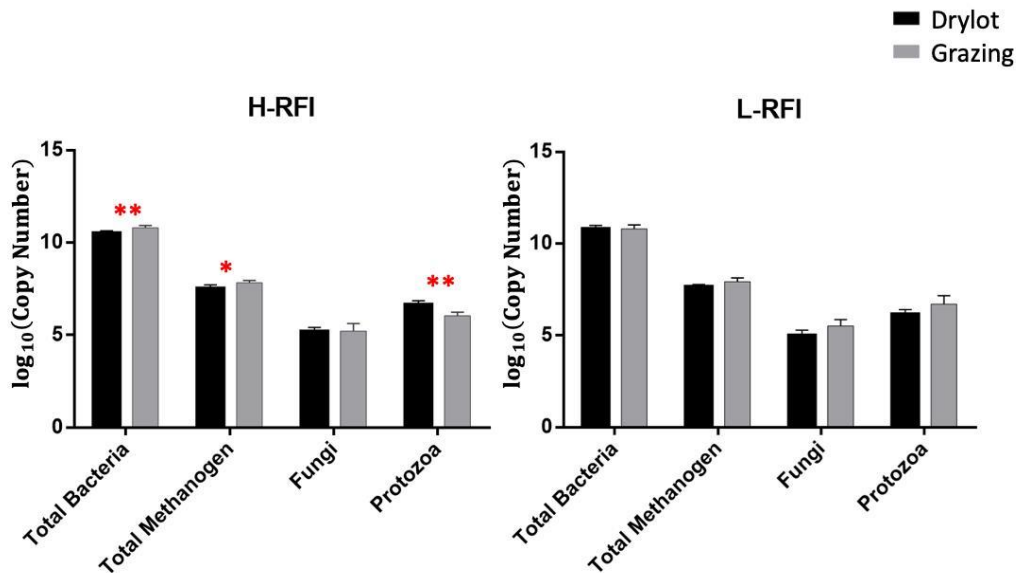


Figure 1. Determination of microbial populations using qPCR. Results showed that the rumen microbiota of efficient (L-RFI) and inefficient (H-RFI) heifers responded differently to the environment change.

** : $p < 0.05$
 * : $0.05 < p < 0.1$

In conclusion, rumen microbiota profiles of cattle grazing on pasture were different at both the population and compositional level compared with those in the drylot. Such differences may lead to altered microbial functions and warrant further study. In addition, the rumen microbiota of efficient and inefficient cattle responded uniquely when the feeding system was changed from drylot to open pasture grazing. These findings add to our understanding of the rumen microbiota and its function in grazing beef cattle. This knowledge will help develop management strategies that optimize beef production efficiency and reduce the environmental impact of cattle raised within these production systems in western Canada.

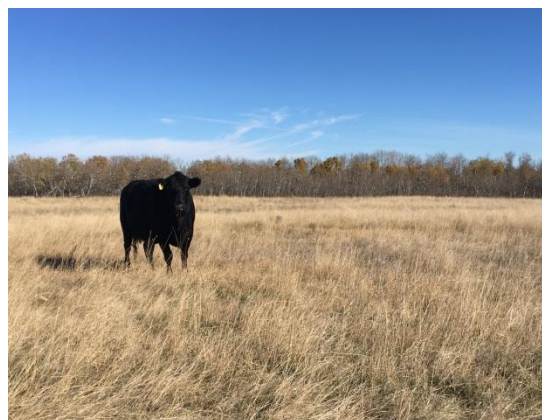


Mattheis Ranch, July 2018. Photo by Lisa Raatz.

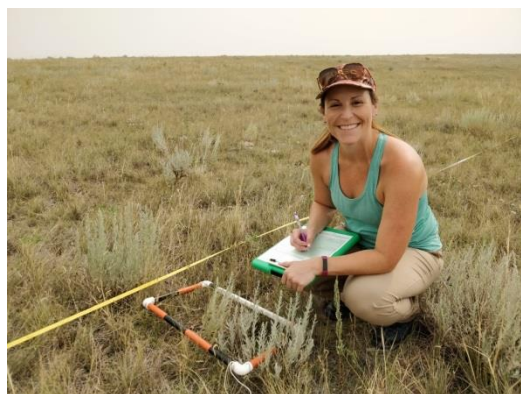
Assessing range health in relation to grazing systems used on Alberta ranches

Prepared by Dr. Edward Bork, University of Alberta

Ranchers are well known for being highly individualized operators that employ a wide variety of grazing management practices, which in turn, may influence the condition of grasslands. Management practices include grazing systems, which characterize where, how often and how intense individual pastures get used during a particular grazing season. Range health is a contemporary method used to report on pasture condition that integrates measures of vegetation composition, structural diversity, hydrologic function, site stability, and threats from invasive weeds.



One of several ranch locations taking part in the study. Photo by Kristine Dahl.



MSc student Kristine Dahl assessing range health, July 2018.

Kristine Dahl recently explored the relationship between grazing systems and range health, including how this may vary across Alberta's growing environments, while completing her MSc thesis under the joint supervision of Drs. John Parkins and Edward Bork at the University of Alberta.

After recruiting 28 willing rancher participants, Kristine travelled across the province in 2016 conducting in-person surveys of the factors influencing rancher management behavior, and also undertook biophysical range health surveys on 3-4 representative pastures across each operation. Pastures included native grasslands and introduced (seeded) pastures, as well as those



Northern Fescue Sub-Region near Castor, AB. Photo by Kristine Dahl.

under forested vegetation. Using specific information on the length of grazing periods and subsequent rest intervals, pastures were characterized as either continuous, slow rotation or fast rotation grazing, with fast rotation further separated into those producers self-described as holistic managers. When range health outcomes were compared among pastures exposed to different grazing systems, few differences were detected. Instead, range health scores generally declined with increasing aridity of the environment and greater levels of observed forage use. Forests were generally in greater health than grasslands, but also exhibited high susceptibility to declines in condition with even low to moderate use. Continuous grazing systems were more prevalent in arid grasslands of SE Alberta, with introduced pastures exposed to continuous grazing more likely to experience decreases in health with increasing aridity. Compilation of the sociological data provided by producers suggested that ranchers across the study region had more in common as grazing practitioners than differences. Several key social themes were identified. Regardless of the type of pasture management system, producers had a strong sense of identity and independence, a belief in what they were doing, and a need to remain financially viable. Although we expected more tension between producers who approached pasture management differently we did not observe these tensions. Instead, producers appeared to accept the diversity of motives and approaches to management found across the ranching community. Results of this study provide direction for further enquiry into the sociological factors regulating rancher behavior, and suggest a need to understand how this translates into differences in environmental outcomes, specifically range health.



Central Parkland Sub-Region near Kitscoty, AB. Photo by Kristine Dahl.

4. Capacity Building

The Rangeland Research Institute continued to build research capacity by expanding the network of range management and ecology research-affiliates in 2018. A call for Competitive Grant proposals was made this past year and a larger sum was offered in order to cover graduate student salaries more fully. One of RRI's goals is to contribute to training highly qualified personnel, and graduate student training is now listed as one of the conditions for funding. As expected, the call attracted a larger number of proposals and six were selected through a peer-review process (Table 4.1). In 2019, no formal call for proposals was made, however, one proposal was invited and was accepted to begin May 2019.

AltaLink's generous donation of a \$655,000 endowment to the Faculty of ALES in 2016 has also increased research capacity by funding an M.Sc. student in Grassland Disturbance Ecology for two years. In 2018, the award was given to M.Sc. student, Sara Barszczewski, whose research project looks at the impacts of litter removal and seasonal clipping and compaction on soil and vegetation. Sara's research aims to determine soil and vegetation response to select mechanisms derived from Adaptive Multi-Paddock grazing systems along a climate gradient within southern Albertan rangelands.

The RRI bid a fond farewell to Don Armitage and his wife, Sandra, who both retired in June to return to Manitoba and continue ranching with one of their sons and his family. Don has been the ranch foreman at Mattheis Research Ranch since before Edwin and Ruth donated their land to the U of A in 2010. However, Marcel Busz and his family were warmly welcomed when they moved into the house in May; Marcel is the new Mattheis Ranch foreman and his arrival in May allowed for some overlap time with Don.



Sara presents aspects of her research at the RRI-AAFC-SRM Soil Health Field Day in Stavely, AB in July 2018.



Don Armitage at Mattheis Ranch, June 2017. Photo by Cait Wills.



L-R: Dr. Barry Irving, Dr. Edward Bork, and rancher, Jim Bauer. ENCS 471 Field school, Sept 2017.

Also in June, Dr. Barry Irving, who has been with the U of A for 35 years in a variety of capacities but most recently in the role of off-site research stations manager, retired to pursue an enlarged role within the Society for Range Management professional organization. Vern Erickson, already a long-time Roy Berg Kinsella Ranch employee has taken on the off-site ranches manager role encompassing both Kinsella and Mattheis Research Ranches. James Willis has expanded his current role as the manager of the U of A South

Campus Swine Research Facility to include providing management oversight to all the research units on South Campus, as well as the off-site ranches. Both Don and Barry will be greatly missed, however, we wish them well and look forward to working closely with Marcel, Vern, and James!

Table 4.1. Research projects funded by the RRI in 2018

Researcher(s)	Project Title
Cahill	Using plant traits to assist conservation and management of Alberta's rangelands
Carlyle, Church	Collaborative development of precision ranching to address climate change issues in cow-calf production
Carlyle, Haughland, Pino-Podas	Evaluating the contribution of lichens to Alberta's grassland biological soil crusts through baseline taxonomic research and manipulative grazing and drought experiments
Chang, Ma	Does defoliation affect carbon flow in rangelands? A test at two ecosites at the Mattheis Ranch
Frost	Interactive impacts of managed pollinators and invasive plants on native plant-pollinator networks and native plant reproductive success
Gamon	Quantifying rangeland carbon balance

5. Communications

The Rangeland Research Institute continued to communicate research findings to our stakeholders in 2018 and partnered with many different organizations to extend research results. Our affiliated researchers and graduate students took the opportunity to speak about their research at field tours, conferences, workshops, and seminars to reach a wide audience including ranchers, producers, land and resource managers, government and non-government organizations, policy makers, industry, academics, students, and interested members of the public (Appendix II). Some of these activities are described below.

The RRI communicated to the general public about the importance of native prairie grasslands, the ecosystem goods and services they provide for society, as well as information about the Mattheis Ranch and the research being conducted. For the second year, the RRI returned to the Telus World of Science for 'Research Day' with an interactive display. Children and adults enjoyed looking at native grass seeds and lichens under the microscope. Our live plant display (particularly our prairie crocus) attracted many families to our table and provided a segway into conversations about grazing, protecting grasslands & biodiversity, and the research being conducted at Mattheis Ranch. The Mattheis Ranch hosted a group of 25 Kindergarten to Grade 12 school teachers aspiring to learn more about grasslands and the services they provide. The RRI provided a field tour for teachers to learn about conservation issues, industrial and agricultural uses of the land, and strategies to take these ideas back to their students to incorporate as part of their curriculum about the environment.



Dr. Edward Bork talks about RRI research and importance of grasslands with K-12 teachers touring Mattheis Ranch, May 2018.

The RRI interacted with ranchers at several venues in 2018, including an information table at a Fire Recovery workshop held in Hilda, AB in May organized by Drs. Cameron Carlyle (U of A) and Eric Lamb (U of S). The workshop provided ranchers with

information about grassland recovery following fire, but also allowed ranchers whose land had been affected by the Hilda and Burstall wildfires to sign up to participate in a collaborative fire recovery research project, of which the AB government has provided funding for the Alberta portion of the project. The RRI was invited to give research updates primarily to ranchers at the 15th Annual Southern Alberta Grazing School for Women in Stavely as well as at the Forage to Beef Demo Days held in Cremona and at the Waldron Grazing Co-op.



PhD students, Baka Amgaa (centre) and Ahsan Rajper (right) talk about their research assessing effects of drought and grazing on root growth and soil microbial communities at the Range Field Day in Oyen, July 2018.

The 2016 Memorandum of Understanding between Alberta Environment and Parks and U of A marked an important agreement to continue the legacy and history of research at the Onefour and Stavely Research stations. RRI affiliated researchers have been conducting research on both important land bases and continue to use these ranches for their research. In July, the RRI partnered with Agriculture and Agri-Food Canada and Society for Range Management to conduct joint field tours at Onefour and

Stavely, as well as Oyen (additionally in partnership with Chinook Applied Research Association). The field tours provided an opportunity for the RRI to build relationships with local area ranchers and land managers, extend research results and discuss range-related issues of concern which warrant further investigation. RRI researchers were given opportunity to speak about their projects and share some preliminary results from their local research sites.

The RRI and its research-affiliates also communicated research results to diverse audiences, including the academic research community, at several conferences and symposia. Dr. Cameron Carlyle, as well as his students, presented research findings to the international science community at the American Geophysical Union in Washington, DC. Dr. Carlyle attended the Soil Health Institute workshop in Chicago, IL

as part of the RRI participation in the North American Project to evaluate soil health measurements. Soil biophysical and climate data from Kinsella, Onefour, and Stavely ranches has been included as part of a larger database of soils across North America. Dr. Edward Bork participated in the Saskatchewan Prairie Conservation Action Plan, 'Prairies Got the Goods' webinar series and spoke about [Does Livestock Grazing Regulate Soil Carbon in Northern Temperate Grasslands?](#) to a diverse audience.

In May 2018, the Mattheis Ranch hosted grassland songbird researcher, Dr. Nicola Koper and her team from University of Manitoba, as well as CBC Calgary reporter and producer Allison Dempster. The group recorded birdsong and wrote a story for CBC news, '[Songbirds channel their inner George Clooney to attract a mate, but is it working?](#)' (Posted July 21, 2018). The story highlights the effects of industrial noise on the risks it poses to breeding grassland birds.

Research affiliates also communicated their research by publishing in refereed journals, many of which are listed in Table 5.1. Publishing ensures that the body of science is continuously building on previous knowledge and permanently documents research findings. In an age of social media and the ease with which unverified claims can be made, publishing in peer-reviewed journals provides a rigorously evaluated high standard.

Other outreach activities presented by the RRI-affiliated researchers in 2018-19 are listed in Appendix II. These outreach activities increase the profile of the RRI, the University of Alberta, and its Research Ranches by extending knowledge about grasslands and the goods and services they provide, including opportunities for grazing management, and rangeland ecology in general, to a large and diverse audience.



Dr. Walter Willms talks about the Onefour Research stations long term and historical research at the Soil Health Field Day at Onefour, July 2018.

Table 5.1. Select peer-reviewed publications authored by RRI affiliated researchers between Oct 2017 and March 2019

- Le, K.D., Carlyle, C.N. Mar 2019. A non-native agronomic legume (*Astragalus cicer* L.) alters multiple ecosystem-services in mixed prairie grassland. *Biological Invasions* 21(3): 935-946.
- Kwak, J.H., Lim, S.S., Baah-Acheamfour, M., Choi, W.J., Fatemi, F., Carlyle, C., Bork, E.W., Chang, S.X. Feb 2019. Introducing trees to agricultural lands increases greenhouse gas emission during spring thaw in Canadian agroforestry systems. *Science of the Total Environment*. 652: 800-809.
- Gholizadeh, H., Gamon, J.A., Townsend, P.A., Zygielbaum, A., Helzer, C.J., Hmimina, G.Y., Yu, R., Moore, R.M., Schweiger, A.K., Cavender-Bares, J. Feb 2019. Detecting prairie biodiversity with airborne remote sensing. *Remote Sensing of Environment* 221:38-49.
- Liu, J., Lansink, N., Bork, E., Carlyle, C., Plastow, G., Guan, L. Dec 2018. Assessment of rumen microbiota in beef cattle with different feed efficiency grazing on an oat pasture. *J. of Animal Science*. 96: 192. Supplement: 3 Meeting Abstract: PSI-39
- Cantalapiedra-Hijar, G., Abo-Ismael, M., Carstens, G.E., Guan, L.L., Hegarty, R., Kenny, D.A., Mcgee, M., Plastow, G., Relling, A., Ortigues-Marty, I. Dec 2018. Review: Biological determinants of between-animal variation in feed efficiency of growing beef cattle. *Animal* 12(Special Issue): 321-335.
- Chuan, X.Z., Carlyle, C.N., Bork, E.W., Chang, S.X., Hewins, D.B. Nov 2018. Long-term grazing accelerated litter decomposition in northern temperate grasslands. *Ecosystems*. 21(7): 1321-1334.
- Grenke, J., Cahill Jr, J.F., Bork, E.W. Oct 2018. Quantification of multi-use trail effects using a rangeland health monitoring approach and Google Earth. *Natural Areas Journal*. 38(5): 370-379.
- Dettlaff, M.A., Marshall, V., Erbilgin, N., Cahill, J.F. Aug 2018. Root condensed tannins vary over time, but are unrelated to leaf tannins. *AOB Plants* 10(4): ply044.
- Potter, B., Baichtal, J.F., Beaudoin, A.B., Fehren-Schmitz, L., Haynes, C.V., Hollidays, V.T., Holmes, C.E., Ives, J.W., Kelly, R.L., Llamas, B., Mahli, R.S., Miller, D.S., Reich, D., Reuther, J.D., Schiffels, S., Surovell, T.A. Aug 2018. Current evidence allows multiple models for the peopling of the Americas. *Science Advances* 4(8): eaat5473.
- Ma, B., Cai, Y.J., Bork, E.W., Chang, S.X. Jul 2018. Defoliation intensity and elevated precipitation effects on microbiome and interactome depend on site type in northern mixed-grass prairie. *Soil Biology & Biochemistry*; 122: 163-172.
- Shrestha, B.M., Chang, S.X., Bork, E.W., Carlyle, C.N. Jun 2018. Enrichment planting and soil amendments enhance carbon sequestration and reduce greenhouse gas emissions in agroforestry systems: a review. *Forests*; 9(6): 369.
- Wang, R., Gamon, J.A., Schweiger, A.K., Cavender-Bares, J., Townsend, P.A., Zygielbaum, A., Kothari, S. Jun 2018. Influence of species richness, evenness, and composition on optical diversity: A simulation study. *Remote Sensing of Environment* 211: 218-228.

- Bennett, J.A., Cahill, J.F. Jun 2018. Flowering and floral visitation predict changes in community structure provided that mycorrhizas remain intact. *Ecology* 99(6): 1480-1489.
- Pyle, L., Hall, L.M., Bork, E.W. Jun 2018. Linking management practices with range health in northern temperate pastures. *Canadian J. of Plant Science*; 98(3): 657-671.
- Broadbent, T.S., Bork, E.W., Willms, W.D. Jun 2018. Divergent effects of defoliation intensity and frequency on tiller growth and production dynamics of *Pascopyrum smithii* and *Hesperostipa comata*. *Grass and Forage Science*. 73(2): 532-543.
- Lyseng, M.P., Bork, E.W., Hewins, D.B., Alexander, M.J., Carlyle, C.N., Chang, S.X., Willms, W.D. Jun 2018. Long-term grazing impacts on vegetation diversity, composition, and exotic species presence across an aridity gradient in northern temperate grasslands. *Plant Ecology*. 219 (6): 649-663.
- Lim, S.S., Baah-Acheamfour, M., Choi, W.J., Arshad, M.A., Fatemi, F., Banerjee, S., Carlyle, C.N., Bork, E.W., Park, H.J., Chang, S.X. May 2018. Soil organic carbon stocks in three Canadian agroforestry systems: From surface organic to deeper mineral soils. *Forest Ecology & Management* 417: 103-109.
- Wang, R., Gamon, J.A., Cavender-Bares, J., Townsend, P.A., Zygielbaum, A., Mar 2018. The spatial sensitivity of the spectral diversity-biodiversity relationship: an experimental test in a prairie grassland. *Ecological Applications* 28(2): 541-556.
- Thomas, B.W., Gao, X.L., Zhao, M.L., Bork, E.W., Hao, X.Y. Mar 2018. Grazing altered carbon exchange in a dry mixed-grass prairie as a function of soil texture. *Canadian Journal of Soil Science*. 98(1): 136-147.
- Potter, B., Beaudoin, A.B., Haynes, C.V., Holliday, V.T., Holmes, C.E., Ives, J.W., Kelly, R.L., Llamas, B., Mahli, R.S., Miller, D.S., Reich, D., Reuther, J.D., Schiffels, S., Surovell, T.A. Mar 2018. Arrival routes of first Americans uncertain. *Science* 359(6381): 1224-1225.
- Abo-Ismael, M.K., Lansink, N., Akanno, E., Karisa, B.K., Crowley, J.J., Moore, S.S., Bork, E., Stothard, P., Basarab, J.A., Plastow, G.S. Feb 2018. Development and validation of a small SNP panel for feed efficiency in beef cattle. *Journal of Animal Science*. 96(2): 375-397.
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6. Strategic Advisory Council

While there was no SAC annual meeting held in 2018, a 2017-18 Annual Report was prepared and shared with SAC members. The current composition of the SAC as of March 31, 2019 is provided in Table 6.1. Notably, the RRI lost an important SAC member at the passing of Jerry Brunen in 2018. Western Sky has extended an invitation to all those who worked with and alongside Jerry to a land naming ceremony in June as a fitting tribute to Jerry's life and passion for land conservation. We will certainly miss the insight and wisdom he provided to the RRI.

Table 6.1. Members of the RRI Strategic Advisory Council, March 2019.

Name	Position, Agency	Location
Barry Adams*	Head, Rangeland Resource Management Program (Retired) <i>Alberta Environment and Sustainable Resource Development</i>	Lethbridge, AB
Dr. Stan Blade	Dean, Faculty of Agricultural, Life & Environmental Sciences, <i>University of Alberta</i>	Edmonton, AB
Dr. Edward Bork	RRI Director (on leave); Professor and Mattheis Chair in Rangeland Ecology & Management, <i>University of Alberta</i>	Edmonton, AB
Dr. Cameron Carlyle	Assistant Professor, Acting RRI Director, <i>University of Alberta</i>	Edmonton, AB
Cherie Copithorne- Barnes	Producer and Chief Executive Officer, <i>CL Ranches Ltd.</i>	Jumping Pound, AB
Edwin Mattheis	Producer (Retired)	Calgary, AB
Ruth Mattheis	Producer (Retired)	Calgary, AB
Karen Raven	Agriculture Land Use Specialist, <i>Alberta Agriculture and Rural Development</i>	Edmonton, AB
Karin Schmid	Beef Production Specialist, <i>Alberta Beef Producers</i>	Calgary, AB
Josie Van Lent	Dean, Agricultural Sciences & Human Service, <i>Lakeland College</i>	Vermillion, AB
Dr. Walter Willms	Researcher (Emeritus), <i>Agriculture & Agri-Food Canada</i>	Lethbridge, AB
Dave Zehnder	Producer; Program Coordinator, <i>Ecological Services Initiative</i>	Invermere, BC

* Chair of RRI Strategic Advisory Council

7. Financial Overview

Operations of the RRI are largely supported by non-agricultural income derived from the Mattheis Research Ranch. The 2018-2019 financial statement for the RRI is shown in Appendix III and summarizes revenue and expenses. Revenue is generated from surface leases associated with oil/gas extraction and utility (powerline) activity. Expenses include costs associated with extension and communications, RRI operational and administrative costs, and secondary research support and capacity building.

The Rangeland Ecology and Management Fund (REMF) was established as an endowment in 2015, and included major funding contributions from powerline construction, a contribution from the Alberta Beef Producers, and significant contributions associated with the placement of a conservation easement on the Mattheis Research Ranch in partnership with Western Sky Land Trust. The current value of the REMF as of March 31, 2019 was \$6,561,476.09 (Appendix IV). In 2018-19, \$800,000 was transferred from the RRI Operations budget to the REM Endowment Fund in order to build the principle and further increase long-term research capacity. The spending allocation for the fund comes from interest generated by the principle and allows the RRI to award research funding through the Competitive Grants Program. In order to offset operational budget shortfalls, Department of AFNS is taking a proportion of faculty staff salaries from the endowment spending allocation commencing in 2018-19. This proportion is expected to increase in future years.

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 2018-19. * 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
Seedbank dynamics in rangelands relative to disturbance history	Edward Bork & Linda Hall
Avi-fauna responses to land use disturbance in mixedgrass prairie	Scott Nielsen
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
Defoliation and altered precipitation effects on forage agronomy	Edward Bork
Defoliation and altered precipitation effects on soil microbial communities on the Mattheis Ranch*	Scott Chang
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 (continued)*	John Gamon
Beef and biodiversity	Dan Farr, Edward Bork, Cameron Carlyle, James Cahill, Tim McCallister & Mike Alexander

GHG assessment in grasslands under contrasting grazing regimes	Cameron Carlyle, Edward Bork & Scott Chang
Grazing management and range health	Edward Bork & John Parkins
Wildfire recovery in the dry mixedgrass prairie	Cameron Carlyle
Effect of adaptive multi-paddock grazing on carbon storage and greenhouse gases	Mark Boyce, Richard Teague, Cameron Carlyle, Edward Bork & others
Nutrient cycling in rangelands under grazing regimes	Daniel Hewins, Edward Bork, Cameron Carlyle & Scott Chang
Assessment of rumen microbiota in beef cattle with different feed efficiency on grazing rangeland*	Leluo Guan, Cameron Carlyle, & Graham Plastow
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 & Zilong Ma
Interactive impacts of managed pollinators and invasive plants on native plant-pollinator networks and native plant reproductive success*	Carol Frost

Appendix II. Select presentations by RRI affiliates in 2018-2019

Outreach and promotional activities undertaken in support of the RRI during 2018-2019.

Abbreviated title	Presenter(s)	Venue	Audience(s)	Date
Producer management and industrial disturbance influences on grassland seed banks in AB	Pyle, Bork, Hall	Mixed Grass Forum: Invasive species; Medicine Hat, AB	Researchers, government, ranchers, resource managers	Apr 2018
Impact of multi-paddock grazing on plant diversity and homogenization in Western Canada	Grenke, Boyce, Cahill	Mixed Grass Forum: Invasive species; Medicine Hat, AB	Researchers, government, ranchers, resource managers	Apr 2018
Invasive species related research at Mattheis Research Ranch	Raatz, Bork	Mixed Grass Forum: Invasive species; Medicine Hat, AB	Researchers, government, ranchers, resource managers	Apr 2018
Grazing effects on soil microbial communities and greenhouse gases emission in Alberta's rangelands	Stolnikova	MSc defense; Edmonton, AB	Researchers, students	April 2018
Influence of disturbance on grassland seed banks in the Aspen Parkland and Dry Mixedgrass Prairie	Pyle	PhD defense; Edmonton, AB	Researchers, students	April 2018
Roots matter: invasive forage grasses, soil microbial communities, and grassland ecosystem services	Lamb	RRI special seminar; Edmonton, AB	Researchers, students	April 2018
Table - Rangeland Research Institute	Raatz, Dahl	Telus World of Science: Meet-a-Researcher; Edmonton, AB	Public, youth	May 2018
U of A grassland fire recovery proposal	Carlyle, Bischoff	Fire Recovery workshop; Hilda, AB	Ranchers, government	May 2018
Table - Rangeland Research Institute	Raatz	Fire Recovery workshop; Hilda, AB	Ranchers, government	May 2018
Breeding songbird responses to roads and powerlines in AB grasslands	Martin	MSc defense; Edmonton, AB	Researchers, students	May 2018

<i>Field tour</i> - RRI: Current research and importance of grasslands	Bork	Inside Education: Grasslands; Mattheis Ranch	Teachers	June 2018
<i>Field tour</i> - Update on RRI Research	Bork	Range Field Day; Oyen, AB	Ranchers, producers, government	July 2018
<i>Field tour</i> - Drought Monitoring	Rajper, Aamga, Carlyle	Range Field Day; Oyen, AB	Ranchers, producers, government	July 2018
<i>Field tour</i> - Effect of grazing systems on greenhouse gas emissions from grassland soils	Shrestha	Range Field Day; Oyen, AB	Ranchers, producers, government	July 2018
<i>Field tour</i> - Downy brome in southern AB grasslands	Raatz	Range Field Days; Oyen, Onefour, & Stavely, AB	Ranchers, producers, NGO's, government	July 2018
<i>Field tour</i> – Update on RRI Research	Raatz, Bork	Soil Health Field day; Onefour & Stavely, AB	Ranchers, producers, NGO's, government	July 2018
<i>Field tour</i> - Litter impacts on rangeland vegetation and soil health	Barszczewski, Carlyle	Soil Health Field day; Stavely, AB	Ranchers, producers, NGO's, government	July 2018
<i>Field tour</i> - Ongoing research in support of rangeland ecological goods and service	Bork	Forage to Beef Demo Days; Waldron Grazing Co-op, AB	Ranchers, producers	July 2018
<i>Field tour</i> - Ongoing research in support of rangeland ecological goods and service	Bork	Forage to Beef Demo Days; Whisky Ridge Cattle Co., Didsbury, AB	Ranchers, producers	July 2018
Evaluating impacts of high voltage transmission line construction on Dry Mixedgrass prairie in Alberta	Najafi	MSc defense; Edmonton, AB	Researchers, students	July 2018
Rangeland Research Institute & research update	Raatz, Bork	15th Annual Southern Alberta Grazing School for Women; Stavely, AB	Ranchers, producers, government, NGO's	July 2018
Grazing management provides an opportunity to conserve the Canadian Prairies through carbon storage	Carlyle	4th North American Congress for Conservation Biology: Connecting the urban to the wild; Toronto, ON	Researchers, government, NGO's, students	July 2018

Effects of environmental and disturbance gradients on Alberta's native bee communities	Kohler	4th North American Congress for Conservation Biology: Connecting the urban to the wild; Toronto, ON	Researchers, government, NGO's, students	July 2018
<i>Field tour</i> - Range health assessment & forestry perspective	Irving	SRM summer tour: Range & Feral Horse ecology on Eastern slopes; Sundre, AB	Ranchers, producers, NGO's, government, researchers	July 2018
<i>Field tour</i> - Rangeland forage trends, shrub encroachment, and horse management in the RMFR	Bork	SRM summer tour: Range & Feral Horse ecology on Eastern slopes; Sundre, AB	Ranchers, producers, NGO's, government, researchers	July 2018
Mitigating effects of access mats on construction traffic in Mixedgrass Prairie of Alberta	James	MSc defense; Edmonton, AB	Researchers, students, public	Oct 2018
Roy Berg Kinsella Research station: History & tour of animal handling facilities	Irving	Lakeland College; Kinsella Ranch, AB	Students, researchers	Oct 2018
Impacts of grazing on biodiversity in Western Canadian grasslands	Armstrong	RRI sponsored talk; Edmonton, AB	Students, researchers	Nov 2018
Grassland conservation by grazing management, GHG reduction and carbon offsets	Carlyle	Ecosystem Services and Biodiversity Network & ABMI Science Symposium: The Role of Science in Creating Ecosystem Services and Biodiversity Markets; Edmonton, AB	Researchers, government, NGO's, students	Nov 2018
Effects of litter removal, soil compaction and defoliation on soil physical and biological properties in grasslands of southern Alberta, Canada	Rajper, Amgaa, Bork, Willing, Chang, Cahill, Carlyle	American Geophysical Union Fall Meeting 2018; Washington, DC	Researchers, government, NGO's, students	Dec 2018
Soil microbial community composition (PLFA) under different grazing systems in the Canadian Prairies	Upama KC, Thompson, Quideau, Boyce, Bork, Carlyle	American Geophysical Union Fall Meeting 2018; Washington, DC	Researchers, government, NGO's, students	Dec 2018
Does the adaptive multi-paddock (AMP) grazing system increase carbon sequestration in Canadian grasslands soils?	Sobrinho, Chang, Shrestha, Bork, Boyce, Carlyle	International meeting of American Soil Science Society; San Diego, CA	Academics, researchers, students, government, industry, planners	Jan 2019

Soil extracellular enzyme activity in rotational grazing is similar to conventional grazing systems in Alberta	Kaliaskar, Shrestha, Gross, Weber, Carlyle, Bork, Boyce, Chang	International meeting of American Soil Science Society; San Diego, CA	Academics, researchers, students, government, industry, planners	Jan 2019
Relationships of range health scores with grazing management practices and producer perspectives in Alberta, Canada	Dahl	MSc defense; Edmonton, AB	Researchers, students, government	Jan 2019
Quantifying carbon storage in agroforestry systems in Alberta	Tieu, Gross, Carson, Bork, Carlyle, Chang	17th Bentley Lecture in Sustainable Agriculture, poster session; Edmonton, AB	Academics, students, government, NGO's, industry	Jan 2019
Are Alberta flagship species an umbrella for songbird conservation?	Cicon, Nielsen, Stenhouse, Farr	17th Bentley Lecture in Sustainable Agriculture, poster session; Edmonton, AB	Academics, students, government, NGO's, industry	Jan 2019
Soil carbon dioxide and methane flux as a function of temperature and moisture in fallow, grass mix, spring rye, biennial rye, and perennial rye	Kim, Hernandez-Ramirez, Daly, Puurveen, Lohstraeter, Power	17th Bentley Lecture in Sustainable Agriculture, poster session; Edmonton, AB	Academics, students, government, NGO's, industry	Jan 2019
Soil extracellular enzyme activity in rotational grazing is similar to conventional grazing systems in Alberta	Kaliaskar, Shrestha, Gross, Weber, Carlyle, Bork, Boyce, Chang	Alberta Soil Science Workshop; Calgary, AB	Researchers, students, industry, government	Feb 2019
Drone measured surface albedo of rangelands under adaptive multi-paddock grazing is similar to conventional grazing	Shrestha, Chang, Worth, Desjardins, Bork, Carlyle, Church, Boyce	Alberta Soil Science Workshop; Calgary, AB	Researchers, students, industry, government	Feb 2019
Overview of research activities in forage, beef & grazing at the University of Alberta	Bork	Alberta Beef, Forage and Grazing Center Meeting	Researchers, producers, NGO's, industry	Feb 2019
Rangeland management and carbon sequestration	Chuan, Bork, Carlyle	Prairie Conservation Action Plan; online webinar	Academics, students, government, ranchers, NGO's, industry	Feb 2019

Grazing impacts on grassland carbon in northern temperate grasslands: A potential path towards understanding	Bork	AAFC Sustainability of Canadian Agriculture; Lacombe, AB	Scientists, planners, ranchers, NGOs, government admin	Mar 2019
Assessment of rumen microbiota of grazing cattle with divergent feed efficiency	Liu, Lansink, Bork, Carlyle, Plastow, Guan	ALES Graduate Research symposium; Edmonton, AB	Researchers, students	Mar 2019
Soil extracellular enzyme activity in rotational grazing is similar to conventional grazing systems in Alberta	Kaliaskar, Shrestha, Gross, Weber, Carlyle, Bork, Boyce, Chang	ALES Graduate Research symposium; Edmonton, AB	Researchers, students	Mar 2019
Quantifying carbon storage in agroforestry systems in agricultural Alberta	Tieu, Gross, Carson, Bork, Carlyle, Chang	ALES Graduate Research symposium; Edmonton, AB	Researchers, students	Mar 2019
Update on research activities in range ecology & management at the University of Alberta	Bork	AB Env & Parks Annual Update Workshop; Calgary, AB	Government, policy makers	Mar 2019
Does livestock grazing regulate soil carbon in northern temperate grasslands?	Bork	Prairie Conservation Action Plan; online webinar	Ranchers, researchers, public, students, government, industry	Mar 2019
The influence of grazing management on plant community diversity and production across Western Canada	Grenke, Carlyle, Bork, Apfelbaum, Teague, Cahill, Boyce	Prairie Conservation Action Plan; online webinar	Ranchers, researchers, public, students, government, industry	Mar 2019

Appendix III. RRI Financial Statement of Actuals, April 1, 2018 to March 31, 2019

	Actuals
Opening Balance	\$814,361.52
Revenue	
Lease/Utility (Powerline) Revenue	\$472,802.75
Total Revenue	\$1,287,164.27
Expenditures	
Transfer to Endowment	\$800,000.00
Property Taxes	\$2,507.23
Temp Support Staff	\$11,511.95
Supplies	\$18,310.42
Travel Expenses	\$4,719.79
Rentals and Leases	\$8,434.16
Total Expenditures	(\$845,483.55)
Net Balance	\$441,680.72

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, 2018 to March 31, 2019

	Actuals
Principal	
Opening Balance (April 1, 2018)	\$5,761,323.94
Contributions	\$800,152.15
Closing Balance (March 31, 2019)	\$6,561,476.09
Spending Allocation	
Opening Balance (April 1, 2018)	\$206,817.17
Current Year Endowment Spending Allocation	\$220,803.11
Total Revenue	\$427,620.28
Current Year Expenditures	
Faculty salary ¹	\$22,955.99
Support staff & fellowship salaries	\$96,836.15
Travel	\$3,225.95
Research Projects	\$240,090.00
Total Expenditures	(\$363,108.09)
Closing Balance After Encumbrances	\$64,512.19

¹ A proportion of faculty staff salary was taken out of the endowment starting in 2018/19 in order to remove it from Department of AFNS operational budget and account for budget shortfalls. The proportion is expected to increase over time.