Beef Cattle Sciences

Oregon Beef Council Report

2021 Edition

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Thank you for the interest in the 2021 Oregon Beef Council Report. This publication contains information about research studies funded by the Oregon Beef Council, and conducted by faculty members from Oregon State University. For questions, suggestions, or comments regarding this publication, please contact David Bohnert (541-573-8910 or dave.bohnert@oregonstate.edu).

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BEEF210

Oregon Beef Council Report

Beef Cattle Sciences

Feeding Spent Hemp Biomass to Lambs as a Model for Cattle [1]

Serkan Ates[2]

Synopsis

Lamb feed intake and liveweight gains were similar to control diet when they were fed diets containing low (10%) spent hemp biomass. While the feed intake of the lambs that were fed diets containing high spent hemp biomass (20%) was lower than those were fed control diet, their liveweight gains did not differ indicating a greater feed conversion efficiency.

Summary

The objective of this study was to determine the effect on health and meat quality and THC and CBD residuals in finishing lambs fed spent hemp biomass in place of alfalfa as the roughage source. We investigated the effects of feeding level and withdrawal period of spent hemp biomass in place of alfalfa in feedlot-finishing lamb diets. Specifically, we assessed THC and CBD residuals in meat cuts, along with evaluating growth performance, carcass traits, and meat quality. Lambs are chosen as proxy to cattle in this study to reduce the cost of the experiment. Over an 8 week-trial period followed by 3 week transition, our result indicated that lambs the lambs that consumed high (20%) spent hemp biomass (HH groups) in their diets had a lower feed intake, while those receiving low (10%) spent hemp biomass (LH groups) had similar feed intake to control diet that contained no spent hemp biomass. While the liveweight gains of the lambs were similar in period 1, the lambs that were fed high spent hemp biomass (20%) containing diet in period 1 had a greater feed intake and liveweight gain when they were fed control diet in period 2. Carcass characteristics and meat quality related parameters are currently being investigated.

Introduction

The 2018 Farm Bill removed hemp (*Cannabis sativa*) from the Controlled Substances Act, classifying it as an agricultural product. Thirty-eight states in the U.S. are in the process of implementing a program for regulating industrial hemp, allowing its cultivation. This has led to a flourishing industry. Oregon is among the leading producers of hemp to produce cannabidiol (CBD), a process that generates a highly-nutritive spent byproduct that could be fed to livestock. Byproducts of hemp are not yet FDA approved for use in animals for food production. Studies conducted in Europe have revealed that hempseed cake is safe for inclusion in livestock feed (EFSA, 2011). However, there are no studies that have investigated feeding spent hemp biomass (i.e., hemp biomass after CBD has been extracted) to

1. This document is part of the Oregon State University – 2021 Oregon Beef Council Report. Please visit the Beef Cattle Sciences website at http://blogs.oregonstate.edu/beefcattle/research-reports/
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livestock, specifically to ruminant animals. The most critical aspect of feeding any hemp byproducts is the potential for cannabinoid residuals in milk or meat, particularly the psychoactive tetrahydrocannabinol (THC). Data from Europe have indicated the presence of unacceptable levels of THC in animals fed fresh hemp, but acceptable levels when using spent byproducts such as hempseed cake. Therefore, there is a critical need to assess the levels of THC residuals in milk and meat to obtain FDA approval to feed hemp byproducts to livestock.

Our long-term goal is to implement the safe use of hemp byproducts in livestock diets and take full advantage of their nutritional and potential medicinal properties to improve animal health and the quality of animal products. The objective of the present proposal is to assess the presence of THC and CBD residuals in meat of ruminant animals fed diets that contain spent hemp biomass. These data are essential for obtaining FDA approval for use of hemp byproducts in ruminant diets. This proposal is predicated upon the fact that hemp is a rapidly growing industry that can provide economically viable and potentially health-improving byproducts to feed ruminants. However, data to obtain FDA approval for hemp use are not available in the U.S. Therefore, there is a critical need to assess the presence of cannabinoid residuals in milk and meat in ruminants fed hemp byproducts and their effect on quality of the animal products and animal health and performance. Our rationale is that data on THC and CBD residuals in animal byproducts and safety are essential for use as livestock feed and this research is needed for the process of obtaining FDA approval for the feeding of hemp byproducts to ruminants. The expanding hemp industry is of very high interest to Oregon and other U.S. livestock producers due to the possibility of obtaining cost-effective, high-quality feed supplements with potential health benefits for animals.

Materials and Methods

A pen feeding trial was conducted using 35 weaned Polypay lambs (44.7kg and 5-6 month-old) for a period of 8 weeks following a 3-week adaptation period. Lambs were individually housed in pens equipped with feeders and water buckets where they were fed corn-barley-soy based finishing diets with 70/30 concentrate/roughage ratio (as fed). Lambs were stratified by weight and assigned randomly to 5 treatments with 7 lambs per treatment. The experiment consisted of two four-week periods from August 7 to October 1. Spent hemp biomass replaced alfalfa in diets as follows: control diet; 70% concentrate-20% alfalfa (+10% grass hay) with no hemp inclusion (control; **CON**); 2) low hemp diet in period 1: 70% concentrate plus 10% alfalfa and 10% spent hemp biomass (+10% grass hay) during only period 1 (28 d) and 20% alfalfa in period 2 (+10% grass hay) (**LH-1**); 3) low spent hemp biomass in both periods: 70% concentrate plus 10% alfalfa and 10% spent hemp biomass (+10 grass hay) during period 1 (28 d) and period 2 (28 d) (LH-2), 4) high spent hemp biomass in period 1: 70% concentrate plus 20% spent hemp biomass (+10 grass hay) during only period 1 (28 d) and 20% alfalfa (+10 grass hay) in period 2 (HH-1); and 5) high spent hemp biomass in both periods: 70% concentrate plus 20% spent hemp biomass (+10 grass hay) during period 1 (28 d) and period 2 (28 d) (HH-2). All diet ingredients were ground with a hammer mill and mixed to prevent feed selection. However, chopped grass hay (10% as fed) was offered to lambs separately to avoid possible acidosis problems. The diets were balanced for energy and protein and formulated to contain 12.1 g kg^{-1} CP (DM basis). Each animal was offered a trace mineral–salt mixture.

Lamb LWG and dry matter intake (DMI) were monitored. Lamb weights were recorded at the beginning of the trial and at 28-day intervals thereafter, following a 12 h fast. Feed samples and unconsumed feed from each group were taken three times each week for DM and nutrient intake determination. All lambs were fed twice daily and the unconsumed feed was collected and weighed prior to morning feeding to determine feed consumption per lamb. The unconsumed feed represented 15-20% of feed offered to lambs.

At the end of the feeding experiment, all lambs were slaughtered at the OSU Clark Meat Lab to study the carcass characteristics and meat quality. Carcass characteristics (hot and cold carcass weight, dressing percentage, offal parts, yield grade and dissected components of the left carcass) of the animals were determined. Meat quality parameters (tenderness, cooking loss, pH, color, shelf life etc.) and fatty acid profile are currently being determined.

Results

Our results indicated that the lambs receiving high (20%) spent hemp biomass (HH groups) in the diet had a significant reduction of feed intake, while those receiving low (10%) spent hemp biomass (LH groups) had similar feed intake to control diet that contained no spent hemp biomass (Figure 2). However, the decrease in feed intake did not affect the average daily gain. The animals receiving rations containing high (20%) spent hemp only in Period 1 (HH1 group) had a large increase in their feed intake in Period 2 when they were fed control diet, resulting in the group with the highest feed intake during this period. The animals receiving low (10%) spent hemp biomass during both periods (group LH2) had a greater feed intake compared to control or the LH1 group in Period 2. The average daily gain tended to be higher in animals that received spent hemp biomass in Period 1 but received the control diet in Period 2. In animals receiving high (20%) spent hemp biomass during only Period 1 (HH1), feeding spent hemp biomass tended to make the animals more efficient in Period 2 when they had control diets. No other differences in performance were observed. Besides not being detrimental to the animals, feeding spent hemp biomass resulted in increased feed intake in the long run, as demonstrated by the feed intake being larger compared to control group in animals receiving 10% spent hemp biomass (LH2). Thus, the data support the safe use of spent hemp biomass to feed ruminants, but also are indicative of an effect of the spent hemp biomass on the appetite of the animals. The higher feed intake induced by the spent hemp biomass could be due to an effect on the rumen or could be a systemic effect.

Several blood parameters of the lambs were measured in both periods (Table 1.). All parameters were within the normal range and no hemp feeding related adverse effects were observed (*All* $P>0.05$).

Of the carcass characteristics and meat quality parameters, only few of them were significantly affected by the feeding treatments (Table 2). In particular, feeding spent hemp biomass to lambs increased ($P<0.05$) the shrink and cook losses in meat. Lambs that were fed spent hemp biomass at both 10 and 20% levels had larger shrink losses as compared to control lambs. While withdrawing from spent hemp biomass led to similar shrink losses with the control in both feeding levels, it did not have any effect on cooking losses. However, the effect of feeding spent hemp biomass was not consistent across the treatments as the cooking loss was similar to control at higher level of spent hemp biomass feeding.

Total cannabinoids in liver were greater ($P<0.01$) in lambs consumed a diet containing 20% SHB than those received 10% SHB in their diets. Withdrawal from SHB for a period of 4 weeks was an effective method to clear the cannabinoids from the liver. We are currently waiting for the cannabinoids analyses results from lean and fat tissues.

Conclusions

Our results indicated that spent hemp biomass can successfully be included in ruminant diets without causing any detrimental effect to animal performance and health. However, it is of note that high terpene content of spent hemp biomass should be eliminated before feeding to the livestock to improve the 'palatability' of the feed. Initial results indicated that withdrawal from spent hemp biomass clears the cannabinoids from liver.

Acknowledgments

This research study was financially supported by the Oregon Beef Council.

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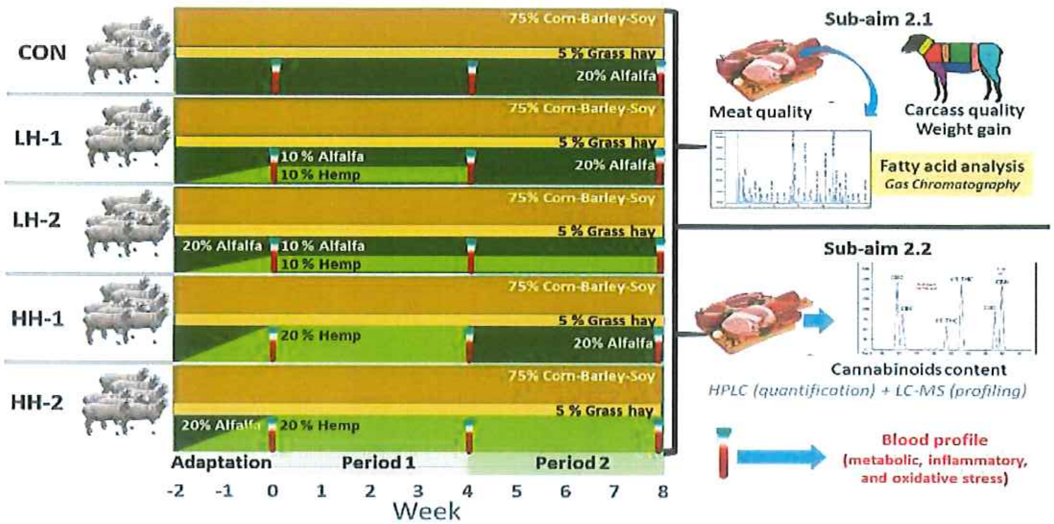

Figure 1. Overview of the experimental design and measurements.

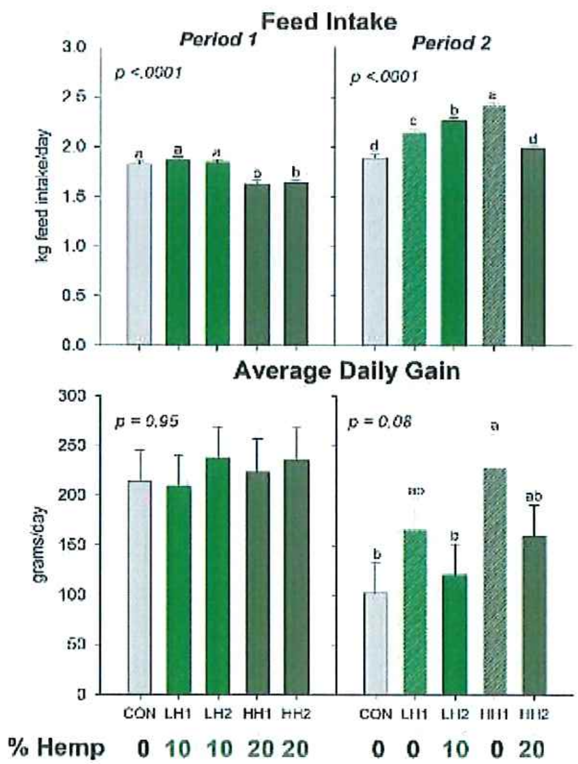

Figure 2. Feed intake (kg) and average daily gain (grams/day) from the lamb experiment. CON = lambs receiving no hemp; LH1 = lambs receiving 10% spent hemp biomass during Period 1 only; LH2 = lambs receiving 10% spent hemp biomass during Periods 1 and 2; HH1 = lambs receiving 20% spent hemp biomass during Period 1 only; HH2 = lambs receiving 10% spent hemp biomass during Periods 1 and 2. See Figure 1 for details. The overall effect is indicated by the p-values reported in the graph (significant when equal or less than 0.05 and a tendency when P equal or less than 0.10) and different letters denote statistical difference between groups.

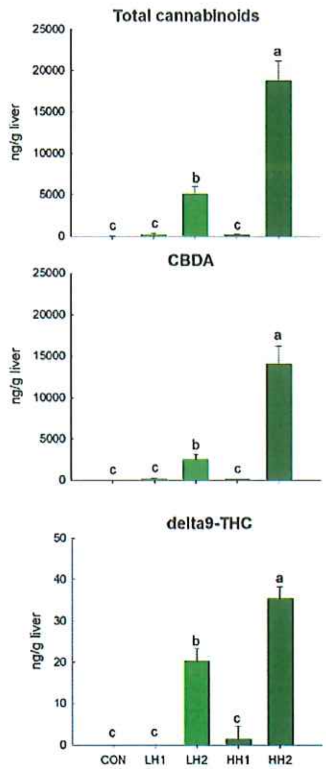

Figure 3. Cannabinoid residuals in livers of the lambs. CON = lambs receiving no hemp; LH1 = lambs receiving 10% spent hemp biomass during Period 1 only; LH2 = lambs receiving 10% spent hemp biomass during Periods 1 and 2; HH1 = lambs receiving 20% spent hemp biomass during Period 1 only; HH2 = lambs receiving 10% spent hemp biomass during Periods 1 and 2. See Figure 1 for details.

Parameters	Period 1 (0-28 d)			SEM	P	Period 2 (28-56 d)					SEM	P
	CON	LH	HH			CON	LH1	LH2	HH1	HH2		
Hematocrit	37.3	34.3	37.2	1.25	0.06	35.6	35.4	34.8	33.7	38.6	1.91	0.42
Lymphocytes	50.5	52.6	51.3	3.90	0.89	39.2	44.5	44.3	38.8	41.2	3.02	0.45
Granulocytes	29.3	30.3	32.3	3.38	0.75	26.9	28.9	29.0	27.2	29.5	1.65	0.69
PMN*	41.7	39.2	40.2	4.49	0.89	37.0	42.2	37.6	41.8	43.1	2.92	0.40
Monocytes	3.73	4.00	4.46	0.44	0.37	1.58	1.73	1.78	3.02	1.84	0.53	0.31
Phagocytosis												
WBC**	20.7	19.0	19.2	1.93	0.74	26.0	19.5	21.9	27.2	22.6	3.24	0.44
PMN	52.1	46.3	44.9	3.99	0.34	28.9	29.7	29.0	32.8	29.7	4.12	0.96
Granulocytes	43.5	39.9	38.6	3.32	0.50	51.6	40.5	51.3	52.3	45.3	5.03	0.38

[1]Animal were fed the control diet or with 10 and 20% spent hemp biomass during period 1 while during Period 2 half the animals that received spent hemp biomass in Period 1 were fed the control diet while the rest continued to get the diet of period 1. In Period 1 there were 3 groups: CON= control; LH= 10% spent hemp biomass; HH= 20% spent hemp biomass. In Period 2, there were 5 groups: CON= control; LH1= animals that received 10% spent hemp biomass in periods 1 received the control diet; LH2= animals received 10% spent hemp biomass; HH1= animals that received 20% spent hemp biomass in periods 1 received the control diet; HH2= animals received 20% spent hemp biomass.
*Polymorphonucleated cells. ** White blood cells

Table 1. Hematocrit and white blood cells (WBC) differential and phagocytosis (all as %) in lambs fed spent hemp biomass[1].

Parameter*	Unit	CON	LH1	LH2	HH1	HH2	SEM	*P*
Carcass								
LW	Kg	53.6	56.7	54.5	56.9	52.9	2.14	*0.53*
HCW	Kg	25.9	27.5	26.8	27.0	24.6	1.10	*0.31*
Dressing	%	48.4	48.6	49.1	47.3	46.5	0.94	*0.25*
CCW	Kg	24.5	25.6	24.9	24.9	22.4	1.08	*0.23*
Shrink loss	%	5.56^{c}	7.07^{abc}	6.82^{bc}	7.65^{ab}	8.84^{a}	0.72	*0.03*
REA	cm^2	14.6	15.4	15.3	15.5	13.5	0.64	*0.14*
BFT	cm	0.48	0.54	0.36	0.40	0.52	0.09	*0.47*
BWT	cm	1.91	1.86	1.61	1.59	1.57	0.13	*0.19*
Yield grade		2.29	2.54	1.83	1.98	2.44	0.34	*0.47*
Cutability est.	%	47.2	47.1	47.9	47.9	47.4	0.44	*0.55*
Meat								
Loin a		20.4	21.2	21.3	21.4	21.7	0.98	*0.88*
Loin b		12.4	12.9	13.3	13.7	13.8	0.87	*0.70*
Loin L		45.3	45.2	45.7	46.0	47.5	1.34	*0.70*
Loin pH		5.69	5.66	5.67	5.57	5.61	0.12	*0.94*
Cook loss	%	14.1^{b}	15.1^{ab}	18.1^{a}	18.3^{a}	16.1^{ab}	1.20	*0.05*
Tenderness	N	24.7^{b}	20.8^{b}	26.5^{ab}	34.0^{a}	24.3^{b}	2.99	*0.03*
Loin shelf life								
Color a*		22.6	23.8	23.5	23.3	23.5	0.34	0.09
Color b*		18.1b	19.5a	19.3a	19.1a	19.2a	0.31	<0.01
Color L*		39.9	40.3	39.6	40.4	40.7	0.54	0.54
Purge loss	%	2.32	2.29	2.22	2.27	2.52	0.10	0.21

[1]Animal were fed the control diet or with 10 and 20% spent hemp biomass during period 1 while during Period 2 half the animals that received spent hemp biomass in Period 1 were fed with the control diet while the rest continued to get the diet of period 1. In Period 2 there were 5 groups: CON= control; LH1= animals that received 10% spent hemp biomass in periods 1 received the control diet; LH2= animals received 10% spent hemp biomass; HH1= animals that received 20% spent hemp biomass in periods 1 received the control diet; HH2= animals received 20% spent hemp biomass.

*LW= hanging live weight; HCW= hot carcass weight; CCW = cold carcass weight; REA= ribeye area; BFT= back fat thickness; BWT= body wall thickness

Table 2. Carcass characteristic, loin color, loin cook loss, and loin tenderness of lambs fed spent hemp biomass[1].

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Beef Cattle Sciences

Using GPS Activated Shock Collars to Prevent Cattle Grazing of Burned Rangeland [1]

Juliana Ranches[2]

Synopsis

The use of virtual fence (VF) collars was effective at preventing cows from grazing burned areas of pastures as well as consuming the feed attractant used in the behavior study. Additionally, the use of VF collars did not negatively impact the cow behavior, as observed by the resumption of normal activities upon removal of collars. Further, cows did not develop a negative association with the VF area, in fact, cows quickly learn to avoid the VF area upon stimuli, which decreased over time.

Summary

Two studies were conducted to assess the use of virtual fence (VF) while evaluating the efficacy of VF in a grazing trial, as well as the behavior of naïve cows when fitted with VF collars. The VF collars were effective in preventing cows from grazing burned portions of pastures, and therefore reducing forage utilization of such areas ($P \leq 0.001$). Behavioral observations, chute score, and exit velocity, collar fit score, latency to approach feed attractant, as well as auditory and electric stimulus count, were evaluated in observational study over multiple runs (runs 1 and 5 = collar off; runs 2, 3, and 4 = collars on). Auditory and electric stimuli were only applied during runs 2, 3, and 4. The response of both stimuli followed the same pattern and was positively correlated ($r = 0.88$; $P < 0.001$). Cows received the greatest ($P \leq 0.01$) number of stimuli during run 2, which decreased in runs 3 and 4, implying that cows quickly learn to avoid the management zone in the VF area. Regarding time spent in the VF area, cows spent the greatest ($P < 0.01$) time at the VF area during run 1 followed by run 5, with runs 2, 3, and 4 with the least amount of time spent at the VF area. Among the behaviors observed, cows engaged in eating behavior at the greatest ($P < 0.001$) percentage of time during run 1 when compared to runs 2, 3, and 4 with no differences observed when compared to run 5, implying that eating behavior was not negatively affected by VF use.

Introduction

In modern agricultural systems, multiple types of fences are used to contain and manage livestock. The containment of cattle in grazing systems uses mainly barbed wire or electric fences, which are time-consuming to build and maintain and are very costly. A recently developed technology, virtual fence (VF), which uses behavioral modification based on global positioning system (GPS) may offer a less expensive and logistically challenging alternative to traditional fencing. The VF can be defined as a structure serving as an enclosure, a barrier, or a boundary without a physical barrier. Animals in VF are fitted with GPS collars, which provide an auditory warning stimulus followed by an electric

1. This document is part of the Oregon State University – 2021 Oregon Beef Council Report. Please visit the Beef Cattle Sciences website at http://blogs.oregonstate.edu/beefcattle/research-reports/
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stimulus if the animal trespasses a predetermined boundary.

The VF technology has the potential to positively influence the management of soils, vegetation, and livestock through more sustainable overall use of land. In the western US rangelands, for example, each year wildfires burn millions of acres resulting in billions of dollars annually in suppression costs and posing significant challenges associated with land, livestock, and wildlife management. Additionally, pastures within grazing allotments are often quite large, frequently in excess of 10,000 acres. If a portion of such pasture burns, that pasture is either excluded from grazing for at least a two-year period, or temporary fencing must be constructed to exclude the burned portion. In such a scenario, the use of VF could improve land utilization by allowing cattle to graze in very specific areas, while excluding other areas, such as recently burned pastures. Further, the proactive use of VF to strategically graze areas based on wildfire risk assessment and land management objectives through reduction of fuel loads and development of fire breaks has tremendous potential to reduce fire occurrence, severity, and size which benefits the ecosystem, air quality, and reduces fire suppression cost.

A collaborative group of OSU (Juliana Ranches, Dustin Johnson, and David Bohnert) and USDA-ARS (Chad Boyd, Rory O'Connor, Kirk Davies, and Jonathan Bates) researchers at the Eastern Oregon Agricultural Research Center (EOARC; Burns, OR) have initiated a research program with the objective to evaluate the efficacy of VF technology for beef cattle. We hypothesized that the VF would be effective at preventing cattle of grazing burned areas of pastures and the use of VF would not negatively impact cattle behavior. In 2020, two studies were conducted, the first evaluate the efficacy of VF to exclude cattle from burned areas of sagebrush steppe pastures, and the second study evaluated the cattle behavior when fitted with VF collars for the first time.

Materials and Methods

Grazing study: A total of eighteen mature Angus × Hereford cows were assigned to one of two treatments: control (cows with non-activated VF collars) and virtual fence (cows with activated VF collars; Vence Corp. Inc. San Diego, CA). Cows were fitted with VF collars (**Figure 1**) and placed as groups of three cows, in one of six 5-acre experimental pastures (Wyoming big sagebrush-dominated plant community) at the Northern Great Basin Experimental Range (NGBER; Riley, OR) for fourteen days during the early summer of 2020. Prior to the beginning of the study, during fall 2019, a strip representing approximately 30% of each pasture was burned. The burned stripped area in each pasture was designated as a management zone within the VF (**Figure 2**). As cows entered this area of the pasture an auditory stimulus followed by an electric stimulus was applied to the cows assigned to the VF treatment. These stimuli were provided by the VF collars according to the GPS location. For both groups, control and VF, animal locations were recorded every 5 minutes using GPS coordinates. Cattle location and forage utilization were collected during the grazing study.

Behavior study: A total of eleven mature Angus × Hereford cows were randomly selected from the EOARC herd to be used in this study. Cows selected for this study were never fitted with VF collars and therefore were considered naïve to the technology. For behavioral evaluation, each cow was fitted with a unique VF collar for the duration of the study.

A VF was used to create a testing arena, where all behavioral variables were collected. The VF was set in a pen adjacent to cattle working facility, allowing to easily move cows in and out of the testing arena. The VF contained one management zone divided in two areas, one where the auditory stimulus was applied and another one where the electric stimulus was applied. The management zones, within the VF, were set at the back end of the pen and were approximately 5 × 35 m for the auditory management zone and 10 × 35 m for the electric management zone (both management zones followed the length of the pen, approximately 35 m). A bale of alfalfa (*Medicago sativa*) hay was placed in the middle of the testing arena to serve as a feed attractant, to stimulate cows to cross the VF. Run 1 was used to allow cows to become familiar with the testing arena, thus cows were not fitted with VF collars, therefore auditory and electric stimuli were not collected at the first run. The testing time (10 minutes) began as the cow entered the testing arena passing through gate one. When the testing time was over cow was moved out of the testing arena to an adjacent pen, through gate two and would later be moved to the squeeze chute through gates three and four (**Figure 3**). Cows were fitted with VF collars at the beginning of run 2 and remained collared until the end of run 4; collars were removed at the beginning of the last run (run 5). The count of auditory and electric stimuli applied to cows, chute score and exit velocity, collar fit score, latency to approach feed attractant, and time spent in the VF, as well as behaviors in the testing arena were collected in each run of the behavior study.

Results

Grazing study: Cows assigned to the control treatment initially spent up to 40% of their time within the burned area, resulting in a heavy forage utilization of the burned area for this group of approximately 70%. Cows assigned to the VF treatment spent less time in the burned area when compared to cows assigned to control treatment, spending approximately 4% of their time in the burned area on the first day in the pasture ($P \leq 0.001$; **Figure 4**). Cows assigned to VF treatment were rarely recorded in the burned area, thereafter, resulting in negligible forage utilization of the burned area for this group of approximately < 3%. This difference in forage utilization between the two groups was noticeable to the naked eye (**Figure 5**) suggesting that VF is effective to contain cattle in specific areas, holding tremendous potential as a land and livestock management tool.

Behavior study: No differences were observed across runs for chute score ($P = 0.85$) or chute exit velocity ($P = 0.37$; **Table 1**) implying that both variables were not affected by the collar use.

Collar fit score was greater ($P < 0.001$) in run 2 when compared to all other runs (**Table 1**). Cows were fitted with VF collars at run 2 explaining the increase in collar fit score when compared to the other runs. During run 2, collar fit score was 3.95 where cows were classified as very alarmed and excited, moving quickly and shaking head (score 4). Interestingly this response was only observed at run 2, suggesting that cows became quickly adapted to VF collars.

Although no differences ($P = 0.12$) were observed for latency to approach the feed (**Table 1**), cows took a longer time to approach the feed attractant during runs 3 and 4 when compared to run 5, suggesting that cows did not lose interest in the feed attractant; however, they were cautious when proceeding to the respective area. Such rationale is supported by the time spent in the VF management zones (**Table 1**), whereas cows spent the greatest ($P < 0.01$) time in the VF management zones during run 1 followed by run 5, with runs 2, 3, and 4 with the least amount of time spent in the VF management zones, implying that cows did not develop a negative association with VF management zones and the feed attractant placed in this area.

Auditory and electric stimuli applied to cows during runs 2, 3, and 4 followed the same pattern and were positively correlated ($r = 0.88$; $P < 0.001$). Cows received the greatest ($P \leq 0.01$) number of stimuli during run 2, which decreased over runs 3 and 4 (**Table 1**) implying that cows have quickly learned to avoid the VF area as similarly observed by Lee et al. (2009).

Among the behaviors observed during each run, there were no differences ($P \geq 0.15$) between runs for browsing, walking, head shaking, walking and head shaking, and running and trotting (**Table 2**). As expected by study design, cows engaged in eating behavior at the greatest ($P < 0.001$) percentage of time during run 1 when compared to runs 2, 3, and 4 with no differences observed when compared to run 5, implying that eating behavior was not negatively affected by VF collar use. In fact, the use of VF collars prevented cows from engaging in eating behavior during runs 2, 3, and 4 (as desired) while eating behavior return to a level similar to the initial run during run 5. Similarly, Campbell et al. (2018) reported that number of cows reaching a feed attractant when evaluating cattle behavior using VF collars, reduced with trial progression. However, in that study the authors have not reported if cows would resume feeding activity in the previous stablished VF, as observed in this study. Cows engaged in idling behavior at greatest ($P < 0.01$) percentages during runs 2, 3, and 4 likely to avoid the stimuli.

A similar pattern was observed among some of the behaviors categorized as agnostic or non-desirable (running/trotting and head shake, jumping, jumping and head shaking, and bucking and running). These behaviors were absent during run 1, peaked ($P \leq 0.02$) during run 2, and were reduced or absent during runs 3, 4, and 5, implying that cow's engagement in non-desirable behaviors was likely due to VF collars, however, this response was transient, only present immediately after cows were collared.

Conclusions

Collectively the findings of both studies, imply that the use of VF collars is effective at preventing cows from entering the VF area, and therefore were effective at reducing the grazing activity in the burned area in the first study, and also prevent cows from consuming the feed attractant present in the testing arena in the second study. Additionally, the use of VF collars did not negatively impact the cow behavior, as observed in the second study by the resumption of behaviors upon removal of collars. Further, cows did not develop a negative association with the VF area, in fact, cows quickly learn to avoid the VF area upon stimuli, which decreased over time. Finally, these preliminary results are very encouraging about the uses of VF as a management tool and are instigating for more research trials.

Acknowledgments

This research study was partially supported by the Oregon Beef Council. Appreciation is extended to collaborators David Bohnert, Dustin Johnson (OSU – EOARC), Chad Boyd, Rory O'Connor, Kirk Davies, Jonathan Bates (USDA-ARS) and Todd Parker (Vence) and to interns Julia Livingston, Emmy Montufar, and Garret Goss-Bodily for assistance with the study development, data collection, and analysis.

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Figure 1. Group of cows fitted with VF collars.

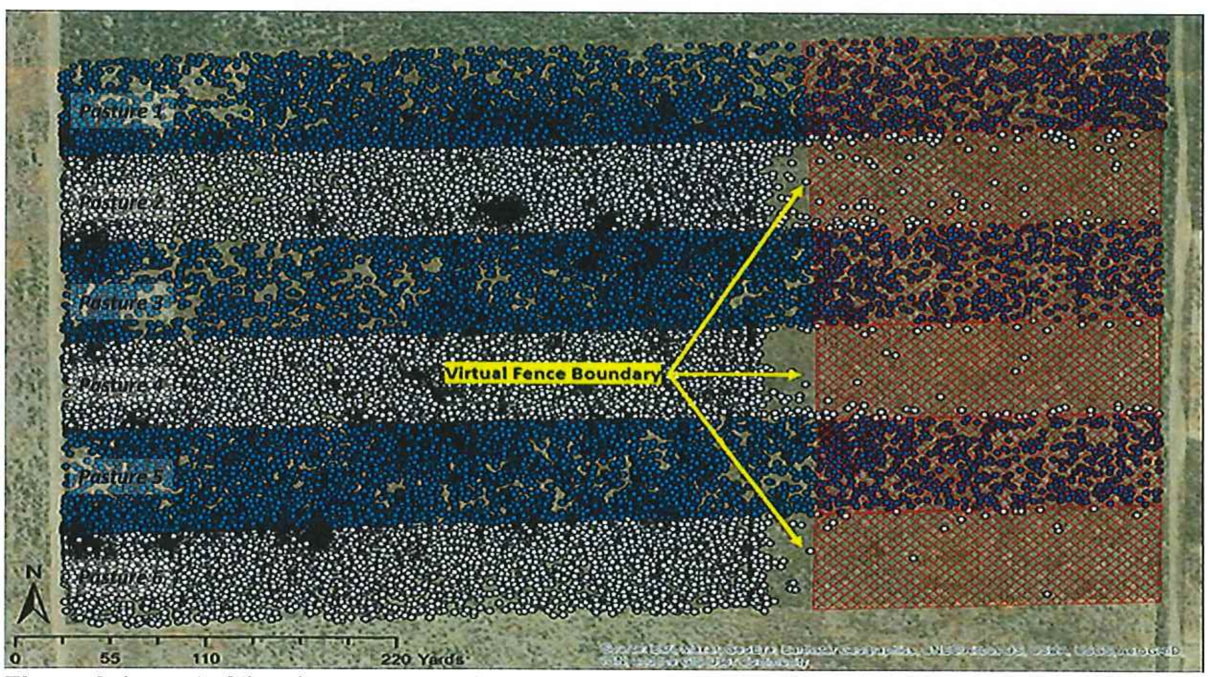

Figure 2. Layout of the six 5-acre experimental pastures used in the grazing trail. Blue (Control) and white (Virtual Fence) dots represent cow locations every 5 minutes during grazing study. Red hatch represents the burned stripped area (management zone) across all six pastures. The VF was established to restrict access of "white dot" cows into the burned area.

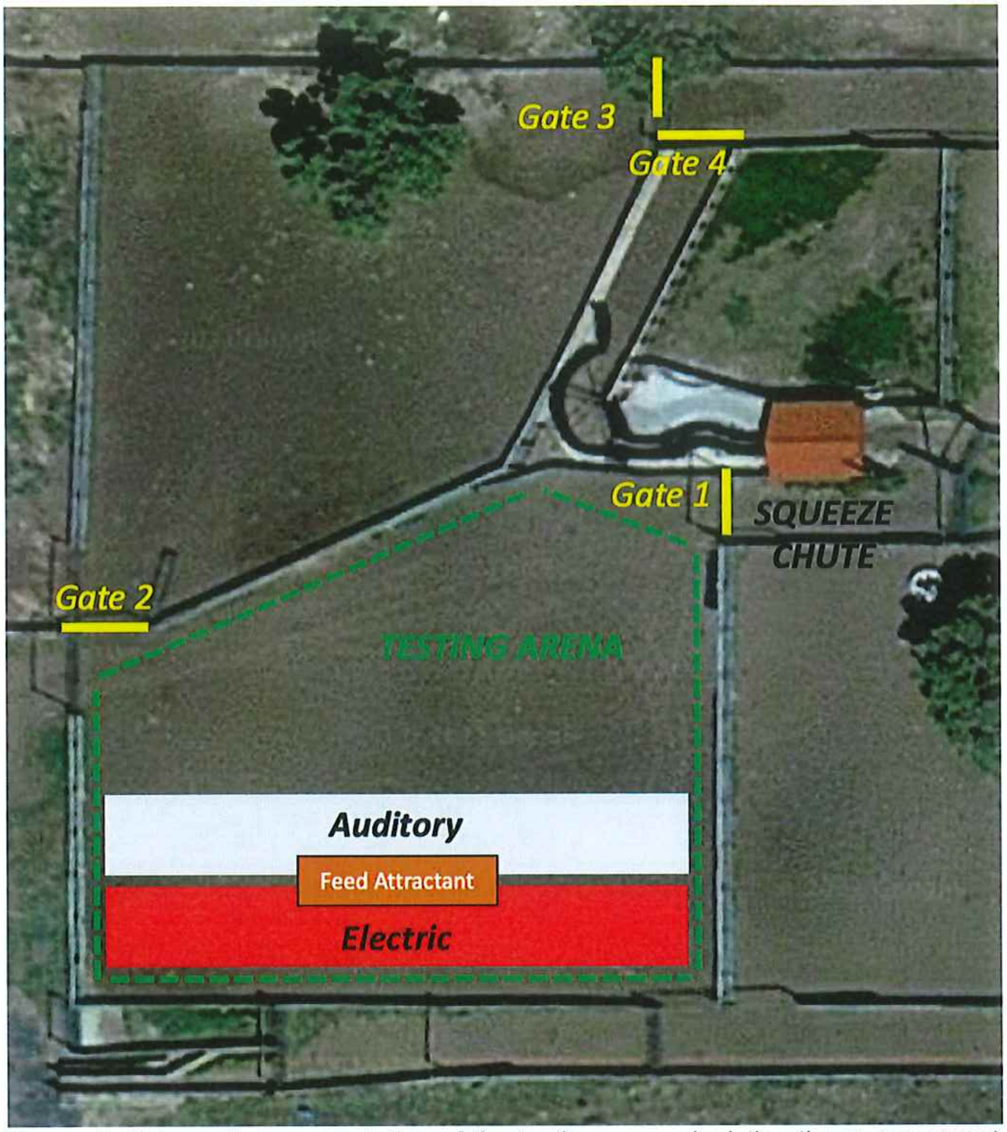

Figure 3. Schematic representation of the testing arena depicting the management zones; auditory and electric, and gates allowing cows to be moved in and out of the testing arena used in the behavior study.

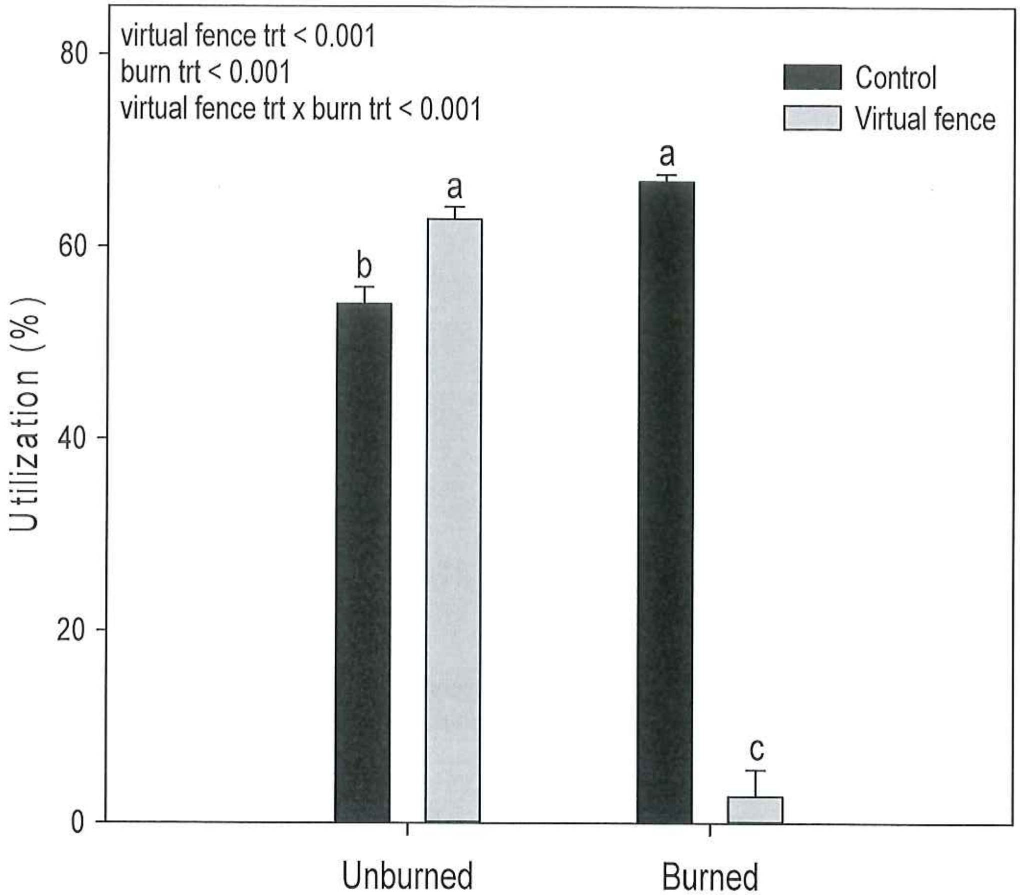

Figure 4. Comparison of percentage of forage utilization in unburned and unburned areas of the pasture for cows assigned to control and VF treatments in the gazing study.

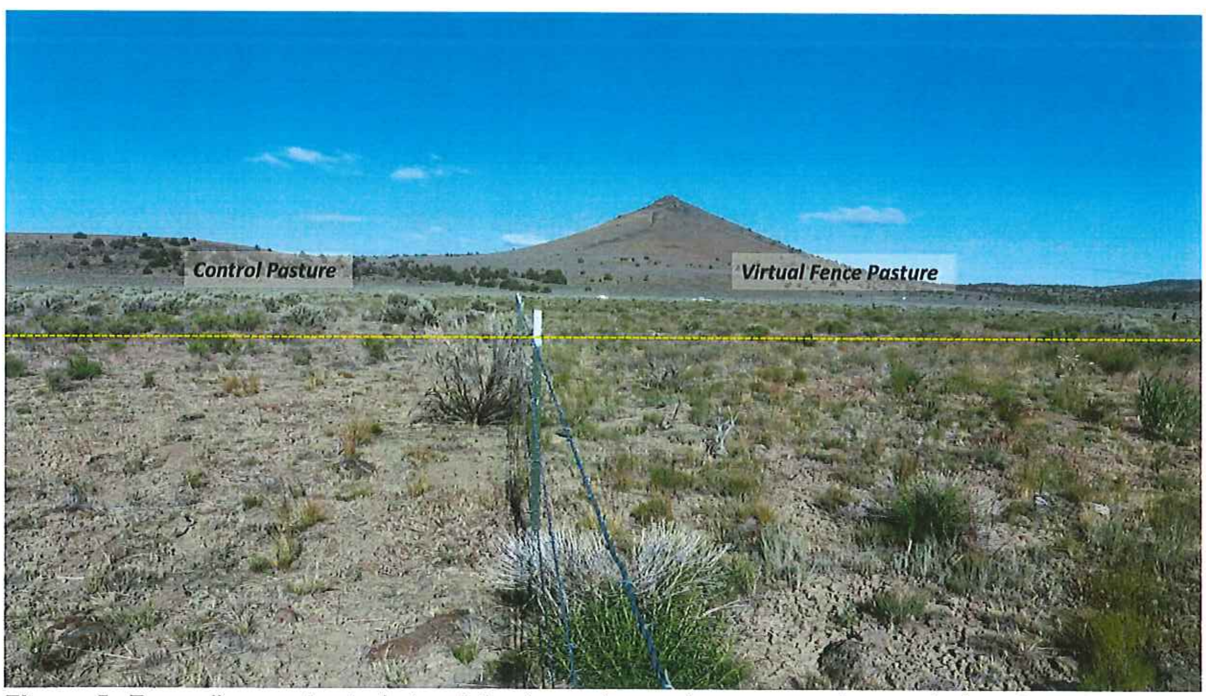

Figure 5. Fence-line contrast photo of the burned area (management zone; below the yellow dotted line) after grazing. Control treatment on left and VF treatment on right (Photo Credit: Stephanie Falck; USDA-ARS).

Item	*Run 1*	*Run 2*	*Run 3*	*Run 4*	*Run 5*	*Largest SEM*	*P-value*
Chute score[1]	1.40	1.25	1.30	1.30	1.40	0.109	0.85
Chute exit velocity, m/s[2]	2.10	1.45	1.80	1.85	1.90	0.244	0.37
Collar fit score[3]	1.45[b]	3.65[a]	1.60[b]	1.30[b]	1.25[b]	0.197	< 0.001
Latency to approach feed, sec[4]	287	283	455	511	418	73.20	0.12
Time spent VF, %[6]	62.7[a]	22.7[b]	18.6[b]	12.2[b]	33.6[a,b]	8.766	< 0.01
Auditory stimulus applied[5]	N/A	11.9[a]	7.95[a,b]	2.14[b]	N/A	2.108	< 0.001
Electric stimulus applied[5]	N/A	6.55[a]	4.7[a,b]	0.545[b]	N/A	1.395	< 0.01

[a, b] Means across rows with different superscript differ.

Table 1. Count of auditory and electric stimuli applied to cows, chute score and exit velocity, collar fit score, latency to approach feed, and time spent in the virtual fence (VF) area in each run of the behavior study.

Behavior[1]	*Run 1*	*Run 2*	*Run 3*	*Run 4*	*Run 5*	*Largest SEM*	*P-value*
Eating, %	47.7[a]	3.85[b]	0.955[b]	1.34[b]	24.0[a,b]	6.943	< 0.001
Browsing, %	10.8	5.60	12.0	6.65	19.9	5.09	0.30
Idling, %	21.9[c]	52.3[a]	54.9[a]	57.8[a]	36.6[a,b,c]	6.95	< 0.01
Walking, %	15.9	17.8	24.9	26.0	18.8	4.01	0.30
Head shaking, %	0.466	3.50	0.970	1.70	0.250	1.0184	0.17
Walking; head shaking, %	0.485	4.01	0.888	2.83	0.252	1.2401	0.15
Running/trotting, %	0.00	1.14	0.92	0.88	0.00	0.9622	0.85
Running/trotting; head shaking, %	0.00[b]	5.54[a]	1.60[b]	0.800[b]	0.00[b]	0.8152	< 0.001
Jumping, %	0.00[b]	1.08[a]	0.232[b]	0.235[b]	0.00[b]	0.2404	0.01
Jumping and head shaking, %	0.00[b]	1.86[a]	0.927[a]	0.00[b]	0.00[b]	0.4050	< 0.01
Bucking and running, %	0.00[b]	1.25[a]	0.232[a,b]	0.00[b]	0.00[b]	0.3074	0.02

[a, b, c] Means across rows with different superscript differ.

Table 2. Activity budget as the average percentage of time spent engaged in each behavior in each run of the behavior study.

Oregon State University

BEEF212

Oregon Beef Council Report

Beef Cattle Sciences

Progress Reports – Animal Sciences [1]

Evaluating Methods to Reduce Calf Stress During Processing in Unweaned Bulls

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Project Objectives: The research objective is to test the hypothesis that managing cow-calf pairs during branding and processing will reduce the levels of the stress hormone, cortisol, which is acutely released at that time. We anticipate that our results will promote a positive image within the beef industry—in Oregon and across the west—and have implications directly related to positive economic returns.

Project Start Date: The project begins winter 2022 with calving.

Expected Project Completion Date: The project will be concluded fall 2022.

Project Status and Preliminary Findings: Introduction: Across the western U.S., cattle processing is a standard procedure performed by cow-calf operators. It is a stressful event that occurs within the first three months of a calf's life when they are earmarked, branded, vaccinated, dehorned, and when bull calves are castrated. Producers use this time to both provide a necessary form of identification and boost overall herd health. When taking into consideration the sheer number of beef cattle that populate the rugged terrains and vast expanses of western rangelands, it is not uncommon for the general public to come across ranchers processing their calves. Because it is commonly in public view, traditional practices associated with calf processing are subjected to increased scrutiny that have the potential to either enhance or damage cattle producers' image through the lens of urban America.

Oregon cow-calf operators skillfully implement practices supporting sustainable operations by implementing practices that are economically viable, socially diligent, and environmentally responsible. Incidentally, many of these practices are consistent with best management practices highlighted by the National Beef Quality Assurance (NBQA) Program, which provides science-based and common sense curriculum to ensure producers are implementing practices that result in a wholesome and quality beef product. Today, the NBQA Program is implemented at the state level, which allows BQA trainers to use science and local understanding to identify best management practices that are consistent with the broader

1. This document is part of the Oregon State University – 2021 Oregon Beef Council Report. Please visit the Beef Cattle Sciences website at http://blogs.oregonstate.edu/beefcattle/research-reports/

NBQA context. Unfortunately, there is limited science-based information characterizing the best management practice during calf branding and processing. The most common scenario across the western U.S. is to use horseback to rope and secure calves prior to branding and processing—either with or without the cow. Interestingly, these effects on calf stress have not been formally reported within the scientific literature, which is to say that producer intuition has gone largely un-validated.

The discipline of animal welfare spans negative/bad welfare to positive/good welfare, is tightly associated with health & performance, and is linked with a society's values and moral interpretation (Ohl et al., 2012). At branding and processing, cattle handling practices have the potential to either enhance or inhibit the overall performance of a calf, depending on the level of stress they experience. Previous work highlights castration and branding as acutely stressful times in a calf's life (Schwartzkopf-Genswein et al., 1997; Tucker et al. 2014), which has implications on economic returns. Unfortunately, little is known about the science of traditional management techniques that cow-calf operators implement—branding and processing calves as cow-calf pairs.

The proposed study improves on the limitations of a pilot study we conducted on a southeastern Oregon cow-calf operation in 2018. At that time, we studied four commonly used methods to process calves and highlighted that processing calves as a cow-calf pair reduced level of stress (Fig. 1). Baseline cortisol was obtained a week before processing and the four different processing treatments included—Heel Only Separating Pairs (HOS); Head & Heel Separating Pairs (HHS), Head & Heel Together (HHT); and Calf Table Separating Pairs (CTS). Figure 1 illustrates cortisol levels exhibited by unweaned beef calves before and after branding and processing. Immediately following processing, both the HOS and HHS expressed nearly identical levels of cortisol release—around 24 ng/ml. However, the CTS treatment yielded the greatest levels of cortisol release at 32 ng/ml, whereas the HHT treatment yielded the lowest levels of cortisol release at 9 ng/ml. These preliminary data illustrate that keeping cow-calf pairs together reduces calf stress at branding and processing.

The current study will implement a uniform calf crops and characterize cortisol release before, during, and after branding and processing.

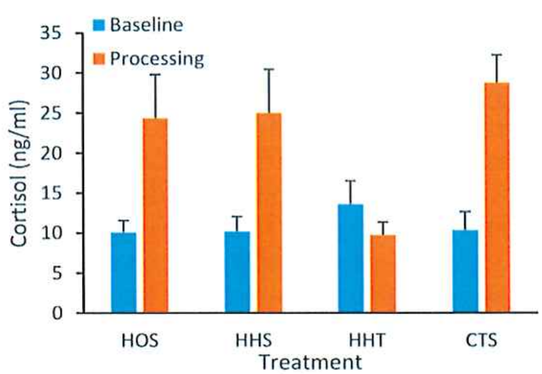

Figure 1. Cortisol levels before (baseline) and after branding and processing. Four treatments included: Heel Only Separate (HOS); Head & Heel Separate (HHS), Head & Heel Together (HHT); and Calf Table Separate (CTS).

Methods & Materials: The proposed experimental site is on the Marchek Ranch near Harper, OR (43°86' N, 117°6' W). It will consist of 50 crossbred, commercial (Angus x Hereford x Charolais), cow-calf pairs consisting of bull calves between 2-3 months old. Calves will be selected for uniformity and randomly assigned to the following treatments—Head & Heel Together (HHT) and Head & Heel Separating Pairs (HHS). Figure 2 illustrates an example of a blood extraction timeline to measure plasma cortisol concentrations. Baseline cortisol will be collected seven days before implementing the treatments after running calves through a chute system. Blood will then be collected before processing, immediately after processing, and then after 30 and 60 minutes.

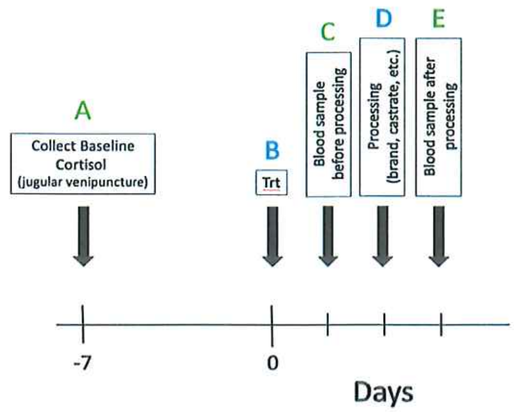

Figure 2. Timeline of blood collection to analyze cortisol: A) 7 days before implementing treatment; B) Treatment (Trt) Separate or maintain cow-calf pairs; C) Sample blood before processing; D) Processing procedure; E) Blood sample after processing—immediately, after 30 mins, and after 60 mins.

The Marchek Ranch has the infrastructure to conduct the applied research project. It has six fenced areas, including an alleyway leading to a round tub and squeeze chute (Figure 3). Cattle will be held in the Wire Lot area prior to data collection with ample access to feed and water. All designated cow-calf pairs will remain in the pasture during collection of baseline data. Designated handlers will capture each calf utilizing the heel and drag method, and the calf will then be restrained by placing a rope over the front and back feet and holding in place. One blood sample per calf will be collected via jugular venipuncture. This method was selected as it presents the least risk of injury to calves and handlers, and the animals will remain in a familiar environment.

Each blood sample will be transferred to a centrifuge within 30 min after collection at 2,500 x g for 30 min. Plasma will then be separated and frozen at -20°C prior to sending for lab analysis.

On the day of processing, all 50 bull calves will be randomly separated into two groups of 25 and assigned to either the HHT or HHS treatment. The first set of 25 calves will consist of the HHS group and be restrained utilizing the head and heel roping technique. Processing procedures will include branding, castration, earmarking, subcutaneous injections of Multimin and Vision 8 Somnus, applied in doses of 3 ml and 2 ml respectively, application of Enforce 3 and Once PMH intranasally at 2 ml each, and 36 mg of Ralgro injected under the skin of the ear. Immediately following processing, another blood sample will be collected. The HHS treatment group will then be moved to the middle holding pen in order to keep the two treatment groups separate. Calves will then be roped to secure blood samples 30 minutes and 60 minutes after initial processing.

The second set of 25 calves will consist of the HHT treatment and also be restrained utilizing the head and heel roping technique. Amount of time taken to restrain each calf will be recorded. The same protocol will be followed to collect blood within this treatment.

Coordination will be arranged at least one month prior to conducting the experiment. The Primary Investigator will work closely with Kerry and Audrey Marchek on phone calls to familiarize ropers with the experimental protocol. For consistency purposes, each handler will be given a designated task to perform throughout the duration of both treatments.

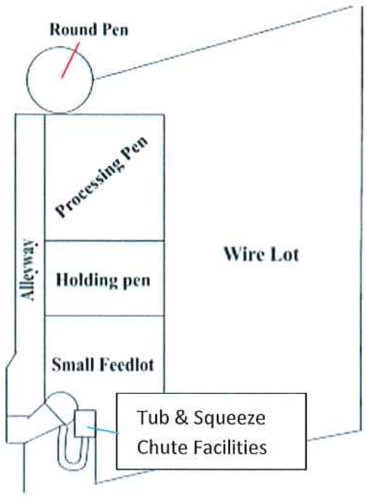

Figure 3. Facility outline of the designated processing area.

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Oregon State University

Oregon Beef Council Report

Beef Cattle Sciences

Progress Reports – Animal Sciences [1]

Monitoring Cattle Behavior to Identify Cattle Disturbance Remotely

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Project Objectives: The research goal is to classify and monitor cattle behavior to identify when calves are removed from their mothers during a simulated theft. The hypothesis is that machine learning will detect a change in maternal behavior after the calf is removed.

Project Start Date: The project begins spring 2022 after calving. The GPS cow collars will be purchased using the limited funding amount.

Project Completion Date: The project will be concluded fall 2022.

Project Status and Preliminary Findings: Introduction: Cattle theft—rustling—is as common today across the vast landscapes of central and eastern Oregon as it was in the late 1800s. Local cattle producers believe that thieves, or rustlers, have an intimate knowledge of the terrain, but more importantly, are familiar with the cow-calf producers' routine schedules, which are closely associated with the culture and heritage of rural communities. They suspect that rustlers heist unbranded, newborn calves when ranchers least suspect it—during Sunday church or during a community event. Historically, the owners would rely on either local law enforcement or the brute force of a rifle to deter theft. Today, there is arguable a more powerful, non-lethal weapon—artificial intelligence—that could give cattle producers an edge.

In Malheur County, the problem is widespread. To combat the problem, the Malheur County Sheriff Department increases aircraft surveillance when beef cows are calving each spring. Around April 1st, cow-calf operators move cows away from the ranch headquarters to more distant rangelands where cows and calves have access to fresh grass. Cows that have not calved by that time will give birth on the new pasture.

1. This document is part of the Oregon State University – 2021 Oregon Beef Council Report. Please visit the Beef Cattle Sciences website at http://blogs.oregonstate.edu/beefcattle/research-reports/

Ranchers typically wait until the end of the calving season to brand calves with their unique brand—indicating ownership. It is in this window of opportunity where cattle rustlers come in and heist the calves. Today, a 550-pound weaned calf costs nearly $800. However, in a 2015 economy, that same weaned calf would sell for nearly $1,600. Multiply that average by 70 calves heisted in two years and you will have a sense of how much money Malheur County cow-calf producer has lost in the past two years—$84,000. The cow-calf operator, like other cow-calf operators who fall victim to rustling, is searching for ways to mitigate losses so that his family operation can remain economically viable. Recent advances in hardware and software may be able to help cattle producers.

Every day, computers can process data more efficiently and more purposefully. Machine learning (ML) is a field of data analysis whereby a human automates analytical models to identify patterns. It is a branch of artificial intelligence centered on the notion that minimum human intervention is necessary for a system to learn from patterns within data. For example, you may have previously seen an alert on your smart phone indicating that the traffic situation has changed and you should budget in additional time or change your route. Another common instance is a smartphone alert indicating that you based on your location, you will be late to a meeting if you fail to move quicker. Artificial intelligence, made from ML, provides direct feedback based on large data sets.

Global positional system (GPS) devices can be research instruments as they communicate with a network of satellites to fix the device location. Researchers have successfully used GPS device technology to monitor grazing distribution and activity (Anderson et al., 2012). The location can be combined with a digital elevation model to obtain additional data, such as elevation use, slope, and distance from water. Historically, cost was the limiting factor for commercial GPS tracking collars. They cost approximately $2,000 per animal and typically last 1.5 years before they succumb to animal damage. Fortunately, there are now more affordable products that are just as reliable for a fraction of the cost.

On the hardware side, Mobile Action i-gotU GPS devices are affordable units suitable for tracking wildlife and livestock. Low-cost GPS collars can be built from scratch for $200 each. They were recently compared to more expensive industry GPS collars. While the i-gotU collars did have a less reliable fix rate and fix schedule, there was little difference between mean distance from water, elevation, and slope. As such, these are suitable for research and have recently been applied to determine grazing distribution (Knight et al., 2018).

On the software side, interdisciplinary research efforts have developed innovative algorithms to predict cattle behavior. For example, a group in Australia trained ML algorithms to classify cattle behavior from collar, halter, and ear tag accelerometer sensors (Rahman et al., 2018). Accelerometers measure the change in gravitational acceleration on or near the head and can indicate livestock behavior. Different magnitudes produced by the accelerometer correspond to different behaviors. In this case, the authors used ML to estimate the distribution of grazing, resting, walking, standing, ruminating, or other actions. It demonstrates that ML can be applied to assess cattle behavior.

Methods & Materials: To test the hypothesis that maternal behavior will change after a simulated theft, the researcher will use an industry cost match a cow-calf operator to purchase 60 Mobile Action i-gotU GPS collars. To test the hypothesis, the researcher will use a crossover design whereby two groups receive similar treatments—control (no simulated theft of calves) and a simulated theft of calves. A Malheur County cow-calf operator has also committed 200 beef cows, and their calves (cow-calf pairs), to the proposed experiment.

Two hundred cow-calf pairs will be randomly divided into two groups of 100 cow-calf pairs (Figure 1). On the initial day (day 0), the researcher and cow-calf operator will deploy 60 GPS collars on 30 random cows in each group. The GPS device within the collar will collect a waypoint every two seconds. Cows will be given 48 hrs to adjust to the GPS collars. On day 2, we will simulate a theft treatment in Pasture A. The cow-calf operator will drive a trailer into the pasture, load calves into a trailer, and then drive the trailer across the fence line at the nearest gate. The cow-calf operator will wait for 15 minutes before returning the calves to the pasture with their mothers. There will be a 24-hour washout period whereby cattle in Pasture A adjust to the treatment disturbance. On the fourth day, cow-calf pairs in Pasture B will receive the same simulated theft treatment as Pasture A cow-calf pairs. GPS collars will be removed 24 hrs after the second simulated theft, and the data will be processed.

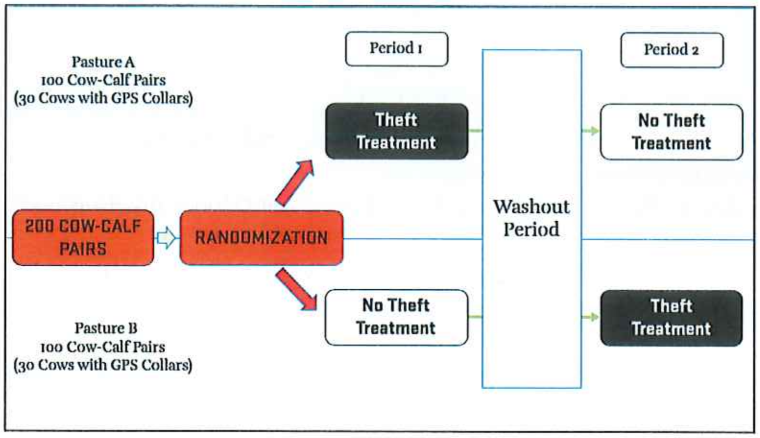

Figure 1. Crossover design whereby two groups receive alternating treatments.

The GPS waypoint data that is acquired every two seconds will be downloaded and stored in a spreadsheet. The researcher will use the Python computing environment and the scikit.learn machine learning library. Supervised machine learning will be used in this experiment. Supervised learning is one type of machine learning that trains the machine using example input and output data. The input data in this case will be GPS position and characteristics (e.g., lateral cow speed). The output data will be a "Yes" if the calf was taken from the cow and a "No" if the calf was not taken. In this way, the algorithm will learn which patterns in the GPS data indicate that the calf was taken. This type of classification scheme is a called a binary classification. The event (i.e., theft) either happened or it did not. The researcher will use a subset of each group of cows to train the machine and then use cross-validation methods with the remaining cow-calf pairs to determine, quantitatively, how accurate this approach is. During this process different supervised learning algorithms (e.g., support vector machines and decision trees) will be tested to determine if one method out-performs the others.

During the data process and classification, the two second data will be down-sampled to 5s, 10s, 30s, and 60s to identify the sensitivity of the classification scheme to the sample rate. The goal of this is to determine the minimum amount of GPS time series data needed to accurately classify the cow behavior. This is an important parameter to know because the less frequent GPS data is collected, the longer the GPS sensor can collect data due to the finite battery life within the collars. The data sample rate also has implications for real-time data transfer and monitoring via cellular or satellite modems that could be installed in a future generation of the collar.

Projected Impact: The proposed interdisciplinary research has potential impacts that are scientific and economic. Potential scientific impacts are that our research will provide foundational work using ML to identify theft from cattle behavior. If our hypothesis is correct, we can expand different theft scenarios to characterize and compare cattle behavior. For example, does maternal behavior from a simulated theft from a cornstalk pasture differ from a simulated theft on the sagebrush steppe? Additionally, does maternal behavior differ when cattle are collected with four wheelers compared to horseback? Potential impacts will also be economic. The mere site of 60 cows with GPS collars may deter cattle rustlers from approaching the herd. Tangible potential impacts could also be developed with real-time GPS monitoring and combined with messages sent to the producer when abnormal behavior is encountered. Once this technology develops, cow-calf operators would theoretically receive updates on their movements and location. Those data have the potential to allow cow-calf operators to develop their pasture to get a more even grazing distribution. In the distant future, potential impacts could also be economic by deterring livestock wildlife interaction (e.g., cattle and wolves).

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Oregon State University

BEEF214

Oregon Beef Council Report

Beef Cattle Sciences

Progress Reports – Animal Sciences [1]

Effect of Feeding Spent Hemp Biomass on Liver Transcriptome, Protein Metabolism and Methane Emission in Ruminants

Contact Person: Massimo Bionaz, Assistant Professor, Oregon State University, Corvallis, OR 97331
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Project Objectives: The objectives of the present proposal are to assess the effect of feeding spent hemp biomass on 1) the biology of the liver of lambs fed with spent hemp biomass via whole transcriptome analysis and 2) on the nitrogen utilization and methane production by the rumen of cows fed spent hemp biomass.

Project Start Date: September 2020

Project Completion Date: December 2021

Project Status and Preliminary Findings: Objective 1: The RNA has been extracted from all the liver tissues and we expect to send the samples to be analyzed at the Center for Quantitative Life Sciences at Oregon State University by end of October 2021.

Objective 2: The experiment with dairy cows was performed between March and July 2021. During the experiment we measured methane emission by collecting the gas emitted from the rumen of the cows using a device designed and constructed at OSU (by Dr. Ates and Dr. Cruickshank) (**Figure 1**). We collected gas for 2 days in a row from 7 cows per group. The collected gas was put in vials and sent to a laboratory in Canada for analysis. Results indicate no difference in methane production between groups (Control=413±67 g/d; Hemp=398±34 g/d; *P*=0.61).

1. This document is part of the Oregon State University – 2021 Oregon Beef Council Report. Please visit the Beef Cattle Sciences website at http://blogs.oregonstate.edu/beefcattle/research-reports/

Figure 1. Set up for the methane emission collection system. A) Cow fully equipped. 2) Dr. Serkan Ates showing a cow with the harness and the collection tube. 3) Dr. Jenifer Cruickshank and Dr. Serkan Ates with the assistance of the biotechnician Benjamin Grismer are setting up the equipment on a cow.

We collected urine using an indwelling catheter draining into a 2 L (1/2 gallon) collection bag (**Figure 2**). We emptied urine every 2 hours for 36h. We measured volume of urine and collected samples in 15 mL tubes for nitrogen analysis. The samples are preserved at -20°C and we plan to measure the various nitrogen compounds before the end of November 2021 using HPLC and a Lico instrument.

Figure 2. Cows after the insertion of the indwelling urine catheter.

Our data indicated significantly lower urine production in cows fed spent hemp biomass compared to cows fed the control diet (**Figure 3**). We are still investigating the reason for this effect.

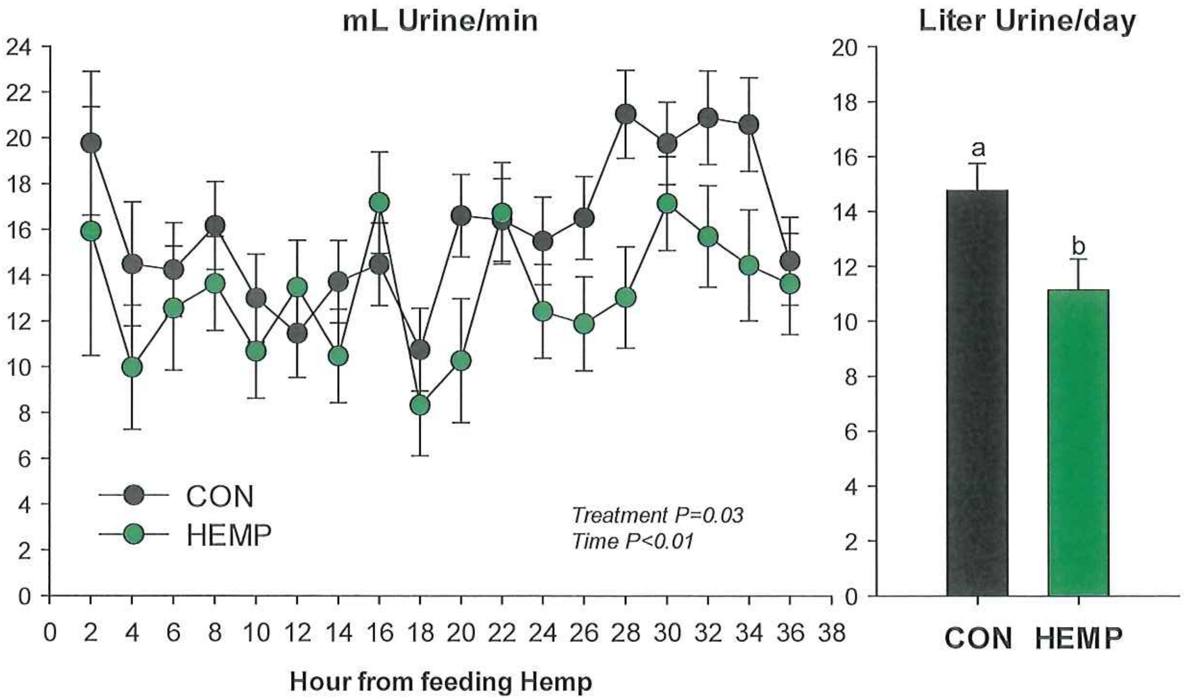

Figure 3. Urine production (as mL/min during the 36 hours of collection and as L/day) in cows fed with spent hemp biomass (HEMP) or the control group (CON).

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Oregon State University

BEEF215

Oregon Beef Council Report

Beef Cattle Sciences

Progress Reports – Animal Sciences [1]

State Evaluation of Mineral Status of Cow Herds and Mineral Supplementation Strategies

Contact Person: Juliana Ranches, Assistant Professor, Eastern Oregon Agricultural Research Center, Burns, OR 97720 **Email:** Juliana.ranches@oregonstate.edu

Collaborators: David Bohnert and Ian McGregor

Project Objectives: The objective of this study is to evaluate the mineral status of selected cow herds in the state as well as to characterize the most common practices of mineral supplementation in the state while teaching producers regarding the mineral nutrition of beef cattle.

Project Start Date: September 2021

Project Completion Date: September 2023

Project Status and Preliminary Findings: In order to accomplish the project goals the state will be divided into 7 regions, following the district division used by the Oregon Cattleman's Association. A total of 4 ranches in each region will be included in the proposed project. In each region, 1 small (< 50 head); 2 medium (up to 500 head); and 1 large (above 500 head) sized ranches will be selected, resulting in a total of 28 ranches assessed in the state at the conclusion of the project.

Ranchers interested to be enrolled in the study will be requested to ***complete a pre-trial survey describing their operation.*** The pre-trial survey was launched in September and can be accessed at: https://oregonstate.qualtrics.com/jfe/form/SV_3e2xv4gUTvDNxUG or by using the QR code below:

The pre-trial survey is currently open for more enrollment. We are currently screening the responses for eligibility criteria. Upon screening of all responses, we will be contacting producers regarding their operation eligibility and will begin scheduling sample collections to evaluate the mineral status of the selected herds. After collections, each enrolled operation will receive a report regarding the mineral status of the herd as well as suggestions regarding mineral

1. This document is part of the Oregon State University – 2021 Oregon Beef Council Report. Please visit the Beef Cattle Sciences website at http://blogs.oregonstate.edu/beefcattle/research-reports/

supplementation management. Once collections are finalized the data on mineral status will be summarized in a single publication.

Expected Outcomes/Products: We anticipate that with the evaluation of cow herds mineral status we will be able to provide producers with more appropriate (tailored) recommendations regarding mineral supplementation strategies in the different locations in the state. Further, we anticipate that discussion about the mineral nutrition and supplementation programs in each visited location will help producers to make more educated decisions regarding the mineral supplementation of their animals. We anticipate publishing the results of this project in popular press magazines, such as the *Oregon Cattleman Magazine*, the OSU Extension website, and at scientific journals such as the *Translational Animal Science.*

Oregon State University

BEEF216

Oregon Beef Council Report

Beef Cattle Sciences

Progress Reports – Animal Sciences [1]

Effects of Trace Mineral Injections on Measures of Performance and Trace Mineral Status of Heifers and Their Calves

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Project Objectives: The main objective of this study is to evaluate the effects of trace mineral injections (ITM; injectable trace minerals) on calf performance and mineral status from birth to post-weaning.

Project Start Date: January 2021

Project Completion Date: December 2022

Project Status and Preliminary Findings: This study was conducted at Eastern Oregon Agriculture Research Center (EOARC – Burns, OR). During the calving season of 2021 (~February), 50 heifers and their calves were randomly assigned at birth to 1 of 2 treatments (n= 24 pairs/treatment):

1) **Injectable trace mineral (1.0 ml/100 lb BW; ITM):** Heifers assigned to the ITM treatment received ITM injection at the calving and breeding (cattle over 2 years: 1 ml/200 lb BW). Similarly, calves born to these heifers received an ITM injection at birth and breeding (1.0 ml/100 lb BW).

2) **Saline:** cattle assigned to the saline treatment followed the same procedure as the cattle assigned to the ITM treatment, however, these heifers and calves were injected with saline.

Body weight and blood samples were collected from all heifers and calves at calving, and a liver sample for mineral status assessment was collected from a subgroup of heifers and calves (n = 12 pairs/treatment).

Pairs were turned out in April, at the Northern Great Basin Experimental Range (NGBER; approximately 35 miles). At breeding, approximately 35 days after turnout, pairs were gathered for the second administration of treatments and sample collections (body weight, blood, and liver).

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Weaning took place at the end of August, and another round of samples was collected. After weaning calves were retained for 45 days in a preconditioning program. Body weights were collected at the beginning and end of the preconditioning program. Blood samples for evaluation of enzymes, hormones (cortisol), and acute phase proteins (ceruloplasmin and haptoglobin) were taken at and post-weaning.

We are currently preparing blood samples to be analyzed in the laboratory for superoxide dismutase, glutathione peroxidase, cortisol, ceruloplasmin, and haptoglobin. All the feed intake and body weight data from the preconditioning phase are being summarized as well as the data related to mineral status.

Expected Outcomes/Products: We expect to develop valuable information for the use of ITM for young heifers and their calves when raised in extensive rangeland.

We expect to publish the results of this study in popular press magazines such as the *Oregon Cattleman Magazine* and to present data from this study at extension meetings for producers and extension agents. Additionally, the results of this study will be presented at the sectional and national meetings of the American Society of Animal Science. We anticipate that the data obtained from this study will be published in scientific journals such as the *Journal of Animal Science*.

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Self-Regenerating Annual Clovers in Western Oregon Forage Systems [1]

Serkan Ates[2]

Synopsis

Self-regenerating annual legumes in particular, balansa clover increased the legume content of the pastures by 25.3% in early spring, providing an excellent quality of forage for grazing or silage. The higher legume content in spring led to greater heifer liveweight gains when the annual legumes were actively growing. No superiority of pastures sown with annual legumes was detected in subsequent seasons or year. The overall benefit of balansa clover in early spring in 2020 was offset by reduced perennial forbs in pastures that were sown with annual legumes, although this did not negatively affected the heifer liveweights.

Summary

The objective of this experiment was to evaluate the effects of self-regenerating annual legumes in pasture and animal production in dairy production systems in western Oregon. The perennial pastures containing either only perennial species or mix of perennial and self-regenerating annual legumes were sown on October 2019. Following the harvest of the forages for silage in early spring, pastures were rotationally grazed from May 28th to October 29th. Our first year results indicated that balansa clover has a high potential to increase legume content of establishing pastures in early spring with its rapid growth rates. Higher legume content of pastures also led to greater heifer liveweight gains by 110 g/head/day during spring period. The persistence of balansa clover and subterranean clover will be monitored in the second year of the experiment. Pastures will be grazed from early April to November in 2021 and heifer liveweight chances will be recorded.

Introduction

Pastures that contain annual legumes are more productive in spring and persistent in summer dry areas owing to lower temperature requirements and drought avoidance strategy of annual legumes. These legumes avoid dry conditions by dying in early summer after seed setting and have an added advantage of growing earlier in spring so providing high quality feed in early lactation. For example, when drilled into grass-dominated pastures, subterranean clover increased pasture yield as much as 40% in New Zealand (Ates *et al.*, 2010). Balansa clover, not as widely tested as subterranean clover, can outperform subterranean clover in heavy clay soils of western Oregon due to its high tolerance of poor drainage. Potential of balansa clover to support high animal production was highlighted in a sheep grazing study at OSU in spring 2018. Lambs that grazed tall fescue-balansa clover pastures grew faster than those grazed tall fescue pastures containing either sub clover, white clover or birdsfoot trefoil. The greater liveweight gain obtained from balansa clover was mainly due to higher clover content of tall

1. This document is part of the Oregon State University – 2021 Oregon Beef Council Report. Please visit the Beef Cattle Sciences website at http://blogs.oregonstate.edu/beefcattle/research-reports/
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fescue-balansa clover pastures (over 35% vs. <20%) in late spring period (Gultekin et al., 2020).

Self-regenerating annual clovers need to produce adequate amount of seeds to persist in a permanent pasture. The production and persistence of annual clovers are mainly dependent on rainfall, grazing management and flowering time (maturity) of the varieties. Early flowering cultivars exploit winter rainfall and ensure high quality forage and seed production early in spring. Later flowering annual clover cultivars always produce greater herbage production, if soil moisture is present. Current subterranean clover seeds available in the market are predominantly earliest flowering varieties (suitable for areas with <15 inch rainfall). However, the amount and seasonal distribution of rainfall in Western Oregon would permit successfully growing mid-late flowering subterranean clover varieties and therefore producing greater amount of high quality forage. Within annual clover pastures, sowing cultivars together in mixtures that differ in flowering time may be useful in exploiting and coping with variable spring rainfall. Therefore, in this study, we have been investigating the total and seasonal pasture productivity, nutritive quality and persistence of annual legumes that belong to different groups of maturity in irrigated and rainfed pastures. The overall objective is to explore the potential of annual legumes in permanent pastures and develop sustainable management practices for higher productivity and persistence. Specific objectives of the study are:

- Determine the forage and livestock production from pastures containing annual legumes with different maturities.
- Assess the production and persistence of self-regenerating annual legume varieties and perennial pasture species in irrigated and rainfed conditions.

Materials and Methods

Site, pasture establishment and measurements: The study has been carried at the Oregon State University Dairy Farm in Corvallis, Oregon (44° 34' N, 123° 18' W 78 m. a.sl.). Multispecies pasture mixtures either containing the combination of perennial species and self-regenerating annual legumes or only perennial pastures species (perennial ryegrass, orchard grass, chicory and white clover) were established in a 2.1-ha plot on October 11 in 2019. Prior to establishment, pasture paddocks were divided into three blocks to serve as replicates for the experiment. Each block was divided into 3 subplots, which were randomly allocated to a combination of (1) perennial species + self-regenerating annual clover mixtures (2) or only perennial pastures without any annual clovers, giving a total 6 plots. Pastures with annual clovers were further divided into three subplot and planted with either early maturing annual clovers, later maturing annual clovers or mix of early-late maturing annual clovers.

Grazing trial: Prior to start of the grazing, pastures were harvested for silage in May. Then they were grazed with dairy heifers from May 28th to October 29th in 2020 and from 22nd Aril to 21st October in 2021. Dairy heifers were offered a dietary treatment of (1) perennial pastures sown with annual clovers or (2) perennial pastures only (with no annual clovers). Twenty-four multiparous Jersey heifers were blocked for age and liveweight and randomly assigned to the two dietary treatments. Pastures sown with three groups of annual legumes (early, mid and mix) were grazed commonly, as one pasture at the same time. Each group of 3-4 heifers were randomly assigned to one of 6, 0.35-ha pasture paddocks where they rotationally grazed within the same pasture at the stocking rate of 8.6-11.4 heifers/ha. Rotation length was adjusted based on the seasonal pasture growth and leaf number counts of the dominant grasses. Each treatment had a core group of 3 heifers (testers) with spare heifers (regulators) to be used in a put-and-take grazing system to match feed demand with changing supply. Heifers were offered an estimated pasture allocation of 8 kg of DM/heifer per day above a post-grazing pasture residual of 1200-1400 kg of DM/ha. Plastic water troughs were moved into the new grazed area to allow ad libitum access to water as heifers were offered new pastures.

Pasture dry matter production and botanical composition: Dry matter production (kg/ha) and herbage growth rates (kg/ha per day) of each pasture combination were measured at each grazing cycle (or cutting for silage) before the animals turned onto pasture plots during active growth in spring, summer and autumn. For the grazed pastures, herbage growth were measured inside 1-m² grazing exclosure cages. Herbage growth was measured from a 0.25 m² quadrat by cutting to a stubble height of approximately 5 cm. Exclosure cages were placed over a new representative area pre–trimmed to 3 cm stubble height at the start of each new growth period. After cutting, cages were relocated to new pre–trimmed sites in each pasture treatment. All herbage from the quadrat cuts will be dried in an oven (65 °C) until constant weight. Quadrat cuts will be sub–sampled for sorting into botanical fractions (grass, legume, herb, weed and dead material) before they are dried.

Liveweight gains of heifers: Liveweight gain of the heifers were determined prior to and following each grazing period (28-36 day intervals). All animals were weighed "empty" after a 12-h withdrawal from feed.

Results

Although in spring (April and May), pastures with annual clovers provided 249-256 kg DM/ha greater forage production, the total annual forage production of pastures did not differ. Overall pastures sown with and without annual clovers had similar (*P*=0.39) total annual forage production in both 2020 (12.45 vs. 12.41 t DM/ha) and 2021 (13.36 vs. 15.04 t DM/ha). In April 2020, pastures containing self-regenerating annual legumes had 31.3% legume content. In contrast, perennial pastures planted without any annual legumes contained only 5.0% legume. (Figure 1.)

However, perennial pastures that were not sown with annual legumes had greater legume and chicory contents during summer. In September 2020, both pasture types had similar legume content (31.0-33.4%). It is possible that faster growth rates of annual legumes, in particular balansa clover in early spring might have suppressed the growth of white clover and chicory, reducing their contents in the pastures during summer. Together with the senescence of annual legumes, this caused a reduced legume content in the pastures sown with annual legumes. However, it appears that white clover recovered this early suppression later in the season once the pressure of annual legumes disappeared. (Table 1.)

The positive effect of the higher legume content of the pastures containing annual legumes were reflected from the heifer liveweight gains. Heifer grazing pastures with annual legumes (AL+) gained 110 g head/d more (P<0.1) than those grazing pastures with only perennial pasture (AL-) species (420 g/head/d vs. 530 g/head/d) during May-June (spring) period in 2020. Pastures were spelt in mid-summer due to low pasture growth caused by irrigation system failure. In late summer period, while the heifers lost 28 g/head/d in AL+ pastures, those grazing AL- pastures gained 186 g/head/d. No differences were detected (P=0.69) for heifer liveweight gains in fall in 2020. In 2021 heifer liveweight gains ranged from 357 g/head/d in fall to 1316 g/head/d in summer but the effect of pasture treatment was not significant (all P>0.05) at any grazing period. (Table 2.)

Conclusions

In conclusion, balansa clover has a great potential in increasing the legume contents and pasture quality in early spring with its rapid growth rates due to its lower temperature requirement than perennial legumes. Although the pasture containing high balansa clover content was not grazed (but ensiled) in early spring, it is highly probably that the higher legume content by 25.3% would have led to greater animal performance as well in early spring. The importance of high legumes for animal performance was still apparent in May-June period when heifers gained 110 g/head/d more liveweight on pastures containing self-regenerating annual legumes. However, balansa clover with its rapid growth rates in early spring and high tolerance to poorly drained, waterlogged soils suppressed the companion perennial forbs leading to reductions in their proportions in pastures sown with annual legumes. Pasture forbs (e.g. white clover, chicory) are highly desired species as they have high feeding value and growth rates particularly in summer. It appears that the overall benefit of balansa clover in early spring was offset by reduced perennial forbs in pastures that were sown with annual legumes.

Currently, the herbage samples are being analyzed for their nutritive value.

Acknowledgments

This research study was financially supported by the Oregon Beef Council.

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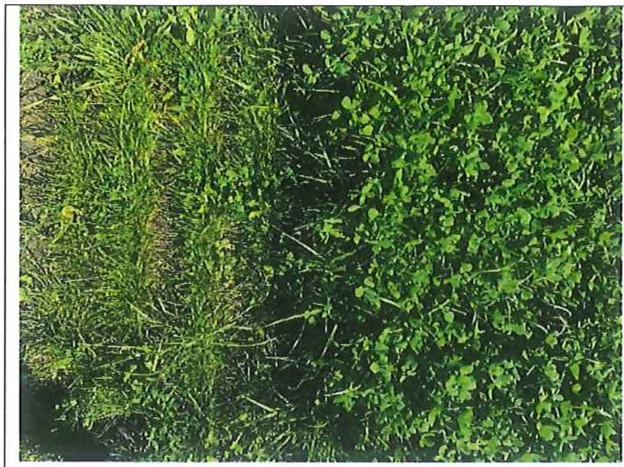	
Pastures with (31.3% clover) and without annual legumes (5%) on 10 April 2020.	Heifers grazing pastures on 7 June.

Figure 1. Pastures with and without annual legumes and heifers grazing.

Year	TRT	Total DM	Grass	Perennial forbs	Annual legumes	Total forbs	Weeds	Dead Material
2020	AL+	12452	7784	2634	1309	3943	415	392
	AL-	12410	6621	5150	0	5150	301	339
2021	AL+	13361	8615	3879	9	3889	294	563
	AL-	15049	7411	6781	0	6781	367	489
SEM		898.3	369.3	902.9	114.0	911.6	137.6	56.4
P_{TRT}		0.39	0.05	0.05	0.01	0.06	0.88	0.30
P_{Year}		0.09	0.07	0.16	0.01	0.42	0.92	0.05
$P_{TRT \times Year}$		0.37	0.95	0.83	0.01	0.39	0.71	0.86

SEM: Standard Error of means; P: level of significance. TRT: treatment, AL+: pastures sown with annual clovers. AL-: pastures sown without annual clovers.

Table 1. Total annual herbage yields (kg DM/ha) of pastures sown with or without annual legumes in 2020 and 2021.

Pasture treatments	2020 (LWG g/d)			2021 (LWG g/d)		
	Spring	Summer	Fall	Spring	Summer	Fall
AL+	530	-28	433	727	1316	357
AL-	420	186	399	629	1071	456
SEM	21.4	37.7	52.3	57.4	194.1	37.1
P	0.07	0.06	0.69	0.35	0.46	0.19

SEM: Standard Error of means; P: level of significance, AL+: pastures sown with annual clovers. AL-: pastures sown without annual clovers.

Table 2. Live weight gains of heifers grazing pastures sown with or without annual legumes in 2020 and 2021.

Oregon Beef Council Report

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Progress Report – Rangeland Ecology & Management[1]

Interspace/Undercanopy Foraging Patterns of Horses in Sagebrush Habitats: Implications for Sage-Grouse

Contact Person: David Bohnert, Director, Eastern Oregon Agricultural Research Center, 67826-A Hwy 205, Burns, OR 97720 **Email:** dave.bohnert@oregonstate.edu

Project Objectives: We are using a case study approach to determine the impacts of season-long (8 months/year) horse grazing on 1) sage-grouse nesting habitat structure and composition and 2) behavioral interactions between nesting sage-grouse and grazing horses within active nesting habitat located near a water source.

Project Start Date: May of 2018

Project Completion Date: May of 2023

Project Status: An approximately 1,100 acre pasture has been fenced and excluded from grazing by livestock. In addition, due to infrastructure challenges we modified the original experimental design. This will result in a longer study but will generate comparable data. Briefly, instead of having 2 separate pastures we will use the same overall acreage in a single pasture with 3 yr of preliminary sage-grouse nesting habitat structure and composition data collected prior to horse grazing. We will then graze horses for at least 2 years and collect comparable data in response to horse grazing.

Vegetation Sampling: All vegetation measurements take place in June of each year of the study. Pre-treatment measurements began in 2018. The pasture was split into three north/south bands that represent increasing distance from water (Figure 1).

Sage-Grouse: Preliminary sage-grouse nesting data has been collected in the study area for almost 10 years. We captured additional grouse the spring of 2018 (Figure 2), 2019, 2020, and 2021 and placed additional sage-grouse tracking collars on them. This practice will continue for the duration of the study.

Horse Grazing: We initiated horse grazing in 2021. We placed 9 pregnant mares and a stud (approximately 1 horse/100 acres), each fitted with GPS collars to track location and resource use, in the pasture from April through November. This stocking rate was based on horse density in the nearest HMA (South Steens). Horses were unmanaged during the grazing period to replicate feral horse grazing. A perennial drainage on the east end of the plots provided water for horses.

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Expected outcomes/products: This research will result in first-of-its-kind data that can be used to characterize the magnitude and nature of the effects of horse grazing on nesting habitat attributes important to sage-grouse and, potentially, the influence of horse grazing on sage-grouse nesting behavior and nest success. These outcomes would be the basis for two peer reviewed journal publications.

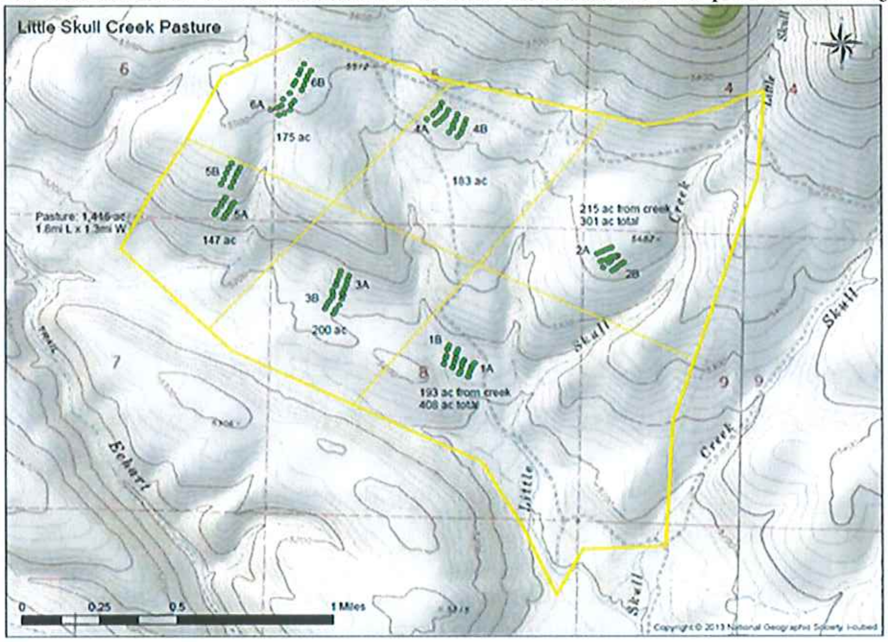

Figure 1. Study Site.

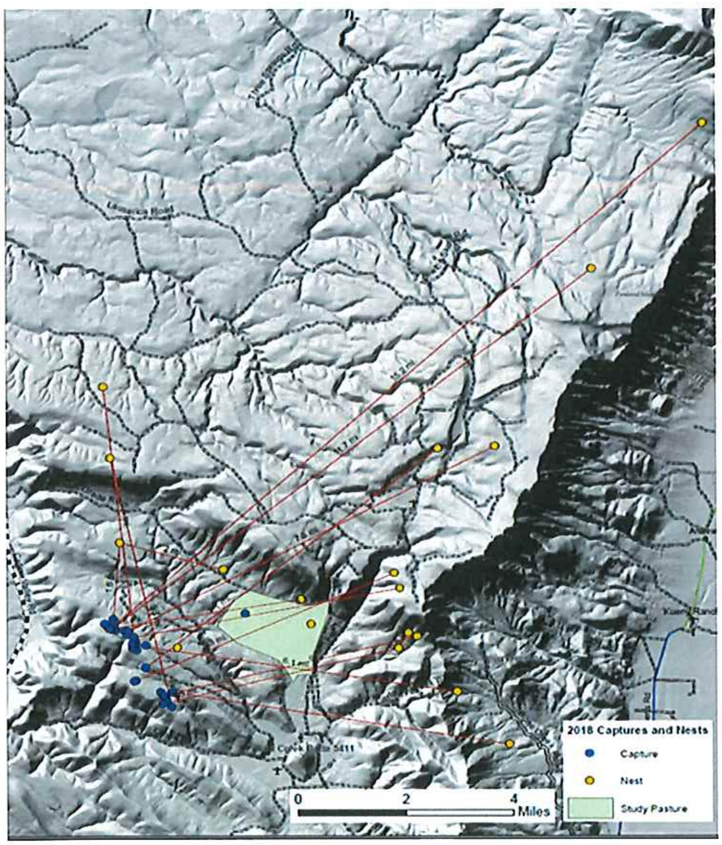

Figure 2. Sage-grouse capture and nesting sites – 2018.

Oregon State University

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Oregon Beef Council Report

Beef Cattle Sciences

Progress Report – Rangeland Ecology & Management[1]

Fine Fuels Management to Improve Wyoming Big Sagebrush Plan Communities Using Dormant Season Grazing

Contact Persons: Sergio Arispe, Associate Professor, Oregon State University Extension Service-Malheur County, Ontario, OR 97914 **Email:** Sergio.arispe@oregonstate.edu

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Project Objectives: The goal of the proposed research is to use an integrated ecological approach to promote rangelands that are resilient to disturbance (specifically fire) and resistant to invasive annual grasses within Wyoming big sagebrush plant communities.

Project Start Date: Fall of 2018

Project Completion Date: While the current USDA-NIFA CARE funding will end in 2022, the PI is authorized to carry out the research through 2028.

Project Status: In fall of 2016, two public land permittees and the Vale District Bureau of Land Management (BLM) Supervisory Rangeland Management Specialist approached the Oregon State University (OSU) Extension Service to implement an experiment to mitigate mega-wildfires in the region. Nearly two years later, the Vale District BLM, OSU Extension Service, and permittees partnered for a landscape-scale dormant season grazing project on three pastures within the Three Fingers Allotment.

Study pastures—McIntyre, South Camp Kettle, and Saddle Butte—are located within the Three Fingers Allotment near Jordan Valley, Oregon (43°19'N, 117°6'W). The allotment is managed by the Vale District BLM with an elevation of approximately 3,800 ft. Annual precipitation ranges between 8"- 12" with the majority falling as rain or snow during the October to March period with an area average annual maximum and minimum temperatures between 40 and 70 F, respectively. Due to repeated wildfires within the pastures, the plant community is dominated by medusahead and cheatgrass; few perennial bunchgrasses and shrubs are present. Historically, livestock grazing on the study pastures has been light to moderate. They are on a rest rotation system so the pastures are not grazed during the same window in

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consecutive years. During 2020, monitoring took place from June 20-June 30. Researchers took data to quantify cover, gap, herbaceous biomass, density, and height.

Cover was collected using the line-point intercept method; a pin was dropped every meter along three, 50 m transects (total points = 150 per treatment plot) and all species and ground cover that the pin hit were recorded. Due to the low density of shrubs, shrubs were counted and measured within three, 2 X 50 m belt transects located along each transect. Of those rooted within the belt transect, shrub canopy height, greatest width, and greatest perpendicular width to the first width was recorded and used to estimate canopy cover and biomass using allometric relationships. To determine the extent and distribution of fuels, foliar canopy gaps (including annuals and perennials) greater than 20-cm were measured along each of the three transects.

Herbaceous biomass was collected using a 0.2 m2 quadrat; samples were clipped to ~1 cm above ground level and sorted as either perennial bunchgrass, annual grass, forbs, or litter. Biomass was collected every 10 m along each of the three transects (total biomass = 15 samples per treatment plot). Density of 8 life-form categories (perennial tall bunchgrass, perennial short grass, perennial forb, annual forb, exotic annual grass, sagebrush, antelope bitterbrush, and other shrubs) were collected using a 0.2 m2 quadrat and were recorded every 5 m along three, 50 m transects (total quadrats = 30 quadrats per treatment plot). Average vegetation height of grasses and forbs were also recorded using the density quadrats to describe the overall height structure on a treatment plot. A report covering the data from 2018 – 2020 was submitted to the peer-reviewed journal *Rangeland Ecology and Management* in August 2021.

Preliminary Results

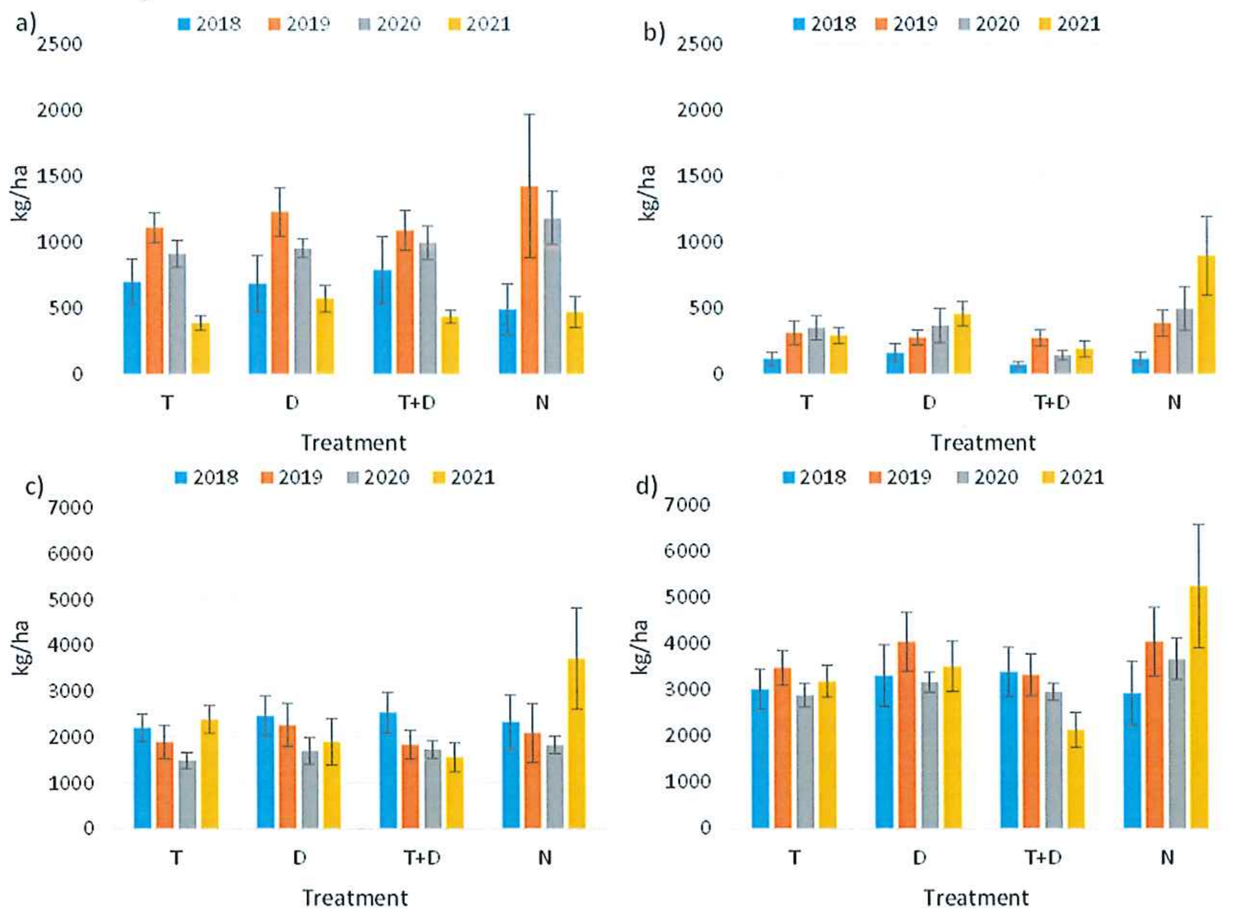

Figure 1. Biomass estimates for grazing treatments: traditional grazing (**T**), dormant season grazing (**D**), traditional + dormant season grazing (**T+D**), and no-graze (**N**). Annual grass (**a**), perennial grass (**b**), litter (**c**), and total biomass (**d**).

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Oregon Beef Council Report

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Progress Report – Rangeland Ecology & Management[1]

A Systems-Based Understanding of Rangeland Watershed-Riparian Systems in Eastern Oregon

Contact Person: Carlos Ochoa, Associate Professor, Oregon State University, Animal & Rangeland Sciences, Corvallis, OR 97731 **Email:** carlos.ochoa@oregonstate.edu

Project Objectives: The long-term goal of this project is to improve production and ecological resilience in rangeland watershed-riparian systems of Oregon by providing science-based information to improve upland and riparian areas management. Objectives:

1) To characterize biophysical and land use relations influencing water quantity and quality indicators (e.g., stream temperature) in a watershed-riparian rangeland system in eastern Oregon.
2) To develop an integrated, systems-based, understanding of ecohydrological relationships and land use information that can be used to develop adaptive management practices, and to inform policy, for achieving or maintaining watershed-riparian system resilience in rangeland ecosystems.
3) To collaborate with stakeholders in the co-production of integrated watershed-riparian systems knowledge that will be disseminated through extension and outreach programming.

Project Start Date: Spring of 2019 (preliminary work started in summer 2018)

Project Completion Date: Fall of 2021

Project Status: This long-term project was established in Malheur County, eastern Oregon. Several ecological and hydrological relationships (e.g., vegetation cover and stream temperature) are evaluated at the Fish Creek watershed-riparian system in Wilks Ranch. This watershed-riparian system offers an excellent opportunity to understand different land use-environment relationships as it runs through different vegetation types and ecotones. An intensive field monitoring approach is being used to assess ecohydrologic and land use connections at the study site. This field-data collection effort is designed to improve understanding of the effects that critical component interactions (e.g., surface and subsurface water flow) may have on-site ecologic functionality and in providing ecosystem services such as forage and water provisioning, habitat, and water quality. The study site was instrumented to monitor multiple hydrologic variables, including stream and ambient temperature, soil moisture, streamflow, and weather variables. We installed 17-stream temperature, four air-temperature, and one water-level monitoring stations from the headwaters to the lower elevation watershed-riparian system. We installed two weather

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stations with satellite-based communication capability for data transfer (Figure 1). We conducted a geologic reconnaissance of the study site, collected soil samples at the weather station sites. In the fall of 2020 and summer of 2019 and 2021, we collected water samples for evaluating water quality parameters (e.g., nutrient load). Also, we established permanent monitoring transects and conducted a vegetation and channel morphology assessment at three different reaches along Fish Creek and Deer Creek.

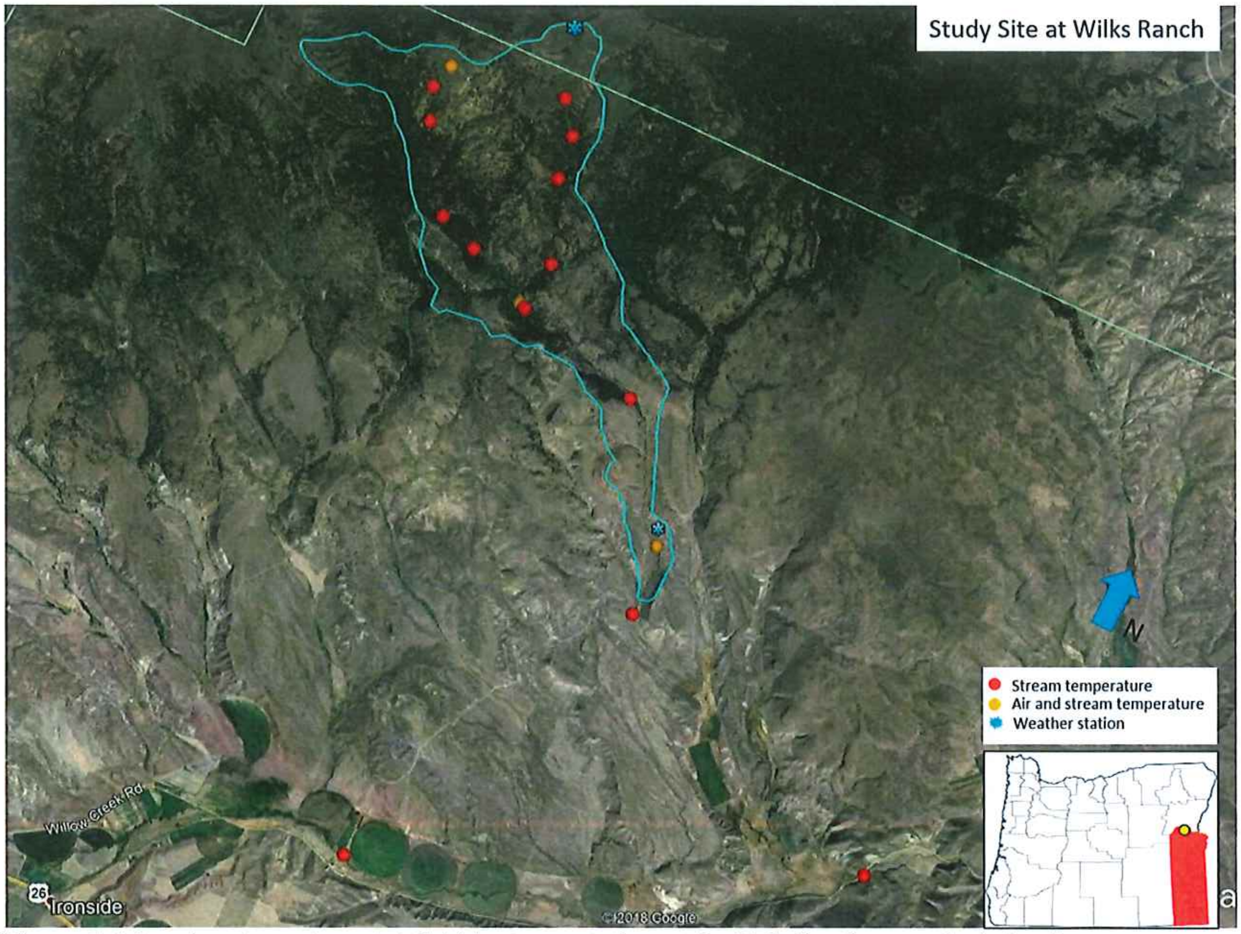


Figure 1. Map showing automated field instrumentation at the Fish Creek watershed-riparian system (outlined in blue; 3200 acres) and Willow Creek.

Preliminary results show that a combination of factors including water source (springs), geology, topography, vegetation shade, and channel morphology may contribute to stream temperature along the stream longitudinal gradient. Figure 2 shows water temperature fluctuations in Fish Creek, from August 2018 through July 2021. It can be observed there was a relative constant temperature for the spring water source while temperature in the stream was more variable throughout the year. During the summer, greater stream temperature was observed in lower elevation locations along the stream.

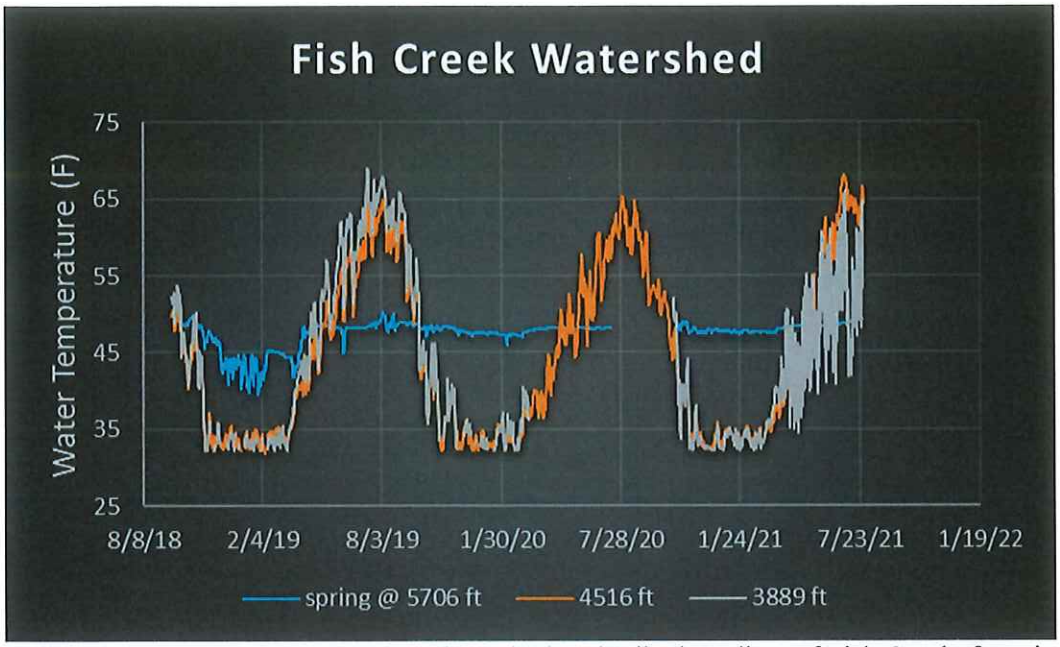


Figure 2. Daily stream temperature along the longitudinal gradient of Fish Creek, from its spring source at 5706 ft to downstream at 3889 ft.

A difference of up to 21 degrees Fahrenheit between the spring at 5706 ft and the lower valley stream location at 3911 ft elevation was observed. A difference of up to 12.6 degree Fahrenheit was noted between the stream location at 4970 ft and the lower valley stream location at 3889 ft elevation. Differences in air temperature between higher elevation sensors and the valley at the outlet of the watershed ranged from 0 to 9.6 degree Fahrenheit (Figure 3).

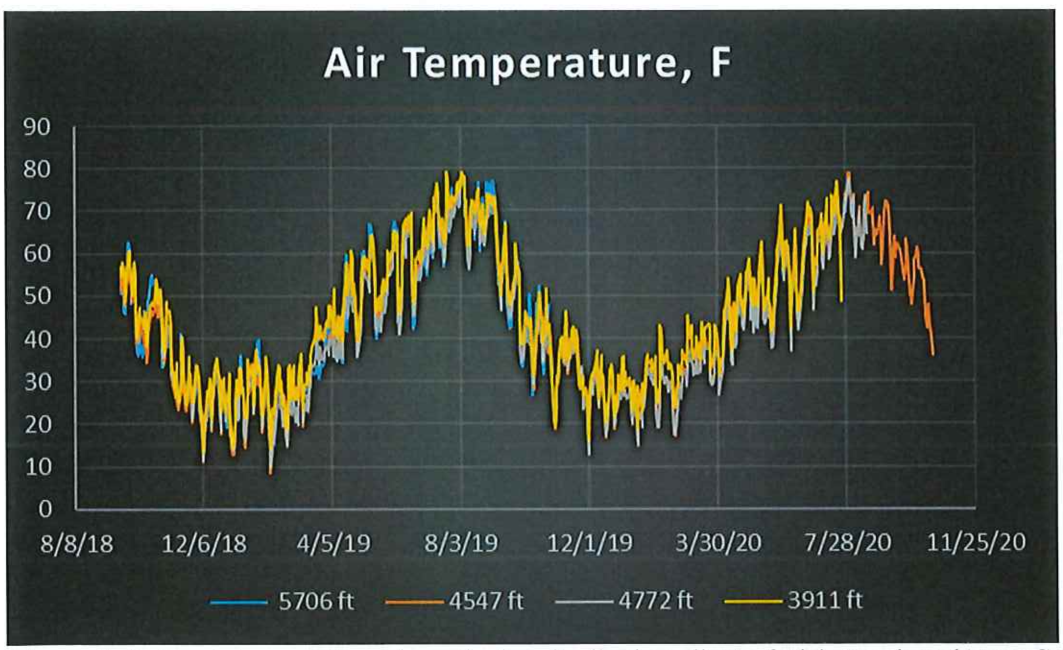


Figure 3. Daily air temperature along the longitudinal gradient of Fish Creek and Deer Creek watersheds, from its spring source at 5706 ft to downstream at 3911 ft.

Ongoing analysis of water quality at different locations along the stream provides a better understanding of potential surface-subsurface water flow mixing influencing stream temperature. Also, elevated concentrations of elements such as Cl can be toxic to aquatic life. Thus, it is of interest to be able to determine Cl concentrations in natural water bodies. Bromide (Br) concentrations in most waters remain stable with time and changes in land use because Br concentrations are defined by geology. Therefore, comparing Cl to Br can be useful to determine the nature and type of Cl additions by nature or management practices. Figure 4 shows Chloride and Bromide concentrations obtained. The relatively low levels of Cl and the calculated Cl:Br ratios validated the spring fed origin of fresh water in the stream for both Fish Creek and Deer Creek.

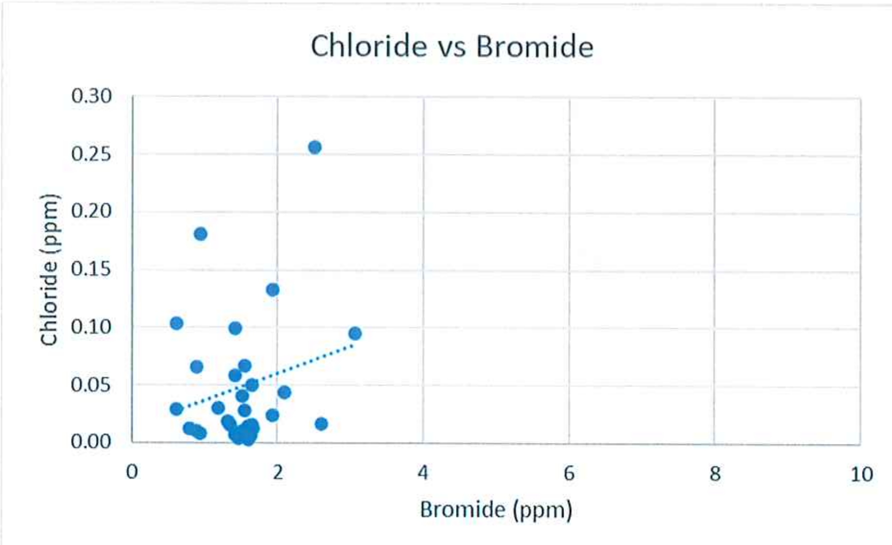


Figure 4. Cl:Br ratios obtained validates the spring fed origin of stream water.

Nutrient loads (e.g., nitrates and phosphates) was relatively low. Nitrates were generally higher at or near the source (spring) and decreased in concentration in waters downstream (Figure 5).

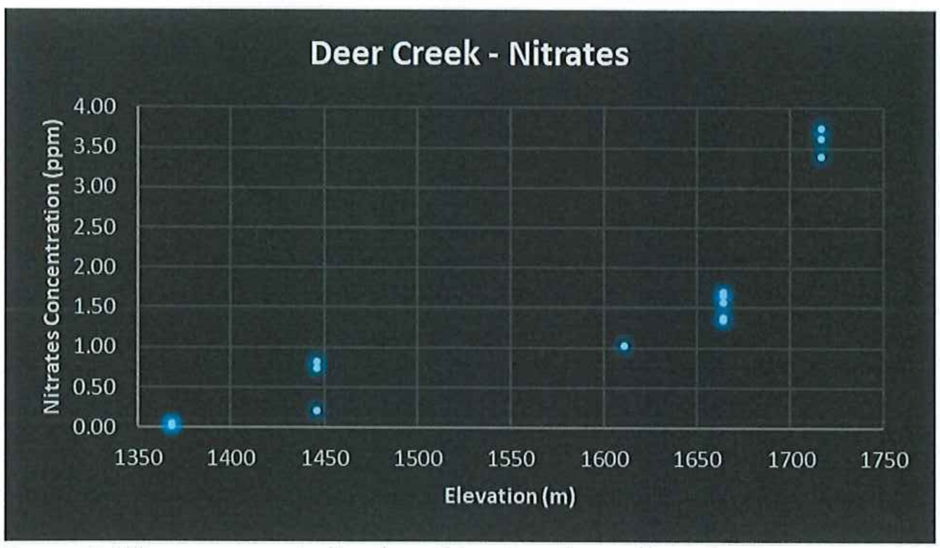


Figure 5. Nitrates concentration (ppm) by elevation at Deer Creek.

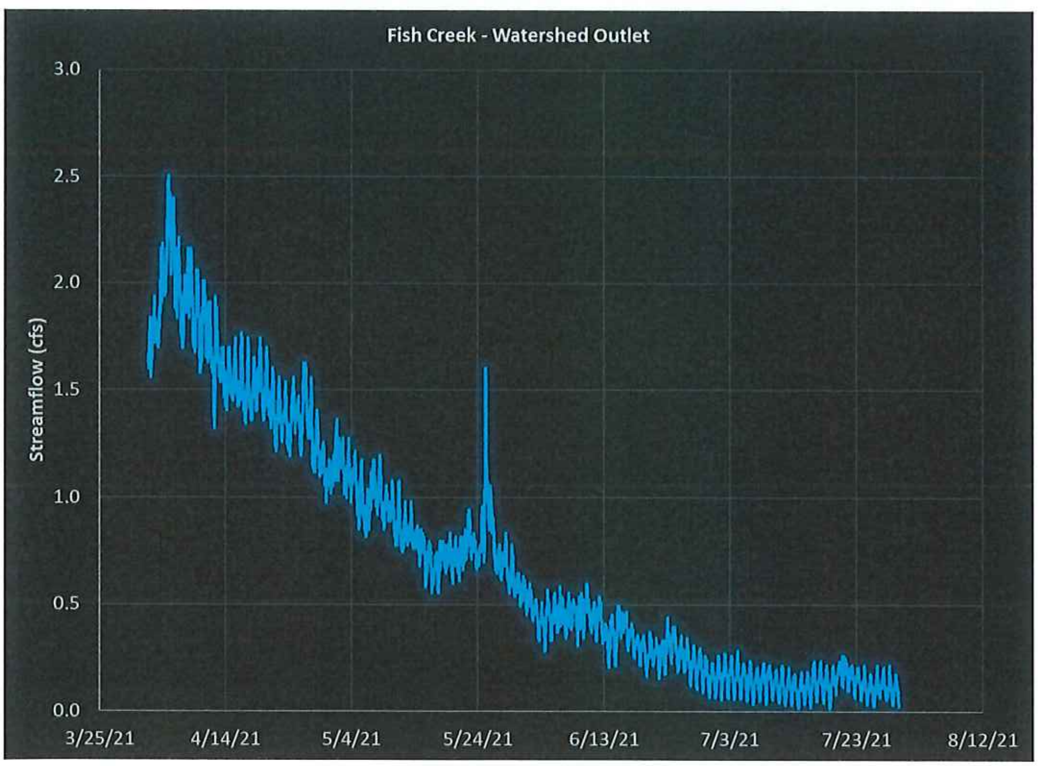
The next images show some of the additional data collection and analysis underway. The core project instrumentation has been installed and data collection and processing is expected to continue for several more years.

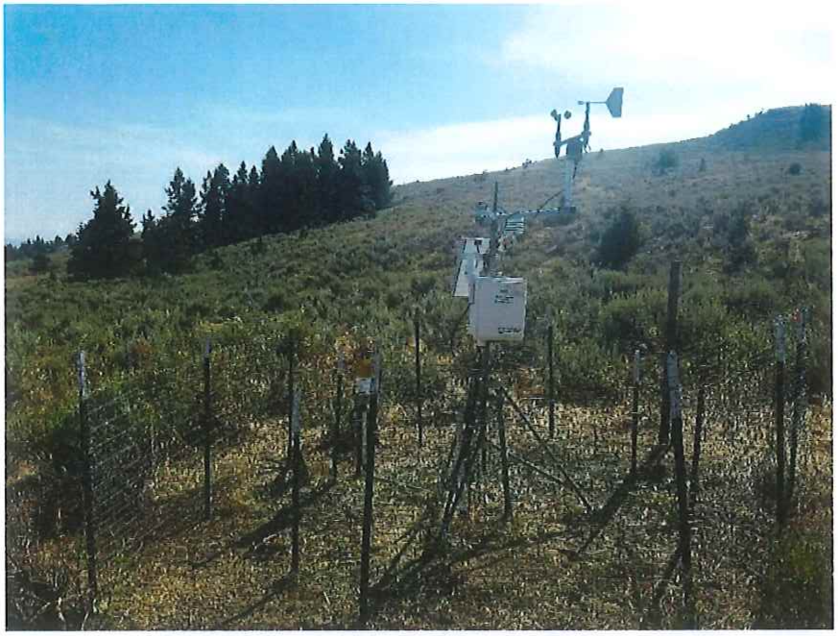
Stream temperature sensor and water quality sampling locations.

Schematic representing three transects for measuring stream morphology and riparian-upland vegetation. Also shows a 330-ft reach for measuring riparian vegetation using the 'greenline' method.

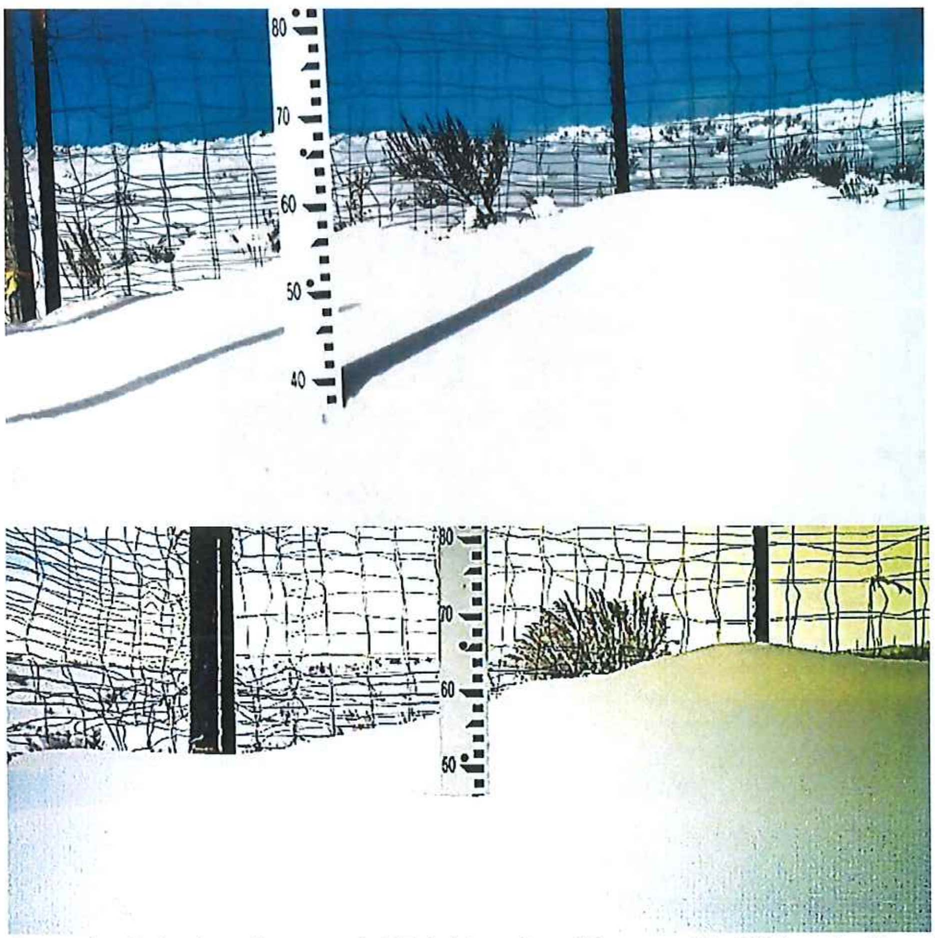
Measuring stream morphology and riparian-upland vegetation conditions.

Streamflow measuring devices (above) installed and hourly streamflow at the watershed outlet (below).





Weather station at Deer Creek headwaters. Also, used for monitoring snow depth.



Snow depth (cm) on January 4, 2020 (above) and January 25, 2021 at the Deer Creek weather station.

OSU Oregon State University

Data retrieved: 2020-10-29 18:23:32 PST

Upslope Deer Creek | Fish Creek Valley

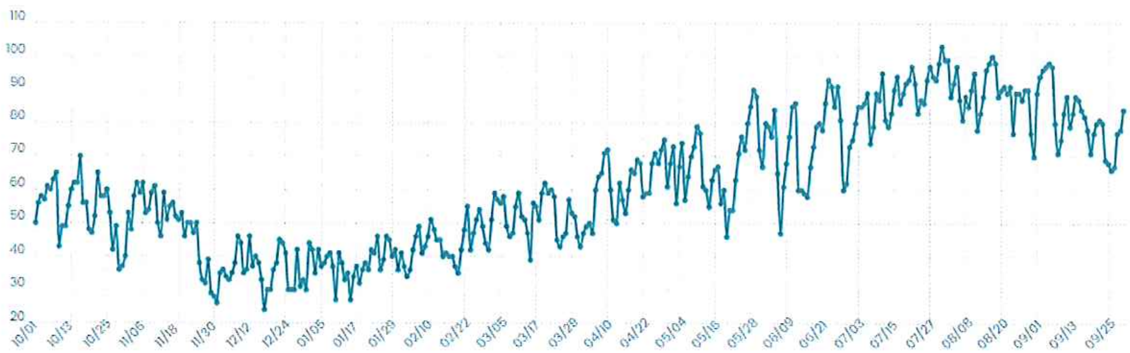
Fish Creek Valley

Set the **Period of Record**: From 10/01/2019 to 09/30/2020

- ☐ Rain
- ☑ Max Air Temp
- ☐ Min Air Temp
- ☐ Avg Air Temp
- ☐ Relative Humidity
- ☐ Max Wind Speed
- ☐ Soil Moisture at 8 inches
- ☐ Soil Moisture at 20 inches
- ☐ Soil Moisture at 32 inches
- ☐ Barometric Pressure

visualize | download

Max Air Temp (°F) Period of record max: 61 °F



Data

mm	dd	yyyy	Rain (inches)	Max Air Temp (°F)	Min Air Temp (°F)	Avg Air Temp (°F)	Relative Humidity (%)	Max Wind Speed (mph)	Soil Moisture at 8 inches (%)	Soil Moisture at 20 inches (%)	Soil Moisture at 32 inches (%)	Barometric Pressure (inches Hg)
10	10	2019	0	49	11	29	58	7	10	10	5	21.69
10	11	2019	0	49	15	31	55	12	9	10	5	21.69
10	12	2019	0	55	17	35	56	13	9	10	5	21.69
10	13	2019	0	60	24	41	51	8	9	10	5	21.69
10	14	2019	0	62	29	44	65	9	10	10	5	21.69
10	15	2019	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Daily-averaged weather data collected from both weather stations can be accessed at https://ecohydro.live/fish-creek-valley and https://ecohydro.live/upslope-deer-creek/.

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Oregon Beef Council Report

Beef Cattle Sciences

Progress Report – Rangeland Ecology & Management[1]

Evaluating Rangeland Health, Structure and Function Using Off-the-Shelf Drone Technology to Inform and Enhance Ecosystem Management

Contact Person: Bryan A. Endress, Associate Professor, Oregon State University, Eastern Oregon University Ag Program, La Grande, OR 97850 **Email:** bryan.endress@oregonstate.edu

Project Objectives: The goals of this project are to: 1) explore the value and potential of consumer-grade drones as a cost-effective tool to evaluate and monitor critical rangeland resources, and 2) provide guidance and recommendations in their use to livestock producers and land managers. Specifically, the project will evaluate drones use to:

1. Measure and analyze rangeland vegetation structure.
2. Estimate rangeland productivity as it relates to vegetation composition and invasive species (annual grasses).
3. Estimate forage utilization and stubble height.

Project Start Date: October of 2020

Project Completion Date: Fall of 2023

Project Status: For this project we chose to evaluate the DJI Phantom P4 drone (Figure 1). These drones are widely available and are in the middle of pack with respect to cost for drones with multispectral capabilities.

2021 was our first field season for this project. We selected 7 study locations that differed in rangeland type and degree of degradation. Study sites included rigid sage, basin big sage and Pacific Northwest bunchgrass communities. Four of the seven locations were heavily invaded by *Ventenata dubia* and the remaining three had invasive grasses present, but at much lower abundances. At each site, we selected 2-acre plots to evaluate the potential of drones aid in rangeland condition.

1. This document is part of the Oregon State University – 2021 Oregon Beef Council Report. Please visit the Beef Cattle Sciences website at http://blogs.oregonstate.edu/beefcattle/research-reports/

Drone missions were flown every 6 weeks through the growing season of 2021 (May – October). Flights were flow at a height of 180 feet which allowed for image resolution of 2.6 centimeters/pixel. Images were processed using Agisoft Metashape, a software program which blends the photographs (around 200 images are taken for each mission) to create a photo-mosaic (Figure 2). Imagery can then be imported into ArcGIS for further analyses- such as the generation of NDVI images and more (Figure 2).

Data analysis from year one is still underway. Preliminary analyses suggest that off-the-shelf drones can be a valuable tool for producers and land managers. Flight missions and image acquisition are relatively straightforward and easy to conduct. This imagery can be excellent for assessing weed distributions, evaluating plant phenology, identifying areas of heavy use by livestock, and mapping the extent and intensity of disturbances (e.g. fire boundaries), etc. The high resolution of the images can let managers and produces even see individual bunchgrass plants and shrubs. Additionally, drone can be helpful in gathering photos and video of remote or difficult-to-access areas.

We are currently analyzing data to determine how well drones are able to measure vegetation structure (e.g. shrub abundance and density, height), forage utilization, and stubble height. While results are not complete, preliminary data indicates that off-the-shelf drones are capable of accurately and consistently detecting vegetation height to within 12 inches of accuracy. Thus, while this is sufficient to estimate height and detect change in taller vegetation (e.g. shrubs), the ability to accurately estimate stubble height remains a challenge. Next year, we plan flying at lower heights, which will increase image resolution to determine what flight conditions are required to properly estimate stubble height.

Preliminary results indicate that NDVI data collected from the drone is of very high quality, and provides more detailed NDVI estimates than satellite imagery (Figure 2). NDVI values can even be examined in 'real time' while the drone is flying, thus enabling immediate information to producers and land managers as to the current status of plant health/stress. Similarly, drones are excellent in quickly and rapidly detecting weed infestations and invasions.

Drones are capable of collecting additional information for more advance and powerful analysis. However, this will require additional costs and training, which may be outside the ability of individual producers and land managers. For example, the software needed (e.g. Agisoft Metashape, Drone2Map, ArcGIS) for some analyses (e.g. NDVI, structure-from-motion, time-series change detection) is not only be expensive, but takes additional training to utilize and interpret the outputs. Thus, based on our current findings, off-the-shelf drones are absolutely a helpful and powerful tool for producers and land managers; the results may be even more powerful and helpful when producers team up with drone and mapping experts for more complex and in-depth analyses.

Field research will continue in 2022 to further elucidate the benefits and limitations of off-the-shelf drones in support rangeland monitoring. We hope this work will assist in the development of new, cost-effective tools that can enable livestock producers, land managers and others to more effectively manage land and make resource management decisions based on detailed, high-quality data. The development of protocols and incorporation of drones into to rangeland monitoring efforts represents a new and powerful way to support effective livestock, grazing and ecosystem management plans and activities. The technology has applicability to inform a wide range of management issue including monitoring and mapping of invasive species, tracking forage utilization and stubble height across pastures and allotments, monitoring habitat quality for sage grouse and other wildlife, monitoring rangeland productivity, and evaluating recovery of rangelands following disturbances such as wildfires.

Figure 1. We utilized a DJI Phantom P4 Multispectral drone. This drone has a multispectral camera which allows us to capture regular (RBG) images, as well as Blue, Green, Red, Red Edge, and Near Infrared bands, which allows us to gain better insight on plant health. Flights are planned and flown using a basic iPad mini and controller.

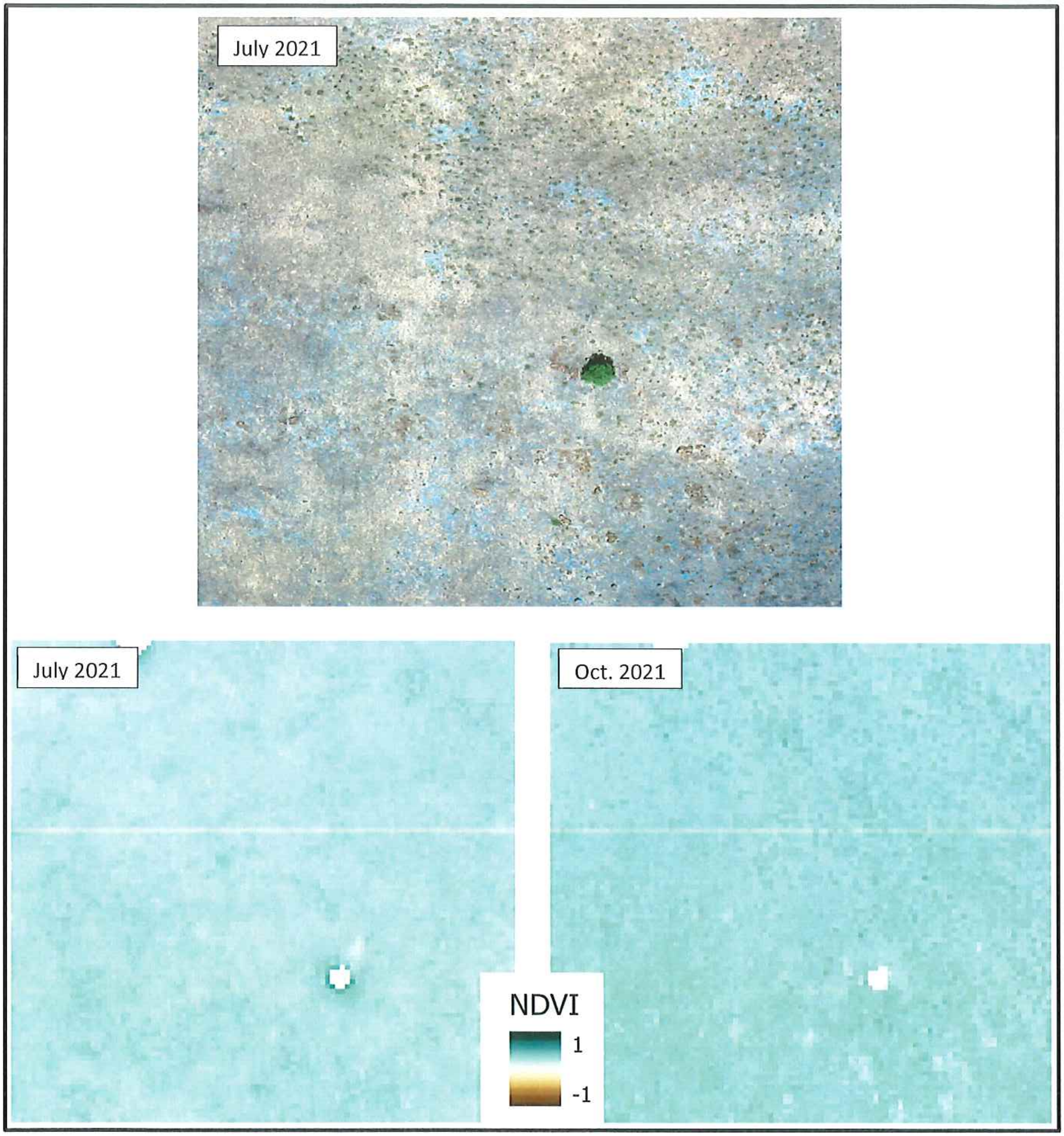

Figure 2. Photographs take from the drone are combined into a 'photomosaic' (top). Imagery can then be analyzed using software to calculate NDVI values (Normalized Difference Vegetation Index). NDVI is a measure of the state of vegetation health based on how the plants reflect light at certain frequencies and ranges from -1 (poor) to 1 (highly productive). These images are of a rigid sage community infested with *Ventenata dubia* (the light brown color in the photomosaic). NDVI images from July (drought conditions) show low productivity (lighter colors) particularly in the areas where Ventenata is abundant. The image from October (2 weeks following first fall precipitation) begins to show the fall 'greenup' with higher NDVI vales than those in July.

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REPORT STATUS OF STUDIES FUNDED BY THE OREGON BEEF COUNCIL

Progress report not required for studies funded prior to 2010-2011 FY and with a full report submitted.

Report Status:	
Final Report Not Submitted	
On Schedule	
Completed	X

Projects funded in 2007 – 2008 FY

Abbreviated Project Title	Senior Investigator	Report Status Progress	Report Status Full
Rangeland Ecology and Management			
Wolf impact on cattle productivity and behavior	D. E. Johnson		X
Development of digital charting system for range health	D. E. Johnson		X
Livestock, plant community, and sage-grouse food sources	J. Miller		X
Animal Sciences			
Digestibility of cool-season in dairy farms	T. Downing		X
Female hormones and immune cells in cattle	M. Cannon		X
Diagnostic test for pregnancy detection in cattle	F. Menino		X
Assay to assess bovine embryo viability during transfer	F. Menino		X
Farm-based livestock manure/biogas production	M. Gamroth		X
Glycerol supplementation to cattle	C. Mueller		X
Copper and Zinc in dairy forage systems	T. Downing		X

Projects funded in 2008 – 2009 FY

Abbreviated Project Title	Senior Investigator	Report Status Progress	Report Status Full
Rangeland Ecology and Management			
Wolf impact on cattle productivity and behavior (cont.)	D. E. Johnson		X
Rangeland vegetation and sediment monitoring	L. Larson	X	X
Animal Sciences			
Late gestation protein supplementation of beef cows	D. Bohnert		X
Grazing options with *Brassicas* and Fodder Radishes	C. Engel		X
Maternal marbling potential and ultrasound technology	C. Mueller		X
Replacement heifers sired by high or low-marbling bulls	C. Mueller	X	X
BVDV and BVDV PI screening to initiate BVDB control	B. Riggs		X
Selenium supplementation and retention in beef cattle	G. Pirelli	X	X
Farm-based livestock manure/biogas production (cont.)	M. Gamroth		X

Projects funded in 2009 – 2010 FY

Abbreviated Project Title	Senior Investigator	Report Status Progress	Report Status Full
Rangeland Ecology and Management			
Wolf impact on cattle productivity and behavior (cont.)	D. E. Johnson		X
DNA analysis for cattle diet in sagebrush rangelands	R. Mata-Gonzales	X	X
Behavior and distribution of cattle grazing riparian zones	D.E. Johnson		X
Animal Sciences			
PFG2α to improve uterine health and reproductive efficiency	M. Cannon		X
Disposition and reproductive performance of brood cows	R. Cooke	X	X
Acclimation to handling and heifer development	R. Cooke	X	X
Farm-based livestock manure/biogas production (cont.)	M. Gamroth		X

Projects funded in 2010 – 2011 FY

Abbreviated Project Title	Senior Investigator	Report Status Progress	Report Status Full
Rangeland Ecology and Management			
Conflict stressors, spatial behavior and grazing budgets of cattle	D. E. Johnson	X	X
Behavior and distribution of cattle grazing riparian zones **(cont.)**	D. E. Johnson		X
Grazing and medusahead invasion in sagebrush steppe	D. D. Johnson	X	X
Weeds to suppress cheatgrass and medusahead	P. Dysart	X	X
Effects of wolves on cattle production systems **(cont.)**	D. E. Johnson		X
Quantities diet analysis in cattle using fecal DNA	R. Mata-Gonzales	X	X
Animal Sciences			
Protein supplementation to low-quality forage	D. Bohnert	X	X
Disposition, acclimation, and steer feedlot performance	R. Cooke	X	X
Nutrition during bull development on calf performance	C. Mueller	X	X
Extending grazing season with warm season and Brassica forages	S. Filley	X	X
Oral Selenium drench at birth to calves	J. Hall	X	X

Projects funded in 2011 – 2012 FY

Abbreviated Project Title	Senior Investigator	Report Status Progress	Report Status Full
Rangeland Ecology and Management			
Revegetating sagebrush rangelands Invaded by Medusahead	D. D. Johnson	X	X
Potential benefits of Sagebrush consumption by cattle	R. Mata-Gonzales	X	X
Effect of wolves on cattle production systems **(cont.)**	D. E. Johnson		X
Conflict stressors, spatial behavior and grazing budgets **(cont.)**	D. E. Johnson	X	X
Animal Sciences			
Effects of camelina meal supplementation to beef cattle	R. Cooke	X	X
The economics of grassed-based dairying in Oregon	T. Downing	X	X
Yeast culture supp. improves feed consumption in cattle	G. Bobe	X	X
Western Juniper - Induced Abortions in Beef Cattle	C. Parsons	X	X

Projects funded in 2012 – 2013 FY

Abbreviated Project Title	Senior Investigator	Report Status Progress	Full
Rangeland Ecology and Management			
Effect of wolves on cattle production systems (cont.)	D.E. Johnson		X
Modification of livestock and sage-grouse habitat after juniper control	R. Mata-Gonzales	X	X
Prescribed burning and herbicide appl. to revegetate rangelands	D. D. Johnson	X	X
Animal Sciences			
Comparison of Ivomec Plus and a generic anthelmintic to beef cattle	R. F. Cooke	X	X
Influence of supplement composition on low-quality forages	D. W. Bohnert	X	X
Yeast culture supplementation and dairy reproductive performance	G. Bobe	X	X
The effect of western juniper on the estrous cycle of beef cattle	C. Parsons	X	X

Projects funded in 2013 – 2014 FY

Abbreviated Project Title	Senior Investigator	Report Status Progress	Full
Rangeland Ecology and Management			
Development of forage value index for Ryegrass	T. Downing	X	X
Effect of wolves on cattle production systems (cont.)	J. Williams		X
Use of herbicide for control of Western Juniper	G. Sbatella		X
Animal Sciences			
Oxidized lipid metabolites to predict disease in dairy cows	G. Bobe	X	X
Cow nutritional status during gestation and offspring performance	R. F. Cooke	X	X
Modifying the hormone strategy for superovulating donor cows	F. Menino	X	X

Projects funded in 2014 – 2015 FY

Abbreviated Project Title	Senior Investigator	Report Status Progress	Full
Rangeland Ecology and Management			
Development of forage value index for Ryegrass	T. Downing	X	X
Research on stream water temperature and sediment loads	C. Ochoa	X	X
Techniques to improve seedling success of forage kochia	D. D. Johnson	X	X
Animal Sciences			
Identification of predictive metabolomics markers in dairy cows	G. Bobe	X	X
Cow nutritional status during gestation and offspring performance	R. F. Cooke	X	X
Modifying the hormone strategy for superovulating donor cows	F. Menino	X	X
Energetic output of beef cows based on lactation and calf crop	C. Mueller	X	
Influence of supplement type and monensin on forage utilization	D. W. Bohnert	X	X

Projects funded in 2015 – 2016 FY

Abbreviated Project Title	Senior Investigator	Report Status Progress	Full
Rangeland Ecology and Management			
Research on stream water temperature and sediment loads	C. Ochoa	X	X
Impacts of wolf predation on stress in beef cattle	R. Cooke	X	X
Techniques to improve seedling success of forage kochia	D. D. Johnson	X	X
Animal Sciences			
Modulation of milk fat synthesis in dairy animals	M. Bionaz	X	X
Peripartal vitamin E injections prevent diseases in dairy cows	G. Bobe	X	
Cow nutritional status during gestation and offspring performance	R. Cooke	X	X
Development of enhanced cattle embryo transfer medium	A. Menino	X	X
Energetic output of beef cows based on lactation and calf crop	C. Mueller	X	

Projects funded in 2016 – 2017 FY

Abbreviated Project Title	Senior Investigator	Report Status Progress	Full
Rangeland Ecology and Management			
Preventing juniper reestablishment into sagebrush communities	C. Ochoa	X	X
Research on stream water temperature and sediment loads	C. Ochoa	X	X
Greater sage grouse response to landscape level juniper removal	C. Hagen		X
Greater sage grouse habitat suitability and management in SE Oregon	L. Morris	X	X
Organic fertility effect on alfalfa hay in Central Oregon	M. Bohle	X	
Annual warm season grasses for forages	G. Wang	X	X
Animal Sciences			
Peripartal vitamin E injections prevent diseases in dairy cows	G. Bobe	X	
Feeding immunostimulants to enhance receiving cattle performance	R. Cooke	X	X
Development of enhanced cattle embryo transfer medium	A. Menino	X	X
In vivo-in vitro hybrid system to perform nutrigenomic studies in cattle	M. Bionaz	X	X
Feeding Se-fertilized hay to reduce parasite load in beef calves	J. Hall	X	X
Evaluation of biological deterrents to manage wolf movements	M. Udel	X	X

Projects funded in 2017 – 2018 FY

Abbreviated Project Title	Senior Investigator	Report Status Progress	Full
Rangeland Ecology and Management			
Preventing juniper reestablishment into sagebrush communities	C. Ochoa	X	X
Conservation measures to restore rangeland on sage-grouse habitat	S. Arispe	X	X
How much water do mature and juvenile juniper trees need?	R. Mata-Gonzales	X	X
Evaluation of stubble height relationship to riparian health and function	B. Endress	X	X
Animal Sciences			
Development of enhanced cattle embryo transfer medium	A. Menino		X
Feeding essential fatty acids to late-gestating cows	R. Cooke	X	X
Impacts of estrus expression and intensity on fertility of beef cows	R. Cooke	X	X
Increasing milk production in bovine mammary cells	M. Bionaz		X
Use of platelet rich plasma for endometritis in beef heifers	M. Kutzler	X	X
Out of Cycle Project			
Identification of cyanobacterium in Lake county	T. Dreher	X	X

Projects funded in 2018 – 2019 FY

Abbreviated Project Title	Senior Investigator	Report Status	
		Progress	Full
Rangeland Ecology and Management			
Interspace/Undercanopy foraging by horses in sagebrush habitats	D. Bohnert	X	
Targeted grazing for control of ventenata dubia in OR meadows	L. Morris	X	X
Conservation measures to restore rangeland on sage-grouse habitat	S. Arispe	X	X
Perennial Bunchgrass re-growth under different utilization strategies	D. Johnson	X	X
Preventing juniper reestablishment into sagebrush communities	C. Ochoa		X
Animal Sciences			
Genomic testing for prod.& perf. traits in crossbreed angus cattle	M. Kutzler	X	X

Projects funded in 2019 – 2020 FY

Abbreviated Project Title	Senior Investigator	Report Status	
		Progress	Full
Rangeland Ecology and Management			
Conservation measures to restore rangeland on sage-grouse habitat	S. Arispe	X	X
Fine Fuels Mgt. to improve sagebrush habitat using grazing	S. Arispe	X	
Influence of Ravens on Sage Grouse in Baker Oregon	J. Dinkins	X	
Grazing Season of use on Sage-grouse habitat	D. Johnson	X	X
Systems-based approach to rangeland riparian systems	C. Ochoa	X	
Animal Sciences			
Invitro/hybrid approach to study nutrigenomic effects of fatty acids	M. Bionaz	X	X
Cytokine Expression in Beef Heifers	M. Kutzler	X	X
Irrigation & Seeding Date effects on Winter forage production systems	G. Wang	X	
Self-regenerating annual clover in Western Oregon forage Systems	S. Ates	X	X

Projects funded in 2020 – 2021 FY

Abbreviated Project Title	Senior Investigator	Report Status	
		Progress	Full
Rangeland Ecology and Management			
Fine Fuels Management to Improve Wyoming Big Sagebrush Plant Communities Using Dormant Season Grazing	S. Arispe	X	
Influence of Juniper Removal in Aspen Stands on Greater Steen's Mountain Wildlife	J. Dinkins	X	
Evaluating rangeland health, structure and function, using off the shelf drone technology to inform and enhance ecosystem management	B. Endress	X	
The relationship between Cattle Grazing and the invasive Annual Grass Ventenoto dubio in Oregon	F. Brummer (L. Morris)	X	
A Systems-based understanding of rangeland watershed-riparian systems in eastern Oregon	C. Ochoa	X	
Irrigation and Seeding Date Effects on Winter Grasses and Forbs Forage Production and Quality in Eastern Oregon	G. Wang	X	
Animal Sciences			
Evaluating Methods to Reduce Calf Stress During Processing in Unweaned Bulls	S. Arispe	X	
Feeding spent hemp biomass to lambs as a model for cattle. Cannabinoid residuals, animal health and product quality	S. Ates	X	X

In Vito, vitro dose-effect response of bovine liver to rumen-protected fatty acids: implementation of nutrigenomic approach in diary cows	M. Bionaz	X	X
Monitoring Cattle Behavior to identify Cattle Distrubance Remotely	S. Arispe	X	
Using GPS activated Shock Collars to Prevent cattle grazing of burned rangeland	J. Ranches	X	X

Projects funded in 2021 – 2022 FY

Abbreviated Project Title	Senior Investigator	Report Status Progress	Full
Rangeland Ecology and Management			
Evaluating rangeland health, structure and function, using off-the-shelf drone technology to inform and enhance ecosystem management	B. Endress	X	
Fine fuels management to improve Wyoming big sagebrush plant communities using dormant season grazing	S. Arispe	X	
Management of self-regenerating annual clovers in rainfed and irrigated production systems in western Oregon	S. Ates	X	
A systems-based understanding of rangeland watershed-riparian systems in eastern Oregon	C. Ochoa	X	
Animal Sciences			
Monitoring cattle behavior to identify cattle disturbance remotely	S. Arispe	X	
Vitamin A & D pre-exposure to prime reproduction success	C. Bishop		
Effect of feeding spent hemp biomass on liver transcriptome, nitrogen metabolism and methane emission in ruminants	M. Bionaz	X	
State evaluation of mineral status of cow herds and mineral supplementation strategies	J. Ranches	X	
Effects of trace mineral injections on measures of performance and trace mineral status of heifers and their calves	J. Ranches	X	

Oregon State University

Beef Cattle Sciences

Oregon BEEF