Precision Management Tools: Innovations in Land and Animal Stewardship to Build Climate Resilience

July 20th, 2022

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‘Precision Ranching’ of Beef Cattle

Prepared by Edward Bork and Carolyn Fitzsimmons

Contemporary beef production relies heavily on grazing lands for a significant portion of the cattle production cycle, including in western Canada. Profitable and environmentally sustainable production requires the alignment of forage use across diverse rangeland landscapes with the inherent tolerances of vegetation to grazing. Balancing this forage use in time and space by ensuring the **“right animal is in the right place at the right time”** is the goal of Precision Ranching.

Alignment of forage resources with forage use can be attained two ways. The first involves strategies to physically control where, when, and how often animals graze, such as through the tactical use of mineral or salt placement, controlling water access, manual herding, or the use of physical fencing to confine animals. The second approach is to identify and select cattle with behavioral adaptations that better align ongoing forage use with available resources (habitat types and dietary plants), and in the process optimize cattle weight gain (and that of their calves) while reducing undesirable environmental outcomes (such as over- or under-grazing.

Typical mosaic of habitats used by cattle during the grazing season within the Aspen Parkland region of western Canada.

The University of Alberta ‘Precision Ranching’ project is an ambitious undertaking addressing both of these strategies to improve the sustainability of beef production. The specific objectives of this project are to: 1) Quantify the selection patterns of cattle within complex foraging environments containing multiple habitats (wetlands, grasslands, shrublands, and aspen forest) and evaluate how these patterns vary from summer (during optimal foraging conditions) through fall (during declining forage quality), 2) Develop and apply novel and cost-effective tools for characterizing the diets of free-ranging cattle having access to diverse pastures, 3) Characterize the energy budgets of free-ranging cattle in space and time, 4) Identify genomic markers for habitat selection, diet selection and cattle activity, and relate these to key economic (e.g., weight gain) and environmental (e.g., enteric methane emission) traits while on pasture, 5) Assess the relationship of the rumen microbiome to diet composition, methane emissions, and cow/calf weight gain, and 6) Explore the utility of virtual fencing for the flexible control of cattle distribution on pasture (as an alternative to permanent fencing).

The integrated dataset from this project has the potential to greatly transform the beef industry. While previous studies on feed efficiency are common, many of these have been done under drylot conditions where diets are standardized and behavioral responses of animals are muted, at least compared to those foraging on open pasture. The technology utilized and applied here will have significant implications for 1) Understanding the inherent behavioral adaptations of cattle to western Canadian grazing lands, including their impact on economic and environmental outcomes, 2) Developing selection tools to allow beef producers to screen their cattle to better align their behavioral activity and forage use with intended outcomes, 3) Providing novel tools and methods to facilitate more widespread screening of cattle behavior in the field, and 4) Exploring alternate technologies to improve beef production efficiency, either using genomic selection, or non-invasive, low-cost tools such as virtual fencing.

Cattle grazing within the University of Alberta Kinsella Research Ranch and fitted with various technologies (GPS collars, GPS eartags, and leg-mounted pedometers) enabling the assessment of habitat selection patterns and activity budgets.

This research is supported by the Smart Agriculture and Food Digitalization and Automation Program of Alberta Innovates, Results Driven Agricultural Research (RDAR), the Canadian Agricultural Partnership (CAP), and the Alberta Beef Producers.

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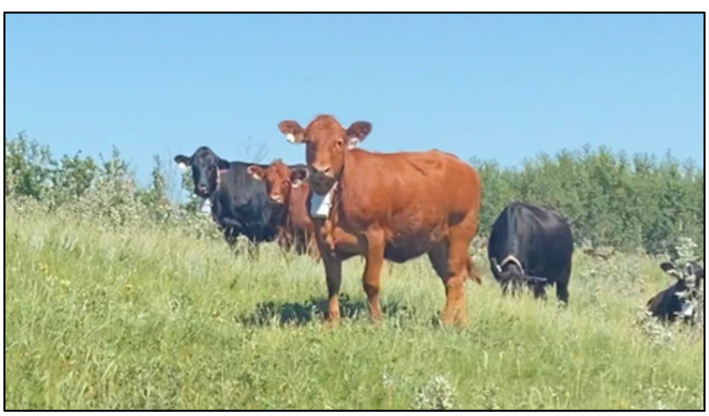
Habitat Selection by Commercial Beef Cows Grazing Heterogeneous Aspen Parkland Rangeland

Prepared by Sydney Lopes, Carolyn Fitzsimmons, Cameron Carlyle and Edward Bork

Cattle grazing on open-rangeland face complex decisions while foraging. This includes the habitats they are likely to select, which may vary from open habitats (grasslands) that are highly accessible, to relatively closed woodland habitats where forage is less accessible due to an abundance of shrubs and/or trees. In addition to accessibility, habitats have a marked impact on cattle distribution patterns due to differences in foraging opportunities (i.e., forage quantity and quality), the availability of water, and the provision of other benefits (e.g., shade during hot weather, protection during storms, etc.). As a result, technologies that facilitate the comprehensive tracking of cattle spatial geolocation in time are particularly useful, provided they do so at a high enough accuracy to facilitate habitat selection studies, and can be collected across many animals to enable genomic evaluation/selection of the herd.

In this study at the University of Alberta Kinsella Research Station, we are collecting detailed habitat selection data on free-ranging beef cows as they graze a typical Aspen Parkland landscape. These environments contain a diverse mix of habitats (open grassland, wetland meadows, aspen forests, and shrublands of wolf willow and snowberry that range from relatively open, to relatively closed) that vary widely in accessibility, and the quantity and quality of forage the provide. In the process, we are comparing three different technologies for their ability to track cattle geolocations. LOTEK Wireless GPS™ collars are being used on 40 cows to track their locations at 15 minute intervals during peak feeding periods (4-10 am; 4-10 pm), during both the summer (July-August) and fall (September-October) grazing periods.

Drone technology is being used to prepare detailed habitat maps, with field sampling used to characterize habitat quality (access and foraging conditions). Resource selection functions will be developed to identify habitats that are preferred and avoided by cattle and assess how this reflects associated cattle production metrics (cow/calf weight gain, fall body condition, cow dietary composition and rumen microbial composition, as well as methane production).



Cattle grazing with various technologies (GPS collars and multiple GPS eartags) allowing the assessment of habitat selection patterns at the Kinsella Research Ranch.

In order to facilitate the scaling of habitat selection across a larger number of animals, we are also testing the use of alternative technologies to track cattle geolocation over time. This includes light-weight ear-mounted global-positioning system (GPS) technologies (GPScollar AS™; CeresTag Pty Ltd™) that rely on solar gain to collect data on cattle positions in summer and fall. While these technologies are available for commercial application, they vary in utility (e.g., programmability), and are not yet proven for Western Canada where cold weather, short daylength, and challenging conditions (forests) are common. Our goal is to utilize low cost GPS technologies to supplement our high-resolution GPS collars in order to scale the habitat assessment of cattle to large numbers (200 head+), at which point we can then link our observed habitat selection functions for individual animals to genotypic data for these animals to detect potential markers for habitat selection.

Our short-term goal is to better understand those behaviors (habitat selection) that predispose a cow to be more productive (e.g., greater cow/calf weight gain and improved cow condition at weaning) while specifically grazing on native rangelands. Additionally, we seek to increase the availability and application of GPS technology for conducting animal-based production research on pasture.

Left: Different technologies being tested at Kinsella Research Ranch in 2022.

Back: LOTEK GPS Collars™ (Canada);

Front Left: GPS eartags from GPS Collars AS™ (Norway);

Front Right: GPS eartags from CeresTag Pty Ltd™ (Australia).

When successful, this will help provide new tools for beef producers to screen and select cattle better adapted to their specific foraging environments, so as to balance economic and environmental outcomes. For instance, having more reliable and low-cost access to cattle geolocation data for larger numbers of cattle may help us to better evaluate cattle for unique foraging environments. Producers grazing primarily forested rangeland may one day be able to select for cattle that prefer forested habitats without sacrificing cow/calf production.

Alternatively, producers seeking to conserve wetland habitats may select for cattle with reduced use of wetland meadows.

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Characterizing Activity Budgets of Free-Range Beef Cows

Prepared by Temitope Oloyede, Carolyn Fitzsimmons, Changxi Li and Edward Bork

Beef cattle grazing on open rangelands exhibit complex activities during feeding, which is unlike cattle fed in drylot under confined conditions. These activities include time spent travelling between resting and feeding areas, as well as time searching for optimal forage sources. It also includes the proportional time spent resting and ruminating. Time allocated to walking, standing and lying down will reflect not only the condition (quantity and quality) of forage resources available to cattle, but also influence animal bioenergetics. For example, conditions of abundant high quantity, high quality forage, as is common during mid-summer in western Canada, are likely to lead to lower search times and shorter feeding bouts, with more time spent resting and ruminating. This in turn, is likely to contribute positively to summer cow weight, milk production, and associated calf growth.

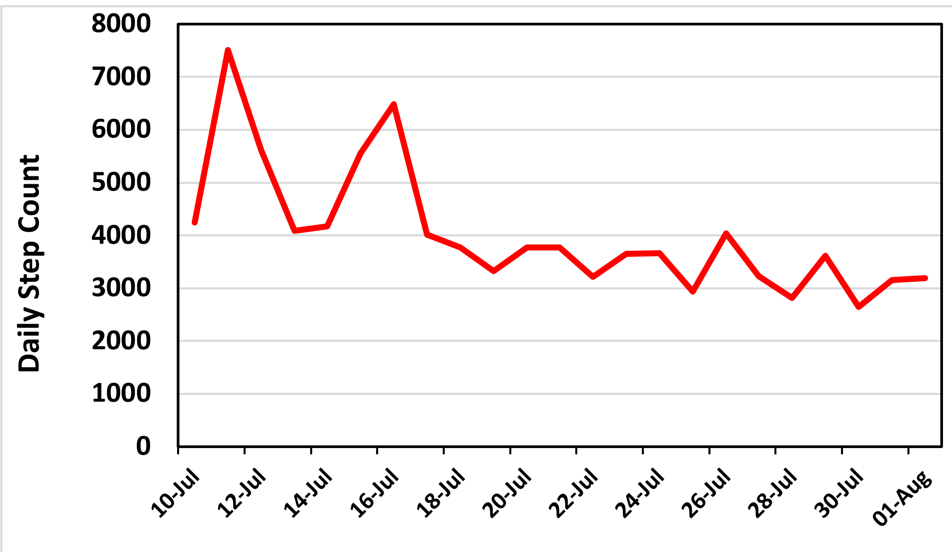
Given the importance of animal activity budgets for influencing the bioenergetics (i.e., energy expenditure and/or conservation) of individual animals, these budgets may help explain individual animal performance metrics, including that of the cow/calf production unit, while grazing on spatially expansive rangelands. For instance, cows that spend less time wandering and searching for feed, and have greater innate ability to locate, consume and digest high quality feed, may support greater production, in part by expending less energy. Tracking animal activity on pasture under free-range conditions has historically been difficult, and has often been limited to passive observations by researchers during relatively short fixed time intervals.

Left: The process of fitting pedometers to track animal movement and activity on pasture.
Right: Cattle with fitted pedometers (see rear left leg) to track their activity in open grassland.

The recent emergence of various pedometer technologies has greatly increased our ability to quantify the activity budgets of livestock, including beef cattle. Similar to wristwatches that track human activity (e.g., steps counts throughout the day), these units containaccelerometers that tally the number of steps taken, in addition to the time spent standing vs lying down.

The University of Alberta is undertaking research to characterize the activity budgets of commercial beef cattle grazing while grazing on native rangelands using IceRobotic^{TM} pedometers for tracking cattle activity. Systematic information on the aggregate activity budgets of cattle, collected from late June through late October of the grazing season over multiple years, will be used to quantify the bioenergetics of beef cattle, and relate this information to associated production metrics (including cow/calf weight gain).

In addition, obtaining this information for large numbers of cattle (>200) will enable us to search for genomic markers previously collected from these cattle that may explain their activity levels, all the while maintaining important economic traits. Collectively, our goal is to utilize behavioral metrics ascertained directly from cattle on pasture to better understand their role in contributing (negatively or positively) to beef production.



Example of a dataset for a single cow examined over a 24-hour period during the 2021 grazing season at the Kinsella Research Ranch.

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Methane Emissions from Commercial Beef Cows During Open-Range Grazing in the Parkland

Prepared by Amir Behrouzi, Edward Bork, John Basarab, and Carolyn Fitzsimmons

Greenhouse gas (GHG) emissions from beef cattle represent less than 4% of all agricultural GHGs in Alberta or about half of agricultural GHGs emissions. However, cattle are widely recognized for their role in contributing to GHGs, including CH_4 (methane) and CO_2 production. Considerable interest exists in reducing the footprint of the CH_4 output from beef cattle, including incentives for reduced days on feed.

Several studies have quantified CH_4 emissions from beef cattle, including at the Kinsella Research Ranch. However, this work has concentrated on animals held in drylot, where the amount and composition of feed intake can be closely tracked using technologies such as automated feeding stations (GrowSafe System, Vytelle). Given that commercial cattle spend a large portion of their production lifecycle grazing on diverse pastures, understanding whether and how feed efficiency in drylot and methane emissions reflect associated animal performance (methane emissions per average daily weight gain) on pasture remains essential.

In this study, the University of Alberta is using GreenFeed emissions monitoring (GEM) system (C-Lock Inc). The GEM system is an automated head-chamber and measures CH_4 and CO_2 emissions from a large number of animals in both drylot and pasture conditions. The system uses spot sampling to measure eructation and exhalation gases while providing pelleted feeds in small amounts to encourage animals to visit system multiple times per day.

GreenFeed emissions monitoring system

Experimental Approaches:

Crossbred replacement beef heifers and cows (60 head/year) that have been measured for feed efficiency in drylot (RFI_{fat} - residual feed intake adjusted for off-test backfat thickness), are monitored for CH_4 and CO_2 production while simultaneously grazing native rangeland containing a diverse mix of habitats and forages over three years (2021-2023).

The GEM system quantitatively measures individual CH_4 and CO_2 emissions while grazing under two different foraging conditions:

- Summer (higher quantity and quality forage in Jul-Aug)
- Fall (higher quantity forage but lower quality forage in Sept-Oct).

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GEM system was used to quantify CH_4 and CO_2 from cattle grazing on open rangeland

Preliminary results (Year One)

In 2021, cattle CH_4 emissions increased from summer to fall with advancing vegetation senescence. In addition, cattle with lower RFI values (efficient animals) grazing on high quantity-low quality pasture in fall emitted less CH_4 and CO_2.

Implications

The results of this study are expected to increase our fundamental understanding of CH_4 and CO_2 emissions associated with cattle while grazing on native rangeland, and where possible, examine how this contrasts with prior assessed CH_4 and CO_2 emissions and feed efficiency (RFI) tested in drylot. We will examine the relationship between CH_4 emissions and important economic traits (cow/calf weight gain), and utilize rumen microbial profiles to explore their contribution to differences in CH_4 and CO_2 emissions that exist among animals. Finally, using aggregate data from all animals throughout the study, we will test the possibility of identifying genomic markers from these animals that may make it possible in the future to select for lower GHG producing cattle.

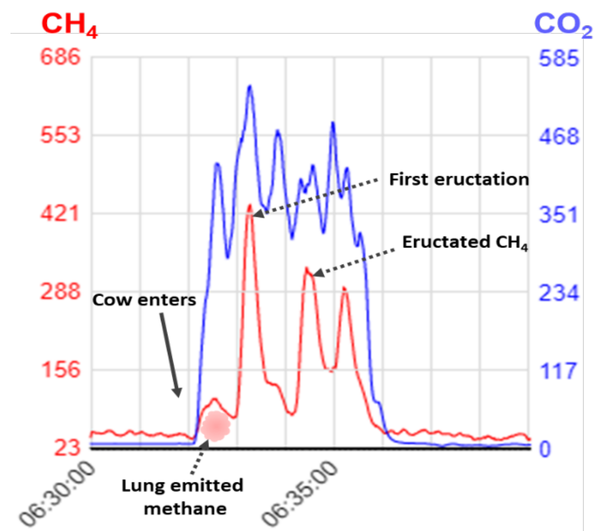

Figure 1. Typical CH_4 and CO_2 data obtained from the GEM, methane production, by source

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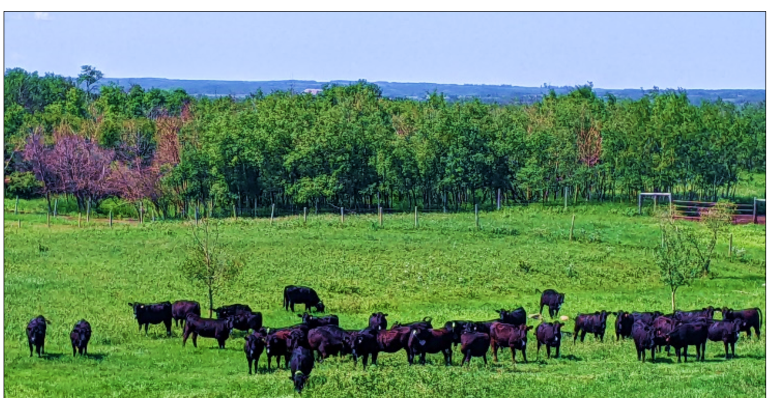
Virtual Fencing for Real-Time Flexible Control of Grazing Beef Cattle

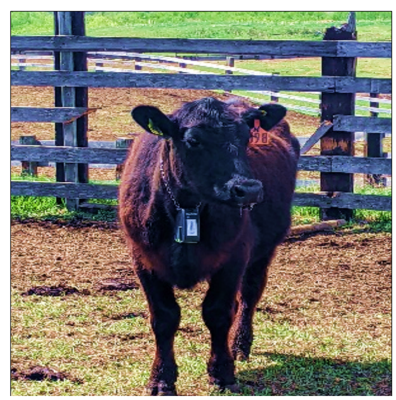
Prepared by Alexandra Harland, Carolyn Fitzsimmons and Edward Bork

Beef cattle production on pasture is heavily dependent on strategies to control where, when and how often animals graze a given area. Along with mineral and salt placement, and control over the availability of water, a common method to manipulate animal use in Canada is physical fencing, including both permanent and temporary (electric) fencing. The use of fencing, in turn, facilitates the implementation of complex grazing systems, including adaptive, multi-paddock (AMP) rotational grazing, in which cattle are moved from one small pasture to another, often at frequent intervals (e.g,, every day or two).

Given the widespread nature and high cost of fencing, strategies to reduce fencing costs have the potential to greatly decrease the cost of beef production, as well as improve the adaptive nature of managing grazing patterns in space and time. Virtual fencing (VF) is an emergent technology intended to control livestock grazing in real-time, while reducing the overall cost of constructing and maintaining physical fencing intended to contain animals. VF technologies are analogous to 'dog shock' containment areas but applied to domesticated livestock such as cattle while grazing.

Once fitted with the collar, global positioning system information is used to continuously track the location of animals in real time, and software is used to create a 'virtual fence' containment area. Animals approaching the boundary receive multiple audio warning signals before ultimately being subject to an electric stimulus, where the latter elicits a response in the animal to move away from the boundary. Following a training period in which cattle learn to expect an electric stimulus after an auditory warning, cattle can be constrained within the VF fence boundary.





Left: a herd of heifers fitted with NoFence™ collars at the Kinsella Research Ranch, allowing for control of their movement in space and time. Right: a cow just after being fitted with a collar.

Because the boundary is programable, it can be readily moved in space and time using a cellular network, thereby allowing for a highly flexible and remote tool to alter grazing behavior and patterns of pasture use.

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The University of Alberta has initiated research testing the application of NoFence™ VF technology to manipulate patterns of cattle grazing in real-time. Initiated in June of 2022, this study is examining the behavior of 49 heifers and 2 bulls, first while being trained following the introduction of VF technology,

and second during the implementation of a simple rotational grazing system. Data are being collected on the type (auditory vs electrical) and frequency of stimuli received, escapes, and how changes in grazing pressure (ongoing forage depletion while in a given pasture) alter these responses.

Results of this work are expected to provide a comprehensive test of VF technologies in Canada for the confinement and management of beef cattle and help chart a pathway to increase the availability and use of VF platforms for contemporary cattle management. Increased use of VF will reduce the cost of infrastructure (fencing) costs for the beef industry, while simultaneously maintaining and even increasing the flexibility of producers in applying contemporary rotational grazing systems (such as AMP) in real-time within grazed environments.

Left: Map of cattle geolocations during a 24 hour period shown as a heatmap, including the last known position of cattle represented by each collar icon. Cattle are contained to the east half of the physical pasture, whereas the west side of the blue polygon is outside the virtual fence boundary. Cattle are also accessing a water source situated within a nearby pasture (bottom) using a virtual fence to isolate the water source within the adjacent pasture. Two isolated observations on the west side of the blue polygon represent 'escapes'.

This study is supported by the Smart Agriculture and Food Digitalization and Automation Program of Alberta Innovates, Results Driven Agricultural Research (RDAR), the Canadian Agricultural Partnership (CAP), and the Alberta Beef Producers.

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Assessing the impacts of weather in western grazing beef females

Prepared by Dr. Gleise M. Silva, Camila Londono, and Sergio Lasso

One of the major goals for the livestock industry worldwide is to ensure adequate food supply for the growing population. However, climate change may impose an additional challenge to this activity by increasing the duration, severity, and spatial distribution of extreme weather events. Greater variation in environmental conditions has been documented in Western Canada with the summer of 2021 being one of the warmest on record. On the other extreme, record low temperatures were also registered in December 2021.

***Environmental effects on cattle productivity**:*

Cattle are homeotherm animals, which means they maintain a relatively constant body temperature over a wide range of environmental conditions to optimal function and survival. For that, an animal must be in thermal equilibrium with the environment, which includes an adequate combination of radiation, air temperature, air movement, and humidity.

Figure 1. Grazing beef females seeking shade during summer.

Environmental stress (cold or heat stress) occurs when air temperature deviates from the animal's thermoneutral zone, affecting production or causing discomfort. Cattle become heat stressed when the animal heat load is greater than the animal's ability to dissipate the heat to the environment. The ability to lose heat is determined by environmental conditions (e.g., humidity, wind speed) as well as animal individual capacity (e.g., breed, hair coat, age, etc.).

Cattle have several physiological and behavioral strategies to overcome the effects of cold or heat stress. During warmer weather, cattle can increase water consumption, sweating and respiration rates, reduce feed intake, and seek for shaded areas (Figure 1) to minimize solar radiation exposure. Under colder temperatures, cattle will increase feed intake to maximize heat production. When those strategies are not enough to maintain adequate heat loss or gain, productivity is reduced. Feed efficient cattle might have lowered nutrient requirements which could represent greater resilience to extreme weather conditions since there is an increase in energy requirements associated with thermoregulation during cold and heat extremes. Therefore, understanding the potential of more feed efficient heifers to endure the extremes of intensified weather conditions could be a key aspect of a resilient beef production system.

Cattle have been selected for feed efficiency to reduce feeding costs and environmental impact but knowledge on how more feed efficient beef cattle on forage-based systems respond to environmental conditions (e.g., winter vs. summer) is still needed. It also remains unclear whether these relationships (RFI and weather resilience) would be more important during one season over another (e.g., summer vs. winter). Such information is necessary to understand the impacts of weather in animal production in our unique environment to support a more resilient beef production in the face of a changing climate.

Research Project: Our current study (Figure 2), funded by the Alberta Beef Producers, will address this knowledge gap by identifying physiological and behavioral changes employed by heifers with divergent RFI during natural fluctuations in weather conditions (e.g., summer and winter 2022-2023) at Kinsella Research Ranch. We hypothesized that more feed efficient beef heifers are more weather resilient because of their greater efficiency in energy utilization, resulting in maintenance of adequate behavior, body weight, and physiological status compared to less efficient animals. During summer 2022, we are testing this hypothesis by measuring behavioral (e.g., time spent walking and lying) and physiological responses (blood metabolites) of cattle throughout summer. Winter evaluations will occur in 2023.

The Alberta Beef Producers (ABP) and the Canadian Agricultural Partnership are supporting this study. We are thankful for the support received by ABP, researchers' Co-PIs at University of Alberta and the Kinsella Research Ranch staff.

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Using drones to measure heat stress in cattle

Prepared by Justin Mufford, John Church, Cameron Carlyle

The long-term sustainability of livestock production is threatened by climate change. Due to increasing amounts of carbon dioxide in the atmosphere, the earth's climate is warming and precipitation patterns are changing. In 2021, the Canadian prairies experienced record-setting temperatures, in which cattle experienced detrimental environmental conditions, risking heat stress, or even death. Measuring heat stress in cattle, and ultimately identifying and selecting cattle that can tolerate higher temperatures, will be critical to ensuring cattle welfare and productivity are simultaneously maintained into the future.

Unmanned aerial vehicle (UAV) or drone image of variously coloured cattle in a feedlot setting.

MSc student, Justin Mufford observes heat stress in cattle using an UAV or drone at the Mattheis Research Ranch.
Photos by: Justin Mufford.

In North America, Black Angus, a breed commonly used in beef production, may be more susceptible to the effects of climate change due to its dark hair coat that absorbs more solar radiation than light-coloured hair. Thus, there is a greater risk of susceptibility to heat stress, and associated reductions in productivity, as well as enhanced morbidity and mortality in these animals, relative to those with lighter colouring. However, observing and assessing cattle responses to heat can be challenging, especially on 'open-range' pasture, where animals may be difficult to locate and monitor.

In a study conducted by Justin Mufford, an MSc student at Thompson Rivers University working with John Church (TRU) and in collaboration with Cameron Carlyle (U of A), unmanned aerial vehicles (UAVs) were used to observe cattle in pasture at the Mattheis Research Ranch and in a privately-owned feedlot setting to measure respiration rate, and other behaviours (e.g., time spent standing) to make comparisons among cattle with different coat colours.

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Observing heat stress in cattle in a ranch setting poses challenges because of the potentially expansive land base. UAV image of cattle grazing at the Mattheis Ranch.

The UAVs allow remote viewing of multiple animals at the same time through recording of high-resolution video, which can then be analyzed using specialized software in the lab. Environmental data were measured at the same time to generate a heat load index (HLI).

The researchers found that animal respiration rate (a common indicator of 'stress') increased with HLI, and darker coated animals had a larger response in the feedlot, but not in pasture environments. Importantly, temperatures in the pasture did not get as high as those in the feedlot, thereby allowing pasture-based animals to experience less heat stress regardless of their hair colour. Additionally, the likelihood that an animal would be standing increased with HLI in both the feedlot and pasture scenarios. Standing increases the rate of convective heat loss and may be a means to reduce body temperature, in turn reducing the risk of heat stress. This study demonstrated that consumer grade UAVs are capable of measuring heat stress behavioural responses in cattle and could serve as a new tool to identify and monitor cattle heat stress responses resulting from anticipated future changes in climate and associated weather patterns.

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Lakeland COLLEGE

Commercial Beef Heifer Replacement Selection

Using promising remote sensing technology to aid your decisions

Dr. Susan Markus, Rancher & Livestock Researcher

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Developing commercial replacement heifers for the beef herd is expensive and time consuming. Investing 2 years and over $2000/hd before her calf is born does not guarantee she stays in the herd for years to come. While your management and feed programs are critical to success, promising technology is available to assist in automating the process. Because reproductive efficiency is 10 times more important than carcass quality and 5 times more important than growth traits for beef herd production efficiency and profitability, estrus detection prior to bull exposure is a focus of this project.

Lakeland College has created a *Heifer Development Demonstration Site* at the Vermilion, AB campus to test and showcase various tools and technologies that may have value. Local rancher-consigned heifers are on trial and will be followed for the next 3 years.

Yearling heifers[*] were assessed for:

1. Conformation
2. Temperament
3. Performance, growth & feed efficiency
4. Reproductive Efficiency
5. Carcass traits

In addition, they were monitored for standing heat using remote sensors and had detailed reproductive tract assessments performed by a veterinarian. Complete genetic merit scores (gEPD: genomically enhanced expected progeny differences) were also generated for the heifers and a *Replacement Heifer Profit Index* is currently being calculated to rank them.

The value of the data is that all phenotypes and genotypes measured are presented to the rancher in one report.

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[*] Born Spring 2021

Genomic Tools for Selection

Prepared by: Diego Martinez Mayorga, Dr. John Basarab
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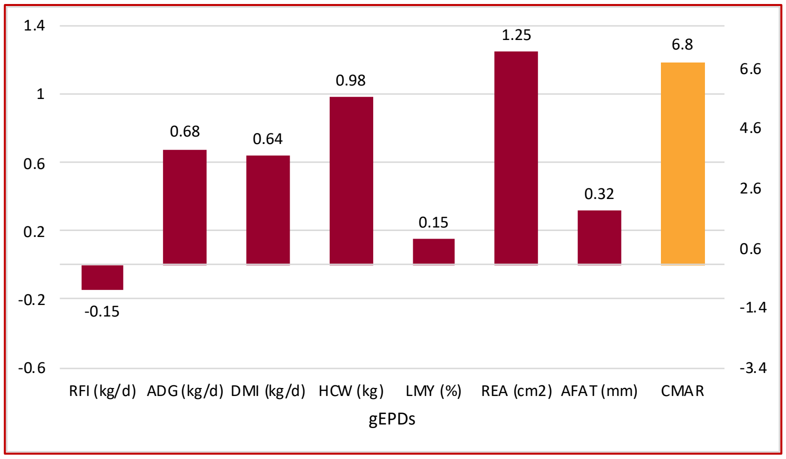
Genomically-enhanced Estimated Progeny Difference (gEPD) and Real-World Validation



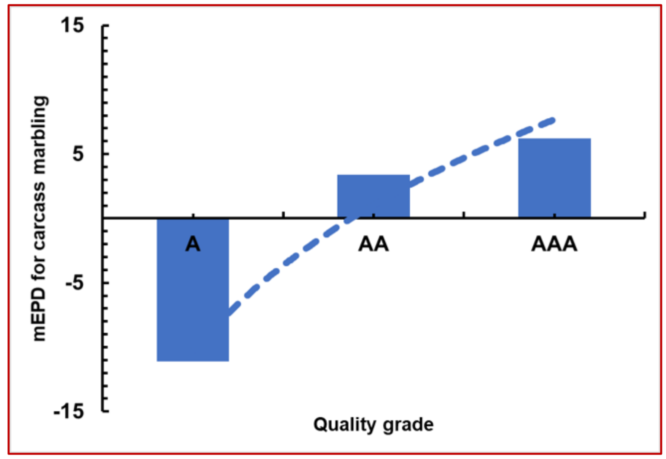


Figure 1 (left). Sample graph showing gEPDs for multiple growth and carcass traits. **Figure 2 (right).** Relationship between mEPD for carcass marbling and quality grade in 4H steers (n=14). Reference population size is 14,146 animals with genotypes and carcass data. These 4H steers were not in the reference population. Courtesy of JA Basarab (July 15, 2022).

Feeder Profit Index (FPI)

Included Traits				
Post-Wean ADG	Feed Intake	Metabolic Mid-Weight	Residual Feed Intake	5 Carcass Merit Traits

Figure 2: The traits included in the Feeder Profit Index (FPI). Carcass traits include hot carcass weight, lean meat yield, rib-eye area, backfat thickness and marbling.

Genomic Breed Composition

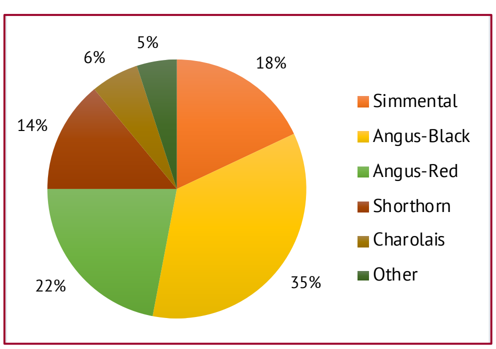


Figure 4: A sample genomic breed composition of a cross-bred animal. The genomic breed composition is determined through SNP markers associated with a breed and the proportion of those markers on the genome. Other than providing information on the breed makeup of an animal, the breed composition allows researchers to calculate the retained hybrid vigour of an animal which is important for managing hybrid vigour in a herd.

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Using DNA Barcoding to Characterize Free-Range Beef Cattle Diets

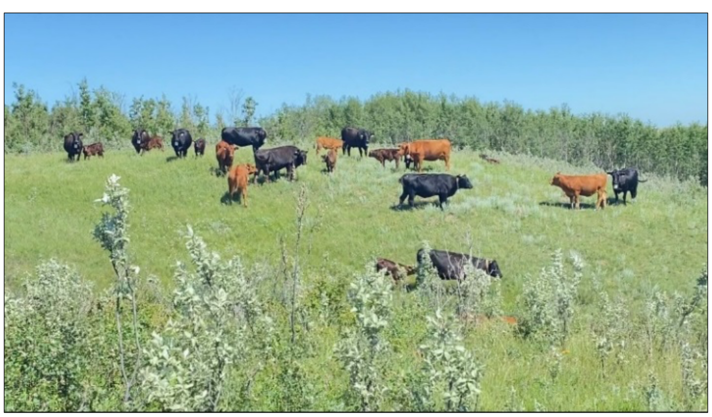
Prepared by Valentine Udeh, Carolyn Fitzsimmons, Leluo Guan, James Cahill and Edward Bork

Cattle exhibit complex foraging behavior in rangeland, with dietary selection influencing nutritive intake, and therefore animal performance. With complex rangeland habitats containing hundreds of plant species, understanding the relative selection and avoidance by beef cattle of different plants is important to both optimize animal use of rangelands, while also maintaining range condition through the process of balancing plant defoliation with subsequent recovery. For example, studies from the University of Alberta Mattheis Ranch in SE Alberta indicate that cattle diets and associated plant selection vary from summer to fall, and differ depending on cattle genomic markers for high and low feed efficiency.

Unfortunately, conventional methods to characterize the diets of commercial cattle are either time consuming (passive observation of grazing animals), invasive to the animal and difficult to scale (esophageal fistulation), or are very expensive and therefore limited to small sample sizes (fecal histology). As a result, novel tools are needed to conduct more comprehensive investigations into the role of dietary selection during grazing, particularly those dietary behaviors likely to regulate the economic and environmental outcomes of open-range livestock grazing.

DNA barcoding is a potential tool that may be used to characterize the diets of free-ranging animals, and is most commonly used in wildlife studies, with limited application thus far in livestock. Barcoding utilizes fecal samples obtained from cattle consuming a mixture of plants, the extraction and sequencing of plant DNA from those fecal samples, and finally comparison to a DNA reference library of various plant species.

This comparison has the potential to determine the presence and relative composition of various plant species (or plant functional groups; e.g., graminoids, legumes, browse) in the diet. When combined with degradation coefficients for different plant species in the digestive tract, estimates of plant intake rates may also be attainable.



Cattle feeding on diverse native rangeland at the University of Alberta Kinsella Research Ranch.

This University of Alberta study is quantifying the diets of free-ranging cattle and their contribution to cow/calf weight gain, as well as other important metrics such as methane emissions. This process involves 3 steps, including: 1) Development of a comprehensive DNA reference library for plant species found in native rangelands of the Aspen Parkland, 2) Drylot trials to calibrate and validate the use of DNA barcoding of fecal samples taken from cattle fed a predetermined diet to detect the presence of added novel plant species in the diet, including at different levels, and 3) Collection of fecal samples from free-ranging cattle, subsequent plant DNA extraction, and then comparison to a reference library for the rangelands in question to quantify plant species presence, abundance, and dietary diversity.

Once the methodology is refined, this process will be applied to up to 200 free-ranging beef cattle to characterize their diets in summer and fall, as well as over multiple grazing seasons, which in turn, will be related to important traits such as cattle weight gain. The assessment of diets for large numbers of cattle will ultimately enable additional tools to be developed to aid the beef cattle industry. For example, we will pursue the exploration of cattle DNA markers that reflect dietary selection. While a long-term process to undertake, this approach could one day be used to select for cattle that are uniquely adapted to local foraging conditions (e.g., rangelands with proportionally higher forest or browse, or wetland plant species), all the while simultaneously maintaining animal performance and the environmental sustainability of grazing activities.

Left: Custom feed rations being prepared for heifers fed in drylot to calibrate and validate diet composition using fecal DNA barcoding. Right: Heifers in GrowSafe being used to conduct the calibration-validation trial to characterize cattle diets.

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