Beef Cattle Sciences

Oregon Beef Council Report

2022 Edition

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Thank you for the interest in the 2022 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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RANGELAND ECOLOGY AND MANAGEMENT PROGRESS REPORTS

Oregon State University

BEEF 222

Oregon Beef Council Report

Beef Cattle Sciences

Evaluating Methods to Reduce Calf Stress During Processing in Unweaned Bulls [1]

Sergio A. Arispe[2], Chris Schachtschneider[3], and William J. Price[4]

Synopsis

Maintaining cow-calf pairs in proximity while processing unweaned bulls reduces acute stress two hours after processing.

Summary

The objective of this experiment was to test the hypothesis that managing cow-calf pairs during branding and processing will reduce the level of the stress hormone, cortisol, which is acutely released at that time. The project consisted of 51 crossbred, commercial (Angus x Hereford x Charolais), cow-calf pairs consisting of bull calves between 2-3 months old. Cow-calf pairs were randomly assigned to the following treatments: calf processing with cow in pen (together) and calf processing without cow present (separate). Seven days before implementing the treatment, we weighed calves and collected baseline plasma cortisol. On the day of processing, calves were processed, which included branding, castration, earmarking, subcutaneous injections of a multimineral and vitamins. Blood samples were collected at processing and then between 150 mins to 272 mins after processing. Bull calves in the together and separated treatments had similar baseline cortisol levels at 12.8±1.4 ng/ml and 12.1±1.2 ng/ml ($P>0.05$), respectively. Plasma cortisol at processing were also similar between the together and separated treatments with 12.0±1.9 ng/ml and 12.9±1.6 ng/ml ($P>0.05$). The greatest difference in cortisol was after processing. Unweaned bull calves that were processed with cows present in the working pen exhibited less stress compared to calves that were separated from cows during processing (13.7±1.2 vs. 25.5±1.7 ng/ml, respectively; $P<0.01$). Results from this experiment highlight that maintaining cows in the working pen while processing unweaned bulls reduces calf stress following the procedure.

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

1. This document is part of the Oregon State University – 2022 Oregon Beef Council Report. Please visit the Beef Cattle Sciences website at http://blogs.oregonstate.edu/beefcattle/research-reports/

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number of beef cattle that populate the rugged terrains and vast expanses of western rangelands, it is not uncommon for the 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.

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. The objectives of the present experiment were to compare plasma cortisol between unweaned bulls processed with and without cows in the pen while processing by comparing cortisol levels before, during, and after processing.

Materials and Methods

The experimental protocol was approved by the Oregon State University Institutional Animal Care and Use Committee. The original experiment was to be conducted in 2020 but experienced setbacks due the global COVID pandemic. Procedures were modified from the original proposal to fit the cow-calf operator's operation.

Fifty-one crossbred (Angus x Hereford x Charolais), commercial cow-calf pairs—consisting of bull calves between 2-4 months old—were used for this study. Calves were selected for uniformity and randomly assigned to the following treatments—Head & Heel Together (HHT; Together) and Head & Heel Separating Pairs (HHS; Separated). Figure 1 illustrates the sampling protocol implemented by researchers to extracted blood for plasma cortisol concentrations.

Baseline plasma cortisol was collected ten days before processing by moving calves through a chute and scale system. Calves were randomly sorted through alternating treatment placement (HHT and HHS) at baseline weight and blood collection. Calves were weighed, given an individual identification ear tag, and blood collected. Collection time averaged 5 minutes and 48 seconds per calf. Calves were then paired and sorted into their respective groups. Each group was placed into adjacent pastures with similar size and characteristics until processing.

On the day of processing, cattle were brought in with their respective groups and processed. Livestock handlers were specifically selected for their ability to handle livestock in an effective and low stress manner. Calves were captured and restrained through head and heel roping on horseback. Once restrained calves were hot iron branded, vaccinated with three injections, and then castrated. Blood was collected via jugular venipuncture immediately after processing was completed before the calf was released to join the herd. Once processing was completed, cattle were moved into a holding pen, with cows for all groups, until post processing blood collection. Processing time averaged 1min 48sec and 2min 19minutes per calf for HHT and HHS groups, respectively.

About two hours after processing, each group were brought into the handling facility and calves were separated and moved through the chute for the final blood collection. Time averaged 3min 31secs and 3min 05 secs per calf for HHT and HHS groups, respectively. Calves where then returned to the main herd after the completion of sample collection.

Blood samples were collected in a 6 ml sodium heparin tubes and stored on ice immediately after collection. Samples were centrifuged at approximately 2,500 x g for 10 mins. Plasma was transferred to 1.5 ml Eppendorf tubes and placed on ice before placing them in a -80°C freezer within six hours.

Plasma cortisol was analyzed using a repeated-measures analysis with the fixed linear model procedure lm () in the R Stats Package (CRAN 2022). The model statement incorporated treatment groups, time, and their interactions as fixed terms. Weight was included in the model as a covariate. Significance was set at $P \leq 0.05$.

Results

Unweaned bulls in together and separated treatments exhibited similar baseline plasma cortisol concentrations with 12.8±1.4 and 12.1±1.2 ng/ml ($P>0.05$), respectively (Table 1). Furthermore, calves in both treatments exhibited similar cortisol levels at the time of processing at 12.0±1.9 and 12.9±1.6 ng/ml for calves kept together with cows during processing compared to calves separated from cows. These values are consistent with plasma cortisol profiles in unweaned bull calves in the literature. King et al. (1991) reported calves castrated at 78 days experienced lower plasma cortisol levels between different castration methods compared to unweaned bull calves castrated at 167 days of age.

Researchers collected blood samples after the initial processing procedures. On average, time of collection for the together treatment was 169±6 minutes compared to 207±6 minutes for the separated treatment group. Calves processed together with the cow exhibited less physiologic stress compared to calves that were separated from cows during processing. In particular, the unweaned bull calves exhibited nearly half the levels of plasma cortisol compared to those bull calves separated from cows, at 13.7±1.2 and 25.5±1.7 ng/ml, respectively (Figure 1).

These data supporting our hypothesis that maintaining bull calves with cows during initial processing, around three months of age, will lower calf stress levels. Based on our findings, it is likely that calves may respond better to processing procedures if the cow is maintained and managed within the same pen at processing. However, cow temperament and worker safety should be prioritized and considered prior to explicitly changing calf management.

Conclusions

In conclusion, results from this experiment highlight that processing unweaned bull calves, together with a cow at their side, during the first three months of life can lower acute calf stress after processing. While the effect of cow presence exhibits a delayed response, the lower plasma cortisol in the together treatment highlights benefits of managing cow-calf pairs together.

Acknowledgments

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Table 1. Plasma cortisol concentrations between treatments at different times in processing.

Time	Together (ng/ml)	Separated (ng/ml)	*P*-Value
Baseline	12.8±1.4 (*n=22*)	12.1±1.2 (*n=23*)	NS
At Processing	12.0±1.9 (*n=9*)	12.9±1.6 (*n=13*)	NS
After Processing	13.7±1.2[a] (*n=18*)	25.5±1.7[b] (*n=25*)	<0.01

Figure 1. Timeline of blood collection to analyze cortisol: A) 10 days before implementing treatment; B) Treatment Separate or maintain cow-calf pairs; C) blood collection immediately after processing; D) Blood collection 2 hours after processing.

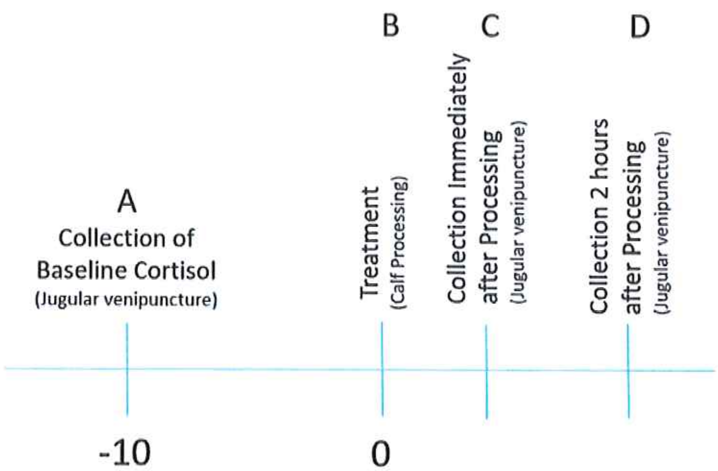
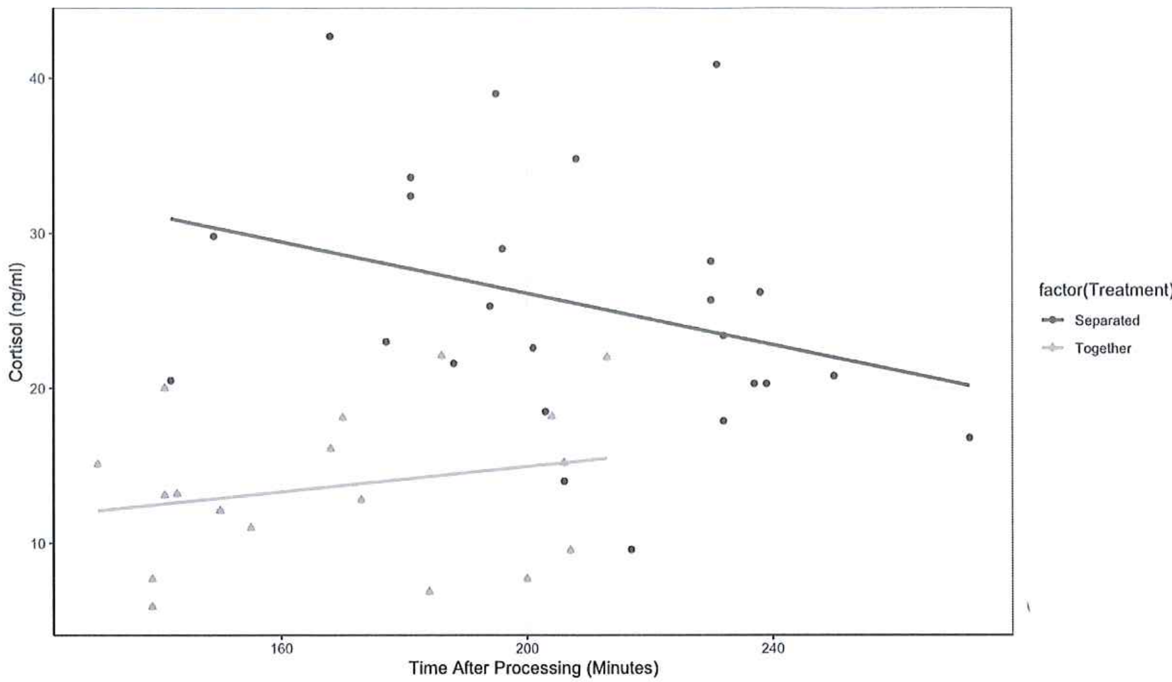


Figure 2. Association between time after processing and cortisol between unweaned bull calves processed with cows (together) and unweaned bull calves processed after being separated from cows. A treatment effect was detected ($P<0.01$).



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Beef Cattle Sciences

Monitoring Cattle Behavior to Identify Cattle Disturbance Remotely [1]

Sergio A. Arispe[2], Scott Duggan [2], and William J. Price[3]

Synopsis

Precision agricultural technologies, like low-cost GPS cow collars, can provide useful data about cow location. These devices can use cow behavior as a proxy to gain insight into cow-calf pair disturbance.

Summary

The objective of this experiment was to test the hypothesis that researchers could detect a change in cow behavior if calves are removed from cows with low-cost GPS cow collars through a simulated "rustling" procedure. In particular, Mobile Action i-gotU GPS devices were deployed on 50 commercial, crossbred (Angus x Hereford) cows in central Oregon. Researchers used a crossover design whereby two cow-calf pair groups either experienced no simulated theft of calves (control) and a treatment that simulated the theft of calves. There was a 24-hour washout period between the simulated theft experienced by both groups. The GPS waypoint data was acquired every 10 seconds, while researchers calculated rate traveled based on coordinates. During theft, cows traveled at a rate of 57.7±0.3 m/min compared to undisturbed cows, which traveled at a rate of 34.5±0.6 m/min. While the current study highlights the use of low-cost GPS collars as a tool to determine cattle behavior, the data is not available in real-time and can only be assessed after data are downloaded, cleaned, and assessed.

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.

Cattle production is an economic driver in the Pacific Northwest that generates nearly $3.2 billion annually. In Oregon, cattle & calves are the second leading agricultural commodity, behind greenhouse & nursery products, with gross farm sales of $588

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million in 2020 (ODA 2021). The Oregon cow-calf sector is the foundation of cattle production with the majority of these producers located in central and eastern Oregon. These cow-calf producers strategically use cattle as a land management tool to manage plant communities on both private and public lands of our state. Unfortunately, these lands are remote and provide the perfect opportunity for cattle rustlers.

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).

The proposed study tested the hypothesis that maternal behavior will change after a simulated theft. To test the hypothesis, we used a crossover design whereby cows in two cow-calf groups received a similar treatment—simulated rustling.

Materials and Methods

The experimental protocol was approved by the Oregon State University Institutional Animal Care and Use Committee. The original experiment was to be conducted in 2021 but experienced setbacks due to the passing of the cow-calf operator who conceived the experiment and the global COVID pandemic. Procedures were modified from the original proposal and conducted on a cow-calf operation in central Oregon in summer 2022.

On the initial day (0 d), 50 commercial, crossbred (Angus x Hereford) cow-calf pairs in central Oregon were randomized in two equal groups—Group A and Group B. Cow-calf pairs within both groups were herded into working pens where the cows were fitted with GPS cow collars. The cow-calf pairs were divided equally between two pastures. Knight GPS cow collars were tracked beginning at midnight Pacific Daylight Time (PDT) on July 6th, 2022 through July 8th, 2022 at 5:00 pm PDT. The Knight GPS cow collars were scheduled to record fixed positions every 10 seconds.

On 1 d, three horsemen herded cow-calf pairs from Group A to a corral where and calves were separated from cows. Cows were then herded by horseback to a corral that was out of sight from the calves. Cows were then maintained separate from calves for 15 minutes before being returned with calves. Afterwards, cow-calf pairs were returned to their respective pasture. On 2 d, a washout period of 24 hours was recorded whereby neither one of the groups experienced disturbance from managers.

On 3 d, the same rustling protocol was implemented on Group B. Fifteen minutes after the cows and calves were reunited, all cows were managed through chute and Knight GPS cow collars were removed prior to returning cow-calf pairs to pasture.

Mean rate (m/min) was calculated between treatment groups when they were not actively managed, control, compared the mean rate during the time when there was a simulated theft. Modifications in protocol complicated the statistical analysis; therefore, only means and standard errors are reported. Due to device malfunction, 41 of the 50 units recorded information. Data are meant to be analyzed as a completely random design using a fixed linear model procedure lm () in the R Stats Package (CRAN 2022). The rustling treatment was used a fixed effect while the cow served as the experimental unit.

Results

Cow rate was assessed between animals that experienced a simulated theft compared to animals that were not disturbed. During theft, cows traveled at a rate of 57.7±0.3 m/min compared to undisturbed cows, which traveled at a rate of 34.5±0.6 m/min. Figure 1 highlights the association between speed and the probability of a simulated calf theft between both groups. Median speeds from boxplots in both groups supports that the simulated theft increases rate due to the associated disturbance.

While the current study highlights the use of low-cost GPS collars as a tool to determine cattle behavior, the data is not available in real-time and can only be assessed after data are downloaded, cleaned, and assessed. These data supporting our hypothesis that low-cost GPS cow collars may be able to detect unwanted cattle disturbance.

Conclusions

In conclusion, results from this experiment highlight that low-cost GPS cow collars may be placed on cows, which are used as a proxy for calf disturbance. During the simulated theft that removes calves from cows, the cow rate increases. Unfortunately, limitations in battery life and streamlining the data in real-time are the major limitation for the cattle industry.

Acknowledgments

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

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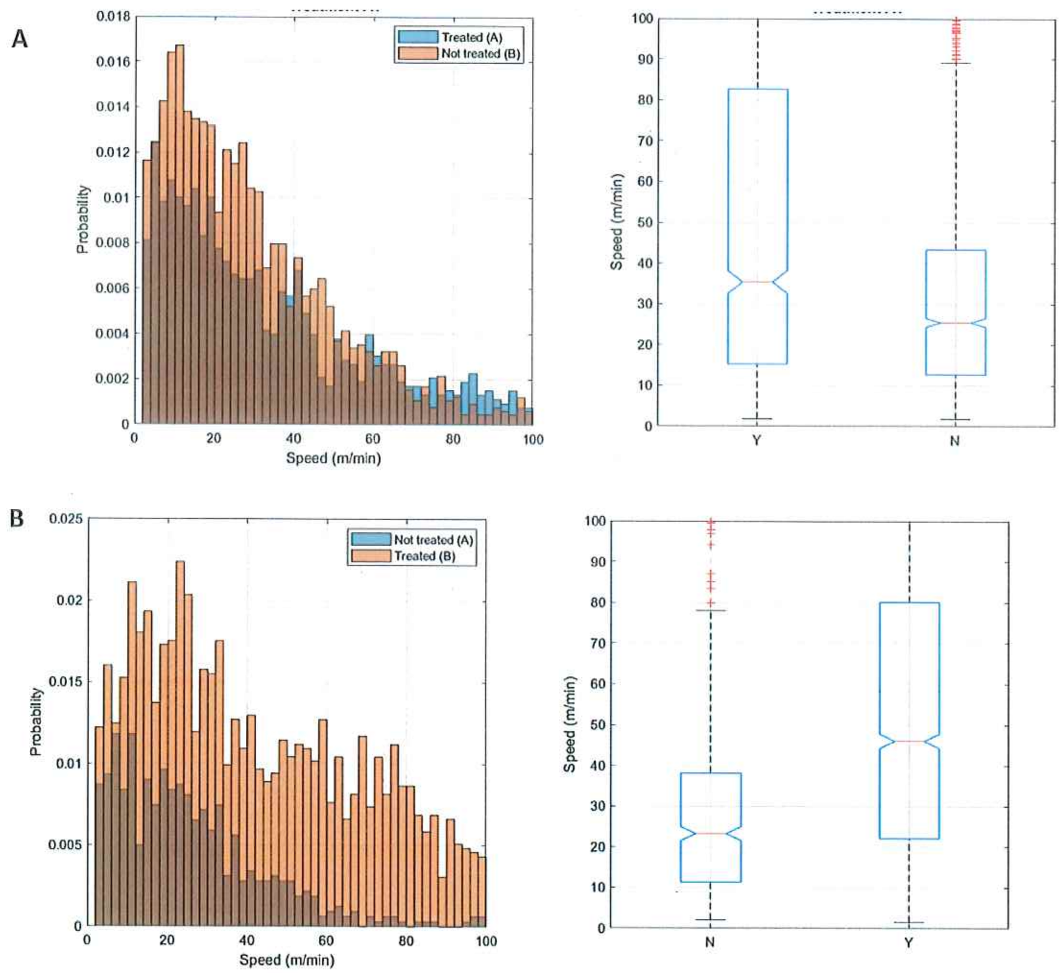

Figure 1. Association between speed (m/min) and probability that calves were rustled from cows and a visualization of summary statistics between cow-calf pairs experiencing rustling—Y; yes, N; no. Box plots highlight the bottom and top quartile range, as well as the median.

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Oregon Beef Council Report

Beef Cattle Sciences

Effects of Trace Mineral Injections on Measures of Performance and Trace Mineral Status of Heifers and their Calves [1]

Juliana Ranches[2] and David Bohnert[3]

Synopsis

Administration of injectable trace minerals (**ITM**) enhanced liver Cu concentration of heifers overtime, and resulted in a consistent numerical advantage on calf body weight.

Summary

The objective of this study was to evaluate the effects of ITM on performance and mineral status of heifers and their calves, when ITM was provided at calving (birth) and at breeding (summer grazing), both challenging periods in cattle production. We hypothesized that heifers and their calves receiving ITM at calving (birth) and at breeding would have improved mineral status and performance when compared to heifers and calves not receiving ITM. During the calving season of 2021, 50 heifers and their calves were randomly assigned to 1 of 2 treatments: 1) Injectable trace mineral (ITM): heifers assigned to the ITM treatment received an ITM injection at the calving and breeding (cattle over 2 years: 1 ml/90 kg BW). Similarly, calves born to these heifers received an ITM injection at birth and breeding (1.0 ml/45 kg 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, blood and liver samples were collected from heifers and calves at multiple time points to evaluate performance and mineral status of heifer-calf pairs. Treatment effects (P = 0.04) were only observed for Cu liver concentration of heifers. Heifers assigned to ITM treatment had greater Cu status than heifers assigned to Saline (67 vs. 42 mg/kg; 9.17 SEM, respectively). No treatment effects were observed for mineral status of calves or performance. However, calves assigned to ITM treatment had consistent numeral advantage on body weight.

Introduction

Trace mineral status is known to be important for physiological functions related to growth, reproduction, and immunity in livestock (Suttle, 2010). For grazing beef cattle, forage is the primary source of trace minerals. However, in some locations forage trace mineral concentration are not sufficient to satisfy the trace mineral requirements of cattle, which requires a supplemental source, such as free-choice loose mineral mixes, trace-mineral-fortified salt blocks, and trace-mineral-fortified energy and protein supplements (Arthington and Ranches, 2021).

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Although those traditional methods of supplying trace minerals to cattle are efficient, they are not are always suitable for all production environments such as the extensive rangelands in eastern Oregon.

In eastern Oregon, from spring to fall, cattle graze native forages (Stipa spp., Pseudoroegneria spicata, Poa secunda, Artemisia tridentata subsp. wyomingensis) in public allotments. Generally, the stocking capacity of these pastures is limited due to the quantity and quality of these forages, which results in a low number of cattle per acre, therefore cattle are managed in very large areas. Due to logistical constraints associated with extensive rangeland pastures, including accessibility challenges, traditional trace mineral supplementation is limited or not provided at all. Thus, the use of ITM can be a tool when traditional mineral supplementation strategies are challenging. Another key advantage of the use of the ITM is the possibility to conveniently plan the delivery of a known amount of trace minerals over specific periods of time, consequently boosting the trace mineral status of these animals during challenging events (Arthington et al., 2014).

In beef cattle operations, breeding, calving and weaning are the most important, and perhaps most challenging periods of the entire production cycle, especially for the still developing heifer. The development of heifers has been widely studied in the past, however, most of the research focus has been on puberty achievement and (Funston et al., 2012) and little research has been done looking into mineral status of heifers. Because of the particularities of this animal's category, the use of ITM in specific periods of time may be warranted to improve production outcomes at challenging moments such as calving, weaning, and breeding season.

Therefore, the objective of this study was to evaluate the effects of ITM on performance and mineral status of heifers and their calves, when ITM was provided at calving (birth) and at breeding (summer grazing), both challenging periods in cattle production. Thus, we hypothesized that heifers and their calves receiving ITM at calving (birth) and at breeding will have improved mineral status and performance when compared to heifers and calves not receiving ITM.

Materials and Methods

The study was conducted at Eastern Oregon Agriculture Research Center (EOARC; Burns, OR). During the calving season of 2021, 50 heifers and their calves were randomly assigned to 1 of 2 treatments: 1) **Injectable trace mineral (ITM):** heifers assigned to the ITM treatment received an ITM injection at the calving and breeding (cattle over 2 years: 1 ml/90 kg BW). Similarly, calves born to these heifers received an ITM injection at birth and breeding (1.0 ml/45 kg 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.

During calving season (~February), heifers were maintained in a dry-lot and were fully monitored for parturition signals as routinely conducted at EOARC. During calving season, heifers were fed alfalfa hay (*Mendigaco Sativa*) ad libitum. At calving, treatment administration were provided within 12h after birth. Blood samples were collected from all heifers and calves at calving. Additionally, a liver sample was collected from a subgroup of heifers and calves (n = 12 pairs/treatment), and birth weights were collected from all calves at birth using an electronic scale. After treatment administration and sample collections at birth, heifer-calf pairs were move to a pasture (approximately 60 acres) and managed as a single group at EOARC until the turnout. Heifer-calf pairs were fed meadow hay and supplemented with alfalfa hay. Pairs had free access to water and free-choice loose mineral supplement. At turnout (~April), sample collections of body weight, blood and liver were conducted. After sample collection heifer-calf pairs were transported to the Northern Great Basin Experimental Range (NGBER; approximately 35 miles). At NGBER heifer-calf pairs were kept as a single group grazing native rangeland pastures (*Stipa spp., Pseudoroegneria spicata, Poa secunda, Artemisia tridentata subsp. wyomingensis*) with free access to water and free-choice loose mineral supplement. Approximately 40 days after the turnout

(~June), heifers were enrolled in a 60-day breeding season, where heifers were artificially inseminated, followed by bull exposure. At breeding, a second administration of treatment was provided, and body weights, blood and liver samples were collected from heifers and calves. At weaning (approximately 130 d after the turnout; ~August) body weight, blood samples, and liver samples were collected from calves, and body weights were collected from heifers. After weaning, calves were allocated to pens according to the treatments for a 45-day preconditioning prior to be shipped to the feedlot. At the end of the preconditioning a final body weight was collected from all calves.

All liver samples collected were sent to a commercial laboratory (Michigan State University, Animal Health Diagnostic Laboratory; Lansing, MI) for determination of trace mineral concentration using Inductively coupled plasma mass spectrometry (ICP-MS).

For data analysis, each heifer and calf were considered the experimental unit in this study. Body weights and liver trace mineral concentration data were analyzed using the mixed procedure of SAS (SAS Inst. Inc., Cary, NC). Briefly, the model statement included treatment, day, and possible interactions, and day was included in the repeated statement. Heifer initial body weight was used as covariate for the analysis of subsequent body weight. Significance was set at $P \leq 0.05$ and tendencies were determined if $P > 0.05$ and ≤ 0.10.

Results

No effects of treatment (P = 0.67) or a treatment × time (P = 0.97) were observed for heifer body weight during the study. Only an effect of time (P <0.0001) was observed where heifer body weight decreased over time regardless of treatment.

For liver Se concentration of heifers there were no effects of treatment (P = 0.59) or treatment × time (P = 0.64). There was an effect of time (P = 0.03) for liver Se concentration where liver Se concentration tended (P = 0.07) to increase over time for heifers assigned to the Saline treatment.

There was an effect of treatment (P = 0.04) for Cu liver concentration where heifers assigned to ITM treatment had greater liver Cu concentration than heifers assigned to Saline (67 vs. 42 mg/kg; 9.17 SEM, respectively). There was a time effect (P <0.0001) where Cu liver concentration increased over time regardless of treatment, but there was no effect of treatment × time (P = 0.11).

For liver Mn concentration of heifers there were no effects of treatment (P = 0.55) or treatment × time (P = 0.61). There was an effect of time (P <0.0001) for liver Mn concentration where concentration decreased overtime regardless of treatment.

For liver Zn concentration of heifers there were no effects of treatment (P = 0.82) or treatment × time (P = 0.46). There was an effect of time (P <0.0001) for liver Zn concentration where concentration decreased overtime regardless of treatment (Table 1).

No effects of treatment (P = 0.41) or a treatment × time (P = 0.80) were observed for calf body weight during the study. Only an effect of time (P <0.0001) was observed where calf body weight increased over time regardless of treatment.

For liver Se concentration of calves there were no effects of treatment (P = 0.89) or treatment × time (P = 0.85). There was an effect of time (P <0.0001) for liver Se concentration where liver Se decreased from birth to breeding and increased from breeding to weaning.

For liver Cu concentration of calves there were no effects of treatment (P = 0.12) or treatment × time (P = 0.48). There was an effect of time (P <0.0001) for liver Cu concentration where liver Cu decreased from birth to breeding and increased from breeding to weaning.

For liver Mn concentration of calves there were no effects of treatment (P = 0.81) or treatment × time (P = 0.58). There was an effect of time (P <0.0001) for liver Mn concentration where liver Mn was maintained from birth to breeding and increased from breeding to weaning.

For liver Zn concentration of calves there were no effects of treatment (P = 0.38) or treatment × time (P = 0.68). There was an effect of time (P <0.0001) for liver Zn concentration where liver Zn decreased from birth to breeding and remained the same until weaning (Table 2).

Conclusions

The results of this study suggest that the use of ITM injections administered to heifers and their calves at strategic moments during the beef production cycle might result in enhanced mineral status, as observed for Cu liver concentration of heifers in this study. Additionally, the improved mineral status of dams might reflect in enhanced calf performance as observed with a numerical advantage of 12 lb at the end of the study for calves assigned to ITM treatment.

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Table 1. Body weight and liver trace mineral concentration of heifers administrated or not (saline) with injectable trace minerals (ITM).

	Treatments[1]			
Item	**Saline**	**ITM**	**SEM**	***P*-value**
Turnout BW (lb)	918[a]	918[a]	13.1	1.00
Breeding BW (lb)	928[a]	925[a]	13.2	1.00
Weaning BW (lb)	853[b]	848[b]	13.1	0.999
Initial Se (mg/kg)[2]	0.69	0.75	0.059	0.48
Breeding Se (mg/kg)[3]	0.85[*]	0.86	0.066	0.92
Initial Cu (mg/kg)[2]	33.4[b]	50.8[b]	9.27	0.21
Breeding Cu (mg/kg)[3]	50.1[a]	85.0[a]	9.96	0.02
Initial Mn (mg/kg)[2]	9.57[a]	10.3[a]	0.612	0.44
Breeding Mn (mg/kg)[3]	6.71[b]	6.93[b]	0.657	0.81
Initial Zn (mg/kg)[2]	273[a]	286[a]	12.9	0.50
Breeding Zn (mg/kg)[3]	214[b]	207[b]	13.9	0.73

[a,b] means within the same treatment with different superscript differ overtime.

[*] There was an effect of time ($P = 0.03$) for liver Se concentration where liver Se concentration tended ($P = 0.07$) to increase for heifers assigned to the Saline treatment.

[1]During the calving season of 2021, 50 heifers and their calves were randomly assigned to 1 of 2 treatments: 1) Injectable trace mineral (ITM): heifers assigned to the ITM treatment received an ITM injection at the calving and breeding (cattle over 2 years: 1 ml/90 kg BW). Similarly, calves born to these heifers received an ITM injection at birth and breeding (1.0 ml/45 kg 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.

[2]Initial liver samples were collected at birth to evaluate mineral status of heifers. Adequate mineral status are reported by the Michigan State University Veterinary Diagnostic Laboratory as Cu: 40 – 650 mg/kg; Se: 0.60 – 3.30 mg/kg; Mn: 5.50 -15.00 mg/kg; Zn: 90-500 mg/kg.

[3]A second liver sample was collected at breeding to evaluate mineral status of heifers.

Table 2. Body weight and liver trace mineral concentration of calves administrated or not (saline) with injectable trace minerals (ITM).

	Treatments[1]			
Item	**Saline**	**ITM**	**SEM**	***P*-value**
Birth BW (lb)	68.0[e]	69.0[e]	10.5	1.00
Turnout BW (lb)	169[d]	176[d]	10.5	0.99
Breeding BW (lb)	250[c]	259[c]	10.7	0.99
Weaning BW (lb)	388[b]	397[b]	8.37	0.99
End Preconditioning (lb)	473[a]	485[a]	10.6	0.98
Initial Se (mg/kg)[2]	1.69[a]	1.84[a]	0.287	0.60
Breeding Se (mg/kg)[3]	0.69[b]	0.68[b]	0.317	0.97
Weaning Se (mg/kg)[3]	1.69[a]	1.62[a]	0.293	0.81
Initial Cu (mg/kg)[2]	251[a]	191[a]	32.1	0.07
Breeding Cu (mg/kg)[3]	52.7[b]	50.2[b]	35.5	0.94
Weaning Cu (mg/kg)[3]	188[a]	175[a]	32.6	0.94
Initial Mn (mg/kg)[2]	3.95[b]	4.25[b]	0.795	0.70
Breeding Mn (mg/kg)[3]	5.36[b]	5.51[b]	0.878	0.86
Weaning Mn (mg/kg)[3]	7.32[a]	6.53[a]	0.759	0.32
Initial Zn (mg/kg)[2]	584[a]	637[a]	45.6	0.24
Breeding Zn (mg/kg)[3]	238[b]	232[b]	50.7	0.90
Weaning (mg/kg)[3]	240[b]	265[b]	45.6	0.60

[a,b,c,d,e] means within the same treatment with different superscript differ overtime.

[*] There was an effect of time ($P = 0.03$) for liver Se concentration where liver Se concentration tended ($P = 0.07$) to increase for heifers assigned to the Saline treatment.

[1]During the calving season of 2021, 50 heifers and their calves were randomly assigned to 1 of 2 treatments: 1) Injectable trace mineral (ITM): heifers assigned to the ITM treatment received an ITM injection at the calving and breeding (cattle over 2 years: 1 ml/90 kg BW). Similarly, calves born to these heifers received an ITM injection at birth and breeding (1.0 ml/45 kg 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.

[2]Initial liver samples were collected at birth to evaluate mineral status of calves. Adequate mineral status are reported by the Michigan State University Veterinary Diagnostic Laboratory as Cu: 40 – 650 mg/kg; Se: 0.60 – 3.30 mg/kg; Mn: 5.50 -15.00 mg/kg; Zn: 90-500 mg/kg.

[3]A second liver sample was collected at breeding and third liver sample was collected at weaning to evaluate mineral status of calves.

Oregon Beef Council Report

Beef Cattle Sciences

Progress Reports – Animal Sciences [1]

Vitamin A and D Pre-Exposure to Prime Reproductive Success

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Project Objectives: Monthly injections of vitamins A and D during winter months to gestating beef cows and first calf heifers prior to calving may improve fertility post-calving. The objective of this study is to determine how Vitamin A and D supplementation in mid- to late gestation affects calving ease and birth weights of calves at parturition, as well as cow fertility at the following breeding. Pregnant Angus and Angus crossbred females of first (n=19) or second (n=11) parity were selected based on gestational age and starting in early October 2021 were randomly assigned to monthly injections of vehicle (control) or 300,000 IU Vitamin A and 45,000 IU Vitamin D (Vitamin AD, Vet One®; n=15/ treatment group); blood samples were collected immediately prior to injections. Calving date and time were recorded, as well as calving ease and birth weights. Blood samples were collected from the calves within 12 hours of parturition. There was no effect of vitamin A and D treatment on calving ease ($p = 0.58$) or birth weight ($p = 0.52$). Artificial insemination (AI) procedures were performed in late April 2022, and conception rates determined by transrectal ultrasonography 40 days post-AI. These found 8/15 controls were pregnant by AI compared to 10/14 AD-injected females (one female could not undergo AI due to late calving at end of March 2022, p=0.061). Cows not pregnant by AI were pastured with a bull of proven fertility, and rectal palpation in the fall to found similar overall pregnancy rates (p=0.54) and similar low rates of pregnancy loss (1/group). Serum analyses of vitamin D levels and progesterone produced during gestation are ongoing.

Project Status and Preliminary Findings: Cattle grazing on winter forage (including grass hay) must be supplemented with a mineral mix containing beta-carotene (the precursor form of vitamin A) to prevent reproductive loss and skeletal malformation in the growing fetus. Gestating cows need 1,300 IU/lb of feed or 34,000 IU/day. Feeding 1 mg of beta-carotene is converted to 400 IU of vitamin A in the liver and small intestines. This means cattle premix and forage should include at least 3 mg/lb of beta-carotene for sufficient vitamin A levels. Fresh grass pasture, such as spring grass, includes about 45 mg/lb

1. This document is part of the Oregon State University – 2022 Oregon Beef Council Report. Please visit the Beef Cattle Sciences website at http://blogs.oregonstate.edu/beefcattle/research-reports/

or 18,000 IU/lb of vitamin A [Nutrient Requirements of Beef Cattle, 2016]. Given the differences in requirements and the levels in grass pasture, it is not surprising that there are very few instances of toxicity.

Vitamin A is a well-known requirement for normal sperm production in males. It is absolutely required in females to maintain integrity of the connective tissues of the reproductive tract and prevent embryo and fetal losses in cases of deficiency. Vitamin A also appears to be beneficial when added to the media for in vitro production of bovine embryos. Previous research investigating the correlation between Vitamin A exposure and fertility of cattle has mostly focused on gestating dairy cows and supplementation or measurement of serum levels only in the last few months before calving. A recent, large-scale study in crossbred goats has shown oral supplementation with beta-carotene immediately prior to and during estrus synchronization increased ovulation rate by ~2-fold [Lopez-Flores et al. 2020]. In addition, postpartum Holstein cows supplemented with beta-carotene had improved corpora luteal activity. A limitation of some of these previous studies is reliance on oral consumption of a premix, which is ingested by animals at different rates. These vitamins can also be administered as a mixture with several other vitamins, each of slightly different composition, which can influence the results.

The most common co-mineral delivered with Vitamin A is Vitamin D. The NRC requirements for beef cattle assume animals receive adequate sunlight for UVB-production of vitamin D [Nutrient Requirements of Beef Cattle, 2016]. However, reports of beef cows living in Idaho and Minnesota had consistently lower levels of Vitamin D than those in Florida in winter, spring and fall months even with increased supplementation [Nelson et al. 2016]. Unlike vitamin A, over supplementation with Vitamin D can cause toxicity. However, toxicity occurs at Vitamin D levels >200 ng/ml (80,000+ IU/day). Most cattle rations are formulated to achieve levels of 20-50 ng/ml, which occurs from feeding 21,000 IU/day or 30 IU/kg BW vitamin D. Previous research has shown that brief increased supplementation of 300,000 IU/week (43,000 IU/day) was associated with a 16-day shorter dry period after calving for dairy cows. Data from women undergoing infertility treatments has also shown those with higher serum vitamin D have improved pregnancy rates, even when their counterparts are not considered "deficient". Many animal nutrition scientists have proposed revising the NRC requirements for vitamin D supplementation given these lines of evidence. To date, the importance of increased vitamin D supplementation on the fertility of beef cows remains under-investigated.

Defining the benefits of Vitamin A and D co-supplementation during the winter months in gestating beef cows could help guide supplementation requirements for beef cattle at northern latitudes, providing a potential benefit to all cattle producers. This supplementation is also inexpensive and has the potential to shorten calving intervals for producers, allowing reduced production costs/calf. Therefore, the objective of this study is to determine how Vitamin A and D supplementation in mid- to late gestation affects calving ease and birth weights of calves at parturition, as well as cow fertility at the following breeding. We hypothesize based on preliminary in vitro studies this will improve fertility post-calving.

Thirty crossbred gestating beef cows (n=11) and first-calf heifers (n=19) at Oregon State University's Soap Creek Ranch were utilized for this research. Beginning in early October 2021, females were randomized (~equal numbers of cows/heifers per group) and received monthly injections of a vehicle (control, n=15) or a commercial supplement containing 45,000 IU Vitamin D (to avoid toxicity) and 300,000 IU of vitamin A (0.6 ml/dose) until calving. Blood samples were collected prior to each injection to monitor serum progesterone and vitamin D levels. All females were transported to OSU Campus Barns in mid-January 2022 and allowed to calve normally. The birth weight of calf and calving ease was recorded in collaboration with OSU's Calving School class (ANS 405). Serum samples were obtained from calves within 6 hours of birth and then at 1 month of age. Post-calving breeding was performed as typical for Soap Creek Ranch using the Select Sync+CIDR method. Briefly, about 6 weeks after calving (Day 0), females were administered an injection of gonadorelin (Cystorelin®) and had a CIDR placed intravaginally. Seven days later (Day 7), the CIDR was removed and an injection of cloprostenol

(Estrumate®) was administered. At this time, Estrotech® patches were placed on the females and they were monitored for signs of estrus. Females were bred by artificial insemination 12 hours after standing heat was observed. All females received another injection of either vehicle or Vitamin A and D at the time of breeding. Females were then checked for pregnancy 40 days after breeding by transrectal ultrasound. Females were turned out to pasture with a bull for 60 days after artificial insemination to allow for pregnancy by natural breeding. All females were checked for pregnancy by rectal palpation in September 2022.

Calving ease was determined by guidelines outlined by the American Angus Association. Females were assigned a calving ease score of 1 if no assistance was necessary and parturition occurred normally within an hour of initiation of active labor. A score of 2 was assigned if minor assistance was required. A score of 3 was assigned if major assistance was required (e.g. multiple people required to pull). A score of 4 would have been assigned for surgical assistance, but this was not required.

Pregnancy rates 45 days post-AI and following exposure to the bull (overall rates) were analyzed using Generalized Linear models functions of SAS (Version 9.4, Cary NC). Calving ease and birth weight of calves were also determined by Generalized Linear Models function of SAS. A $p<0.05$ was considered significantly impacted by treatments, while $p>0.05<0.1$ were considered trends towards differences. Data with p-values >0.1 were considered non-significant.

As a result, there was no effect of vitamin A and D treatment on calving ease (Generalized Linear Model analyses, $p = 0.58$; 1.44 ± 0.2 treated, 1.29 ± 0.19 control group). There also was no effect of treatment on birth weight (Generalized Linear Model, $p = 0.52$, 71.75 ± 2.73 lbs treated, 74.38 ± 3.04 lbs control group). These data are depicted in Figure 1. It can be concluded from these data that there were no negative impacts on parturition success by monthly injection of the vitamin AD supplement.

Treatment with vitamin A and D prior to calving improved pregnancy rates from AI from 8/15 (controls) to 10/14 (one female calved too late for AI in late April 2022; Generalized Linear Model Analyses, $p = 0.061$). Overall pregnancy rates following exposure to the bull, as determined for non-pregnant females in Fall 2022 were not different by treatment group (14/15 vitamin AD versus 13/15 control; Generalized Linear Model, $p = 0.54$). These are depicted in Figure 2. Similar numbers of first-calf heifers experienced pregnancy loss following AI (n=1/group). We conclude these data strongly support the idea that maintaining adequate vitamin A and D levels during late gestation has a positive impact on fertility post-calving. Analyses of progesterone levels during gestation, vitamin D status of dams and calves, and weaning weight of calves are ongoing.

The conclusions are that the data support the stated hypothesis that maintenance of adequate levels of vitamins A and D during short days/winter months in gestating beef cows and first calf heifers has the potential to increase fertility post-calving. These data demonstrate this may be an effective method to improve production outcomes including a more uniform calf crop at weaning. This also provides an additional benefit by increasing the contribution of desired sires selected by artificial insemination to that calf crop to improve performance. Further data analyses are ongoing to determine the impact on calf vitamin D status at birth and effect on growth rates. Efforts are also underway to expand these studies to determine if oral supplementation of vitamin A and D also provides similar benefits.

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

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Figure 1. Effect of vitamin AD (VitAD) or control injections on Calving Ease and Birth Weight of calves. Data are presented displaying means (circles), medians (lines) and confidence intervals (95%) for these data. Generalized linear model analyses (P values) are depicted above graphs. There were no significant impacts of VitAD treatment on these parameters.

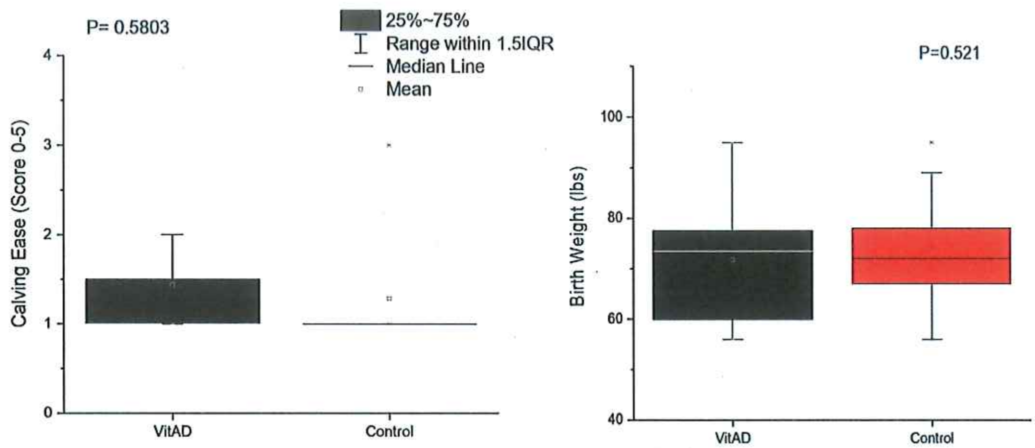
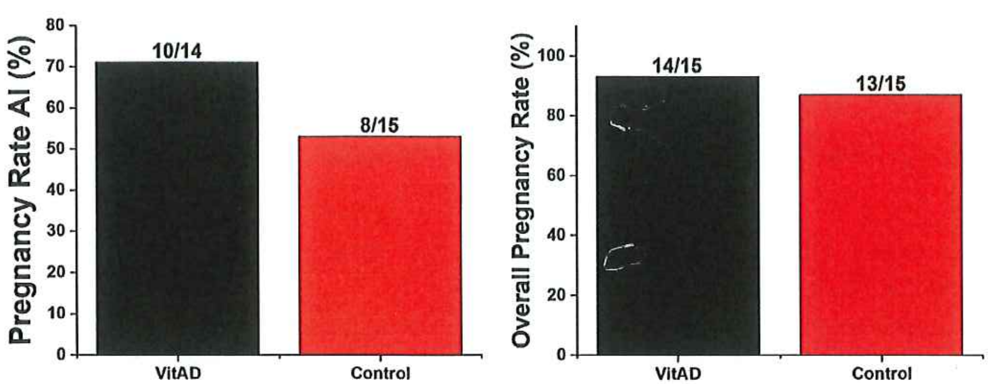


Figure 2: Pregnancy rate in vitamin A and D (VitAD) and control-treated females. Ratios are indicated above each group. Pregnancy rates following AI tended to be improved by VitAD treatment (p=0.061), but no differences were detected between groups after exposure to the bull (p=0.54). Overall rate includes all females who became pregnant, and includes 1 female/group with pregnancy loss.



Progress Reports – Animal Sciences [1]

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

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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. We are currently screening and enrolling ranches for visits to be conducted during later winter and spring 2023.

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.*

1. This document is part of the Oregon State University – 2022 Oregon Beef Council Report. Please visit the Beef Cattle Sciences website at http://blogs.oregonstate.edu/beefcattle/research-reports/

Initial data collected at two different locations within the same region have presented discrepancy in supplementation strategy, which has resulted in discrepancy in liver trace mineral concentration between these locations (Table 1). As observed "Ranch A" had average trace mineral concentration of Se, Cu, and Mo out of expected adequate levels. In fact Se and Cu concentrations were indicating a deficiency of those two minerals which was likely affected by the greater level of Mo. Trace mineral supplementation strategies for this location were recommended including the use of injectable trace minerals (ITM) for a quick replenishment of trace mineral reserves. No issues were identified with "Ranch B" which had all animals presenting trace mineral status within the expected adequate range.

Table 1. Summary of liver trace mineral concentrations of cows sampled at different locations.

Region	*Ranch*	*BCS*	*Age, yr*	*Category*	*Selenium, mg/kg*[1]	*Iron, mg/kg*[1]	*Copper, mg/kg*[1]	*Zinc, mg/kg*[1]	*Molybdenum, mg/kg*[1]	*Manganese, mg/kg*[1]	*Cobalt, mg/kg*[1]
	1	.	3	Open	0.21	288.52	7.31	165.59	2.44	5.47	0.06
	1	.	3	Lactating	0.24	495.79	7.5	265.84	6.48	13.51	0.21
	1	.	3	Lactating	0.16	465.13	8.53	191.28	3.18	6.84	0.12
	1	.	3	Open	0.33	374.34	13.59	195.41	4.54	9.26	0.18
1	1	.	3	Open	0.26	360.84	5.62	243.02	5.08	12.2	0.19
	1	.	3	Open	0.2	277.49	75.92	260.06	3.60	25.68	0.15
	1	.	3	Lactating	0.14	271.54	10.4	243.52	5.65	1.77	0.15
	Avg. Ranch A[2]		.	.	***0.22***	***361.95***	***18.41***	***223.53***	***5.74***	***10.68***	***0.15***
	2	4.5	4	Pregnant	1.2	442.32	54.39	141.3	3.77	8.6	0.25
	2	5	4	Pregnant	1.34	393.24	86.41	154.32	4.25	9.48	0.25
	2	4.5	4	Pregnant	1.17	349.84	30.45	130.66	3.69	8.68	0.2
	2	4	4	Pregnant	1.43	722.21	96.55	141.71	4.22	10.14	0.25
	2	4	4	Pregnant	1.52	346.07	142.01	149.27	4.94	11.13	0.22
	2	4	4	Pregnant	1.39	589.22	85.39	156.56	3.92	9.01	0.26
	2	4	4	Pregnant	1.2	370.48	124.65	112.9	3.73	7.77	0.16
1	2	3.5	4	Pregnant	1.25	407.54	62.35	129.33	3.94	8.71	0.2
	2	4	4	Pregnant	1.33	389.18	37.03	145.74	4.07	8.48	0.21
	2	5	4	Pregnant	1.24	633.4	41.49	139.47	3.37	7.9	0.2
	2	4	4	Pregnant	1.3	493.48	93.12	144.62	4.11	11.81	0.25
	2	4	4	Pregnant	1.18	396.08	73.92	139.82	3.01	6.95	0.19
	2	5	4	Pregnant	1.25	539.78	64.9	160.02	2.64	6.52	0.19
	2	4	4	Pregnant	1.27	449.74	75.49	138.13	3.79	8.58	0.21
	Avg. Ranch B	.	.	.	***1.29***	***465.90***	***76.30***	***141.70***	***3.82***	***8.84***	***0.22***

[1]Adequate mineral status are reported by the Michigan State University Veterinary Diagnostic Laboratory (MSU VDL) as Se: 0.60-3.30 mg/kg; Fe: 170-750 mg/kg; Cu: 40-650 mg/kg; Zn: 90-500 mg/kg; Mo: 1.80-4.70 mg/kg; Mn: 5.50 -15.00 mg/kg; Co: 0.10-040 mg/kg.

[2] Ranch average of each mineral highlighted in red are out of the expected adequate range according to MSU VDL.

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Oregon State University

BEEF 227

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

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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 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 early 2023.

Objective 2. The experiment with dairy cows was performed between March and July 2021. An initial progress report for this project was provided for the 2021 OBC report. Please, see more details on the methods used to collect and analyze methane emission in that report. As indicated in the prior progress report, there was not an effect of feeding spent hemp biomass on methane emission. Complete data will be provided in the final report. See prior progress report for details on the collection of urine and data on urine volume. After the 2021 OBC report was published, we have completed the analysis of the nitrogen content in urine and feces using HPLC for the analysis of urea, creatinine, purine derivatives, and allantoin. Ammonia was measured in urine using a commercial ELISA kit, while total N was measured in urine, feces, and feed, including feed residuals. Digestibility of the diet and nitrogen metabolism were calculated using the above data. Except for a lower total N excretion due to a lower urine volume in cows fed spent hemp biomass (see 2021 OBC report) and a lower N intake due to a significant lower feed intake in cows fed spent hemp biomass vs. control cows, we did not find any effect of feeding spent hemp biomass on nitrogen metabolism. Complete data will be provided in the full report that will be submitted once the transcriptomic analysis of the liver will be completed.

1. This document is part of the Oregon State University – 2022 Oregon Beef Council Report. Please visit the Beef Cattle Sciences website at http://blogs.oregonstate.edu/beefcattle/research-reports/

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Oregon State University

BEEF 228

Oregon Beef Council Report

Beef Cattle Sciences

Fine Fuels Management to Improve Wyoming Big Sagebrush Plant Communities Using Dormant Season Grazing [1]

Sergio A. Arispe[2] and William J. Price[3]

Synopsis

The goal of the research was to promote rangelands that are resilient to disturbance (specifically fire) and resistant to invasive annual grasses by using fall-winter (dormant season) grazing within Wyoming big sagebrush plant communities dominated by invasive annual grasses.

Summary

The invasive annual grass, medusahead, infests rangelands across the western US. It can degrade functionally healthy ecosystems and reduce the amount of forage available for livestock and wildlife. This research explores promoting recovery of perennial vegetation at the landscape-scale using dormant season grazing as an applied management strategy to reduce the negative impacts of medusahead. In particular, we assessed four treatments from 2018 – 2022, which included: traditional grazing (May – October 15th), dormant season grazing (October 15th – February 28th), traditional+dormant season grazing (May – February), and no grazing. To date, there has been no change in biomass with either annual or perennial grasses. While in 2022 litter biomass in the traditional, dormant, and traditional+dormant season grazing treatments was 1,000 lb/ac, and litter biomass in the no graze treatment was 1,500 lb/ac, there were no statisitical differences. The density of tall perennial grass increased in the traditional+dormant season grazing treatment between 2018 and 2022 (4 plants/meter in 2018 to 10 plants/m in 2022) while Sandberg's bluegrass increased in the traditional+dormant season grazing between 2018 and 2022 (4 plants/m in 2018 to 12 plants/m).

Introduction

Medusahead (*Taeniatherum caput-medusae* (L.) Nevski) is an introduced annual grass primarily from the western Mediterranean region of Eurasia (Young, 1992). It is capable of dominating secondary succession of western rangelands from the Great Basin to the Columbia Plateau and estimates suggest it has invaded nearly five million acres of rangeland across the western US (Davies and Johnson, 2008; Duncan et al., 2004). Medusahead and other invasive annual grasses across the sagebrush steppe of Oregon, like cheatgrass (*Bromus tectorum* L.), pose major problems for rangeland health including, decreased species diversity, diminished forage quality, and increased accumulation of litter resulting in a combination of increased fine fuel accumulation and reduced fuel moisture content (Davies, 2011; Davies and Johnson, 2008; Davies and Nafus, 2013; Duncan et al., 2004; Young, 1992). Perhaps the most significant threat is the development of an annual grass-fire cycle resulting in more frequent fire. For example, Whisenant (1992) observed fire frequency increasing from 0.1 fires/year to 0.5 fire/year when introduced annual grass cover increased from 40% to 90%. This increase in fire frequency further perpetuates the dominance of invasive annual grasses, including medusahead, while degrading big sagebrush (*Artemisia tridentata* Nutt.) rangeland (Davies and Svejcar, 2008; Nafus and Davies, 2014; Young, 1992; Young and Evans, 1970).

Materials and Methods

In fall of 2016, two Oregon cow-calf producers 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 Area

The three pastures in the study: McIntyre, South Camp Kettle, and Saddle Butte – are located within the Three Fingers Allotment near Jordan Valley, OR (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 and 12-in. with the majority falling as rain or snow during the October to March period with an area average minimum and maximum 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 managed on a rest rotation system so the pastures are not grazed during the same window in consecutive years.

Two experimental exclosures (referred to as blocks from here) were randomly located within each of the three pastures. Each block included four 150-m by 150-m paddocks which were each assigned one of the four grazing treatments: **traditional** (May-October), **dormant** (October-February), **traditional+dormant** (May-October), and **no graze** (cattle have been excluded since the summer of 2018). In total there are six replications of each grazing treatment. Vegetation data was collected in each treatment paddock within a plot consisting of three 50-m transects spaced 25-m apart.

Data Collection

Herbaceous biomass was collected using a 40 cm x 50 cm frame; 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 (15 samples per treatment plot).

Cover was collected using the line-point intercept method; a pin was dropped every meter along three, 50-m transects (150 points per treatment plot) and all species and ground cover that the pin hit were recorded. Due to low density of shrubs, shrubs were counted and measured within three, 2 m 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. 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.

Density of 5 plant function groups (perennial tall grass, perennial short grass (Sandberg bluegrass), perennial forb, annual forb, and shrub seedlings) were collected using a 40 cm x 50 cm frame and recorded every 5 m along three, 50 m transects (30 frames per treatment plot).

Biomass, cover, and density data were analyzed using a linear mixed model procedure in R statistical software (R Core Team, 2022). Fixed variables are treatment, year, and treatment-by-year interactions and the random variable is block and its interactions. Treatment means are reported with standard errors (mean ± S.E.) and considered different when $P \leq 0.05$.

Results

After four years of grazing treatments there is not a measurable difference in annual grass biomass (P=0.87; Fig. 1a). Mean annual grass biomass in 2022 was 742±87 lbs/acre. In 2022, perennial grass biomass in both the traditional and traditional+dormant season grazing treatments (286±94 lbs/ac and 291±114 lbs/ac, respectively) had less biomass than the no graze treatment (P<0.001; 618±303 lbs/acre). Perennial grass biomass in the dormant season grazing treatment was 446±108 lbs/ac and did not differ from the other treatments (P=0.16; Fig. 1b). Litter biomass did not differ between grazing treatments in 2022 (P=0.11), with mean litter biomass being 1162±170 lbs/ac (Fig. 1c).

In 2022, cover of invasive annual grasses did not differ between treatments (P=0.14), mean annual grass cover was 65±5%. Percent cover of perennial grass was not different in the traditional, dormant, or no graze treatments (13±4%, 17±6%, and 18±7%, respectively), but perennial grass cover in the traditional+dormant grazing treatment (9±4%) was less than the dormant and no graze treatments (P=0.03). Cover of perennial and annual forbs did not differ between treatments (P=0.74, 0.08), although annual forbs did differ from year to year (P<0.001), likely due to changes in precipitation. Cover of annual forbs was less than 9% and perennial forbs were less than 5% in all five years. Cover of sagebrush and other shrubs was negligible in all paddocks as it was less than 1% in all observations.

The density of perennial tall grasses in 2022 was greater in the dormant and traditional+dormant grazing treatments (9.6±3.8 and 10.2±4.9 plants/m^2) compared to the traditional and no graze treatments (3.8±1.7 and 3±1.1 plants/m^2; P=0.03; Fig. 2a). There is suggestive evidence that the density of Sandberg's bluegrass greater in the dormant and traditional+dormant grazing treatments (6.2±3.4 and 9±4.7 plants/m^2) than that in the traditional and no graze treatments (1.8±0.9 and 2.7±1.1 plants/m^2; P=0.09; Fig. 2b).

Conclusions

Current results indicate that year-to-year differences in precipitation have a much larger impact on vegetation biomass and cover than grazing. But the increase in density of both perennial tall grasses and perennial short grasses is evidence that dormant season grazing combined beyond traditional summer use may promote establishment of perennial species. Currently this study is scheduled to continue through 2028 to continue observing impacts that dormant season grazing may have on plant communities.

Acknowledgments

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Figure 1. Biomass estimates for grazing treatments: **Traditional** (May-Sept.), **Dormant** (Oct.-Feb.), **Traditional+Dormant** Season, and **No Graze**. Figures are clockwise from top-left: annual grass (**a**), perennial grass (**b**), litter (**c**), and total biomass (**d**).

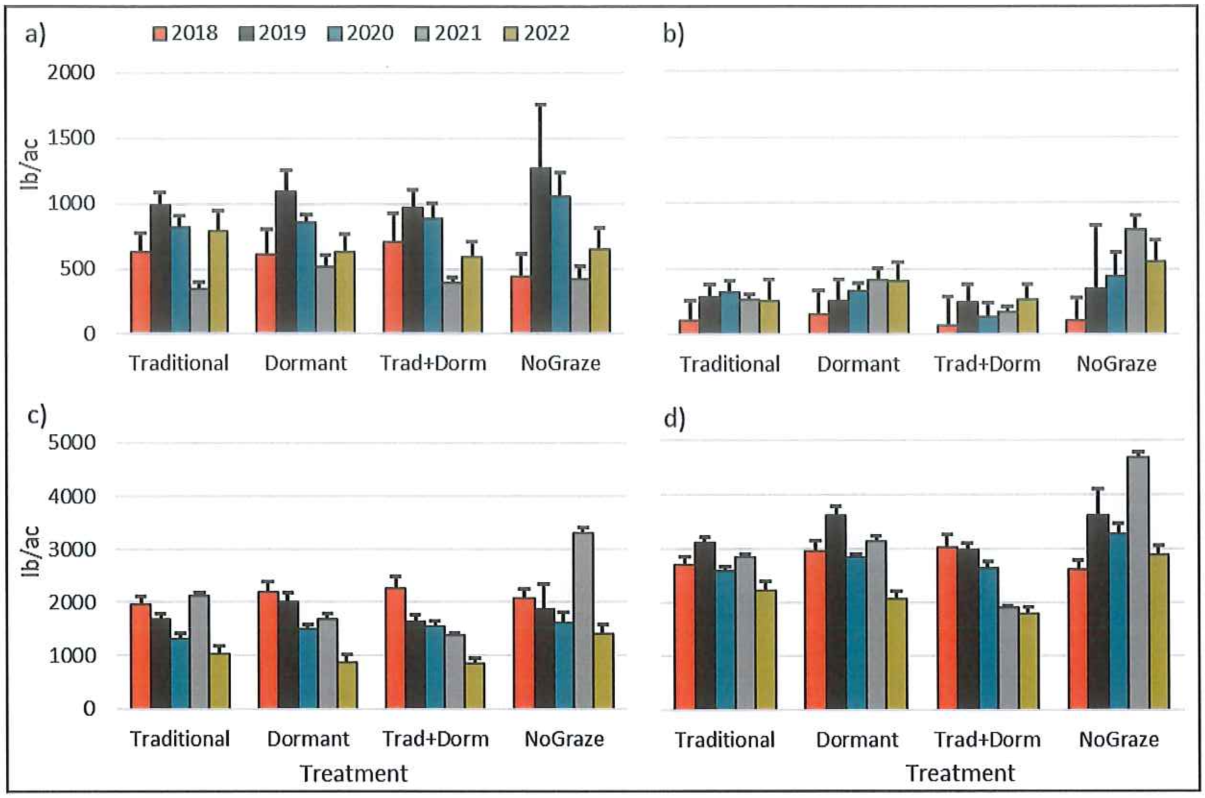
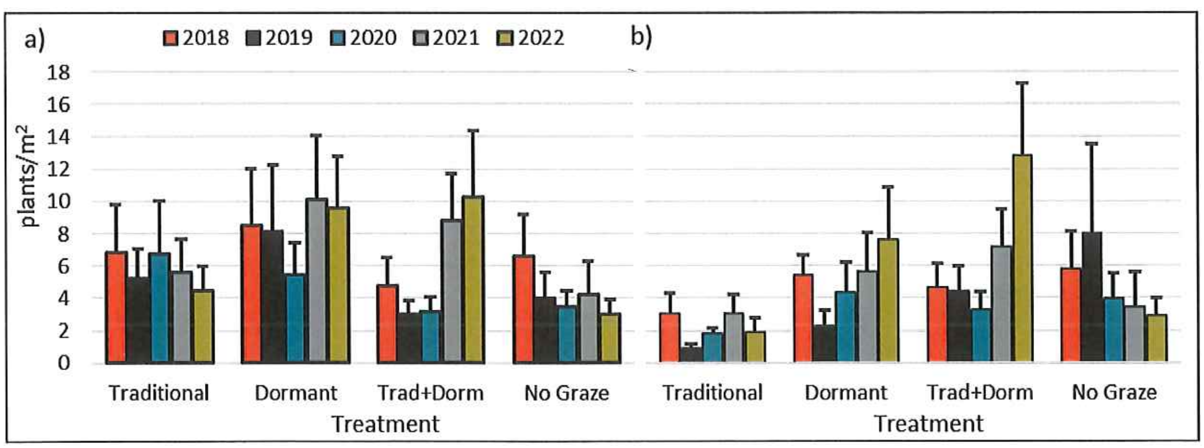


Figure 2. Density estimates for grazing treatments: **Traditional** (May-Sept.), **Dormant** (Oct.-Feb.), **Traditional+Dormant** Season, and **No Graze**. Figures tall perennial grass (**a**) and Sandberg's bluegrass (**b**).



Oregon State University

BEEF 229

Oregon Beef Council Report

Beef Cattle Sciences

Influence of Ravens on Baker, Oregon Sage-grouse Population: Assessment of Raven Removal for the Benefit of Sage-grouse [1]

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Synopsis

The efficacy of lethal and non-lethal management of common ravens (*Corvus corax*; hereafter ravens) for the benefit of greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) is being assessed in an eight-year study in Baker and Malheur counties. We have completed four years of pre-treatment and two years of treatment data collection. Initial findings indicate raven density may be contributing to lower sage-grouse nest success, and initial raven treatment effectiveness was inconclusive.

Summary

The main objective of this study is to evaluate the efficacy of lethal and non-lethal raven management, following an adaptive management plan, on sage-grouse nest survival and eventually sage-grouse lek trends. To do this, we are utilizing a Before-After-Control-Impact (BACI) study design comparing sage-grouse nest and chick survival, lek count trends, raven nest survival, raven density, and raven nesting pair presence before and during raven management. We have completed four years of pre-treatment data (2017–2020) and two years during treatment (2021–2022) in the Baker (lethal treatment), Cow Lakes (non-lethal treatment), Bully Creek (no treatment), and Soldier Creek (no treatment) Priority Areas of Conservation (PACs). In the lethal study PAC, the adaptive management plan focuses on management of raven nests and if that is not effective, then lethal management of adult ravens; whereas, the adaptive management plan focuses on raven nests then increasing removal of roadkill and potentially other food subsidies in the non-lethal study PAC. Preliminary results indicate that mean raven density was higher in sage-grouse nesting areas when compared to the overall mean raven density for each study PACs. Additionally, overall sage-grouse nest survival was 36%, below the range wide average. Treatment data collection started in 2021 and will continue through 2024. We observed an increase in raven renesting attempts during treatment years with some raven pairs attempting multiple renests. Preliminary results for two years of raven management resulted in an inconclusive treatment effect on sage-grouse nest survival in the Baker and Cow Lakes PACs. Analyses are ongoing to determine if raven densities have changed in localized sage-grouse nesting areas during treatment. Sage-grouse lek trends cannot be analyzed relative to treatments until more data is gathered after treatment.

1. This document is part of the Oregon State University – 2022 Oregon Beef Council Report. Please visit the Beef Cattle Sciences website at http://blogs.oregonstate.edu/beefcattle/research-reports/
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Introduction

Greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) distribution and abundance in western North America has declined over the last century (Connelly et al. 2011, Nielson et al. 2015), which has prompted multiple petitions to the U.S. Fish and Wildlife Service (USFWS) to list sage-grouse as Threatened or Endangered (U.S. Fish and Wildlife Service 2015). In Oregon, sage-grouse populations have declined concurrently with populations in the remainder of their distribution (Nielson et al. 2015). Sage-grouse breeding populations are now confined to six Oregon counties, largely within 20 mapped areas of high population density, known as Priority Areas for Conservation (PACs). Population trajectory within these PACs is variable; however, populations have declined alarmingly within the Baker PAC, in Baker County, and Cow Lakes, in Malheur County.

Multiple factors influence productivity of sage-grouse populations, including the quantity and condition of habitat, the level of anthropogenic disturbance in an area, weather, and predation (Connelly et al. 2011). Landscape factors, such as juniper encroachment, annual grasses, and fire, have negative consequences on sage-grouse population growth (Baruch-Mordo et al. 2013, Coates et al. 2016). Ground nesting birds, such as sage-grouse, are susceptible to increased densities or occupancy of generalist predators, such as common ravens (*Corvus corax*; hereafter ravens; Bui et al. 2010, Coates and Delehanty 2010, Dinkins et al. 2016, Peebles et al. 2017, Coates et al. 2020). Raven abundance has increased throughout the western United States (Harju et al. 2021, Dinkins et al. 2021) with much of this increase in abundance attributed to increased human activity. Human activity subsidizes raven populations through increased food resources (roadkill, dead livestock, etc.) and perch and nesting structures (buildings, powerlines). Recent research indicates relatively high raven density in sage-grouse habitat leads to lower sage-grouse nest success and population growth declines, especially when raven density exceeds a threshold where grouse productivity is below that required for population persistence (Coates and Delehanty 2010, Dinkins et al. 2016, Peebles et al. 2017, Coates et al. 2020). Coates and Delehanty (2010) found this threshold of raven abundance to be 7.3 ravens observed per 10 km transect, or 0.45 ravens/km^2; Dinkins et al. (2016) observed a doubling in sage-grouse nest success in their study areas after raven densities were lethally reduced from 0.40–0.45 ravens/km^2 to ~0.25 ravens/km^2; and Coates et al. (2020) found sage-grouse nest success in the Great Basin was much lower where raven density was greater than 0.20 ravens/km^2, and sage-grouse nest success was well below the range-wide average at densities above 0.40 ravens/km^2 (this study was inclusive of raven data from the Baker PAC). However, it should also be noted that densities above 0.20 ravens/km^2 and greater probability of raven occupancy, regardless of density, have resulted in lower sage-grouse nest success (Bui et al. 2010, Dinkins 2013, Dinkins et al. 2016, Coates et al. 2020), and sage-grouse lek counts began to decrease above this density in Wyoming (Peebles et al. 2017).

Understanding mechanisms influencing sage-grouse habitat use and demographic rates related to habitat quantity and quality, including interactions among habitat and predators, is essential to ensure long-term effective restoration success. Sources of perch and nesting structures attract ravens and may increase their foraging ability. In addition, ravens have greater use of areas where intact sagebrush habitat adjoins disturbed habitat (Howe et al. 2014), and raven abundance and carrying capacity were greater where sagebrush had burned (Dinkins et al. 2021). Sage-grouse minimize the risk of predation indirectly by avoiding risky habitat and directly by avoiding avian predators (magpies, *Buteo* hawks, ravens, golden eagles, and northern harriers; Dinkins et al. 2012, Dinkins et al. 2014). Combined effects of avoidance of suitable sagebrush habitat with high raven abundance, raven presence negatively influencing sage-grouse nest success, and increasing raven abundance in sagebrush habitats may have considerable implications for sage-grouse population growth in the future. These findings suggest increases in raven abundance along with habitat degradation—

in the form of anthropogenic features, juniper encroachment, annual grass invasion, and fire—may interactively reduce nest success and use of functional habitat available to sage-grouse.

Oregon Department of Fish and Wildlife (ODFW), our project, and Coates et al. (2020) have quantified high densities of ravens throughout sage-grouse PACs in Baker and Malheur counties in Oregon. During 2017–2019, OSU estimated raven density in the Cow Lakes PAC at 0.87 ravens/km^2, which was approximately twice as high as any other monitored sage-grouse PACs (Baker, Bully Creek, Crowley, or Soldier Creek; Dinkins Lab unpublished data). Raven densities in all of these PACs were well above 0.2 ravens/km^2, and most were above 0.4 ravens/km^2. The Cow Lakes sage-grouse PAC has exhibited decline in the number of males per lek complex over the past decade. Similar to the Baker PAC, the Cow Lakes PAC has lowered to a level of concern for federal and state management agencies. While lethal removal of ravens has been demonstrated in Wyoming to increase sage-grouse nest success (Dinkins et al. 2016), non-lethal management techniques have often been cited as viable and long-term best management strategies for reducing conflict of ravens with sensitive wildlife species, including sage-grouse. However, there has never been an assessment of the efficacy of any non-lethal management techniques to reduce raven predation on sensitive wildlife in the sagebrush ecosystem. There is wide agreement that non-lethal management has great potential as mitigation strategies, but there needs to be assessment of how to implement a non-lethal management program in order to achieve management objectives. Thus, we implemented and started to evaluate the efficacy of lethal and non-lethal management actions. In the Baker PAC, lethal management is being conducted under an adaptive management framework starting with lethal removal of raven nests and will only advance to removal of adults after 2 years of nest removal failing to lower local raven occupancy or increasing sage-grouse nest success. Whereas, non-lethal management will include removal of roadkill and livestock carcasses and removing nests from human structures prior to egg-laying, to reduce local raven abundance and occupancy within the Cow Lakes sage-grouse PAC. The premise of these management actions would be to reduce predation risk on sage-grouse nests and young chicks, thereby, increasing sage-grouse productivity.

Materials and Methods

Study Area

During 2017, our study included the Baker, Bully Creek, and Crowley Sage-Grouse Priority Areas for Conservation (PACs). We were able to add the Cow Lakes and Soldier Creek PACs to the study for 2018–2022 (Figure 1). Prior to the start of the 2020 season, we had to reduce data collection in the Crowley PAC due to reductions in personnel and funding. The Burns Paiute Tribe and a local landowner have elected to continue raven surveys at 19 random points on the west side of the PAC to be used in our long-term comparisons of raven density and lek counts. All study PACs have a mixture of public lands administered by the BLM and private lands.

Study Design

Our study is stratified by a lethal raven management area (nest destruction and possibly adult removal implemented by ODFW), a non-lethal raven management area (removal of roadkill/bone pits and nest removal prior to egg laying), and two study areas without targeted raven management in eastern Oregon. The Baker PAC has four years of pre-treatment data (2017–2020) and two years of treatment data (2021-2022). The Cow Lakes PAC has three years of pre-treatment data (2018–2020) and two years of treatment data (2021–2022). Data collection will continue as lethal and non-lethal raven management efforts are implemented following the adaptive management framework through 2024. The Bully Creek and Soldier Creek PACs do not have targeted raven management and will continue to be monitored throughout the duration of the study. We will compare the relative change in sage-grouse seasonal habitat use, nest success, and chick survival before and after management of ravens. In addition, we will evaluate raven habitat use, abundance, and nest success before and after management actions.

Implementation of Lethal Management

Adaptive management strategy – During the first year of raven management for this study, ODFW proposed take of ≤100 raven nests located in the Baker PAC with us monitoring the effects. If raven occupancy in sage-grouse habitat during nesting season within the treatment area decreases and sage-grouse nest success increases, nest take will be considered successful. If raven occupancy remains stable or increases and sage-grouse nest success does not improve, nest take will be considered ineffective. If raven occupancy decreases and sage-grouse nest success does not increase, nest take will be considered inconclusive. Successful treatment assessments from the first year will result in the take of ≤100 raven nests during the second and third years of the study. Inconclusive treatment assessments from the first year will result in the take of ≤100 raven nests during the second year of the study. If the treatment was deemed ineffective or inconclusive during the first and second years, take of ≤500 adults will be implemented during the third and fourth years of the study. A successful treatment assessment following the second year of the study will result in the take of ≤100 nests during the third year. If the treatment was deemed ineffective or inconclusive during the second year, take of ≤500 adults will be implemented during the third and fourth years of the study.

Implementation of Non-lethal Management

Implementation of non-lethal raven management and related assessments will be conducted for four years (2021–2024) during the breeding season (March–July); however, in this report we assess the first two years of implementation during this agreement in a similar fashion to lethal management. In and around the Cow Lakes PAC, we removed as much roadkill as possible on a bi-weekly or weekly basis along all paved and gravel roads with speed limits ≥35 miles/hour during 2022. Roadkill removal included all animal biomass, inclusive of rodents to larger mammals (i.e., deer), that were detected while slowly driving along roads. Dead animals were taken to a landfill location >50 km from any of our monitored sage-grouse PACs. Focus was placed on roads within 20 km of active sage-grouse leks. We quantified the amount and location of roadkill and dead livestock subsidies within and near the Cow Lakes PAC prior to removing and documented all newly detected roadkill throughout the breeding season. Roadkill and dead livestock were quantified but left in place within the Bully Creek and Soldier Creek sage-grouse PACs. We recorded the perpendicular distance from the center of the road to each roadkill in order to estimate total roadkill and our detection probability.

In addition to removing food subsidies, we non-lethally removed raven nests (i.e., removal prior to egg laying) and installed perch deterrents or raven effigies within the Cow Lakes PAC when feasible during 2021 and 2022. This only occurred prior to eggs being laid in ravens nests built on human structures. Raven nests were not manipulated in the Bully Creek or Soldier Creek sage-grouse PACs.

Sage-grouse Monitoring

We will maintain a sample of approximately 60–80 radio-marked sage-grouse females each year of our study. Captures will occur at night using spotlights and hoop-nets during the spring near lek locations and in the fall around roosting sage-grouse locations. Female sage-grouse were fitted with either a VHF necklace (radio-tracking), a GPS-only rump-mounted transmitter, or a combination of a VHF necklace with an attached small GPS unit. We programmed GPS units to gather 2–5 locations per day.

We planned to capture enough sage-grouse to maintain a sample of 15–20 birds in each study area during each year. We monitored VHF-collared sage-grouse females with ground tracking using radio telemetry receivers and Yagi antennas during April–August and aerial surveys during the remainder of the year. Locations have and continue to be recorded bi-weekly via ground tracking and monthly via aerial surveys. Female sage-grouse marked with GPS units have and continue to provide 2–5 locations/day.

Female survival has and continues to be recorded with the aid of telemetry signal (mortality switch). Mortality sites were visited as soon as possible to assess sage-grouse carcasses and potentially identify cause of death (e.g., disease, fence or power line strike, predator, etc.). Nest locations were visually documented while ground tracking. We recorded nest fate as successful or unsuccessful after a hen has left her nest. Successful nests were defined as having evidence that at least 1 egg hatched as determined by shell membrane condition. We assessed brood survival bi-weekly by either visually detecting chicks or observing hen behavior that indicates the presence of chicks (e.g., hesitation to flush, feigning injury, or clucking). Brood failure was determined as 3 consecutive visits without detecting chicks and counting chicks at night 35-days after estimated hatch date.

Raven Monitoring

To quantify the relative local abundance and occupancy of ravens, we conducted 10-minute point count surveys at random locations throughout sage-grouse PACs as well as high-use subsidy locations (e.g., roads and livestock dumps) multiple times each breeding season. These random point count locations were located at least 2.5 km apart to avoid double counting individuals (Dinkins et al. [2012] for survey details). In addition, we conducted point count surveys at randomly locations along county and paved roads from March–July. These road surveys are representative of roads in and near the sage-grouse PACs and amount of roadkill was documented.

Raven nests within monitored sage-grouse PACs were located during travel to our random point count survey locations and while conducting other related field work. Raven nests were monitored visually by observers in the field to assess nest occupancy and success across the breeding season. Nest sites were monitored after removals (lethally or non-lethally taken down) to determine if re-nesting occurred.

We continue efforts to fit up to 40 ravens with GPS-collars to evaluate raven habitat use, adult survival, and locate nests in or around our study areas. Potential raven nests located via GPS collar data were verified by observers in the field and monitored throughout the breeding season. Clusters of GPS locations will also be used in upcoming analyses to identify high-use areas subsidized resources.

Data Analysis

Our assessment of the effects of lethal and non-lethal mitigation of high raven density in sage-grouse habitat was conducted by comparing local raven abundance in treatment areas (Baker and Cow Lakes PACs) and reference areas (Bully Creek and Soldier Creek PACs) in eastern Oregon. We also compared local raven abundance before and after implementation of lethal and non-lethal raven management (described above). The study design allows us to compare the relative change in local raven abundance before and after manipulation of raven nests and food subsidies.

Raven density was analyzed using distance sampling. This analysis method accounts for imperfect detection and allows us to assess landscape factors that affect raven abundance. Covariates in this analysis included study area, year, proportion visible, percent tree cover, proportion of agriculture, proportion of development, road density, distance to agriculture, distance to development, distance to landfill, and distance to powerlines. All landscape covariates were obtained from remotely sensed GIS data from Rangeland Analysis Platform, National Land Cover Database (NLCD), and Homeland Infrastructure Foundation-Level Data (HILFD). All raven density estimates were reported as number of ravens/km^2.

Raven nest-site selection was assessed using resource selection functions (RSFs) with generalized linear models within a use-availability framework. Predictor variables were extracted for observed nest (use point) and random locations (available point) at three spatial extents representing average distance traveled from the nest (570 m), average home range size (1,440 m), and average territory size (3,600 m). A buffer of 3,600 meters was extended around each of the study areas to account for total average territory size for those ravens nesting on or near the PAC boundaries. Covariates for this analysis included: distance to sage-grouse lek, distance to road, distance to open water, road density, topographic ruggedness, and proportion of exotic grass, perennial grass, and sagebrush.

Sage-grouse nest survival was assessed using Cox proportional hazard models. This analysis method evaluates risk and allows us to explore what factors may be contributing to nest failure. Covariates for this analysis included: study area, year, habitat cover variables, drought, cumulative burned area, proportion burned, distance to and proportion of agriculture and development, road density, edge, raven density, as well as interactions between raven density, fire, invasive annual grass cover, and anthropogenic variables. Habitat and disturbance covariates were evaluated at five spatial extents. Two spatial extents, 90 m and 180 m, correspond with mean distances traveled by sage-grouse hens during recesses from their nests. Three spatial extents, 570 m, 810 m, and 1,470 m, correspond with mean foraging distance of nesting ravens.

The effects of the first two years of raven nest removal (lethal and non-lethal) on territory occupancy rate is being used to inform the adaptive management strategy. Treatment efficacy will be evaluated in terms of average time (days) spent at the nest site and nest success. Average time spent at the nest site will be calculated for raven nests based on observations from multiple visits during breeding season. Dates of nest initiation and fate will be calculated based on nest status at each visit (e.g. approximate age of chicks). A t-test, or similar analysis, will be used to compare the average time spent at the nest site for treatment versus non-treatment nests. Raven nest success will be assessed using Cox proportional hazards models, including a variety of covariates which may reasonably have an effect on nest success or failure (e.g., nest structure and landscape characteristics) which will be evaluated at multiple relevant scales. To evaluate the long-term influence of ravens on sage-grouse populations and benefits of raven removal, sage-grouse lek trends in removal and non-removal study areas will be compared to raven abundance across eight years.

Results

Ravens

During the 2017–2022 breeding seasons, 289 active nests, at 178 unique nest locations, were monitored throughout all five study PACs (Table 1). A total of 73 GPS PTTs were deployed on adult or post-fledged ravens and 4 raven chicks between January 2018 and September 2022 (Table 2), eight of which had at least one confirmed nest in and around our study areas. Preliminary results for changes in time-at-nest are not available at this time, as calculations are ongoing; However, we did observe an overall increase in renesting attempts during the treatment years (Table 3), with some raven pairs attempting multiple renests (Table 4), This apparent increase in renest rate during treatment years may indicate prolonged time at the nest site with human intervention. Additionally, preliminary findings from the eight GPS-marked breeding ravens larger foraging excursions from the active nest. While raven nest success has not been analyzed to account for bias and specific influential factors, preliminary nest success results show a marked decrease in successful nests in the Baker PAC (lethal removal) between pre-treatment and treatment years (Table3).

Raven RSFs – Preliminary results for resources selection analyses indicate positive relationships with relative probability of nest use when closer to sage-grouse leks and roads, and at higher road density, and at higher proportions of exotic grasses, and sagebrush cover within 570 m of the nest. Predictive maps created from these preliminary results show predicted relative probability of use for raven nests in the Baker, Bully Creek, and Cow Lakes PACs (Figure 2). Location data from 77 PTT-marked ravens captured during 2017–2022 is currently being compiled for resource selection function analysis of roosting and foraging locations, as well as a movement analysis. Our preliminary findings indicate breeding ravens in the study area traveled a maximum distance from their nest ~5.6 km before lethal raven treatment, then ~48.4 km during treatment (Figure 3).

Raven densities in PACs – Our preliminary raven density model included data from 2,257 point count surveys conducted at 156 random locations across the

Baker, Bully Creek, Crowley, Cow Lakes, and Soldier Creek PACs from 2017–2021. All raven detections within 2,100 m of the survey location were used, and we detected at least one raven 844 times across all surveys (Table 5). There was a substantial amount of clustering in our data set, where 26% of our detections included two or more ravens with flock sizes ranging from 2 to 45 individuals. Raven density ranged from 0.24–0.97 ravens/km^2.

Our final model indicated that proportion of visible area within 2,100 m and tree cover within 2,100 m negatively affected detection. Density varied by study area and was positively affected by distance to agriculture, distance to development, and road density within 2,100 m of the survey location. Mean predicted density estimates for Baker, Bully Creek, Cow Lakes, Crowley, and Soldier Creek seen in Figure 4. Within the Baker, Bully Creek, Cow Lakes, and Soldier Creek PACs, mean predicted raven density in sage-grouse nesting areas was higher than predicted means for the entire PAC (Figure 4).

Oregon Department of Fish and Wildlife began lethally removing raven nests in the Baker PAC, and Idaho Power Company began non-lethally removing nest structures on power lines in the Cow Lakes PAC. Historic raven nest locations identified by OSU throughout 2017–2020 breeding seasons were provided to both Baker City ODFW and Idaho Power Company prior to commencement of removal efforts. During 2021–2022, we monitored 129 raven nests and removed 45 in the Baker and Cow Lakes PACs (Table 6).

Roadkill Monitoring – There were 19, 23 and 27 random point counts along the road survey routes that were surveyed each time the routes were completed in Baker, Bully Creek and Cow Lakes, respectively (Table 6). Technicians also completed a point count at each of the roadkill items they documented. More detailed data on assessment of roadkill subsidies and number of ravens using those subsidies is pending data entry.

We began removing roadkill on 3 May 2021 for approximately two weeks. We encountered logistical challenges that prevented further removal in 2021. For the remainder of the 2021 field season, we gathered more data associated with distribution of roadkill, type of roadkill, and raven use of the roadkill. Roadkill was removed during the 2022 breeding season, but data is still being compiled. Data on the number and type of roadkill encountered and removed still needs to be entered into databases.

Sage-grouse

From 2017–2022, we deployed 230 transmitters on sage-grouse (Table 7). In all years, the number of alive female sage-grouse available to track during spring, summer, and winter varied based on trapping success, collar battery life, and adult survival (Table 7). Due to a faulty batch of VHF radio collars deployed in late 2017, we were unable to track or get nest survival information for 33 individuals. Through ground and aerial tracking of VHF marked individuals combined with locations from GPS marked individuals we have accumulated over 80,000 locations to be used in adult survival and habitat selection analyses.

Sage-grouse nest site selection and survival – Analyses for sage-grouse nest site selection are ongoing. Our preliminary Cox proportional hazards model for sage-grouse nest survival included 171 nests from 101 individuals across the Baker, Bully Creek, Crowley, Cow Lakes, and Soldier Creek PACs from 2018–2022 (Table 8). Due to a low sample size ($n = 7$), Crowley nests were pooled with Bully Creek nests for all analyses. Nest survival across all study areas and years was 36%. A preliminary nest survival model with habitat covariates found that nests have increased risk of failure as percent tree cover increases at as scale of 1,470 m. However, our model indicates that nests were more likely to succeed as topographic ruggedness (TRI) increases within 810 m. Preliminary results from this model were inconclusive for a treatment effect of raven management in the Baker and Cow Lakes PACs on sage-grouse nest success in both 2021 and 2022. Further survival analyses are being conducted in a mixed-model framework in order to better account for individual and site-specific variation.

Conclusions

Preliminary results indicated that raven densities varied across all PACs. The raven density in Baker was lower than expected but may still be contributing to low sage-grouse nest survival when combined with the intensity of habitat fragmentation and the isolation of the population (Figure 4). Raven densities were much higher than expected in the Cow Lakes PAC and may be contributing to population declines in that area (Figure 4). Sage-grouse nest survival across all study areas and years was 36%, which was below the range-wide means of 38% for yearling females and 53% for adult females, respectively (Taylor et al. 2012). Analyses are ongoing to help determine how much nest predation by ravens is contributing to overall population declines when combined with the habitat loss and fragmentation from wildfire and anthropogenic activities. Our preliminary findings indicate breeding ravens in the study area may travel much further from their active nest than is expected based on the literature. Implications of our results will be further detailed upon completion of data collection and analysis of data associated with our objectives, after field season 2024.

Acknowledgments

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Figure 1. Boundaries for our five study PACs selected as study areas (Soldier Creek PAC includes two separate areas). PACs designated with blue are reference study PACs; whereas, ravens were and continue to be manipulated with lethal or non-lethal management techniques in study PACs designated with gray starting in 2021.

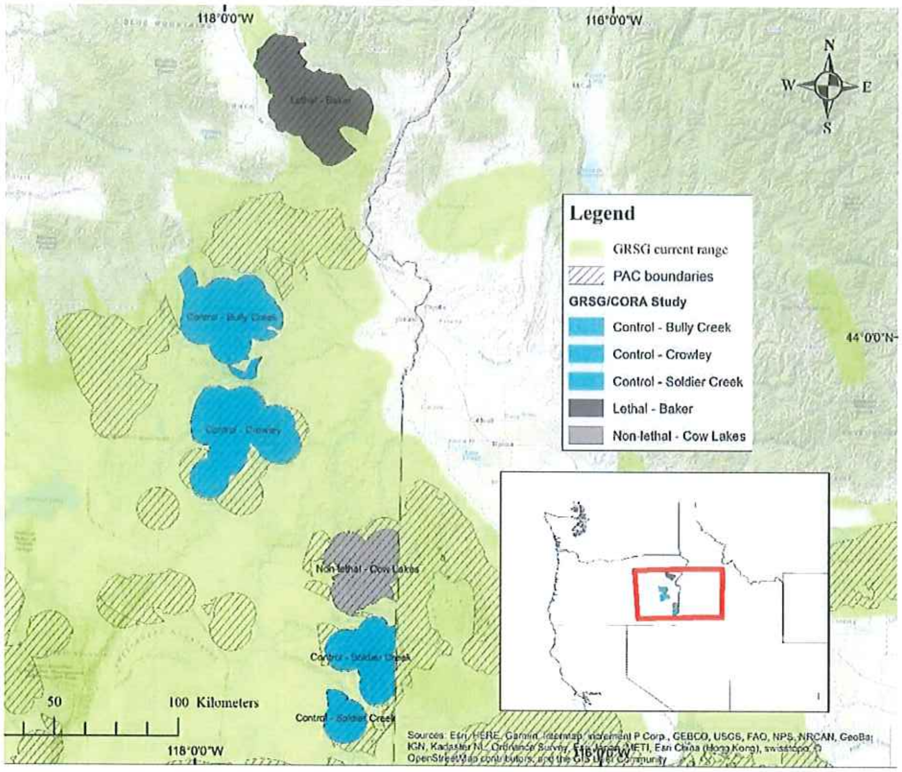

Figure 2. Relative probability of raven nest site selection. Informative covariates indicated that raven selected nest sites closer to sage-grouse leks and roads, and areas with higher road density, proportion of exotic grasses, and sagebrush cover within 570 m. Predictive maps created from preliminary results for raven nests in the Baker (A), Bully Creek (B), and Cow Lakes (C) PACs, 2018–2021.

Figure 3. Breeding season (March–July) GPS data from a marked raven with recurring nest in the center of the cluster of pink and green points. The pink points, and associated minimum boundary outline in pink, are location data from the 2021 nesting season (pre-treatment; maximum observed distance from the nest ~5.6 km). The green points, and associated minimum boundary outlined in green, are location data from the 2022 nesting season (during treatment; maximum observed distance from the nest was ~48.4 km). The blue circle surrounding the northeast cluster of points represents literature derived average 3.6 km breeding raven territory size.

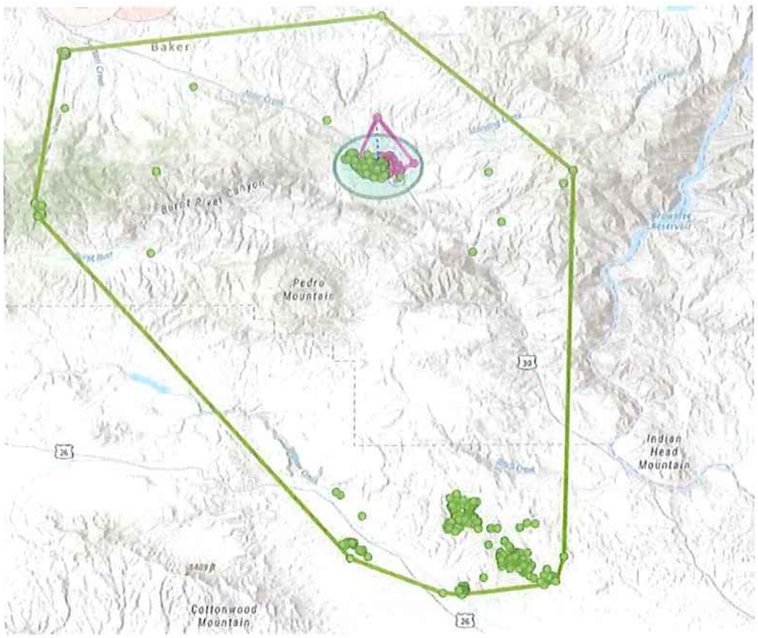

Figure 4. Mean raven density estimates in sage-grouse nesting areas compared with the overall mean predicted raven density from 2017–2021 for the Baker, Bully Creek, Cow Lakes, and Soldier Creek PACs.

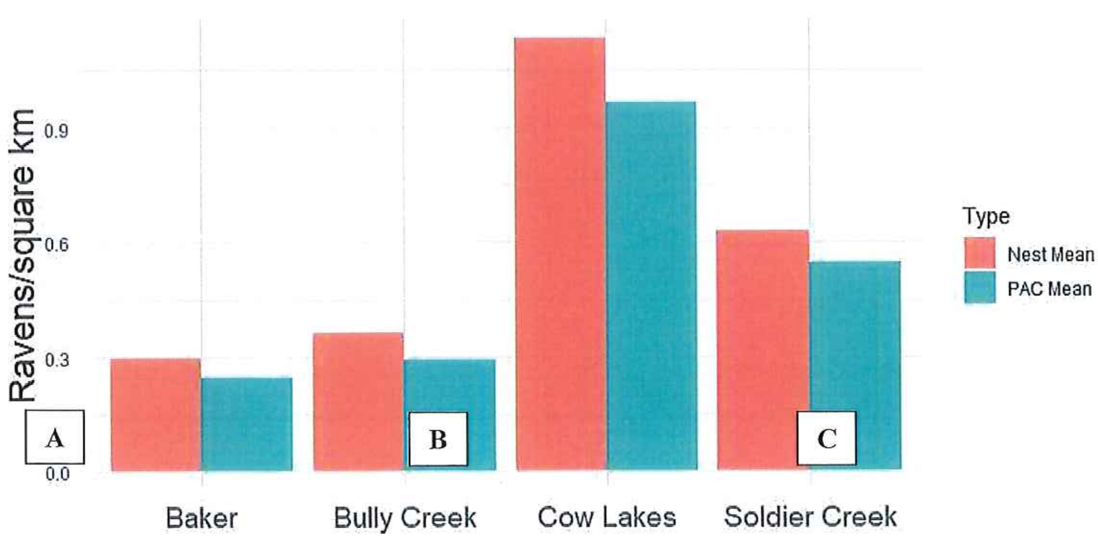

Table 1. Raven nest sample sizes by PAC during breeding season 2017–2022.

Study PAC	2017	2018	2019	2020	2021	2022
Baker	2	23	16	24	30	20
Bully Creek	5	9	16	11	10	11
Cow Lakes	-	19	14	17	24	20
Crowley	3	1	5	0	0	0
Soldier Creek	-	1	2	2	1	3
Total	10	53	53	54	65	54

Table 2. Adult raven marking by PAC between January 2018 and June 2022.

Study PAC	VHF-marked	GPS-marked
Baker	2	49*
Bully Creek	0	2*
Cow Lakes	0	20*
Crowley	0	0
Soldier Creek	0	0
Total	2	67

*We put 4 PTTs on chicks with 2 in Bully Creek, 1 in Baker, and 1 in Cow Lakes.

Table 3. Apparent raven nest success for nests monitored in the Baker PAC, 2017–2022. These are preliminary results.

	2017	2018	2019	2020	2021	2022
# nests monitored	2	28	34	49	63	78
# active nests	2	27	15	23	28	35
# successful nests	1	11	6	11	7	5
# failed nests	0	13	1	6	17	28
# unknown fate	1	3	8	6	1	2
Apparent nest success	50.0	40.7	40.0	47.8	25.0	14.3

Table 4. Renesting rates for all study areas 2017–2022. These are preliminary data.

Study PAC	2017	2018	2019	2020	2021	2022
Baker	0/2	3/21	0/11	0/18	2/27	9/34
Bully Creek	0/3	0/7	0/14	0/7	NA	0/3
Cow Lakes	-	0/19	1/11	016	NA	NA
Crowley	0/3	0/1	-	-	-	-
Soldier Creek	-	0/1	0/1	0/2	NA	0/1
Total	0/8	3/49	1/37	0/43	NA	NA

Table 5. Total number of completed 10-minute point count surveys during the reporting periods 2018–2021.

Study PAC	2018 Random	2019 Random	2020 Random	2021 Random	2022 Random
Baker	123	64	86	67	*
Bully Creek	85	71	65	71	*
Cow Lakes	61	92	57	42	*
Crowley	106	99	*	*	*
Soldier Creek	70	71	42	36	*
Total	445	397	250	216	*

*Data still need to be entered into database.

Table 6. Roadkill point count surveys conducted during breeding season 2021. Data for 2022 still needs to be entered into databases.

Study PAC	Total length (km)	Start date	End date	Frequency
Baker	278	6/1/2021	7/2/2021	Monthly
Bully Creek	187	4/15/2021	7/15/2021	Weekly
Cow Lakes	199	4/15/2021	7/15/2021	Weekly
Crowley	NA	NA	NA	Monthly
Soldier Creek	NA	NA	NA	Monthly

Table 7. Total sage-grouse alive and available for tracking during breeding season 2021, winter 2021–2022, and breeding season 2022. The sample for each season was quantified after accounting for sage-grouse that died or had collar failure during the breeding season and addition of new transmitter deployments in August 2021 and spring 2022.

Study PAC	Breeding season 2021			Winter 2021–2022			Breeding season 2022		
	VHF-only	VHF/ Lotek	PTT	VHF-only	VHF/ GPS*	PTT	VHF-only	VHF/ GPS*	PTT
Baker	6	8	0	4	11	0	3	5	0
Bully Creek	5	7	0	5	6	0	6	1	0
Cow Lakes	2	3	2	0	2	2	0	13	2
Soldier Creek	2	5	1	2	3	1	4	8	2
Total	41			36			44		

*Includes active Lotek or Ecotone GPS units deployed with VHF collars.

Table 8. Sage-grouse nest and brood sample sizes by PAC 2019–2022.

Study PAC	Nests 2019	Broods 2019*	Nests 2020	Broods 2020*	Nests 2021	Broods 2021*	Nests 2022	Broods 2022*
Baker	6	2	14	0	8	2	7	1
Bully Creek	5	3	9	4	8	3	5	2
Cow Lakes	8	1	8	unk	4	1	11	1
Crowley	1	0	2	unk	-	-	-	-
Soldier Creek	9	2	9	2	2	1	12	3
Total	29	8	42	6	22	7	35	7

*Number of broods found and tracked, including broods found after nesting season.

Oregon State University

BEEF 230

Oregon Beef Council Report

Beef Cattle Sciences

Influence of Juniper on Greater Steens Mountain Wildlife: Potential Benefits of Juniper Removal in Aspen and Riparian Areas [1]

Cara Christensen[2], Vanessa Schroeder[3], Dustin Johnson[3], Jon Bates[4], Samantha Wolfe[4], and Jonathan B. Dinkins[5]

Synopsis

Avian point count surveys and autonomous recording units (ARUs) successful gathered avian abundance and species richness data, inclusive of vocal birds (e.g., songbirds) and visually identified birds (e.g., raptors). Game cameras successfully gathered data on multiple native ungulate species related to juniper expansion into areas of aspen, riparian, and sagebrush vegetation.

Summary

In the Great Basin, juniper (*Juniperus occidentalis*) woodlands have expanded into areas previously dominated by sagebrush (*Artemisia spp.*) plant communities since the late-19th century. This expansion has resulted in habitat loss and degradation for many avian species and native ungulates; in response, land managers are removing juniper from infilled areas. Limited information currently exists on the effects of juniper removal in sensitive vegetation types such as aspen (*Populus tremuloides*) stands and riparian areas. Understanding where and why juniper expansion negatively affects sensitive wildlife species in these areas is essential to ensure long-term effective restoration success. We have collected four years, 2019–2022, of avian abundance and diversity data (point count surveys and ARUs) and three years, 2020–2022, of mammal data (cameras). We seeking to answer 1) how the abundance of mule deer and songbirds change before and after juniper removals associated with aspen, riparian, and sagebrush vegetation, 2) how avian predator densities change across a juniper cover gradient in aspen, riparian, and sagebrush vegetation types, and 3) what effect juniper removals in aspen, riparian, and sagebrush vegetation types have on songbird species richness (number of different species)? Our study area encompasses 1,800 km^2 of Steens Mountain and surrounding area. Juniper removal areas have been established by Bureau of Land Management with treatment occurring during Fall 2020–2024. We surveyed birds and native ungulates within juniper treatment areas and reference survey locations (randomly generated). Surveys were spread across all vegetation types and juniper gradients. In 2019 and 2020, we collected pre-

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treatment wildlife data throughout the study area for abundance, species richness, and general habitat classification. In 2021 and 2022, we collected the first two years of post-treatment data. From 2019–2022, we completed 497 point count surveys at 82 independent locations across four years with 4,204 birds from 101 unique species. Data from ARUs and cameras is still being processed, but these sampling techniques have been successful for collecting sensitive wildlife data. These preliminary evaluations will provide insights into the short-term effects of juniper removal on avian abundance and inform management agencies about the influence of juniper expansion on avian species in sagebrush and aspen plant communities.

Introduction

The sagebrush ecosystem has undergone landscape scale changes due to expanding distribution of conifer species into areas previously dominated by other plant species. The resulting changes in plant communities have resulted in negative, positive, and neutral effects on native wildlife species (Knick et al. 2003, Bombaci and Pejchar 2016, Holmes et al. 2017). Of particular interest for conservation and management has been the effects of western juniper (*Juniperus occidentalis*; hereafter juniper) expansion on wildlife, which has documented negative relationships with sagebrush associated species (Welstead 2002, Knick et al. 2005, Noson et al. 2006, Holmes et al. 2007, Holmes et al. 2017). However, there is little information related to the mechanisms driving these patterns for songbirds.

While representing proportionally small areas throughout the northern Great Basin and sagebrush ecosystem, quaking aspen (*Populus tremuloides*; hereafter aspen) stands and riparian areas play an essential role as critical plant communities, providing essential habitat for a diversity of wildlife (Maser et al. 1984; DeByle 1985). Despite historically covering over 2.9 million ha across the western US, aspen stands have precipitously declined due to expanding conifer species, such as juniper (Bartos and Campbell 1998, Wall et al. 2001). In southeast Oregon, close to 100 species of wildlife utilize aspen/grass or aspen/sagebrush (*Artemisia* spp.) communities to reproduce and forage (Maser et al. 1984). While research indicates removal of western juniper from aspen stands has been successful with fall burning (Bates et al. 2006) or mechanical removal (Jones et al. 2005), there is limited peer-reviewed research assessing the effects of western juniper removal in key habitats such as aspen stands and riparian areas related to wildlife. However, one northern California study found that aspen stands provide greater bird abundance and species richness than conifer forests, and the removal of conifers in aspen stands led to a 24% short-term increase in total bird abundance, and positively benefited aspen focal species (Burnett 2008).

Despite limited research focused on the effects of juniper removal in aspen stands, the effect of juniper removal in sagebrush ecosystems is better documented, and generally demonstrates increased abundance of sagebrush-obligate birds with decreasing abundance of woodland associated birds (Knick et al. 2014, Bombaci and Pejchar 2016, Holmes et al. 2017). Management agencies are keenly interested in these results, because the abundance of sagebrush-obligate and associated songbirds has declined from 1958–2011 in the Great Basin (Sauer et al. 2013). Juniper expansion has also been identified as a threat to greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) habitat and populations (Baruch-Mordo et al. 2013, Knick et al. 2013, Doherty et al. 2015). Avian species are not the only benefactors from juniper removal treatments; mule deer (*Odocoileus hemionus*) fawn winter survival was higher in areas where junipers were removed (Bergman et al. 2014). Mule deer had higher use and were less vigilant in open areas and interior forest compared to forest edges (Altendorf et al. 2001); however, mule deer habitat use was not influenced by juniper in southeastern Idaho (Anderson et al. 2012). Concomitantly, abundance of woodland associated bird species is greater in areas of juniper expansion into sagebrush vegetation (Holmes et al. 2007, Holmes et al. 2017). However, as juniper expansion advances through successional stages toward closed-canopy woodland (phase III), songbird abundance and diversity are likely to decrease as the shrub understory is lost (Miller et al. 1999).

Understanding mechanisms influencing sensitive wildlife species related to large scale habitat loss and fragmentation, including juniper expansion, is essential to ensure long-term effective restoration success. The effects of removing junipers on songbirds and mule deer have been previously assessed, but not specifically in aspen and riparian areas within a sagebrush dominated ecosystem. The goal of this project is to understand how juniper removal in aspen, riparian, and sagebrush vegetation types influences the abundance and habitat use of sensitive wildlife and their potential predators, specifically mule deer and songbirds. We also aimed to assess how juniper expansion and removal related to species richness. Our study has concluded the pre-treatment phase and some of the post juniper removal phase; thus, results are preliminary as more years of data post juniper removal are required to fully assess the effect of juniper removal. During 2019–2022, we successful collected data on multiple wildlife species to evaluate the abundance and richness of corvids, raptors, and songbirds, as well as the frequency of use of mule deer related to aspen, juniper, and sagebrush vegetation. We compare abundance of sensitive wildlife species, specifically songbirds and mule deer, before and after juniper removals associated with aspen, riparian, and sagebrush vegetation, and species richness associated with juniper phase.

Materials and Methods

Study Area

This study was conducted in the North Steens Ecosystem Restoration Project Area, Five Creeks Management Area, and Steens Mountain Sage-Grouse PAC in Harney County, Oregon (Figure 1). Our study area encompasses 1,800 km^2 of Steens Mountain and surrounding area (hereafter; Steens). Steens is primarily comprised of sagebrush ecosystem and is a mix of private and public ownership with BLM as the primary land management agency. Precipitation primarily falls in the winter as snow, November through January, and rain in spring between the months of March and May. Annual precipitation from the nearest weather station, located at the Malheur National Wildlife refuge (elevation 1,250 m), has a 254 mm long term annual average. Juniper vegetation has expanded within 1,450 m and 2,100 m (Miller and Rose 1995); whereas, sagebrush is dominant above and below the juniper zone with mountain big sagebrush (*A. tridentata vaseyana*) dominate above 1,600 m and mountain and Wyoming (*A. t. wyomingensis*) big sagebrush dominant from 1,200–1,600 m.

Study Design

Survey locations were stratified by treatment (planned juniper removal), sagebrush reference (no juniper removal), and aspen reference (no juniper removal) for our comparison of before and after juniper removal. Sagebrush reference survey locations were randomly generated across the study area using ArcGIS, with no points closer than 2,500 m to prevent duplication of detections of our largest avian predators (e.g., golden eagles [*Aquila chrysaetos*]). Sagebrush reference locations were removed when the survey location was inaccessible due to terrain or property ownership. Randomly generating locations did not result in adequate aspen reference locations, so more aspen reference locations were selected by identifying the nearest aspen grove from sagebrush reference locations. Juniper treatment areas (~1.2 km^2) were selected by BLM. Juniper removal treatments within each treatment area were not uniform and depended on juniper expansion phase and aspen stand age. For this study, different treatment methods were considered separate treatments (e.g., lop and scatter versus pile and burn). Point count survey locations within treatment areas were located at the centroid of each unique treatment type within each treatment area (Figure 1: locations within colored polygons). Roughly one 1.2 km^2 treatment area will be treated by BLM and associated contractors annually for 5 years (2020–2024). Landscape scale associations of corvids, raptors, songbirds, and mule deer and habitat characteristics will be evaluated using reference survey locations.

Bird Monitoring

Point count surveys were conducted when survey locations were accessible starting in late-May and ended in mid-July or when we detected a precipitous decline in bird abundance (i.e., as migrants began leaving the study area and detection of songbirds vastly decreased). Corvid and raptor surveys consisted of a 10-minute point count survey using the methods from Dinkins et al. (2012). Abundance of songbirds and other non-predatory bird species was quantified using a 5-minute point count survey conducted directly after the corvid and raptor survey. Surveys were conducted starting 30 minutes prior to sunrise to 5 hours after sunrise in order to maximize survey effort while balancing declines in songbird abundance associated with time of day utilizing standard distance sampling protocols. Distances to birds, primarily identified visually (corvids and raptors), were recorded using a digital rangefinder, and distances for birds primarily detected based on auditory (songbirds) were estimated using measurement to the patch of vegetation from which the bird was heard. Point count surveys were conducted twice at each survey location and were not conducted during active precipitation or in high winds. In addition to conducting repeat surveys at different times of day to help mitigate temporal bias, we will account for differences in detection probability related to time of day within our analyses.

We placed autonomous recording units (ARUs, Swift Terrestrial Passive Acoustic Recording Unit manufactured by Cornell Lab of Ornithology) at reference and treatment locations before and after juniper treatments for 5–7 day intervals to quantify changes in songbird species richness. ARUs recorded for 5-minute intervals hourly starting one hour before sunrise and ending one hour after sunset. Acoustic recorders have been shown to be comparable to human observers at quantifying species richness (Shonfield and Bayne 2017), and their ability to continuously sample throughout the day for extended periods increases the likelihood of capturing rare species often missed during singular point count surveys.

Ungulate Monitoring

We placed game cameras throughout treatment sites and a random subset of reference areas to generate a relative use index (counts per day) of ungulate abundance and use, pre- and post-juniper removal similar to O'Brien (2011). Cameras were set during summer months for 2020, then year-round from July 2021 onward as cameras were capable of functioning through the winter and spring. Cameras were programmed to take three photos in rapid succession when movement was detected. Images from these cameras have been and continue to be tagged and processed for all wildlife species, although the focus of the analyses will be wild ungulates. Images of mule deer were also categorized by the age class and sex of the individual(s) captured (i.e., doe, buck, or fawn). For the 2020 game cameras photos, we manually sorted through all photos that detected wild ungulates and recorded the number of individuals in each photo. For 2021 onward, we are using Wildlife Insights to process wildlife imagery; Wildlife Insights uses machine learning to identify and sort through blank images, or images without wildlife present. This platform also allows us to quickly tag the number of individuals and the sex and age for mule deer, specifically. However, we are still in the process of cataloguing 2021 and 2022 imagery data. Processed game camera photos will be used to generate detection or non-detection data of each species at each study site.

Vegetation Assessment

We quantified vegetation at reference and juniper treatment survey locations by categorizing phase (0, 1, 2, or 3) of juniper expansion within a 250-m radius of each survey location. We also record the number of juniper and aspen trees within a 30-m, 20-m and 10-m radius for phase 1, phase 2 and phase 3 points, respectively, in order to determine juniper and aspen density. In 2019 (first year of the study), researchers also mapped the area within 125 m of each survey location into finer scale vegetation classifications and recorded the percentage of juniper around each site (methods modified from Johnson et al. 2019). Additional macrohabitat scale vegetation and habitat features will be quantified using GIS layers.

Data Analysis

At the completion of juniper treatments (2024), the abundance of corvids, raptors, and songbirds will be estimated using N-mixture models from the

UMARKED package of R. These models will be based on raw counts from songbird surveys and counts generated by training a classifier using Kaleidoscope Pro Analysis Software (Version 5.4.7 by Wildlife Acoustics, hereafter Kaleidoscope) to process ARU recordings. This type of model uses covariates to describe differences in abundance and detection probability. We will incorporate differences in vegetation collected in the field and extracted from GIS layers. Species richness and evenness, obtained from ARUs for songbirds and point count surveys for corvids and raptors, was preliminarily evaluated for differences across the gradient of juniper and before and after juniper removals associated with aspen, riparian, and sagebrush vegetation. We conducted non-metric dimensional scaling with the package VEGAN in R, and relationships were visualized with ordination plots using the EnvFit function. We describe the species and number of detected birds in this report.

Multi-year occupancy of wild ungulate species will be estimated across a gradient of juniper expansion in sagebrush, aspen, and riparian areas and before and after juniper treatment using the UNMARKED package in R. These multi-year (dynamic) occupancy models provide estimates of initial occupancy, colonization, extinction, and detection probabilities for a given species. A variety of models incorporating different combinations of the following covariates will be considered: yearly site covariates, site covariates, and observation level covariates collected in the field and using GIS layers to extract covariates to the study points. We describe the species and number of detected ungulates in this report.

Results

Avian Point Count and Audio Recording Surveys

We conducted avian point count surveys from 21 May – 15 July 2020, 11 May – 15 July 2021, and 11 May to 14 July 2022 stratified by juniper expansion phase and with or without aspen (Table 1). We completed 497 surveys at 82 independent locations across three years with at least one repeat survey conducted at all locations. During all surveys combined, we detected 4,204 birds from 101 unique species (Tables 2 and 3). Juniper treatments started to be implemented in the fall of 2020 with new treatments conducted during fall of 2021 and 2022. We stratified and summarized these detections based on the juniper phase and aspen presence/absence at survey locations (Tables 2 and 3). The number of species detected remained relatively stable across juniper phases when aspen was present. Note there is no sampling in phase 3 juniper without aspen. The number of individual birds detected appears to be highest in juniper phases 1 and 2 in areas without aspen present (Table 2). For raptor-focused surveys, number of individual raptors detected appears to be greater at locations without aspen (Table 3). These are preliminary summary results, and we have not accounted for differences in effort or detection probability, which likely confounds interpretation of patterns based on number of detections.

Cornell swift ARUs were deployed at 39 locations in 2020, 62 locations in 2021, and 71 locations in 2022. In 2020, 64 unique bird species were detected on ARUs. Of these species, American robin (*Turdus migratorius*), northern flicker (*Colaptes auratus*), and western meadowlark (*Sturnella neglecta*) were the most commonly detected. We are still processing the ARU data from 2021 and 2022.

Bird Species Richness – Thus far, we have preliminarily analyzed our 2019 data relative to species richness. Species richness appeared to be higher in phase 1 and 2 juniper without aspen compared to phase 0 and treated areas without aspen. Our results indicated that aspen stands support a unique bird community. Cavity nesters and passerines were significantly correlated with aspen, as were the following species: mountain chickadee (*Poecile gambeli*), yellow warbler (*Setophaga petechia*), warbling vireo (*Vireo gilvus*), common yellowthroat (*Geothlypis trichas*), and house wren (*Troglodytes aedon*). Species richness appears to be highly associated with good condition aspen. Cavity nesters were more closely associated with aspen having stage 1 juniper encroachment. A well-defined bird community was associated with healthy sagebrush steppe. Horned lark (*Eremophila alpestris*), savannah sparrow (*Passerculus sandwichensis*), and the sagebrush-obligates (including Brewer's sparrow [*Spizella breweri*]) were associated with sagebrush. Western meadowlark and vesper sparrow (*Pooecetes gramineus*) were significantly associated with grassland. Grassland was also characterized by its high species evenness.

Mule Deer Surveys

In 2020, we set a total of 61 cameras that recorded over 4,864 combined total trap days (Table 4). Game cameras were deployed at 65 locations in 2021 and 78 locations in 2022. Cameras were stratified over a gradient of juniper encroachment. Over 30,000 images captured wildlife or livestock just during 2020, and we have documented the total number of detections by juniper phase for each native ungulate species (mule deer, elk, and pronghorn; Table 4). These preliminary data to not account for differences in effort, detection probability, or counting of the same individual multiple times. Our 2021 and 2022 camera data is currently being processed with machine learning instead of manually processing each image, and we are still in the process of cataloguing 2021 and 2022 data.

Conclusions

Our initial findings indicate that our sampling methods are capable of detecting differences in species habitat use (occupancy), abundance, and richness across the gradient of juniper expansion on Steens Mountain. While we have not yet analyzed habitat use or abundance of our full dataset with accounting for differences in observer bias and survey effort, aspen and early phase juniper expansion appear to have the highest abundance and diversity of birds. Whereas, native ungulate activity differs among juniper phases depending on species. Species richness is a good metric to represent ecological function. Our initial species richness results indicated that greater species richness was associated with high quality aspen with only one year of data collection. However, these results are preliminary, and we plan to further answer our study questions after inclusion of data collected in subsequent years. While study longevity will be important in answering our study questions, we suspect that restoring and maintaining aspen stands in the greater Steens area will benefit birds and mule deer.

Full implications of our results will be detailed upon completion of data collection and analysis of all data associated with our research objectives. This report is associated with years 1–4 of a 6–8 year study; thus, represents preliminary findings. Our research will help inform management decisions on the effectiveness of juniper removal as a conservation strategy for multiple wildlife species and will provide crucial information on abundance of numerous avian species and mule deer relative to aspen, juniper, and sagebrush ecosystems in the greater Steens Mountain area. In addition, understanding the relationship between juniper and key sage-grouse avian predators will help land managers make better informed decisions when managing for multi-species and multi-use landscapes.

Acknowledgments

Our research was funded by the Bureau of Land Management, Oregon Beef Council, Oregon State University, and the Oregon Wildlife Foundation. We would like to thank our collaborators at the Bureau of Land Management and USDA-ARS for their role in the planning and implementation of this project. We would also like to thank Roaring Springs Ranch, the Otley family, and the countless other private landowners who allowed access to their land for this study. Lastly, we want to thank seasonal technicians Devin Hendricks, Cade Tiller, Andrew Meyer, and Grace Vielleux for their hard work collecting data and deploying equipment.

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Figure 1. Map study area (outlined in red) for assessing corvid, raptor, and songbird abundance in the greater Steens mountain area in relation to vegetation classifications, juniper, aspen, and riparian areas. Colored polygons indicate proposed juniper treatment areas in riparian areas and/or aspen stands. Each proposed treatment is roughly 1.2 km^2 in size, and treatments are planned through 2025. The 2020 polygon was treated in the fall of 2020 and the 2021 polygon was treated in August 2021.

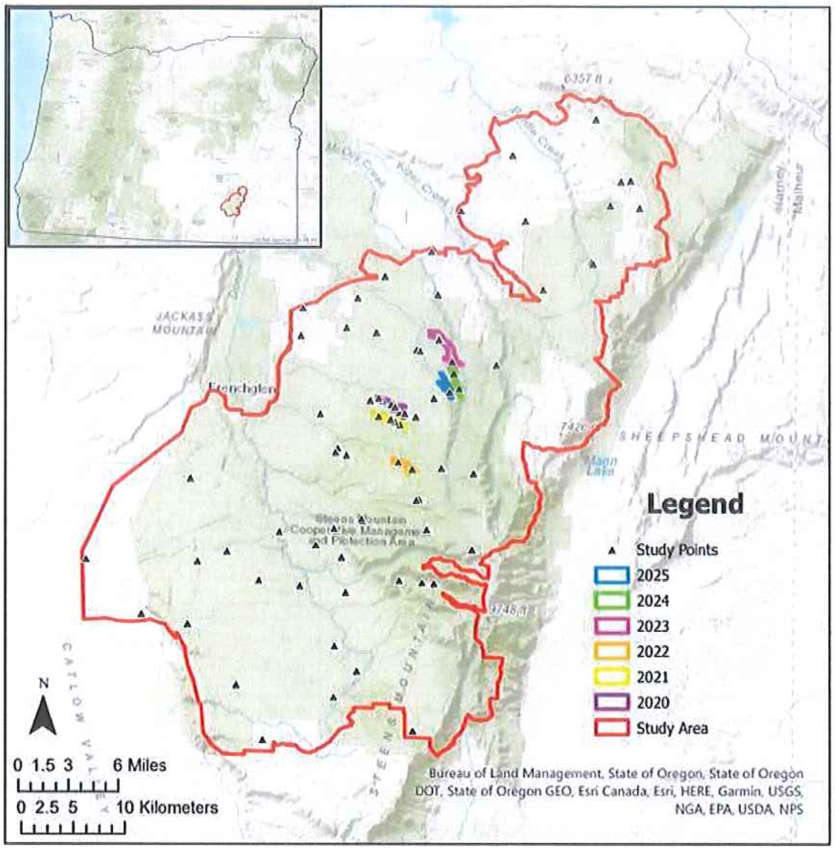

Table 1. Number of study locations sampled in areas with aspen present and without aspen present stratified over phase of juniper expansion (Phase 0, 1, 2, 3, and treated). Each study location was visited 1-2 times per field season and one songbird focused point count and one raptor focused point count was conducted each time.

Phase of Juniper Expansion	Year					
	2020		2021		2022	
	Aspen	No Aspen	Aspen	No Aspen	Aspen	No Aspen
Phase 0	10	10	10	10	10	10
Phase 1	10	21	9	22	9	20
Phase 2	11	11	9	11	8	11
Phase 3	4	3	3	1	2	1
Treated	NA	NA	4	2	7	3

Table 2. Total number of individual detected at sites with and without aspen, stratified over phase of juniper expansion (Phase 0, 1, 2, 3, and treated) during songbird-focused point count. This does not account for detection probability, observer bias, or different vegetation and terrain among locations.

Phase of Juniper Expansion	Year					
	2020		2021		2022	
	Aspen	No Aspen	Aspen	No Aspen	Aspen	No Aspen
Phase 0	146	123	148	154	174	169
Phase 1	134	308	176	403	153	403
Phase 2	175	152	147	180	145	188
Phase 3	53	47	55	16	39	12
Treated	NA	NA	73	45	152	49

Table 3. Total number of individuals detected at sites with and without aspen and stratified over phase of juniper expansion (Phase 0, 1, 2, 3, and treated) during raptor and avian predator-focused point count. This does not account for detection probability, observer bias, or different vegetation and terrain among locations.

Phase of Juniper Expansion	Year					
	2020		2021		2022	
	Aspen	No Aspen	Aspen	No Aspen	Aspen	No Aspen
Phase 0	10	4	5	17	3	6
Phase 1	9	29	9	27	3	11
Phase 2	9	6	5	8	3	6
Phase 3	1	0	2	0	1	0
Treated	NA	NA	3	3	5	1

Table 4. Total number of detections of native ungulates (mule deer, elk, and pronghorn) stratified by juniper phase at each study location in 2020. Total number of sites indicates the number of survey locations in each juniper phase with one camera set at that location. Number of trap days indicates the total number of days that cameras were recording at locations within the indicated juniper phase. Ungulate activity reported as the average number of detections per 10 trap days.

Juniper Phase	Total # Locations	Total # of Trap Days	Ungulate Activity		
			Mule Deer	Elk	Pronghorn
0	10	610	7.72	8.15	0.49
1	17	1275	3.93	10.75	8.42
2	22	1694	2.35	1.46	0.90
3	12	1272	3.44	7.76	None detected

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Oregon State University

BEEF 231

Oregon Beef Council Report

Beef Cattle Sciences

A Systems-Based Understanding of Rangeland Watershed-Riparian Systems in Eastern Oregon [1]

Carlos Ochoa[2]

Synopsis

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.

Introduction

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.

Project Status

This report describes the first phase (3-yr) of a long-term (10+ years) project being conducted in a rangeland watershed-riparian system in Malheur County, eastern Oregon. Several ecological and hydrological relationships (e.g., vegetation cover and stream temperature) are being evaluated at the Fish Creek watershed-riparian system in Wilks Ranch. This 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. The field-data collection effort was designed to improve understanding of the effects that critical component interactions (e.g., stream and weather variables) may have on on-site ecologic functionality. 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 stations with satellite-based communication capability for data transfer. We conducted a geologic reconnaissance of the study site and collected soil samples at the weather station sites. In the fall of 2020 and summer of 2019, 2021, and 2022, we collected water samples to evaluate water quality parameters (i.e., P, Cl, N, Br). Also, we established monitoring transects and conducted a vegetation and channel

1. This document is part of the Oregon State University – 2022 Oregon Beef Council Report. Please visit the Beef Cattle Sciences website at http://blogs.oregonstate.edu/beefcattle/research-reports/
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morphology assessment at three different reaches along Fish Creek and Deer Creek.

The study site encompasses a 3200-acre watershed (Figure 1) and runs through different vegetation types, from mixed-conifer to ponderosa, to sagebrush-steppe. Multiple springs and seeps occur in the watershed's upper portion due to the site's fractured basalt geology. The streams at the site are relatively narrow (3-7 ft wide) and shallow (< 3 ft deep). Additional temperature records and sampling of water quality (i.e., nutrients) are being conducted at two locations along Willow Creek (See Figure 1).

Preliminary results show that a combination of factors, including climate, geology, topography, vegetation cover, and channel morphology, are associated with stream temperature variability at the study site.

Vegetation cover and channel morphology were assessed at three reaches varying from 300 to1000 ft in length in the upper and lower parts of the watershed (Figure 2). Riparian and adjacent vegetation cover consisted of conifers and clumps of deciduous (cottonwood, aspen) in the upper and mid elevations and deciduous trees (cottonwood, willow) and sagebrush in the valley bottom of the watershed. Riparian vegetation cover was slightly higher and more variable (54% to 66%) in the lower elevation reaches than in the conifer-dominated reaches (57% to 58%).

Multi-linear regression analysis showed that air temperature was the factor most closely related to stream temperature along the entire reach. The air temperature was generally lower at the highest elevation sites than at the lower valley site, but mixed results were observed between the mid-elevation and lower elevation sites. Daily mean air temperature fluctuated between 10 degrees Fahrenheit in the winter and 80 degrees in the summer (Figure 3).

Figure 4 shows water temperature fluctuations in Fish Creek from August 2018 through June 2022. During the summer, greater stream temperature was observed in lower elevation locations along the stream. A difference of up to 12.6 degrees was noted between the stream location at 4970 ft and the lower valley stream location at 3911 ft elevation. It can also be observed that there was a relatively constant temperature for the spring water source, while the temperature in the stream was more variable throughout the year. A difference of up to 21 degrees between the spring and the lower valley stream location was observed.

Overall, stream temperatures followed a similar seasonal pattern to air temperature. The temperature of subsurface flows, such as that of springs and shallow groundwater, showed a more muted seasonal variability. Figure 5 illustrates daily-averaged temperature for air, stream, and groundwater near (~ 50 ft) the stream in a shaded location in the lower (3911 ft) portion of the watershed. It can be observed that while all sensors recorded a similar pattern of higher temperatures in the summer and lower ones in the winter, groundwater temperature showed a delay in response compared to stream and air temperature. Also, the difference between the highest and lowest seasonal temperature was less than in the other two (i.e., air and stream).

An even less pronounced response to air temperature seasonal variability was observed in the water coming out of the fractured basalt as springs. Figure 6 shows the seasonal temperature variability for air and the spring (groundwater) at the highest elevation site, which lacks any riparian vegetation cover. The spring water temperature remained relatively constant, slightly below 50 degrees, throughout the year.

The statistical analysis showed that riparian vegetation cover and streamflow were less correlated with stream temperature along the entire stream. However, measurements of water temperature taken with a high precision thermometer every 30 ft during the summer in a 3500-ft reach near the headwaters showed that the very shallow water (< 6 inches deep) stream was influenced by direct sunlight exposure and subsurface flow. Water temperatures of up to 56 degrees were observed in the exposed (no vegetation cover) areas. The temperature was 49-50 degrees in shaded areas and dropped to 46-48 degrees in areas with subsurface flow contributions. The temperature was 50 degrees at the end of the reach, where one of the continuous monitoring sensors is located.

The ongoing analysis of nutrient loads from samples collected 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 help determine the nature and type of Cl additions by nature or management practices. Figure 7 shows the 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. Nutrient loads (e.g., nitrates and phosphates) were relatively low. Nitrates were generally higher at or near the source (spring) and decreased in concentration in waters downstream (Figure 8).

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

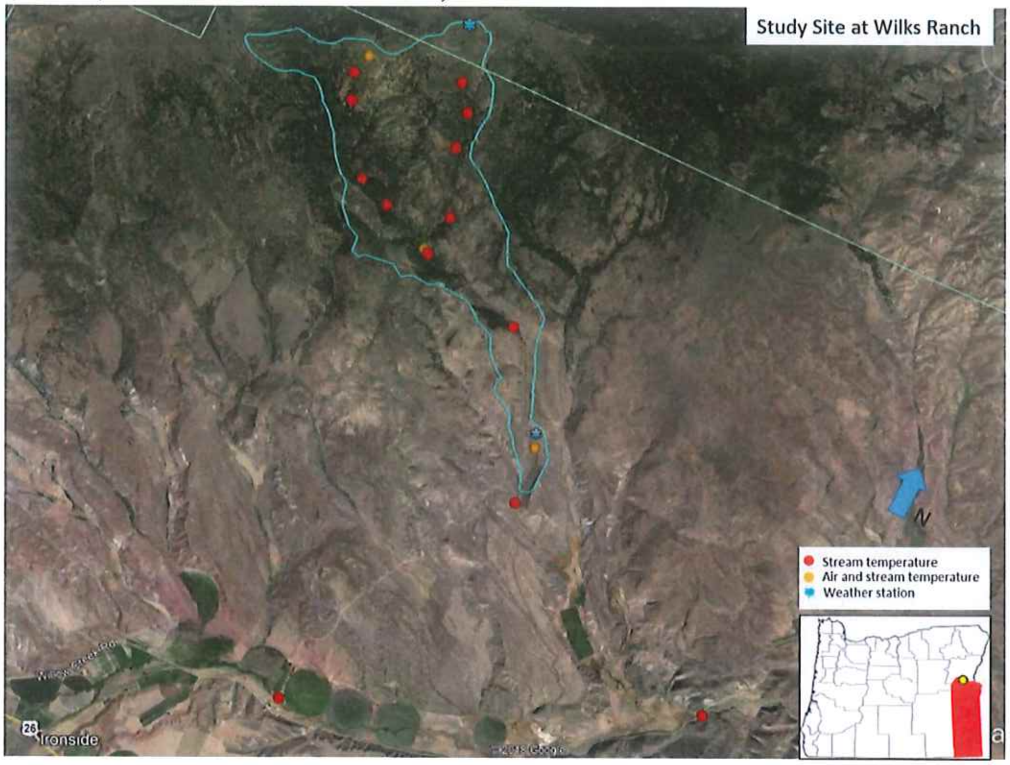


Figure 2. Schematic illustrating a 330-ft reach and methodology used to characterize stream morphology and riparian-upland vegetation. The line intercept method was used to determine cover along three 30-m transects perpendicular to the stream. Riparian area cover above the stream in the monitored reaches was collected using a canopy imager.

Figure 3. Mean daily air temperature at various elevations in Fish Creek, from the spring source at 5706 ft to the valley at 3911 ft.

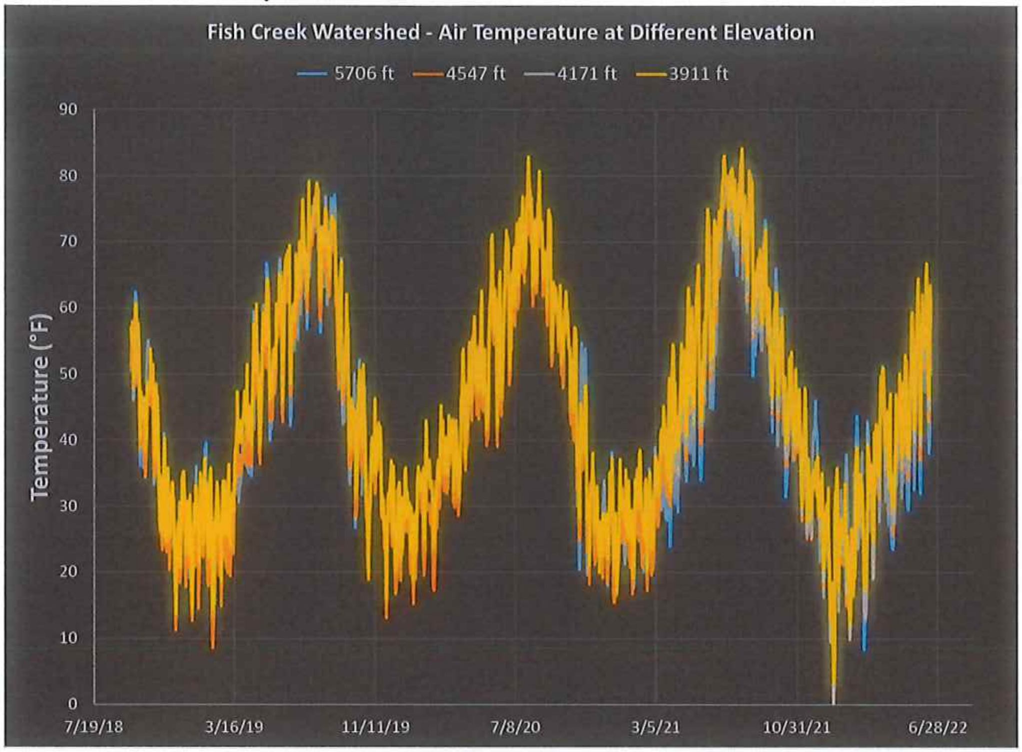


Figure 4. Mean daily stream temperature along the longitudinal gradient of Fish Creek, from its spring source at 5706 ft to downstream at 3911 ft.

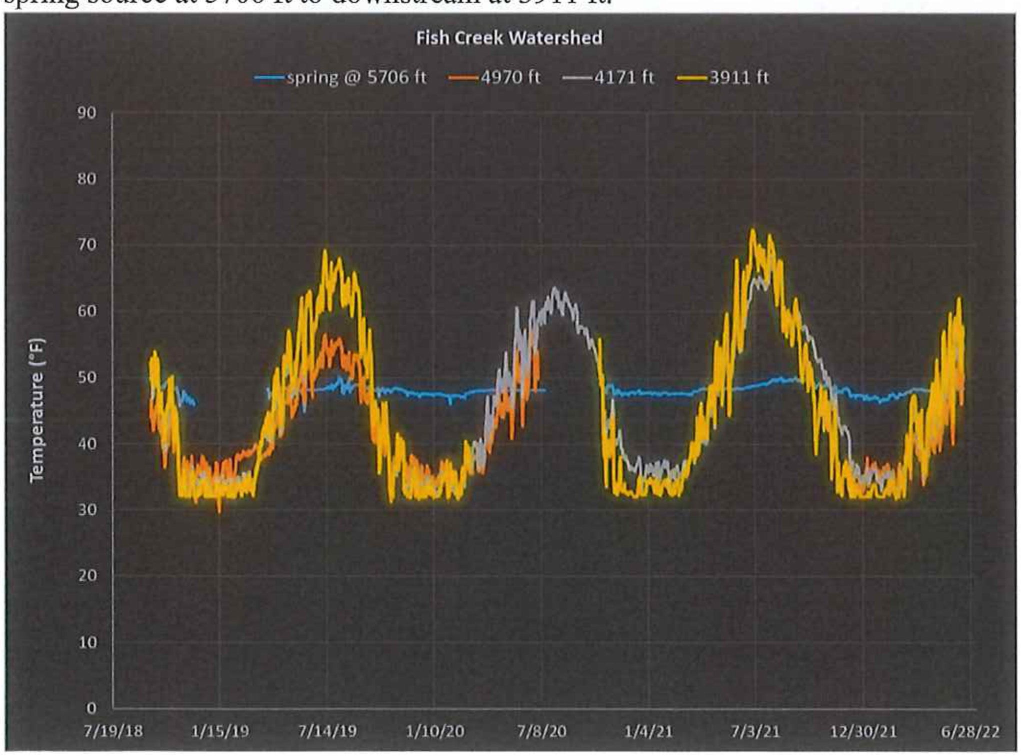


Figure 5. Air, stream, and shallow groundwater temperature fluctuations in the lower valley site.

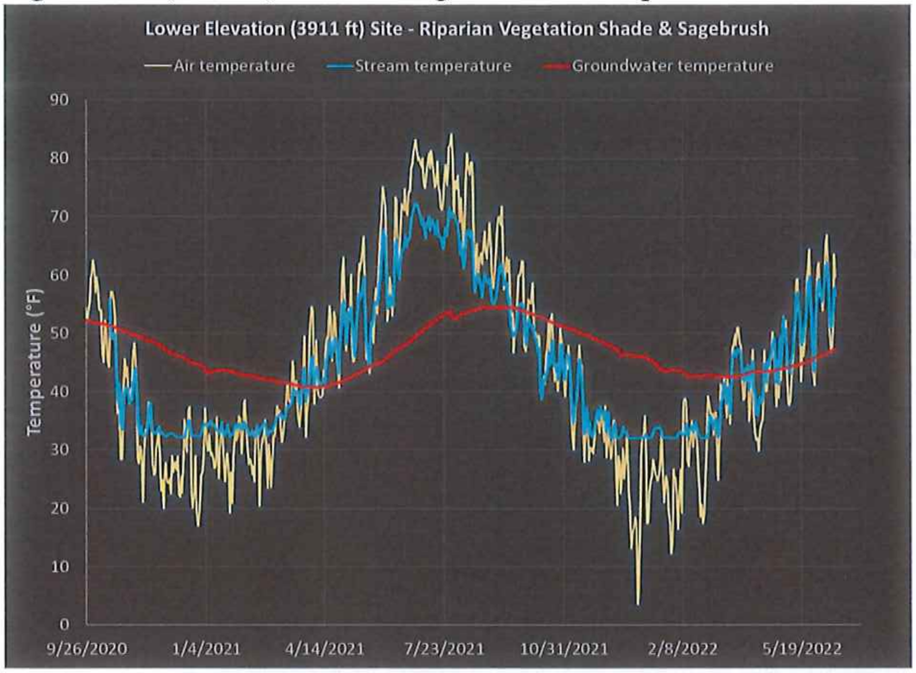


Figure 6. Air and spring water temperature in the headwaters of the Fish Creek watershed.

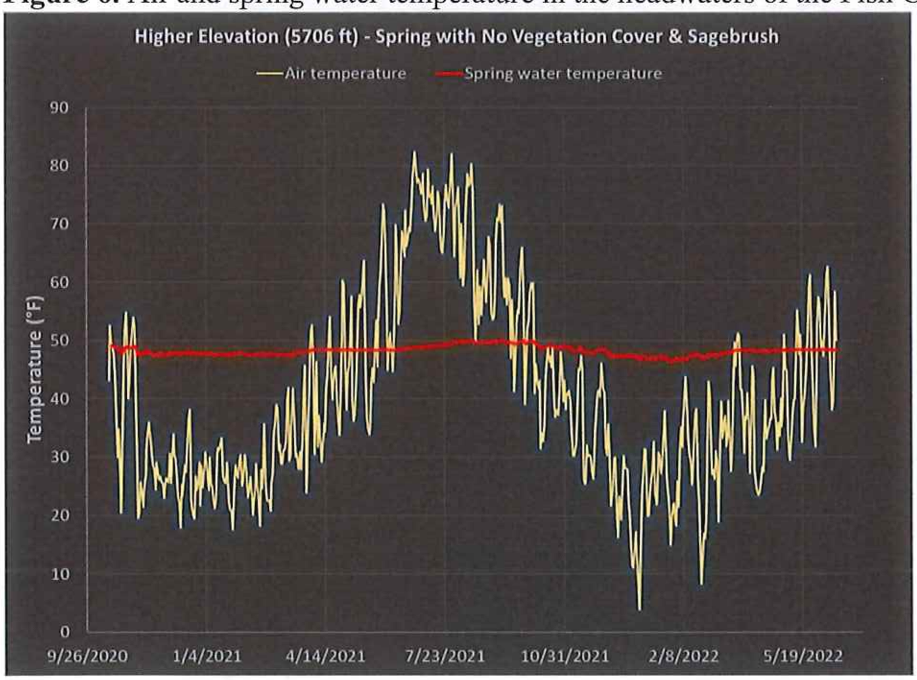


Figure 7. Cl: Br ratios obtained validate the spring-fed origin of stream water.

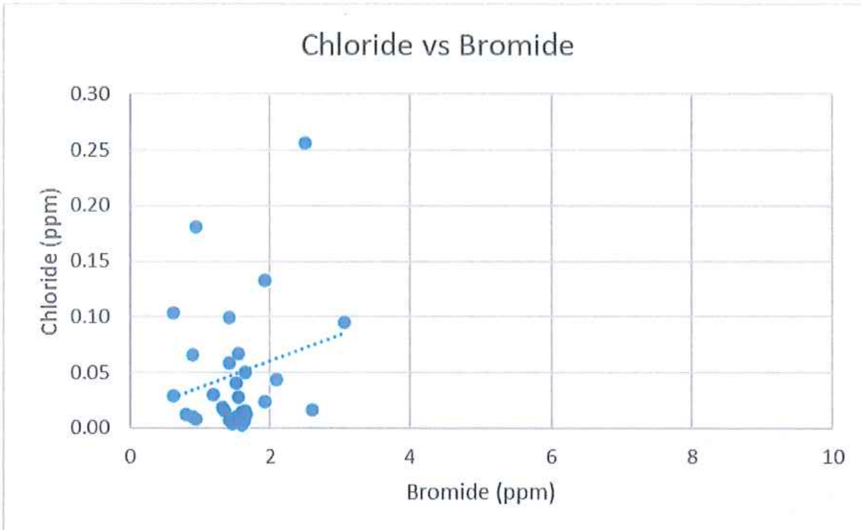
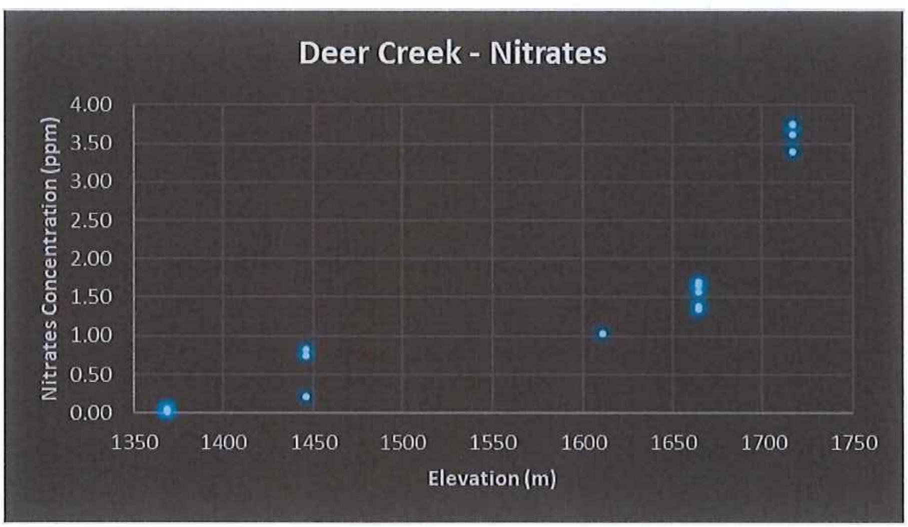
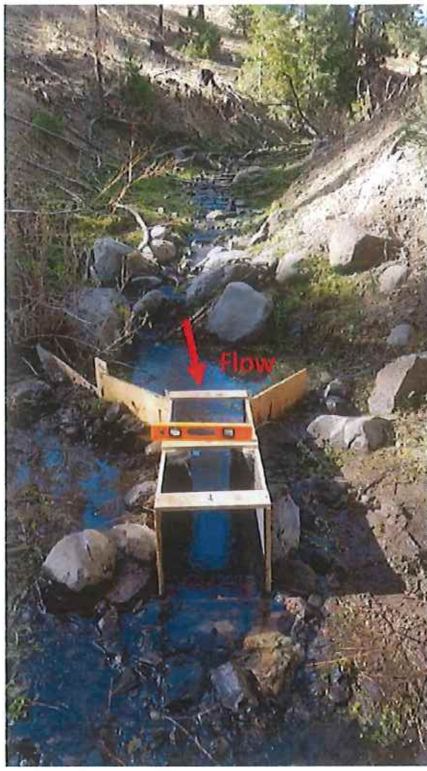


Figure 8. Nitrates concentration (ppm) by elevation at Deer Creek.

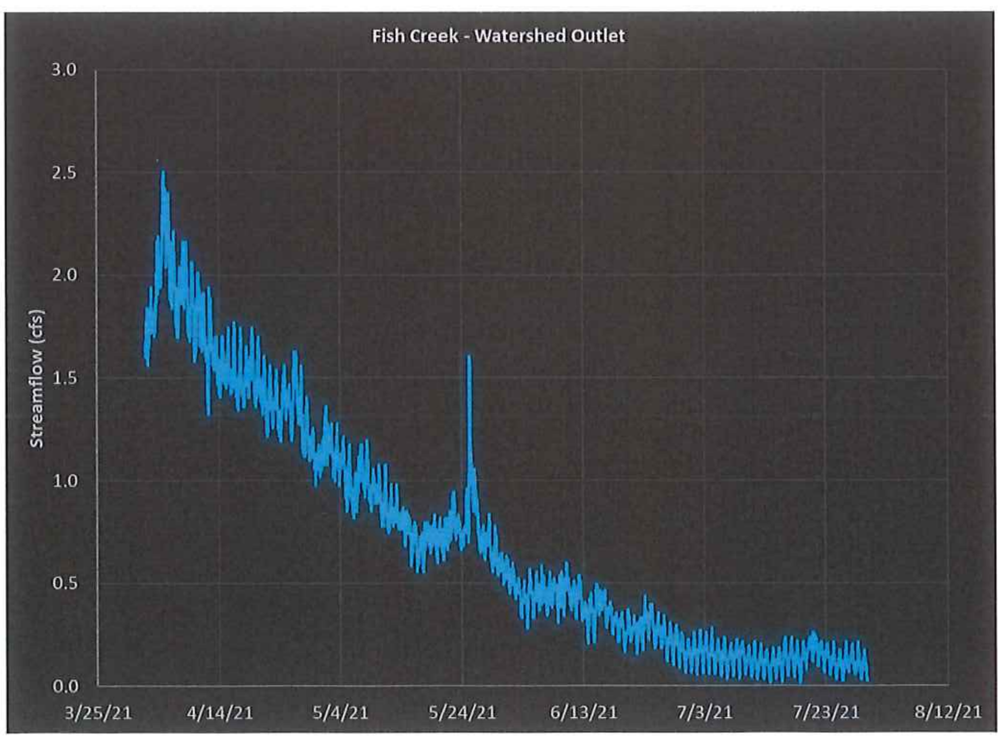


Photos: The following images show some of the additional data collection and analysis underway. The core project instrumentation has been installed, and data collection and processing are expected to continue for several years.

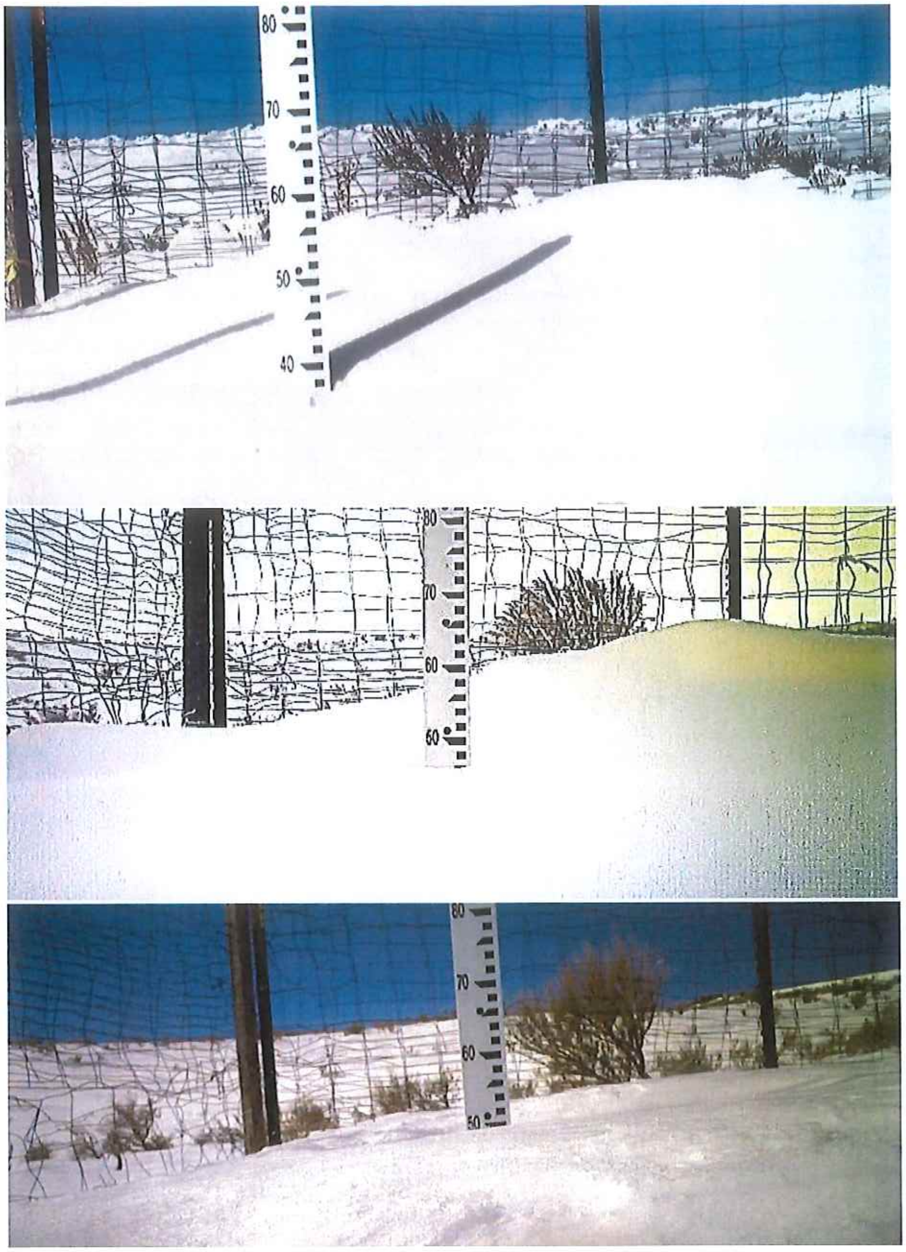
Stream temperature sensor and water quality sampling locations.



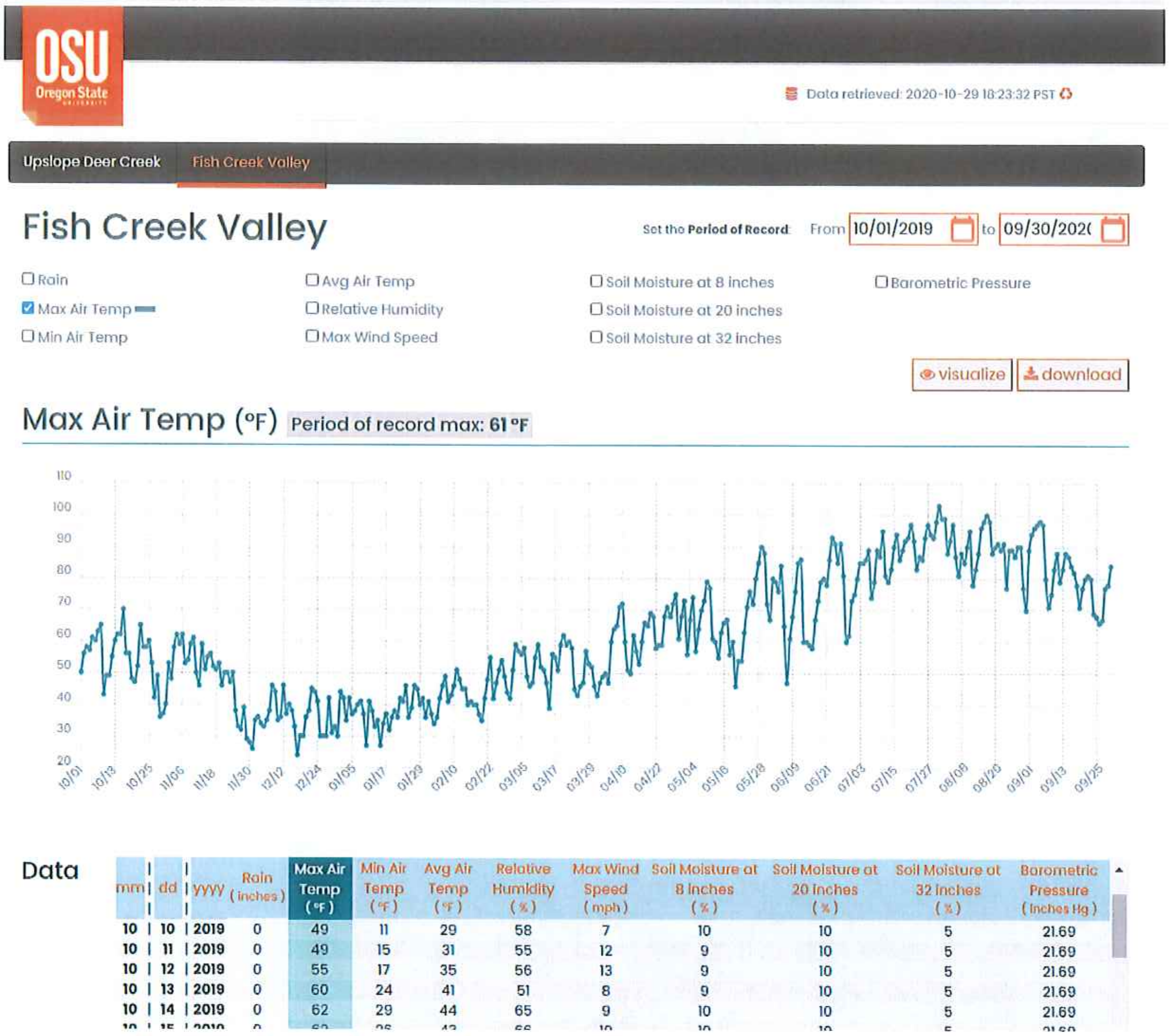
Streamflow measuring devices (above) installed and hourly streamflow at the watershed outlet (below). Streamflow was relatively low, peaking at 2.5 cubic feet per second (cfs) in April of 2021, following snowmelt runoff.



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



Snow depth (cm) at the Deer Creek weather station is shown for January 4, 2020 (top), January 25, 2021 (middle), and February 20, 2022 (bottom image).



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

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/.

Oregon State University

BEEF 232

Oregon Beef Council Report

Beef Cattle Sciences

Progress Reports – Rangeland Ecology and 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, Oregon State University, Eastern Oregon Agricultural Research Center-Union, Union, OR 97883

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Project Objectives: 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 2020

Project Completion Date: Fall 2023

Project Status and Preliminary Findings: For this project we chose to evaluate the DJI Phantom P4 drone. This model is widely available and are in the middle of pack with respect to cost for drones with multispectral capabilities.

We now have 2 years of field data (summer 2021 and summer 2022). We are evaluating the drone at 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 in Union County. 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 – 2022 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 both years (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. Imagery can then be imported into ArcGIS for further analyses- such as the generation of NDVI images and more.

We continue to work through data analysis. Preliminary finding suggest that while off-the-shelf drones can be a useful tool for land mangers and producers, several factors may limit widespread use. These include: 1) the training needed to process and analyze spatial imagry can be more than is feasible for producers 2) estimates of certain varaibles (e.g. stuggle height) have errors larger than is helpful for management (e.g. ± 7 inches), and 3) the time required to process and analyze the information is longer than is appropriate to describe real time range heath characteristics or inform management actions (e.g. pasture moves). real-time pasture moves, etc. Intial findings suggest that the processing needed to analyze drone imagry makes their use by producers to estimate range condition, stubble height and utliziation unrealistic. This does not meet that they cannot provide benfits to producers but their use may be more beneficial for other activities such as locating, hearding and moving livestock, and checking the status of water developments, springs, etc. Imagry from dones can also be helpful to identify areas of heavy use by livestock, mapping the extent and intensity of disturbances (e.g. fire boundaries), etc. and in gathering photos and video of remote or difficult-to-access areas.

Drones are capable of collecting additional information for more advance and powerful analysis. However, the additional costs and training are likely prohibitive and 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 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.

Oregon State University

BEEF 233

Oregon Beef Council Report

Beef Cattle Sciences

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.

1. This document is part of the Oregon State University – 2022 Oregon Beef Council Report. Please visit the Beef Cattle Sciences website at http://blogs.oregonstate.edu/beefcattle/research-reports/

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.

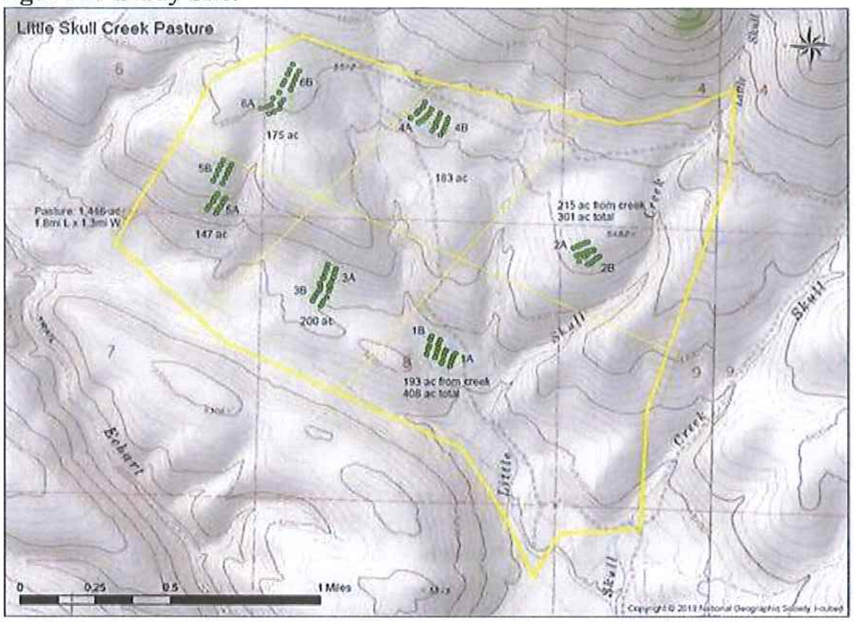
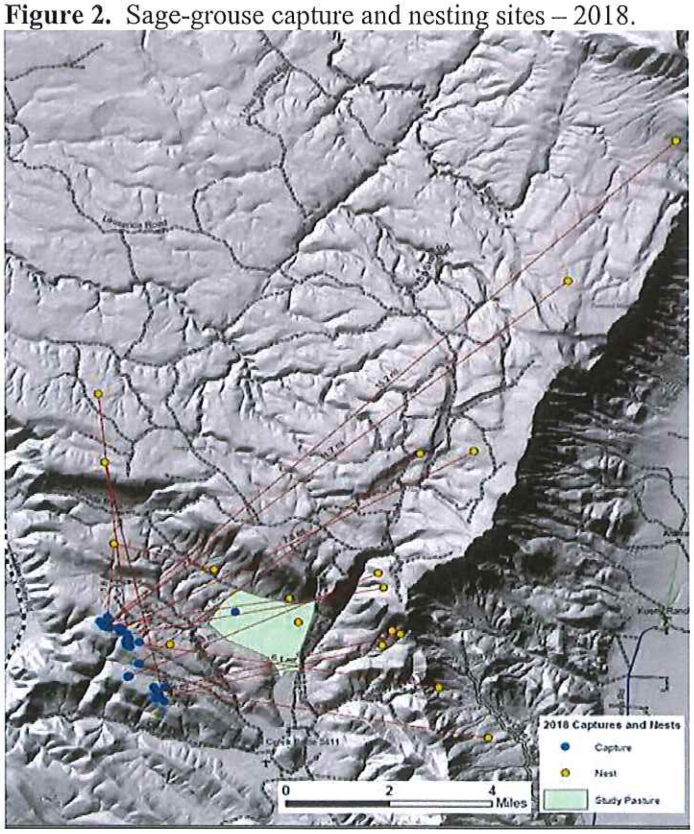


Figure 2. Sage-grouse capture and nesting sites – 2018.



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	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	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	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	Report Status 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	Report Status 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	X
Influence of Ravens on Sage Grouse in Baker Oregon	J. Dinkins	X	X
Grazing Season of use on Sage-grouse habitat	D. Johnson	X	X
Systems-based approach to rangeland riparian systems	C. Ochoa	X	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	Report Status Full
Rangeland Ecology and Management			
Fine Fuels Management to Improve Wyoming Big Sagebrush Plant Communities Using Dormant Season Grazing	S. Arispe	X	X
Influence of Juniper Removal in Aspen Stands on Greater Steen's Mountain Wildlife	J. Dinkins	X	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	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	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 dairy cows	M. Bionaz	X	X
Monitoring Cattle Behavior to identify Cattle Disturbance Remotely	S. Arispe	X	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	X
Animal Sciences			
Monitoring cattle behavior to identify cattle disturbance remotely	S. Arispe	X	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	

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Beef Cattle Sciences

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