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Beef Cattle Sciences

# Oregon Beef Council Report

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Beef Cattle Sciences

# Oregon Beef Council Report

## Copper Accumulation in Dairy Forage Production Systems<sup>1</sup>

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### Synopsis

Use of copper sulfate in footbaths causes concern for accumulation in dairy production systems.

### Summary

Dairy farmers often use either copper sulfate or zinc sulfate solutions in footbaths to control diseases of the hoof. Solutions are frequently changed before each milking requiring significant quantities of copper and/or zinc a year. Used solutions are dumped into the dairy manure handling system and applied to fields in their liquid manure system. The objectives for this project were to survey 30 dairy farms in Oregon to estimate the amount of copper sulfate and zinc sulfate used in footbaths, measure mineral concentrations in soils on the farm, assess the concentration of copper and zinc in the manure system, and measure minerals in the forage produced on the dairy. Footbath practices were recorded for each dairy. Soils samples were collected from two major fields at 6" deep and analyzed for copper and zinc. Forages grown on the farm were sampled and analyzed for copper and zinc content, and manure was collected directly from milk cows and from the liquid manure storage system. Forages, soils and manure were all analyzed at Agri-Check Labs, Umatilla, OR. Footbath usage by farm ranged from no usage to continuous usage. Soil copper concentrations ranged from 0.7 to 34.7

ppm and averaged  $5.7 \pm 6.6$ . Soil zinc concentrations ranged from 0.6 to 41.8 ppm averaging  $10.1 \pm 9.3$ . Forage copper concentrations ranged from 1 to 10 ppm averaging  $3.4 \pm 2.1$  and zinc ranged from 3 to 51 ppm averaging  $13.8 \pm 10.3$ . Fresh manure copper concentrations directly from milking cows were very consistent, typically at 10 ppm, with copper concentrations in the manure storage ranging from 2 to 58 ppm averaging  $10.3 \pm 12.02$  ppm. The use of copper sulfate and zinc sulfate in footbaths on dairies in Oregon continues to be a common practice. Over 75% of dairy soils tested are considered high ( $> 2$ ppm) in copper concentration and 38% were extremely high ( $> 5$ ppm). Using copper sulfate and zinc sulfate in footbaths is creating potential long term environmental and cropping challenges on many Oregon dairies.

### Introduction

Lameness is common problem on US dairy farms with a reported 22% of cows affected (Cook, 2003; USDA, 2002). It has been reported that over 47% of dairies in the US use copper sulfate in

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footbaths to control diseases of the hoof such as hairy heel warts. Hairy heel warts were first reported in the United States more than 25 years ago and have since spread rapidly, becoming a major management concern for dairy producers both in the U.S. and in other parts of the world (Shearer, 1998). Between 1991 and 1994, the frequency of infection on California dairies increased from 31% to 89% (Read and Walker, 1991). In addition to being extremely contagious, hairy heel warts are also a very expensive problem. It has been reported that hairy heel warts cause 20% of all dairy lameness cases, with each case of lameness costing \$90 to \$130 to dairy producers (Shearer, 2000). In Oregon, some professional hoof trimmers believe hairy warts are the cause of the majority of the lameness found on dairies (Perkins, 2009).

Medicaid footbaths are a common technique for treating foot problems on dairies. One advantage to the using a footbath is that the bath can be located in the exit lanes of the milking parlor and all milking animals can be mass treated with little direct labor input. This treatment is also considered a great way to control the onset of foot ailments because of the ability to treat animals before the problem becomes acute. Although less labor intensive than individual applications, footbaths must be properly managed. While a variety of disinfectants have been tried, copper sulfate, zinc sulfate and formaldehyde are the most common additives. Copper sulfate has commonly been favored as a footbath disinfectant due to its ease of use and apparent effectiveness. Copper sulfate is bacterostatic by reacting with proteins from the target bacteria (Laven and Hunt, 2002).

Typically, footbaths solutions with copper sulfate are mixed at a 5% solution and are considered effective for 150-300 cows. Therefore, a 60 gallon footbath would often take 25 lbs of copper sulfate. Since copper sulfate is 25% copper, somewhere around 6 lbs of elemental copper is used and disposed into the dairies waste system each time the footbath is changed. A 300 cow dairy using a footbath could use up to 6 lbs of copper per milking. If they operated the footbaths 50% of the time, they would still be adding 2,190 lbs of extra copper into their waste system each year. Applying this extra copper over a 200 acre dairy would be the equivalent of 10.95 lbs of copper per acre a year. One study of 4 dairies in Wisconsin indicated copper application rates from footbath disposal ranged from 4.6 to 10.4 lbs of copper per acre a year (Rankin, 2009).

Plants require very little copper, whereas annual removal rates for most crops range around 0.1 lb per acre a year. Soil copper loading rates can easily exceed crop usage and potentially could reach the maximum copper soil concentration in a relatively short number of years. Copper applied to soils is strongly bound and exchangeable copper is held much tighter than other cations. This strong binding potential typically keeps copper from leaching from soil, but rather allows for copper accumulation in the soil surface. Copper is not taken up in plants easily, so often there are increased copper levels in plant roots grown in high copper soils. Plant copper toxicity often results in reduced root growth and damage to root cell membranes. Due to mineral interactions, plant iron deficiency is possible with elevated soil copper levels.

The objectives of this study were to survey 30 dairies in Oregon to access copper sulfate and zinc sulfate usage in footbaths and to sample soils, liquid manure, fresh manure, and farm grown forages for copper sulfate and zinc sulfate content analysis in order to use this data as the basis of an Extension educational program to assist the dairy industry in understanding the potential for copper and zinc accumulation with the recurrent use of foot baths.

## Materials and Methods

Thirty dairies in Oregon were invited to participate in this project. Approximately half the dairies were located in the Willamette Valley and the other half along the north coast in Tillamook County. Dairy producers were surveyed about their historical usage of copper or zinc and their current program for controlling hoof diseases on their dairies. Within each dairy, two fields that were considered major manure application fields were selected for soil sampling and soils were sampled at a depth of 6". Pasture-based dairies also had soil samples taken at 2" in permanent pastures to look at potential surface copper and zinc soil concentrations. Manure samples were collected from the liquid manure storage facilities and directly from cows in the milking barn. In addition, a sample of forage produced on the dairy was taken. Soils, manure, and forages were sent to Agri-check, Inc. in Hermiston, OR. All samples were analyzed for copper and zinc concentrations.

## Results

### Survey Information

Hoof health concerns were recognized as a major issue for a majority of surveyed dairies. The largest single health issue observed was hairy or strawberry warts, followed by foot rot and abscesses. Footbaths were used on 90% of the surveyed dairies, with copper sulfate being the most common treatment used in the bath. Approximately 25% of the dairies regularly using a footbath were using a combination of copper sulfate and formaldehyde in rotation. Zinc was also included to a lesser extent in rotation with copper and formaldehyde. Only two farms specifically used zinc sulfate as their product of choice for mixing the footbath solutions. Seven of the farms surveyed had used copper sulfate and zinc sulfate historically, but had stopped in recent years. One producer indicated they had stopped specifically because of concerns about accumulating copper. Table 1 illustrates the percentage of current usage of copper and zinc. Quantities of copper being used ranged from zero to an estimated 15 lbs of copper per acre a year. Annual crop needs for copper are typically only around 0.1 lbs per acre a year.

**Table 1.** Percentage of dairies surveyed that used footbaths including Copper sulfate and Zinc sulfate usage.

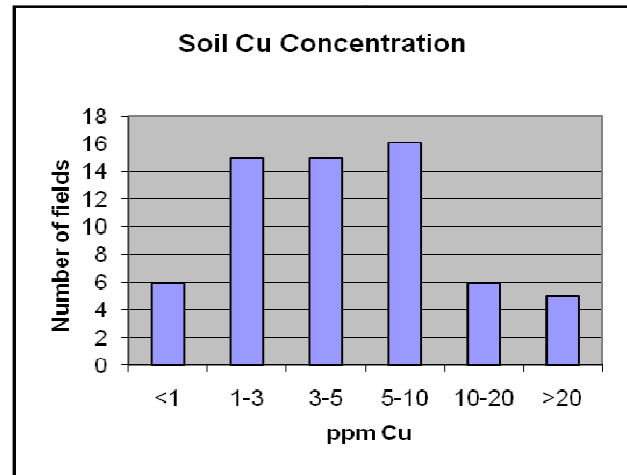
Footbath usage	Percentage
No Footbath	10%
1-3 times week Copper sulfate	27%
>50 of the time Copper sulfate	33%
Used Copper and Zinc sulfate in the past	23%
Regular use of Zinc sulfate	6%

### Lab Analysis

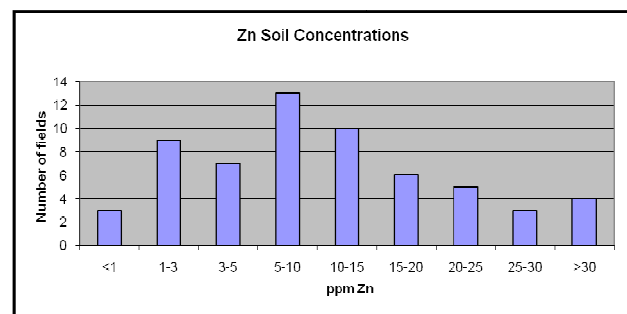
Soil copper concentrations taken on pasture-based dairies at 2" deep ranged from 1.4 to 79.8 ppm, averaging  $17.8 \pm 24.5$ . Soil copper concentrations from all dairies taken at 6" deep ranged from 0.7 to 34.7 ppm, and averaged  $5.7 \pm 6.6$ . Generally, soil copper levels over 2 ppm are considered high, and values over 5 ppm are considered extremely high. Figure 1 illustrates the copper concentration (ppm) in soils taken at the 6" depth by the number of fields. Soil zinc concentrations ranged from 0.6 to 41.8 ppm, averaging  $10.1 \pm 9.3$ . Figure 2 illustrates the zinc concentration (ppm) in soils taken at the depth of 6".

Copper concentrations in forages ranged from 1 to 10 ppm, averaging  $3.4 \pm 2.1$ . Zinc in forages ranged from 3 to 51 ppm, averaging  $13.8 \pm 10.3$ . Copper concentrations in manure obtained

directly from milk cows were very consistent, typically at 10 ppm, with copper concentrations in the manure storage ranging from 2 to 58 ppm and averaging  $10.3 \pm 12.02$  ppm. These are shown graphically in Figures 3 and 4, respectively.



**Figure 1.** Soil copper concentrations (ppm) on cooperating dairy farms.

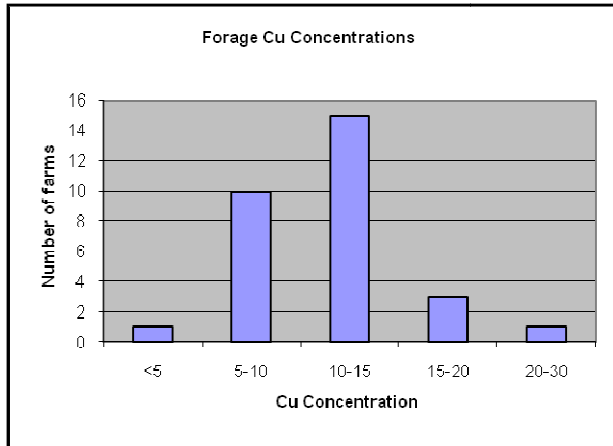


**Figure 2.** Soil zinc concentrations (ppm) on cooperating dairies

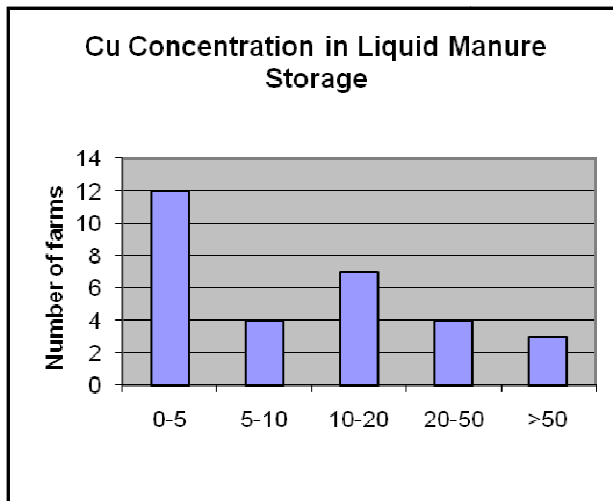
## Conclusions

Oregon dairies continue to look for successful management strategies to control or eliminate hairy warts. The use of footbaths continues to be a major strategy with copper sulfate and formaldehyde being used as common disinfectants. Approximately one third of the farms included on this study used footbaths the majority of the time. Although no actual usage data existed on farms regularly using copper sulfate, estimates indicate farms regularly using copper could be applying as much as 10-15 lbs of copper per acre from the disposal of foot bath solutions, which is considered as much as 100-150 times the annual copper need for most crops.

It is important to note there have been no reported toxic levels of copper in forages produced on dairies in the US. However, agronomists agree that continual usage of copper, without any accounting for accumulations, will eventually cause problems with plant productivity. Dairy nutritionists typically design total rations to have approximately 20 ppm of copper. Sometimes, adverse effects of copper can be noted in rations over 50 ppm, whereas diets containing more than 80 ppm of copper are considered toxic to cattle.



**Figure 3.** Forage copper concentrations (ppm) of home grown forages for cooperating dairies`



**Figure 4.** Copper concentrations (ppm) in liquid manure storage on cooperating farms

#### Management Recommendations:

- 1) Understand your current copper soil levels on your farm. If you believe it is important to continue to use copper sulfate in footbaths, include copper analysis as part of

regular soil testing to at least understand the current situation.

- 2) Dispose of copper solutions across the total acres of the farm to reduce loading on smaller tracts of land.
- 3) Consider reducing the concentration and frequency of footbath usage to accomplish herd foot health needs, but reduce the total copper used annually.
- 4) Use a clean water wash foot bath directly before the treated one to improve the efficacy of the footbath. Organic matter binds copper and reduces its effectiveness.
- 5) Consider new foot bath products to reduce the usage of copper sulfate. Several studies have reported that 5% formalin treatment is effective in controlling hairy heel wart outbreaks. Formalin has a wide range of antibiotic activity, it is non-corrosive, it is biodegradable, and use of formalin is not regulated by the Federal Pasteurized Milk Ordinance. Formaldehyde is toxic and is considered a carcinogen, which can pose a health hazard to employees as well as a risk of contamination of meat or milk. If formalin is to be used for the treatment and control of heel warts, workers should be aware of its hazards and take steps to protect themselves.

### Acknowledgements

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Beef Cattle Sciences

# Oregon Beef Council Report

## Late Gestation Supplementation of Beef Cows: Effects on Cow and Calf Performance <sup>1</sup>

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### Synopsis

Our data demonstrate the potential consequences of not maintaining cows in good BCS (> 5) at calving; greater calf losses, less weaned calves, decreased calf performance, lower subsequent pregnancy rate, and decreased economic return.

### Summary

We conducted a 2-yr study to evaluate the influence of cow BCS and dried distillers grains (DDGS) supplementation during late gestation on cow and calf productivity. The experimental design was a 2 × 2 factorial; 2 BCS (4 or 6) and supplemented or not supplemented. Calf birth weight was greater with BCS 6 cows compared with BCS 4 ( $P = 0.002$ ), and greater for supplemented compared with unsupplemented cows ( $P = 0.05$ ). In addition, weaning weight was greater for BCS 6 compared with BCS 4 ( $P = 0.05$ ) and calf weaning weight and ADG to weaning were greater for the offspring of supplemented compared with unsupplemented cows ( $P \leq 0.02$ ). We noted no differences in post-weaning calf performance or carcass characteristics ( $P > 0.10$ ). However, BCS 6 cows had approximately 10% more live calves at birth and at weaning ( $P < 0.001$ ) compared with BCS 4 cows. Also, pregnancy rate was 91% for BCS 6 compared with 79% for BCS 4 cows ( $P = 0.005$ ).

Supplementation during late gestation resulted in an estimated net return of \$7/cow if calves were sold at weaning compared with not supplementing. More importantly, because of additional weaned calves, the estimated net return for BCS 6 cows at weaning was \$71/head more than BCS 4. Likewise, with retained ownership, BCS 6 cows yielded a net return of \$130/head more than BCS 4 cows. This research demonstrates the potential consequences of not maintaining cows in good BCS (> 5) at calving; greater calf losses, less weaned calves, decreased pregnancy rate, and lower economic return

### Introduction

Protein supplementation of late-gestation beef cows consuming low-quality forages has been shown to increase cow body weight and BCS at calving (Sanson et al., 1990; Bohnert et al., 2002). Also, cows with a BCS less than 4 may breed late or not at all in a controlled breeding season. As a result, it is recommended to have cows in good body condition prior to calving to maximize reproductive performance. Recent research has suggested that providing supplemental protein to mature cows during the last 90 d of gestation improves calf survivability, yields greater economic return with retained ownership (Stalker et al., 2006), and improves weaning weight and fertility in heifers

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(Martin et al., 2007). This is novel work that demonstrates supplementation of the cow during the last third of gestation can affect the productivity of the offspring which was *in utero* during supplementation. The aforementioned cows began protein supplementation with an average BCS of 5 or greater. Based on this information, we hypothesize that cows in poor body condition (BCS  $\leq 4$ ) will respond more favorably to supplementation than cows in good condition (BCS  $\geq 5$ ).

The objectives of the current study were to determine the influence of cow BCS and DDGS supplementation during the last third of gestation on cow reproductive performance, calf growth and performance through the feedlot, and steer calf carcass characteristics. Also, if supplementation is to be profitable it must improve net returns; therefore, we estimated the economic impact of treatments.

## Materials and Methods

A 2-yr project was conducted to evaluate the effects of BCS and late-gestation DDGS supplementation of cows consuming low-quality forage. Each year, 120 cows were used in a  $2 \times 2$  factorial design. The factors were cow BCS (4 or 6) and supplementation (with or without supplementation). Each year, during a pre-study period (approximately 60 d prior to study initiation), 120 cows that had been palpated pregnant were stratified by BCS, blocked by age and weight, and randomly allocated to 1 of 4 treatment combinations: BCS 4 with no supplementation (BCS4 NS), BCS 4 with supplementation (BCS4 S); BCS 6 with no supplementation (BCS6 NS); BCS 6 with supplementation (BCS6 S). The cows were then managed as 2 separate groups based on BCS treatment (BCS 4 or BCS 6). The 2 BCS groups were placed in separate pastures and nutritionally managed to reach their respective target BCS by the study start date. During the pre-trial period all cows received meadow hay and the BCS 6 cows were supplemented with alfalfa as needed to help reach the target BCS by study start date.

At the beginning of the study, in early January each year, all 120 cows were placed into a 65 acre flood meadow pasture that had been harvested for hay the previous summer. All cows received approximately 28 lb/head/d of low-quality (about 6% CP) meadow hay through calving. Supplemented cows received DDGS every Monday, Wednesday, and Friday so that the total amount of DDGS provided over the week averaged 2 lb/head/d.

Upon calving, cows were weighed and body condition scored. Calves were weighed and a sample of blood collected for determination of serum IgG level (a measure of immune status). After being weighed, all cow/calf pairs were placed into an adjacent 65 acre pasture and provided approximately 30 lb/head/d of meadow hay until all cows had calved. At that time, all of the cow-calf pairs were transported to the Northern Great Basin Experimental Range (NGBER) and managed a single herd until weaning when calves averaged approximately 140 d of age.

At weaning, all cows were weighed and body condition scored and all calves were weighed. All weaned calves were transported from the NGBER and placed on a flood meadow pasture that had been rake-bunched (Turner and DeCurto, 1991) the previous summer. In addition, DDGS were provided to the weaned calves on Monday (2 lb/head), Wednesday (2 lb/head), and Friday (3 lb/head). After approximately 45 d, the weaned steer calves were placed in a commercial growing lot for approximately 60 d and then finished in a commercial feedlot in Northeast Oregon. In addition, cows were rectally palpated in mid-October each year for determination of pregnancy.

Cow and calf performance data were analyzed as a Randomized Complete Block using the PROC MIXED option in SAS (SAS Inst., Inc., Cary NC). The model included treatment, block, year, treatment  $\times$  block, treatment  $\times$  year, and block  $\times$  year. Data were analyzed using pen (treatment  $\times$  year) as random variable. Treatment differences were evaluated using the following contrasts: BCS 4 vs. BCS 6; Supplemented vs. Not Supplemented; and the interaction of BCS and Supplementation.

Binomial data (cow pregnancy rate, live calves at birth and weaning, and proportion of carcasses grading choice) were analyzed as a Randomized Complete Block using the PROC GLIMMIX procedure of SAS. The model, random variable, and contrasts were the same as used previously for the cow and calf performance data.

## Results

The total number of cows that were removed from the study because of death, loss of a calf, or palpated not pregnant was 19, 15, 4, and 6 for BCS4 S, BCS4 NS, BCS6 S, and BCS6 NS, respectively (Table 1). In addition, the number of calves lost through slaughter was 9, 8, 2, and 3 for BCS4 S, BCS4 NS, BCS6 S, and BCS6 NS, respectively.



**Table 1.** Losses of cows and calves.

Item	BCS 4		BCS 6	
	Supplement	No Supplement	Supplement	No Supplement
<b>Cows</b>				
n	60	60	60	60
Prepartum	1 <sup>c</sup>	0	0	0
Parturition	0	0	0	0
Cow Lost fetus during study	2	1	0	0
Lost calf prior to turnout	5 <sup>d</sup>	3 <sup>d</sup>	0	0
Palpated not pregnant	11	11	4	6
<b>Total (all causes)</b>	<b>19</b>	<b>15</b>	<b>4</b>	<b>6</b>
<b>Calves</b>				
Prepartum	2	1	0	0
Parturition	5 <sup>d</sup>	3 <sup>d</sup>	0	0
Weaning	1 <sup>e</sup>	1 <sup>e</sup>	1 <sup>e</sup>	0
Growing lot <sup>a</sup>	1 <sup>i</sup>	0	1 <sup>g</sup>	1 <sup>h</sup>
Finishing lot <sup>b</sup>	0	3 <sup>f,g</sup>	0	2 <sup>f</sup>
<b>Total (all causes)</b>	<b>9</b>	<b>8</b>	<b>2</b>	<b>3</b>

<sup>a</sup> Only remaining steer calves were placed in growing lot; n = 27, 26, 35, and 25 for supplemented and unsupplemented BCS 4 and supplemented and unsupplemented BCS 6, respectively.

<sup>b</sup> Only remaining steer calves were placed in finishing lot; n = 26, 27, 34, and 24 for supplemented and unsupplemented BCS 4 and supplemented and unsupplemented BCS 6, respectively.

<sup>c</sup> Cow got on back and suffocated.

<sup>d</sup> Calves born dead, no dystocia observed.

<sup>e</sup> Cause of death unknown.

<sup>f</sup> Calves died of pneumonia.

<sup>g</sup> Calf died of bloat.

<sup>h</sup> Crippling injury.

## Cow Performance

The initial weight of BCS 6 cows was approximately 136 lb heavier than the BCS 4 cows ( $P < 0.001$ ; Table 2). Likewise, the initial BCS of treatments came close to meeting our targeted values of 6 and 4 for BCS 6 and BCS 4 cows, respectively; the BCS 6 cows averaged 5.7 while BCS 4 cows averaged 4.3 ( $P < 0.001$ ). At calving, the difference in weight and BCS between BCS 6 and BCS 4 cows remained ( $P < 0.001$ ). However, we did note a supplementation effect with both cow weight and BCS at calving. At calving, the supplemented cows weighed more ( $P < 0.001$ ) and carried more BCS ( $P < 0.001$ ) than unsupplemented cows. At weaning, the BCS 6 cows were still heavier (66 lb;  $P < 0.001$ ) and had a greater BCS (0.6;  $P < 0.001$ ) than BCS 4 cows. In addition, the supplemented cows had a greater BCS than unsupplemented cows ( $P = 0.02$ ) at weaning.

No difference in the proportion of live calves at birth and weaning were observed due to supplementation ( $P > 0.15$ ); however, a difference was noted because of BCS treatment. The percentage of live calves at birth for the BCS 6 cows averaged 100% compared with 90% for the BCS 4 cows ( $P < 0.001$ ). Also, the percentage of live calves at weaning averaged 99% and 88% for BCS 6 and BCS 4 cows, respectively. Therefore, if we

extrapolate our data to a couple of theoretical cowherds entering the last third of gestation with an average BCS of 6 or 4, we could expect to have almost 11% more calves at weaning with the BCS 6 herd compared with the BCS 4 herd; an extra 11 calves per hundred cows.

Cow pregnancy rate was not affected by supplementation treatment ( $P = 0.93$ ); however, there was a difference between the BCS 6 and BCS 4 cows. The mean pregnancy rate for BCS 4 cows was 79% compared with 91% for the BCS 6 cows ( $P < 0.01$ ). Our breeding season was 60 d, so it is possible that a longer breeding season would have resulted in greater pregnancy rates, but the calving interval would be longer, cows may not have a calf within a 365-d interval, and consistency and calf weight at weaning would be less.

## Calf Performance

Calf birth weight increased with cow BCS (91 vs. 85 lbs for BCS 6 and 4, respectively;  $P = 0.002$ ; Table 3) and with supplementation (90 vs. 87 lbs for supplemented and not supplemented, respectively;  $P = 0.05$ ). However, no incidents of dystocia were noted during the study. There was no treatment effect on calf serum IgG level at birth ( $P \geq 0.10$ ).

**Table 2.** Cow performance relating to body condition score (BCS) and supplementation (Supp.) during late gestation. <sup>a</sup>

Item	BCS 4		BCS 6		SEM	P-value		
	Supp.	No Supp.	Supp.	No Supp.		BCS 4	Supp.	BCS
						vs.	vs.	x
						BCS 6	No Supp.	Supp.
Initial wt., lb <sup>b</sup>	1,110	1,107	1,239	1,251	10	<0.001	0.65	0.46
Calving wt., lb	1,171	1,091	1,256	1,186	11	<0.001	<0.001	0.63
Wt. at Weaning, lb	1,151	1,130	1,214	1,198	12	<0.001	0.10	0.81
Initial BCS <sup>c</sup>	4.32	4.39	5.67	5.75	0.05	<0.001	0.14	0.83
Calving BCS	4.57	4.33	5.51	5.18	0.05	<0.001	<0.001	0.36
Weaning BCS	4.74	4.61	5.30	5.19	0.05	<0.001	0.02	0.84
Days to calving	76	79	76	76	2.5	0.58	0.55	0.43
Live calf at birth, %	86.7	93.3	100.0	100.0	2.7	<0.001	0.22	0.22
Live Calf at Weaning, %	85.0	91.7	98.3	100.0	3.0	<0.001	0.16	0.40
Pregnancy rate, %	77.2	80.7	92.8	90.0	4.6	0.005	0.93	0.48

<sup>a</sup> Pretrial period was 11/1/06 to 1/4/07 in year 1 and 11/8/07 to 1/3/08 in year 2; During pretrial, BCS 4 and BCS 6 cows were managed as 2 separate groups and fed to reach target BCS by study start date.

<sup>b</sup> Initial pretrial wt. Averages: Overall = 1105 ± 99 lb; BCS 4 = 1105 ± 94; BCS 6 = 1105 ± 105.

<sup>c</sup> Initial Pretrial BCS Averages: Overall = 4.30 ± 0.32; BCS4 = 4.28 ± 0.26; BCS 6 = 4.31 ± 0.36.

**Table 3.** Calf performance relating to cow body condition score (BCS) and supplementation (Supp.) during late gestation.

Item	BCS 4		BCS 6		SEM	P-value		
	Supp.	No Supp.	Supp.	No Supp.		BCS 4	Supp.	BCS
						vs.	vs.	x
						BCS 6	No Supp.	Supp.
Birth wt., lb	86.1	84.8	93.9	88.6	1.6	0.002	0.05	0.21
Igg. Mg/dL	5,880	6,348	5,836	6,088	231	0.49	0.10	0.62
Weaning wt., lb	415	395	424	411	7	0.05	0.01	0.58
Weaning age, days	140	137	140	141	2.8	0.46	0.65	0.53
ADG to weaning, lb	2.36	2.28	2.36	2.30	0.03	0.81	0.02	0.70
Growing lot initial wt., lb	456	439	472	459	12.2	0.11	0.18	0.86
Growing lot final wt., lb	564	545	582	565	13.4	0.14	0.16	0.94
Growing lot ADG, lb	1.39	1.33	1.41	1.30	0.08	0.97	0.26	0.74
Feedlot initial wt., lb	564	545	582	565	13.4	0.14	0.16	0.94
Feedlot final wt., lb <sup>a</sup>	1,294	1,278	1,308	1,277	25	0.79	0.32	0.74
Feedlot ADG, lb	4.03	4.21	4.18	4.14	0.2	0.84	0.71	0.54
Feedlot days on feed	178	166	177	166	7	0.84	0.10	0.86
Hot carcass wt., lb	815	805	824	804	16	0.79	0.32	0.74
Backfat, inches <sup>b</sup>	0.70	0.66	0.64	0.66	0.04	0.32	0.83	0.36
Ribeye area, inches <sup>2</sup>	13.5	13.1	13.5	13.4	0.28	0.65	0.37	0.66
KPH, %	2.07	1.99	1.93	2.24	0.11	0.62	0.25	0.05
Marbling <sup>c</sup>	423	403	434	420	14	0.33	0.24	0.84
Yield grade	3.4	3.4	3.3	3.40	0.15	0.49	0.86	0.70
Choice, %	57.6	38.6	65.7	62.4	11	0.13	0.28	0.42
Retail product, % <sup>d</sup>	48.7	48.8	49.0	48.9	0.36	0.50	0.88	0.66

<sup>a</sup> Calculated from hot carcass weight assuming a 63% dressing percentage.

<sup>b</sup> Thickness measured at the 12<sup>th</sup> rib.

<sup>c</sup> Marbling score: 400 = small, 500 = modest

<sup>d</sup> USDA Retail Yield Equation: 51.34 – (5.78\*inches backfat) – (0.0093\*pounds hot carcass weight) – (0.462\*percentage kidney, pelvic, and heart fat) + (0.74\*ribeye area in square inches)

**Table 4.** Economics relating to cow body condition score (BCS) and supplementation (Supp.) during late gestation

Item	BCS 4		BCS 6		BCS Difference <sup>a</sup>	Supp. Difference <sup>b</sup>
	Supp.	No Supp.	Supp.	No Supp.		
<b>Cow-Calf Phase</b>						
Returns						
More Calves Weaned <sup>c</sup>	0.00	0.00	54.14	52.50		
Weaned Calf Value	488.98	465.32	499.87	484.78		
Costs						
Supplement	15.25	0.00	15.25	0.00		
Hay	90.73	96.10	90.80	90.10		
<b>Net Returns</b>	<b>383.00</b>	<b>369.22</b>	<b>447.96</b>	<b>447.18</b>	<b>71.46</b>	<b>7.28</b>
<b>Growing Lot Phase</b>						
Returns						
Calf Value	577.91	558.23	596.96	578.97		
Costs						
Purchase Cost	488.98	465.32	499.87	484.78		
Growing Lot Feed Costs	82.90	82.90	82.90	82.90		
Growing Lot Health Costs	1.95	0.93	1.80	2.14		
<b>Net Returns</b>	<b>4.08</b>	<b>9.08</b>	<b>12.39</b>	<b>9.15</b>	<b>4.19</b>	<b>(0.88)</b>
<b>Feedlot Phase</b>						
Returns						
Carcass Value	1140.04	1125.78	1152.11	1124.73		
Costs						
Purchase Cost	577.91	558.23	596.96	578.97		
Feedlot Feed Costs	501.48	468.35	495.10	468.36		
Feedlot Health Costs	0.58	4.59	2.72	11.98		
<b>Net Returns</b>	<b>60.07</b>	<b>94.61</b>	<b>57.33</b>	<b>65.42</b>	<b>(15.97)</b>	<b>(21.32)</b>
<b>Retained Ownership</b>						
Returns						
More Carcasses <sup>c</sup>	0.00	0.00	124.77	121.81		
Carcass Value	1140.04	1125.78	1152.11	1124.73		
Costs						
Supplement	15.25	0.00	15.25	0.00		
Hay	90.73	96.10	90.80	90.10		
Growing Lot Feed Costs	82.90	82.90	82.90	82.90		
Growing Lot Health Costs	1.95	0.93	1.80	2.14		
Feedlot Feed Costs	501.48	468.35	495.10	468.36		
Feedlot Health Costs	0.58	4.59	2.72	11.98		
<b>Net Returns</b>	<b>447.15</b>	<b>472.91</b>	<b>588.31</b>	<b>591.06</b>	<b>129.66</b>	<b>(14.26)</b>

<sup>a</sup> Difference in net returns between the average of BCS 6 and BCS 4 treatments.

<sup>b</sup> Difference in net returns between the average of supplemented and non-supplemented treatments.

<sup>c</sup> Increased returns resulting from increased percentage of live calves at weaning (10.83%) for the average of BCS 6 treatments compared with the BCS 4 treatments.

Calf weaning weight was greater for BCS 6 compared with BCS 4 cows ( $P = 0.05$ ) and for supplemented cows compared with those cows not receiving supplement ( $P = 0.01$ ). In addition, calf ADG to weaning was greater for calves from dams that received supplement during the last third of gestation ( $P = 0.02$ ). This agrees with previous work indicating that supplementation of cows pre-calving increases weaning performance of calves (Stalker et al., 2006).

No notable treatment effects were observed in steer calf performance in the growing lot or feedlot ( $P \geq 0.10$ ). The only carcass characteristic

affected by treatment was KPH which decreased with supplementation for BCS 4 cows and increased with supplementation for BCS 6 cows ( $P = 0.05$ ). The reason for this observation is not readily apparent. None of the other carcass characteristics were affected by treatment ( $P \geq 0.13$ ).

### Economics

Table 4 lists the estimated net returns of treatments broken down in 4 production phases; cow-calf, growing lot, feedlot, and retained ownership. The most notable affect on net returns was because of cow BCS. The BCS 6 cows returned

approximately \$71/cow more than the BCS 4 cows if calves were sold at weaning and approximately \$130/cow more if we retained ownership of the calves through the feedlot. The primary reason for the disparity in net returns is due to more live calves at weaning. Supplementation had minimal effects on net returns with the greatest benefit noted in the cow-calf phase where supplemented cows had a \$7/cow greater net return than unsupplemented. Nevertheless, it is interesting to note the approximately 500% greater health costs in the feedlot for calves from unsupplemented compared with supplemented cows (\$8.28 vs.\$1.65/head).

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## Conclusions

Supplementation of beef cows during the last third of gestation resulted in cows with greater BCS at calving and weaning compared with not supplementing. In addition, calves from cows that received supplement were heavier at weaning and had greater ADG from birth to weaning. However, the greatest effect of cow productivity was because of cow BCS entering the last third of gestation. The BCS 6 cows were in better condition at calving and weaning, they had approximately 10% more live calves at birth and weaning, and they had an 11% greater pregnancy rate than BCS 4 cows. As a result, estimated net returns for BCS 6 cows were approximately \$71/cow greater than BCS 4 if calves were sold at weaning and \$130/cow if ownership of calves was retained through the feedlot. These data demonstrate the potential economic importance of making sure your cows are in a good BCS ( $\geq 5$ ) prior to entering the last third of gestation.

## Acknowledgments

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Beef Cattle Sciences

# Oregon Beef Council Report

## Oregon bio-security education and demonstration program using Bovine Viral Diarrhea Virus, Persistently Infected (BVD PI) cattle screening as a model to minimize risk of infectious disease and initiate BVD control <sup>1</sup>

Barbi A. Riggs<sup>2</sup>, Randy Mills<sup>3</sup>, Charles T. Estill<sup>4</sup>, and Chad Mueller<sup>5</sup>

### Synopsis

The Oregon biosecurity education and demonstration program uses BVD PI cattle screening as a model to minimize risk of infectious disease and initiate BVD control.

### Summary

The objective of this project was to evaluate the prevalence of BVD PI in beef cattle in Oregon. To date 9,822 heads of cattle have been enrolled in the OSU Biosecurity/BVD program, representing 39 ranches located in 16 counties. Of which, 8,404 animals have completed BVD PI screening from 36 ranches. Preliminary results indicate the prevalence of BVD PI in Oregon is 0.07%. However, 11% of ranches that have completed BVD PI screening had at least one animal testing positive for BVD PI. Data suggests that the prevalence of BVD PI among all cattle is lower than the reported national prevalence (0.13-2.0%). However, data indicates that there are more ranches (11%) in Oregon that have at least one animal test positive for BVD PI than the national rate (4%). The preliminary data does not adequately represent the geographical distribution of the cattle population

or ranches in Oregon and therefore further BVD PI screening needs to be conducted.

### Introduction

The purpose of this project is to introduce and implement biosecurity planning to reduce the risk of introduction and spread of disease within the Oregon cattle industry. This project has three important components; education, diagnosis, and financial benefit for Oregon beef producers. To date only two of the three components have been documented: education and diagnosis.

Bovine Viral Diarrhea virus (BVD) has received significant attention from the private sector and academia as a disease that causes insurmountable economic loss to the cattle industry throughout the U.S. The economic impact has driven the industry to begin adopting premium payments for cattle sold as BVD persistently infected (PI) free. The increased public awareness and added market value creates the opportunity to educate ranchers on biosecurity practices, using BVD as a model, with additional opportunity to increase revenue of Oregon cattle sold as BVD PI free. The long term impact of this project on the Oregon cattle industry includes

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improved herd health, resulting in improved performance, marketability, profitability and improved consumer confidence of Oregon raised cattle. It is our intent that this project will help not only control the prevalence of BVD in the state but will also impact prevalence of other diseases of concern such as trichomoniasis and paratuberculosis. Biosecurity education will prepare the Oregon cattle industry to contain other potential catastrophic diseases such as foot and mouth disease (FMD).

Bovine Viral Diarrhea virus (BVD) is a complex disease that causes beef cattle to have a range of symptoms from sub-clinical manifestations to death; including acute infections with respiratory tract disease, digestive tract disease, and conditions associated with the immunosuppressive effects which favor secondary infections. Fetal infections are the most important manifestation of BVD, particularly when susceptible pregnant heifers/cows develop a viremia after the initial acute infection. There are several possible outcomes of fetal infection, depending on gestational stage when the fetus is exposed: abortions, congenital abnormalities, and newborn calves born immunotolerant to the BVD and are PI throughout their lifetime (Fulton, 2002). The PI animal is the most important animal in regards to transmission of BVD to susceptible cattle as the PI animal has a very high persistent viremia and BVD is shed throughout life.

It is difficult to establish the economic impact BVD PI animals have on the cattle industry. Impacts including performance loss, reproductive efficiency loss, and carcass effects that BVD induced secondary diseases may have. Studies indicate that in herds with at least one PI animal present, the cost of BVD was reported to be \$14.85-\$24.84 per cow/year (Larson et al, 2002). The feedlot segment reports the cost of BVD per head is between \$30.00 to \$47.00 (Hessman, 2006). The economic impact of BVD has driven the interest for control programs around the country.

Vaccination programs alone cannot control or eliminate BVD. A successful control program must include not only proper vaccination, but removal of PI animals and implementation of proper biosecurity measures to minimize or eliminate risk of re-exposure to BVD (Dubovi, 2001; Fulton, 2002). Implementation of a biosecurity plan will reduce risk of exposure to many other economically important infectious diseases and prepare producers

for biological risk management in the event of a disease outbreak, local or national.

The prevalence of BVD in the state of Oregon is undocumented. Studies show that prevalence of BVD in the U.S. beef cattle population is between 0.13% and 2.0%. The prevalence of herds that have at least one PI is around 4% (O'Connor et al., 2007; Wittum et al., 2001). While most herds are BVD PI free; of the herds that have BVD PI animals, it is likely that there will be more than one PI animal in the herd. It will be our intention that the prevalence of BVD PI in the state of Oregon be documented as a result of this study.

## Materials and Methods

Enrollment for this project began October, 2008. Beef cattle producers were exposed to the OSU Biosecurity/BVD PI control program via oral presentations or written articles at local and state Oregon Cattlemen's Association meetings, OSU Extension programs and state and local media. Each of these oral presentations or written articles was designed to educate ranches on the disease of BVD and about the importance of biosecurity.

Ranches were recruited to participate in the OSU program and test for BVD PI at each educational event. Ranches enrolled in the program submitted an application and questionnaire to the OSU Biosecurity/BVD team and in return received testing supplies to collect and submit ear notch samples to Animal Profiling International, Inc. for BVD PI screening. Cattle herds were screened through reverse transcriptase polymerase chain reaction (PCR) technology using pooled animal tissue samples of 28 samples or less. A reverse transcriptase-PCR assay on pooled fresh tissue is a sensitive and specific method of screening cattle for BVD PI.

A PCR test positive for BVD PI ((+) PI) required a second test 3 weeks after the initial sample to differentiate transient from persistent infection. If the (+) PI animals are confirmed to be persistently infected upon the second test result, the animal was quarantined from any and all non-PI animals until euthanasia or harvest could occur. The dams of a calf that is (+) PI, as determined by the above method, was also tested for BVD PI by using PCR and protocol as outlined above.

**Table 1.** Oregon cattle and ranches tested for BVD PI through OSU Biosecurity/BVD program and Animal Profiling International.

Timeline	Cattle Enrolled	Ranches Enrolled	Cattle Tested	Ranches Tested	Cattle PI (+)	Ranches with at least one PI (+)	Prevalence of BVD PI in Cattle	Percent of Ranches that have at least one BVD PI (+)
<b>OSU Biosecurity/BVD Program</b>								
Oct. 2008 to July 2009	9,822	39	8,404	35	6	4	0.07 %	11%
<b>Animal Profiling International</b>								
2006			6,230		13		0.21%	
2007			7,258		15		0.21%	
2008			8,913	93	7	3	0.06%	3.23%
2009 (Jan-July)			11,422	111	7	4	0.06%	7.92%
Total API			33,823		56		0.17%	

## Results

The OSU BVD/Biosecurity program opened October 2008. To date we have spoke to cattlemen across the state of Oregon at seven different locations. The program has been highlighted in the Oregon Beef Producer Magazine and various other periodicals. We are reaching out to our clientele via written, web, and spoken education. To date 864 producers have either attended a seminar or a trade show in which Oregon Biosecurity/BVD Control Program was highlighted. More than 300 producers have actively collected our written research and educational materials and 9,000 people have been exposed to the program via popular media.

To date, 9,822 cattle have been enrolled in the program and 8,404 animals have completed the testing. This represents 35 ranches (Table 1). The OSU program was initiated in October, 2008 and will continue until October, 2010. Preliminary data in this study showed a 0.07% prevalence of BVD PI, or roughly one animal per 1500 head of cattle tested. This is below the national prevalence number of 0.13%-2.0%. However, the preliminary OSU data showed 11% of herds tested had at least one PI positive (+) animal, which is well above the estimated national number of 4% of herds tested had at least one PI (+) animal.

Animal Profiling International, the contracted laboratory conducting the reverse transcriptase-PCR assay for BVD PI, has documented prevalence of the disease in Oregon over the past four years (Table 1). In 2006 and 2007 the prevalence of animals having BVD was close to the national figures (0.21%), however, over the past

2 years the prevalence was lower than the national average (0.06%).

This study was designed to determine if the beef cattle population (1,390,000 head) in Oregon had a greater or lesser prevalence of Bovine Viral Diarrhea Virus persistently infected animals than what is found in the US cattle population. Nationwide, the prevalence of BVD-PI has been estimated to be between 0.13 and 2.0%. If we assume that the true prevalence is roughly in the middle of this range (1.05%) then we would like to know if Oregon has a higher or lower prevalence than the average national prevalence estimate. Using Win Episcope 2.0 to estimate Sample Size for Threshold Levels with Expected proportion in the population of 1.06% and Threshold Proportion in Group of 1.7% with 99% confidence and 95% Power of Test we needed to sample 5,376 animals. The current study has sampled 8,404 animals. However, this represents only 16 counties in Oregon, of which 6 of the counties had only one ranch enrolled in the OSU BVD/Biosecurity program. This data set is not adequate to evaluate if geographical regions within Oregon have similar prevalence rates. Furthermore, some of the counties with the largest cattle populations are under-represented (Malheur, Union, Wallowa, Klamath and Lake). Likewise, Harney county, with the largest cattle population in the state, has not enrolled nor tested any cattle to date. Prevalence of BVD PI cattle reported in this study are preliminary numbers only, a more complete data set representing a greater number of counties and a greater proportion of cattle



needs to be collect in order to have a more clear idea of the true prevalence of BVD PI in the state of Oregon.

## Conclusions

In conclusion, preliminary results from this study suggest the prevalence of BVD PI among all cattle in Oregon (0.07%) may be lower than the national prevalence rate (0.13%-2.0%). On the other hand, the number of ranches in Oregon with at least one BVD PI animal (11%) appears to be larger than the national figure (4%). However, the data collected to date does not adequately represent the differences in geographical populations of cattle or ranches. Further BVD PI diagnosis needs to be conducted to provide a more accurate prevalence number.

## Acknowledgments

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Beef Cattle Sciences

# Oregon Beef Council Report

## Outreach, Technical Assistance and General Project Facilitation for Farm-based Livestock Manure/Biogas Production Systems <sup>1</sup>

Amanda Green<sup>2</sup> and Mike Gamroth<sup>3</sup>

### Synopsis

In an effort to remain profitable, many of today's livestock operations have grown larger and more concentrated to benefit from economies of scale and to make up the decline in profit margin through an increase in volume. This growth has forced farmers to face new challenges in the management of manure. These challenges include nutrient concerns, environmental concerns, and health concerns, in addition to problems in community relations. Anaerobic digesters offer an effective way for livestock operations to respond to these concerns.

### Summary

Biogas production on livestock operations requires a large investment and project development is time-consuming. This project is meant to assist producers in the development of renewable energy projects. The Coordinator helps identify interested livestock operations where an anaerobic digester and associated electric power generation makes business sense, helps identify appropriate technology, assists applicants in the process of securing cost-share funds and permits, and assists in getting a digester built and operating to full potential. Often the work is with developers and agencies willing to build or fund anaerobic digesters.

### Introduction

In the mid 1970's, rising oil prices triggered interest in farm scale digestion for energy production. The early failure rate was high; however anaerobic digesters have increased since the Environmental Protection Agency's AgSTAR program inception in 1994. These anaerobic digesters have shown potential to provide an environmentally-friendly solution to several farm-based problems with one technology. As of December 2008, there are 121 farm-scale digesters operating at commercial livestock farms in the United States, with 2 located in Oregon. Anaerobic digesters can help farms to produce energy, control odor, improve air quality and reduce greenhouse gas emissions. A digester can make valued by-products like irrigation water, nitrogen for fertilizer, low-phosphorus manure, and biofibers. The biogas captured can be used to generate hot water, electricity or pipeline-quality natural gas.

The process of building a farm digester is onerous. It is far too technical and time-consuming for the average livestock producer. This project has connected experienced digester developers with suitable farms for energy generation.

### Materials and Methods

This project is beginning its third year. The Renewable Energy Project Coordinator has helped identify and make contact with livestock operations

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interested in a manure-to-gas system. She has inventoried appropriate digester and generation technology for the Oregon livestock operations. Using analysis software, she has helped livestock producers with an initial look at the technical and business potential for a biogas project on their operation. Where the initial scope is positive, she helps livestock producers commission a feasibility study, including identifying and managing consultants, as well as identifying and helping to apply for sources of study funding (e.g., Energy Trust of Oregon, USDA Value-added grants, Oregon Department of Energy). Where a feasibility study proved promising, the Coordinator advises livestock operations on project funding, system specifications, and facilitates relevant agreements such as the power purchase agreement with the utility. When a producer chooses not to build and operate a digester on their own, the coordinator can connect the producer with a reputable digester development company. In all cases the Coordinator is the liaison between the farms and the contractors. The ultimate goal of the project is to collaborate with Energy Trust of Oregon and other entities as appropriate to build the Oregon market for a farm-based anaerobic digestion. Community outreach about developments and updates is part of the approach. Farm field days, printed case studies, and fact sheets are used.

## Results

To date, information on anaerobic digesters has been presented at 11 producer meetings. Often the information on renewable energy production is accompanied by information on energy conservation as requested by Energy Trust of Oregon. At least 20 producers have received individual farm visits or basic feasibility printouts by the authors. Revolution Energy Solutions (RES) of Washington, D.C.; Andgar Corporation, Ferndale, WA; GHD, Inc., Chilton, WI; and Farm Power Northwest, Mount Vernon, WA have been identified as developers willing to design, fund, and operate digesters in Oregon. RES has been successful in getting Lane County Planning Department approval for siting a digester on a dairy near Junction City and signed the power purchase agreement with the Emerald Public Utility District on October 12<sup>th</sup>. They have 5 other operations in Marion County going through land use approval now. The power from these will be sold to Pacific Power and Light and Portland General Electric.

## Conclusions

Anaerobic digesters offer solutions to concerns of nutrient management. Anaerobic digestion converts much of the organic nitrogen into ammonium yielding an effluent with 60-80% ammonium. Ammonium availability is a predictable fertilizer, whereas organic nitrogen availability is unpredictable. The higher the percentages of nitrogen in the ammonium form, the less uncontrolled release of nitrogen from organic compounds to the soil. To maximize the benefit of manure fertilization and minimize leaching losses, ammonium is preferred. Studies have shown that through the digestion of manure, offensive odors have been drastically reduced, and in most cases become undetectable. In addition to addressing the environmental and health concerns associated with manure, anaerobic digestion also provides potential economic benefits from its byproducts. Through the anaerobic digestion of agricultural waste, biogas is released, mostly in the form of methane. This methane can then be collected and channeled into a generator to produce electricity, or burned to produce heat. The dried fiber that can be produced from the manure can also be used on the farm as fertilizer, feed supplement, bedding, or other uses. Moreover, the fiber can be commercialized for these uses as well.

The cost of an anaerobic digester systems vary widely depending on size and the intended purposes. Plug flow digesters range from \$200,000 for 100 dairy cows, to \$1.8 million for 7,000 dairy cows. These costs, of course, must be weighed against revenue streams developed with digestion's by-products. Revenues come from electric generation, and sale of digested fiber for compost, and from reduced costs for natural gas and propane, as well as reduced bedding costs. When the biogas produced by the system is put to work, digesters could have payback periods of five to seven years, substantially more attractive than the costs typically associated with conventional approaches. Additionally, livestock operations that produce biomass to be used in Oregon as biofuel are eligible for a tax credit on their Oregon Income Tax return at \$5 per wet ton of animal manure processed.

## Acknowledgments

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Beef Cattle Sciences

# Oregon Beef Council Report

## The Impact of Fiber Digestibility on Energy of Cool Season Grasses<sup>1</sup>

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Troy Downing<sup>2</sup>

### Synopsis

Fiber digestibility is a significant factor in the overall energy content of cool season ryegrasses.

### Summary

Nutritionists have known for years that forages with the exact same laboratory analysis could produce significantly different performance in lactating cows. It has been speculated that neutral detergent fiber digestibility (NDFD) may explain much of this variation in performance. The objectives of this study were to demonstrate the NDFD variation between varieties of ryegrass and season of harvest, and to use this information as the basis for an educational Extension program. Large differences in NDFD were found among 11 varieties of ryegrass. This information was used to change the way livestock rations are balanced and will hopefully convince grass seeds companies to focus more on fiber digestibility in the future.

### Introduction

Plant fiber has three major components: cellulose, hemicellulose, and lignin. Cellulose and hemicellulose are digestible to some extent by ruminants. Ruminants can convert these fiber components to energy because the rumen provides the correct environment for bacteria and other microorganisms to break down the fiber. Lignin is indigestible, and thus cannot be used by ruminants for energy.

Most of the energy that a cow receives in her diet comes from carbohydrates, which are a combination of non-fiber carbohydrates (grains) and fiber carbohydrates. As the digestibility of the fiber fraction increases, the total net energy of the forage increases as well as total feed intake (Nocek and Russell, 1988; Titel, 2000). Increasing neutral detergent fiber digestibility (NDFD) by 1% resulted in a 0.37 lb increase in dry matter intake and boosted fat-corrected milk production by 0.55 pounds (Oba and Allen, 1999a).

Several factors can affect forage's NDFD, including the amount of lignin, hybrid or variety, soil fertility, weather conditions, and forage harvest and storage practices (Oba and Allen, 1999a; Casler and Jung, 2006; Jung, 1989). In the past few years, several researchers have looked closely at NDFD in corn and alfalfa; particularly the variation among varieties (Beckman and Weiss, 2005; Oba and Allen, 1999b). However, limited research has been done regarding the NDFD variation in cool-season grasses.

In one study in the Midwest, the average NDFD of grass hay/silage samples submitted for fiber digestibility analysis was 53%, while individual samples ranged from 36 to 74% (Hoffman, 2003). For a typical dairy ration, this variation could result in a 5 lbs/cow daily difference in milk production. Similar production responses and variation would be expected in growing sheep and cattle as well.

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1. This document is part of the Oregon State University – Beef Research Reports. Published in November 2009. Please visit the Beef Cattle Sciences website at <http://beefcattle.ans.oregonstate.edu>.  
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Livestock producers and nutritionists have known for years that forages with the exact same laboratory analysis could have significantly different performance in lactating cows. In the past few years, research has shown that the digestibility of neutral detergent fiber (NDF) may explain much of this variation. However, in Oregon very few nutritionist or producers have been accounting for fiber digestibility in grass while balancing rations. Part of the resistance for change has been the lack of understanding on the large variations seen in grasses compared to corn or alfalfa. This project was designed to highlight the large variation in the NDFD of grasses and persuade producers and nutritionist to change the way they balance rations. The objectives of this project were to: 1) Determine fiber content and the variation in digestibility of eleven common ryegrasses; 2) Evaluate variation by cutting; 3) Determine annual energy differences due to NDFD differences; and 4) Use the information as part of an educational Extension program aimed at both livestock producers and the grass seed industry.

## Materials and Methods

Eleven ryegrasses commonly grown in Oregon were selected and planted in September in Tillamook, OR. Plots were 5' x 20', replicated three times and all planted at the same time. Plots were fertilized annually using four separate applications of nitrogen of approximately 75 lbs/acre/year (total of 300 lbs of nitrogen annually).

For two years, the plots were mechanically harvested six times per year at approximately 28 day intervals beginning in March and continuing through August. Yield data was recorded and samples were collected and dried in a 55°C forced-air oven for 48 hour and analyzed for dry matter content. All samples were ground with a Wiley Mill (1mm screen; Arthur H. Thomas, Philadelphia, PA). Samples were analyzed for neutral detergent fiber (NDF) and NDFD (VonSoest et al., 1991.) Fiber digestibility was determined in our lab using a Daisy II Incubator (Ankom Technology, Macedon, NY).

Digestibility and yield data were analyzed and developed into an educational Extension program that was conducted across the state in two statewide workshops and six regional programs. Information was included in newsletters going to producers, nutritionists, and the grass seed industry as well as being presented at the Pacific Northwest Nutrition Conference. Data were analyzed as a

completely randomized design with the MIXED procedure of SAS (SAS Institute, Cary, NC).

## Results

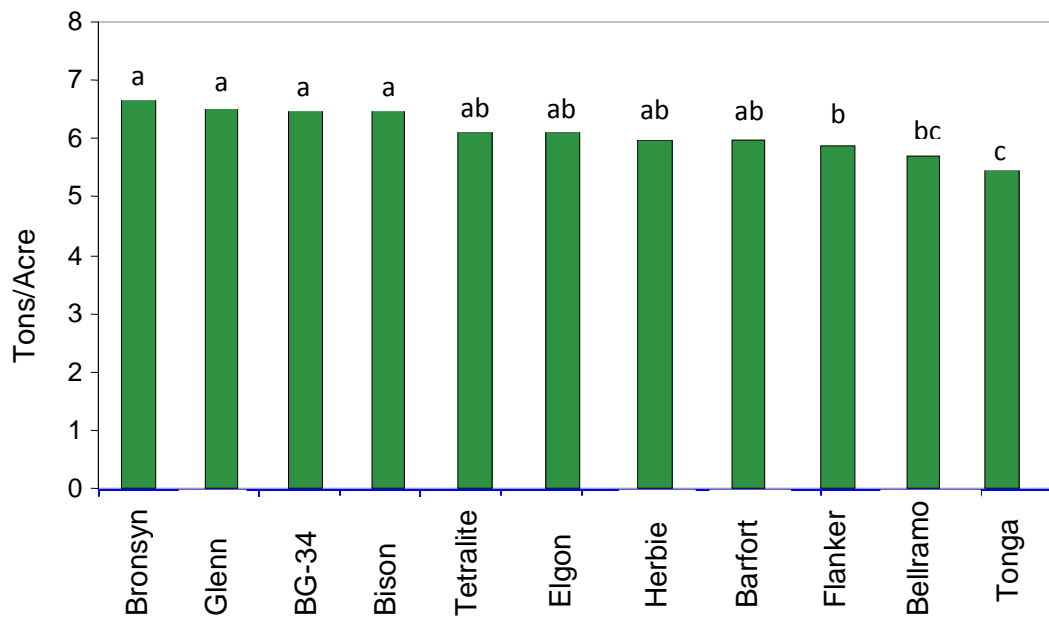
Total dry matter ranged from 5.8 tons to 6.5 tons per acre. Bronsyn was the highest yielding ryegrass both years and Tonga was the lowest producing variety both years (Figure 1). Figure 2 illustrates the NDF of each variety over the two years studied. Data indicated there was a 10% difference in NDF content between the highest variety (Bronsyn) and the lowest variety (Tetralite). The NDF values ranged from a high 48.6% down to 44.4%

Figure 3 illustrates the NFD digestibility by variety. Elgon recorded the highest NDFD at 81.9% and Flanker had the lowest average of 73.9%. Figure 4 illustrates the total pounds of digestible fiber harvested annually by variety. This value is generated by multiplying the yield times the percentage of digestible fiber. This analysis showed a 32% variation in digestible fiber per acre from the highest variety of ryegrass (Glenn) to the lowest variety (Tonga).

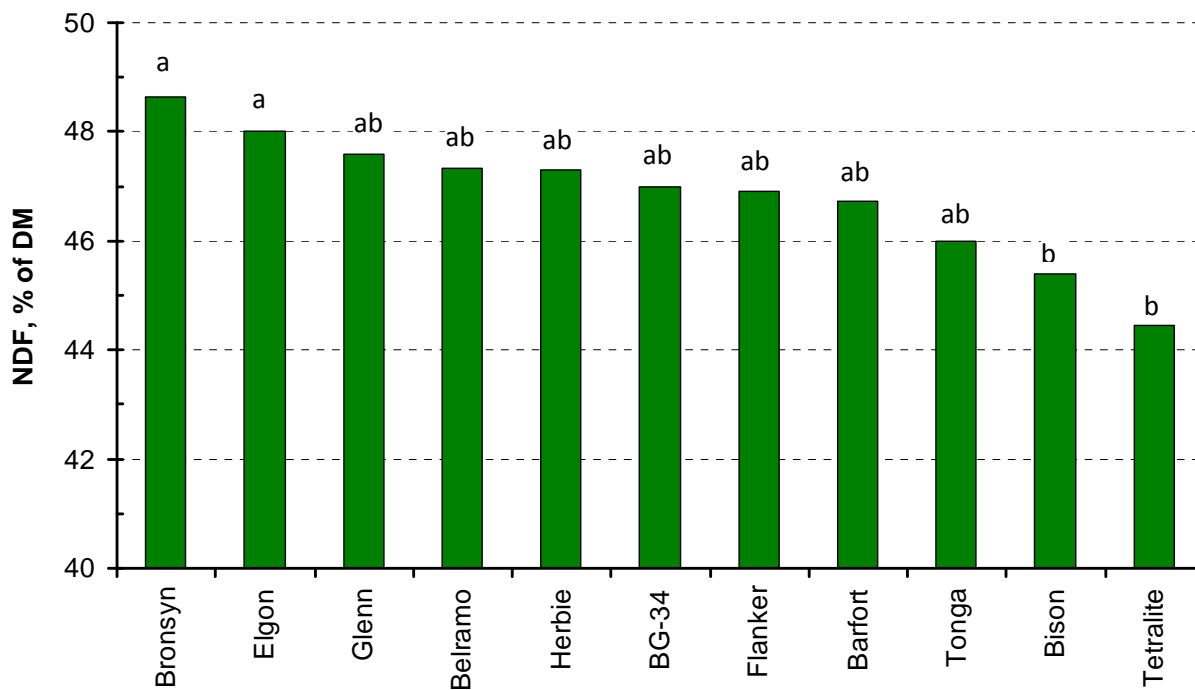
One major goal of this project was to understand seasonal changes in fiber and fiber digestibility. Figure 5 illustrates NDF and NDFD values by cutting for all varieties averaged. Neutral detergent fiber values averaged 45% of the total dry matter in March, but ended up at 51% by August. Conversely, NDFD was at 83% in March and declined to around 65% by August. All varieties were harvested on the same day on approximately 30 cuttings, six times throughout each year.

## Conclusions

As we continue to learn more about NDFD in grasses, it becomes apparent there are significant variations that have large financial impacts on producers and alter animal performance. The difference seen from the best ryegrass to the worst is significant for several reasons. First, a 10% increase in digestible fiber means there is more energy available in the rumen for microbial growth and ultimately for milk production and/or animal performance. This increased energy actually increases nitrogen efficiency allowing the rumen to make better utilization of the nitrogen in the forage. Better nitrogen utilization reduces losses in the form of ammonia gas and excretions in the urine.

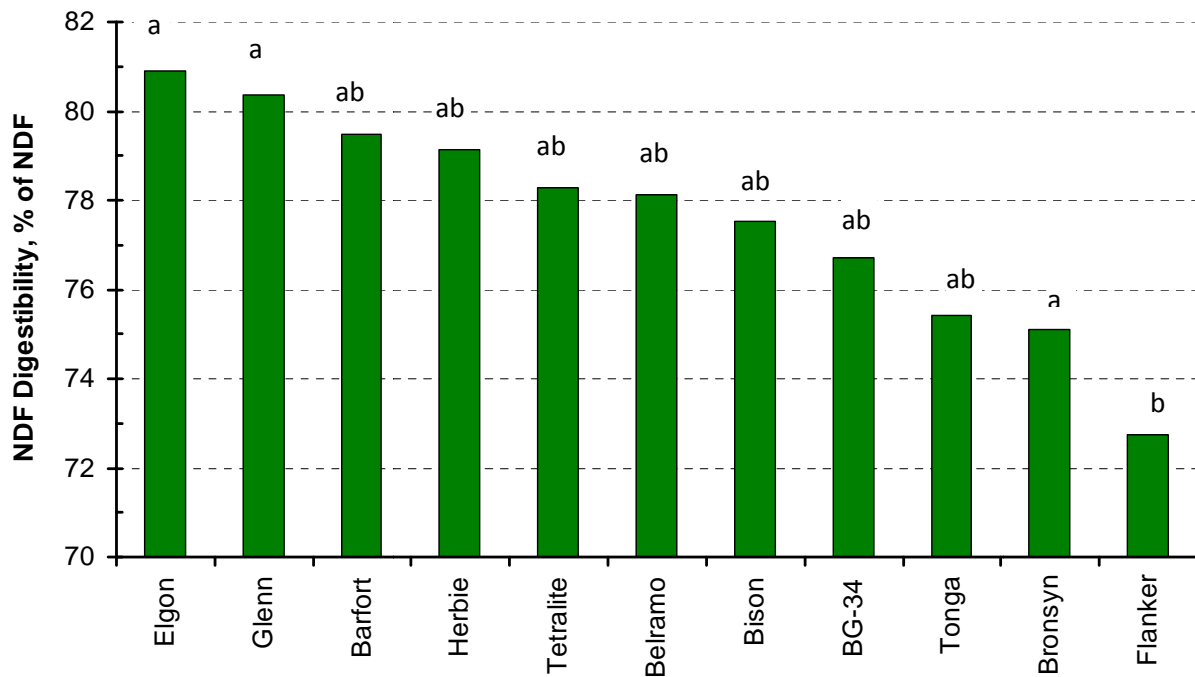


**Figure 1.** Annual dry matter yield of six cuttings of 11 perennial ryegrasses. Means different superscripts differ ( $P < 0.05$ ).

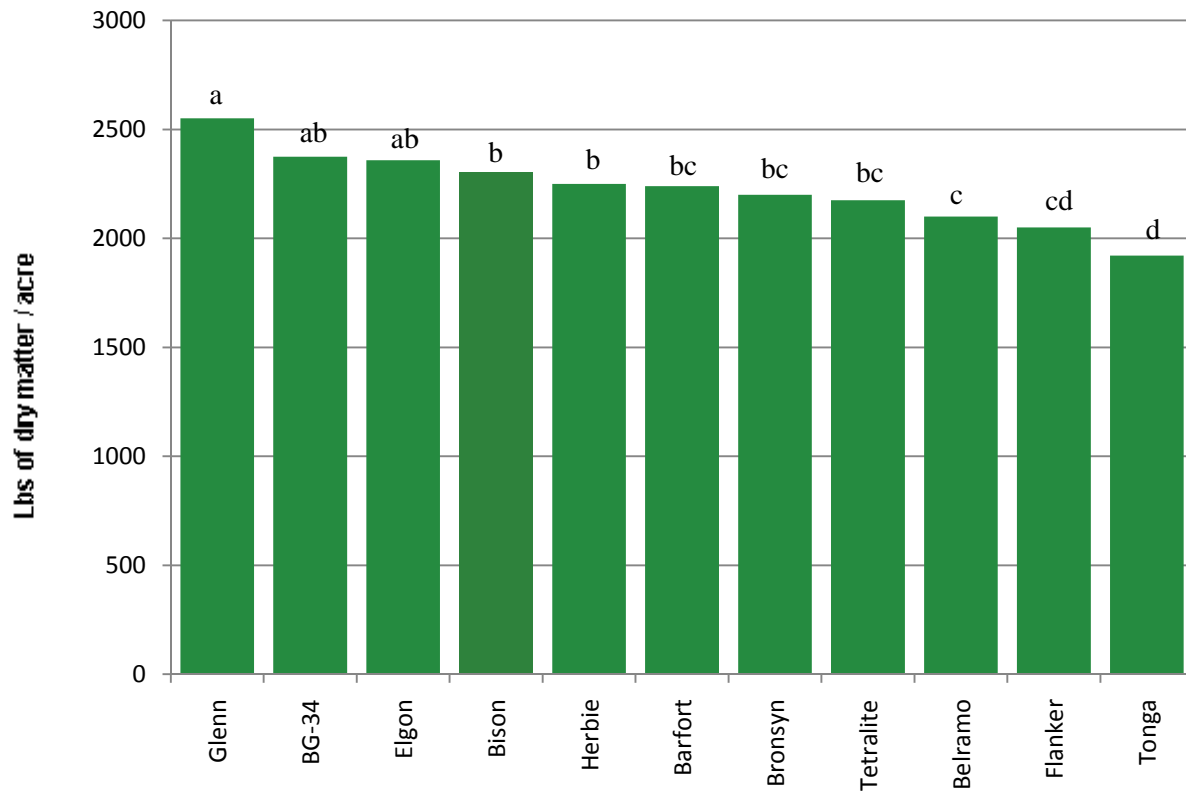


**Figure 2.** Average neutral detergent fiber (NDF) of 11 perennial ryegrasses from six cuttings each year. Means different superscripts differ ( $P < 0.05$ ).

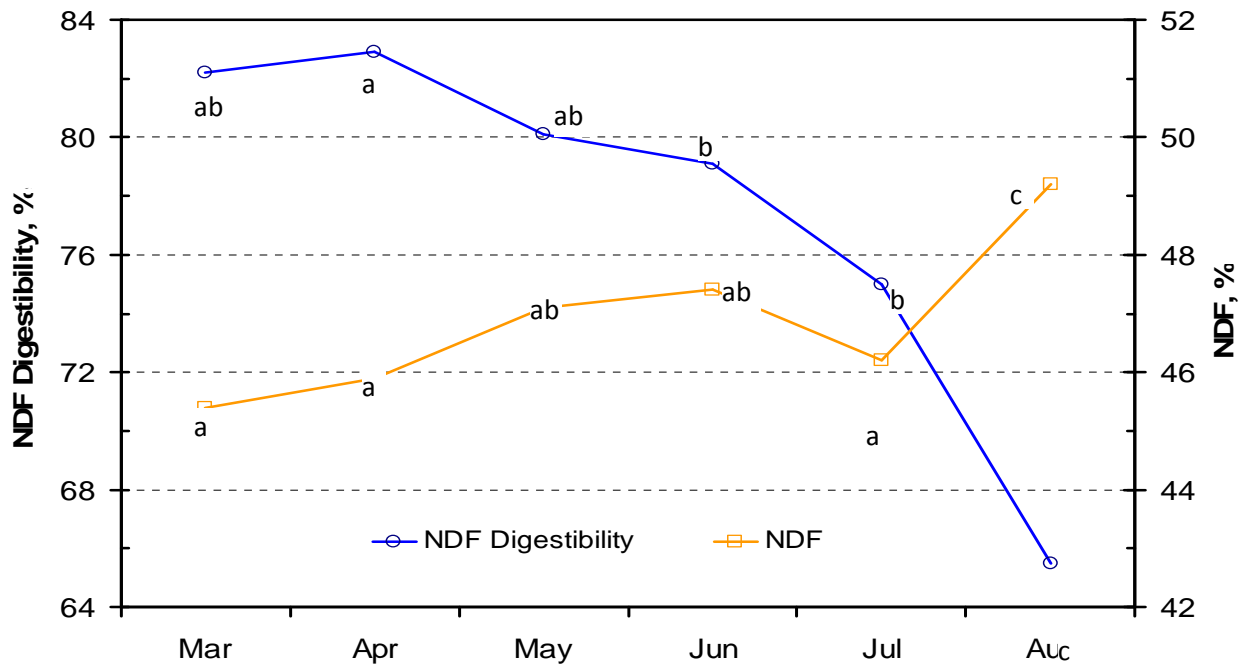




**Figure 3.** Average neutral detergent fiber digestibility (NDFD) of 11 perennial ryegrasses from six cuttings each year. Means different superscripts differ ( $P < 0.05$ ).



**Figure 4.** Average annual digestible neutral detergent fiber (DNDF) yield of 11 perennial ryegrasses from six cuttings each year. Means different superscripts differ ( $P < 0.05$ ).



**Figure 5.** Average change of all varieties in neutral detergent fiber (NDF) and neutral detergent fiber digestibility (NDFD) from March to August. Means within a line with different subscripts differ ( $P < 0.05$ ).

Differences observed in total digestible fiber harvested per acre (32%) has significant impacts on farm productivity. It is estimated that the amount of extra energy produced from digestible fiber advantage of the ryegrass with the highest NDFD compared to the ryegrass with the lowest NDFD is enough to produce an extra 28 cwt of milk per acre per year. Even at \$15.00 per cwt, this is a difference of \$420 from extra digestible fiber per acre. We would expect to see additional growth and productivity from grazing beef and sheep as well.

Accounting for NDFD in grasses is turning out to be critical for the livestock industry. It is probably more important as a producer to understand the NDFD of grasses than even corn silage or alfalfa because there is more variation seen in the grass population. This educational program suggested that fiber digestibility variation in ryegrasses can potentially have significant impacts on the quantity of digestible fiber harvested. This project helped producers see the large variations in grasses they plant and the need to test variety performance before re-establishing new pastures. This project has already changed the way rations are balanced in Oregon. Hopefully, this research will cause seed companies to produce varieties of grasses with higher NDFD values in the future.

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Beef Cattle Sciences

# Oregon Beef Council Report

## Progress Reports – Animal Sciences

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### Effects of acclimation to handling on performance and reproductive development of replacement heifers

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**Project Objectives:** A two-year study is being conducted to determine if acclimation of Angus × Hereford heifers to human handling after weaning improves their disposition and hastens their reproductive development.

**Project Start Date:** October 2009

**Expected Project Completion Date:** October 2011

**Project Status:** In August 2009, 45 replacement heifers were weaned and assigned to the first year of the study. Heifers were separated into two treatment groups (acclimation or control), and exposed to treatments. Briefly, acclimated heifers were brought to the cattle working facility three times weekly for 4 weeks, where they were be exposed to common handling practices, and returned to pasture within two hours. Control heifers remained undisturbed on pasture. Disposition was assessed and blood samples were collected prior to and after the acclimation period from all heifers to determine treatment effects on heifer temperament and blood concentrations of cortisol and inflammatory proteins (physiologic measures of stress). Heifer puberty status and body weight is being evaluated monthly and will continue until the breeding season, which is scheduled for May 2010. Approximately 60 days after the breeding season, heifer pregnancy status will be also evaluated to determine treatment effects. As soon as the 2009 disposition, blood, and reproductive data is available, it be statistically analyzed, published in the next edition of the Oregon Beef Council Report, and presented at extension and scientific meetings. The same research protocol will be conducted in 2010, and data from both years will be combined, analyzed, and published into extension materials and scientific literature.

### Effects of disposition on reproductive performance of brood cows

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**Project Objectives:** A two-year study is being conducted to determine the probability of brood cows to become pregnant according to measures of disposition, such as temperament score and blood concentrations of substances associated with behavioral stress, assessed prior to the beginning of the breeding season.

**Project Start Date:** April 2009

**Expected Project Completion Date:** November 2010

**Project Status:** In April 2009, all mature cows from the EOARC-Burns and EOARC-Union were evaluated for disposition and sampled for blood immediately prior to the breeding season. These blood samples were already analyzed for concentrations of cortisol and inflammatory proteins. In August 2009, disposition was also evaluated in the Burns calves at weaning to determine if there is an association between the dam's and calf's disposition. Pregnancy status of cows from both herds will be assessed in November/December 2009. As soon as the pregnancy data is available, we will determine if disposition and blood substances associated with behavioral stress, such as cortisol and inflammatory proteins, affected the reproductive performance of cows during year 1 of the study. Data from 2009 will be published in the next edition of the Oregon Beef Council Report as a full report, and presented at extension and scientific meetings. The same research protocol will be conducted in 2010, and data from both years will be combined, analyzed, and published into extension materials and scientific literature.

### **Impact of maternal marbling potential on growing/finishing performance of single-sired calves and how ultrasound technology may optimize both performance and costs to maximize carcass merit**

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**Project Objectives:** This study is a small segment of a larger study designed to evaluate the impact of retaining replacement females sired by bulls based on marbling characteristics. The objectives of the current study are two-fold: 1) the impact of grandsire marbling traits on gain performance and carcass merit of single-sired calves, and 2) can ultrasonography be utilized early in the weaning process to determine carcass merit-outcome groups.

**Project Start Date:** November 2008

**Expected Project Completion Date:** December 2009

**Project Status:** Forty-two heifers/steers were weaned and ultrasounded the second week of November 2008. All calves were commingled and backgrounded on pasture for 60 days. During the backgrounding phase all calves received a commercial protein pellet, along with ad libitum access to grass/grass hay. During the final 30 days of backgrounding calves also received 3 pounds per head per day of cracked barley to increase caloric intake to offset increased thermal output. During the third week of January 2009 calves were again ultrasounded, then transported to a commercial feedlot for finishing. A third ultrasound image was collected after 70 days on feed during the finishing period. All calves were sent to harvest at the same time (June 2009). Carcass data was collected on all calves at time of slaughter.

As of this progress report we are in the final stages of summarizing the ultrasound, gain and carcass parameters collected during the project. The final report should be published by the end of December 2009. The full report will be published in the OSU Beef Research Reports and presented at scientific meetings this upcoming year. We are currently planning on repeating this project starting November 2009 to further substantiate the data collected during the first year. Both year's data will be published in the scientific literature.

### **Production value and efficiencies of replacement beef heifers sired by either high or low-marbling bulls**

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**Project Objectives:** This is a 2-year study evaluating the impact of sire-marbling traits on replacement heifer production efficiencies and subsequent calf crops. This project is designed to evaluate reproductive performance, growth and maintenance of body condition in heifers sired by either a high-marbling (HIGH) bull or a low-

marbling (LOW) bull. The impact of grandsire marbling traits on calf crop performance (gain and health) and value (carcass) will also be evaluated.

**Project Start Date:** May 2008

**Expected Project Completion Date:** July 2010

**Project Status:** Ninety-two (from an original 102 head) replacement heifers were initially ultrasounded in May 2008. At the time of ultrasound, a blood sample was also collected from each heifer for analysis of growth hormone (GH), insulin-like growth factor 1 (IGF-1), leptin and ghrelin. Samples for leptin and ghrelin analysis were sent to South Dakota State University, but due to a backlog of samples they were not able to start analyzing the samples until February 2009. Reproductive performance and maintenance of body condition starting in May 2009 have been collected and analyzed. The gain performance and carcass merit of the first calf crop is currently being summarized. A second set of blood samples will be collected from the replacement heifers in November 2009. Also, the second calf crop is scheduled for backgrounding and finishing starting November 2009. A more complete interim report will be available by February 2010, with a final OSU beef report available in August 2010.

## **Rumen characteristics and forage digestibility of low, medium and high quality forages supplemented with various levels of dietary glycerol**

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**Project Objectives:** This study is designed to evaluate total tract digestibility, rate of ruminal nutrient digestibility, and rumen fermentation characteristics of various glycerol inclusion levels fed with low-, medium-, or high-quality forages.

**Project Start Date:** February 2009

**Expected Project Completion Date:** April 2010

**Project Status:** The animal collection portion of this project commenced in late February 2009. Four ruminally-fistulated steers were started on the 'LOW' period in February and concluded the first part of June 2009. During the 'LOW' phase steers received a wheat straw-based diet with either 0%, 5%, 10% or 20% feed grade glycerol (DM basis). Over four collection periods each steer was exposed to each forage-glycerol combination. During each collection period the steers were given 10 days to adapt to the diet, followed by a 5-day sampling period. During the sampling period each steer was fitted with a fecal collection bag to determine diet digestibility, and rumen fluid samples and in-situ bags were utilized to determine rumen fermentation characteristics and rate of fiber digestibility. Starting in early July 2009 the steers were switched to the 'HIGH' phase; which was based on alfalfa hay. Similar to the LOW phase, each steer was exposed to either 0, 5, 10 or 20% glycerol. Starting in mid-September 2009 the steers were switched to the 'MED' phase; which was based on a mixed-grass hay. As of this progress report two of the four MED collection periods have been completed, with the final two periods scheduled to be completed by the end of November 2009.

Due to a lack of labor to analyze feed, fecal and rumen samples during the spring of 2009 we have not completed the data analysis for the LOW or HIGH phases; therefore no data is presented in this progress report. With the hiring of several students this fall most lab analyses should be completed by January 2010. A complete research report should be completed and sent out to both the Oregon Beef Council and OSU extension personnel by April 2010. This data will also be presented at scientific meetings and published in the scientific literature.

## Selenium supplementation and retention in beef cattle

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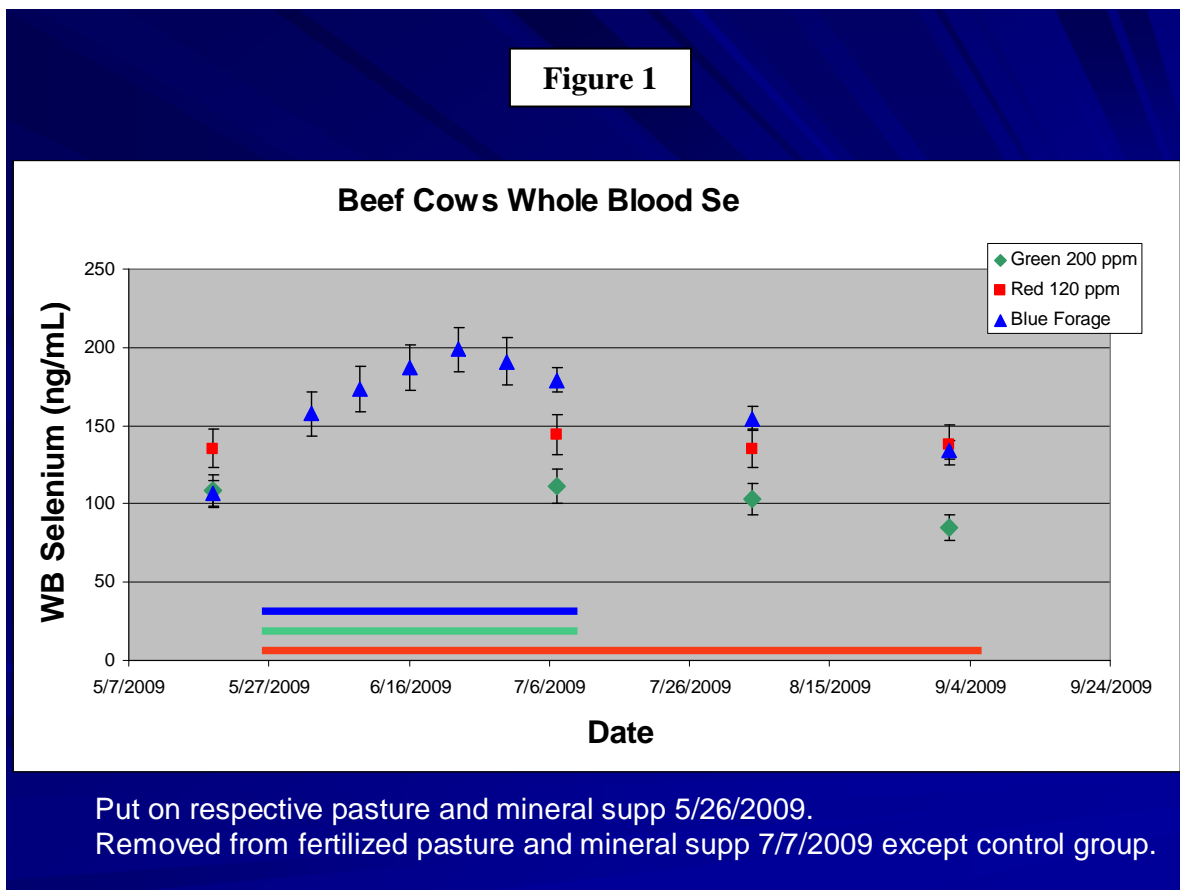
**Project Objectives:** The objective of this study is to evaluate selenium retention (by measuring blood levels) in beef cows by comparing salt-mineral selenium supplementation to grazing a pasture fertilized with selenium.

**Project Start Date:** March 2009

**Expected Project Completion Date:** December 2009

**Project Status:** The project consists of three groups of 15 cows each. Selenium enriched fertilizer was applied to 13 acres of pasture at OSU's Soap Creek Ranch in March. Cows and their calves were turned out to treatment areas in May after pre-treatment blood samples were taken. One group grazed for 40 days on the selenium fertilized forage. The second group grazed non-selenium fertilized forage for 40 days, but received a mineral supplement with selenium at 200 parts per million. The third group grazed non selenium fertilized forage and received a mineral supplement with the legal FDA level of selenium (120 ppm). After the 40 day grazing period, all groups were blood sampled and then allowed to graze non-selenium fertilized forage without selenium in the mineral with the exception of the 120 ppm group which receives mineral throughout the trial.

Average blood levels to date for the groups are shown in Figure 1. The selenium forage group reached higher whole blood selenium levels than the other two treatments. The forage selenium and 200 ppm selenium are dropping at consistent levels while the 120 ppm selenium is holding steady.





Beef Cattle Sciences

# Oregon Beef Council Report

## Behavior and Distribution of Cattle Grazing Riparian Zones <sup>1</sup>

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### Synopsis

The spatial and diurnal behavior of cattle grazing 3 riparian pastures is being investigated in northeastern Oregon. Time spent in streams and in buffers at increasing distances from streams is being quantified as well as ecological site use and preference during resting and grazing periods.

### Summary

The objective of this research is to study cattle site use and behavior in riparian pastures so that the nature of use by livestock can be determined and potential ecosystem impacts can be scientifically evaluated. Through the course of this study, we will employ high resolution GPS trackers to examine the fine scale distribution of livestock on 3 managed riparian grazing systems over 2 years. Patterns of land use in relation to stream channel, stream banks and vegetative communities are being documented as well as use of and preference for ecological sites.

### Introduction

In 2002 the National Research Council (NRC, 2002), conducted a literature review of research pertaining to management of riparian areas that found:

*“Traditional agriculture is probably the largest contributor to the decline of riparian areas...”*

and

*“The primary effects of livestock grazing include the removal and trampling of vegetation, compaction of underlying soils, and dispersal of exotic plant species and pathogens. Grazing can also alter both hydrologic and fire disturbance regimes, accelerate erosion, and reduce plant or animal reproductive success and /or establishment of plants. Long-term cumulative effects of domestic livestock grazing involve changes in the structure, composition, and productivity of plants and animals at community, ecosystem, and landscape scales.”*

Most land managers are acutely aware of riparian health issues and over the last 30 years modern, science-based riparian management systems have been developed. These systems were created by private individuals, university faculty, USDA/ARS, NRCS, and Federal Agency personnel and were designed to reduce impact of livestock on critical environmental attributes of riparian systems such as

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1. This document is part of the Oregon State University –Beef Research Reports. Published in November 2009. Please visit the Beef Cattle Sciences website at <http://beefcattle.ans.oregonstate.edu>.
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1) vegetation along the green line, 2) streamside shrubs and shading, and 3) bank overhang that can negatively impact native plants, fish and wildlife (Leonard et al. 1997, Mosley et al. 1998, Whitaker-Hoagland et al. 1998). Managerial systems typically adjust the timing and/or intensity of grazing such that cattle impacts are controlled while economic benefits to producers are maintained. Fundamental to the development of modern management systems was knowledge of animal distribution within the context of site preference and site accessibility (Stuth 1991).

Also developing over the last 30 years was Global Positioning Systems (GPS) tracking technology and electronic/computer technologies that have substantially expanded our ability to monitor ecosystem parameters and animal location. Modern GPS tracking collars can position animals at 1 second intervals with accuracies within 11.5 ft. (3.5 meters) while modern computer technology allows the analysis of the data in a Geographic Information System (GIS) context within a reasonable time frame.

We are using these modern technologies to refine knowledge of the spatial and temporal behavior of cattle grazing riparian pastures so that accurate assessment of grazing induced change can be determined. The specific objectives of this project are to:

1. Quantify site specific grazing intensities within riparian pastures
2. Determine where and how frequently cattle interact with streams, stream banks and green line vegetation
3. Determine where cattle rest and graze in relation to streams in riparian pastures
4. Determine animal preference for ecological sites found in riparian pastures
5. Suggest managerial strategies that improve ecosystem services while promoting profitable livestock production.

## Materials and Methods

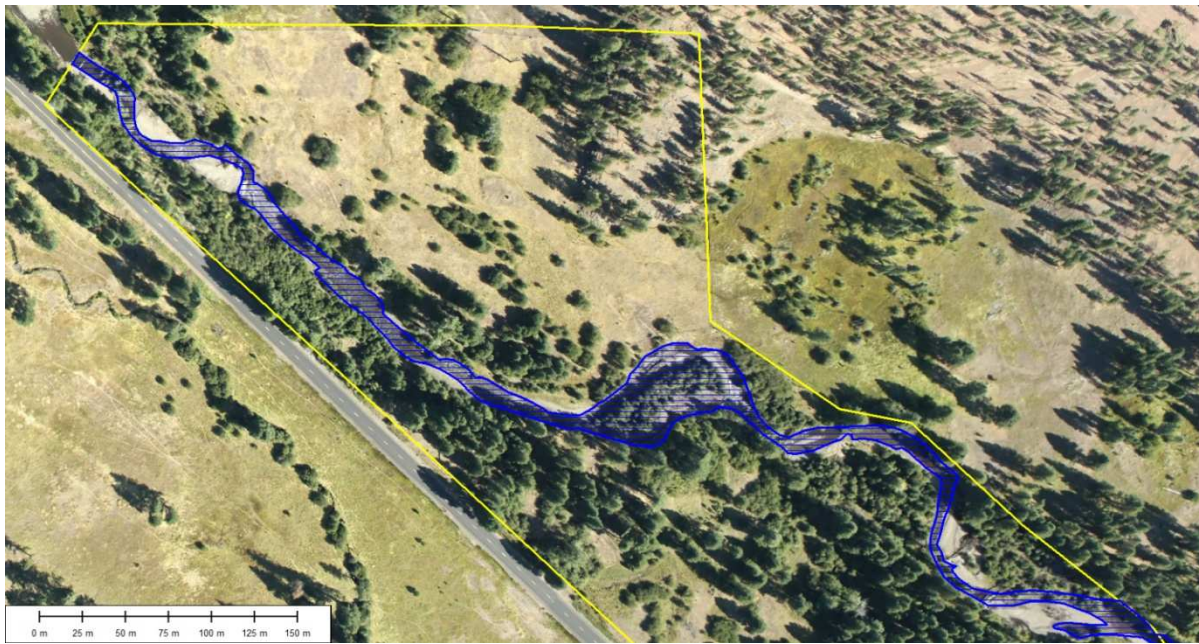
This study is being conducted on 3 sites in northeastern Oregon (with an additional site that will be used if available) that represent the variation found in riparian pastures of northeastern Oregon. Two sites are located on property managed by the Eastern Oregon Agricultural Experiment Station at Union (Catherine Creek and Milk Creek) and two

are on privately owned and managed ranches. Streams vary in width from less than a yard (1 m) to more than 25 ft. (8 m) wide. Pastures vary in size from 139.4 acres (56.4 ha) to 250 acres (101.17 ha). All pastures are grazed during the summer or fall by beef cattle as an integral part of a broader ranching production system.

Each pasture was delineated using a GPS and photographed from the air on 17 September 2009. Aerial images were acquired at high resolution (20cm by 20cm ground pixel size or 1:706 scale) using a Canon EOS Rebel XSi 12.4 megapixel conventional color digital camera mounted in the belly of a Cessna 182 aircraft. Images were corrected for lens curvature and geographically registered to USDA National Agriculture Imagery Program (NAIP) 2005 imagery (Figure 1). Pasture mosaics are being made that show vegetative communities and stream position.

The GIS layers for vegetative communities and stream boundaries in each pasture are being mapped during field visits using our high-resolution, rectified photographs. Other features of note and any off-stream water points were positioned using GPS. All pasture data layers (aerial photographs, vegetation, stream, and boundaries) are being entered into a GIS database using ArcGIS 9.3 (ESRI 2009) and Global Mapper 10.0 (Global Mapper Software LLC 2009).

Nine cow GPS collars were built for the project to compliment 10 existing cow collars. Ten mature cows were fitted with GPS-tracking collars (Johnson et al. 2006) as they entered the study pastures (Figure 2). These units collected a location position at 1 second intervals for approximately 6 days. After the initial trial, batteries were replaced and the same animals were tracked for another 6 days, thus two trials were (or will be) conducted in each pasture. We have completed 2 trials in the first 3 pastures and have recorded approximately 225 full-day track logs for cows. Data for the last pasture will be collected as soon as animals are permitted to graze.



**Figure 1.** Aerial photograph of a portion of Catherine Creek outlined in blue, and the associated riparian pasture. This information has been incorporated into a GIS upon which cow track logs can be laid.

Three of the 10 GPS collars deployed in the first pasture malfunctioned and were repaired or replaced in subsequent trials. Each daily track log provides approximately 86,400 positions which contain longitude, latitude, altitude, date, time, velocity, an index of the quality of the fix and the number of satellites used in the fix. These 1-second GPS track logs allow us to infer behavioral activities such as resting (stationary positions), grazing (low velocity or stop-and-go movement), and walking with intent (moderate velocity movement; Figure 3). The animal track log is being attributed with these behavioral classes using animal movement classifier software (Johnson et al. 2009).



**Figure 2.** Cow fitted with a GPS tracking collar. These collars record positions at 1 second intervals for approximately 6 days.

Since this study has only been funded for 3 months, we will report results of a preliminary investigation which was conducted in September of 2008 on Oregon State University's Hall Ranch in conjunction with information from the current investigation.

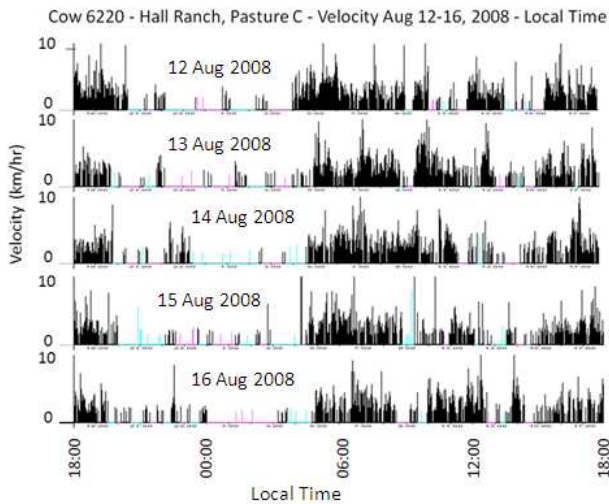
## Results

Results thus far are limited since we haven't finished collecting our first year's data and funding has only been available for about 3 months (the Department of Rangeland Ecology & Management, Oregon State University permitted us to spend in advance of receiving funding from OBC). Because of the scope of this project and demand from other research efforts in eastern Oregon, we needed to establish a GIS laboratory at Eastern Oregon University. We obtained three desktop computers from Oregon State University and configured them to be used as GIS workstations on this project, as well as the OBC Wolf/Cattle Behavior Study. These computers are loaded with ArcGIS 9.3 and Global Mapper 10.0 software, as well as custom built software for analysis and the correction of aerial photographs. We also added hard drive capacity to deal with the large data files we are compiling.

We also acquired a laptop GIS computer and equipped it with a GPS antenna, 12 volt DC power inverter, and software that allow us to conduct "mobile mapping" and digitize GIS features in the field. For example, we can display on the laptop



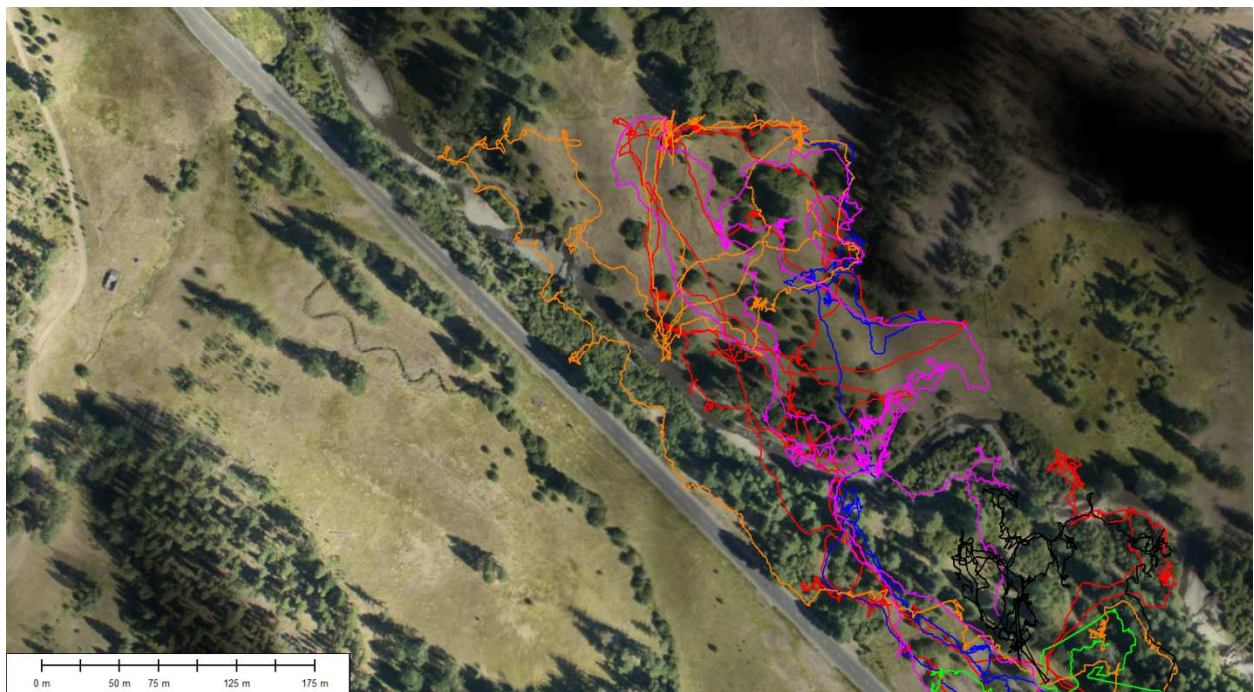
aerial photos, 7.5 minute topographic maps or any other GIS data and the computer screen will center on our current location. As we move about the pasture or down the road, the screen display is refreshed to keep our position centered on-screen. Thus we can always see where we are in relation to the GIS data layers. This yields tremendous field mapping capability and we are using it to map vegetation, stream channels, range improvements, etc. and to build our GIS databases.



**Figure 3.** Velocity histogram of Cow 6220 between 12 and 16 August, 2008. Each day is represented by one row of the histogram.

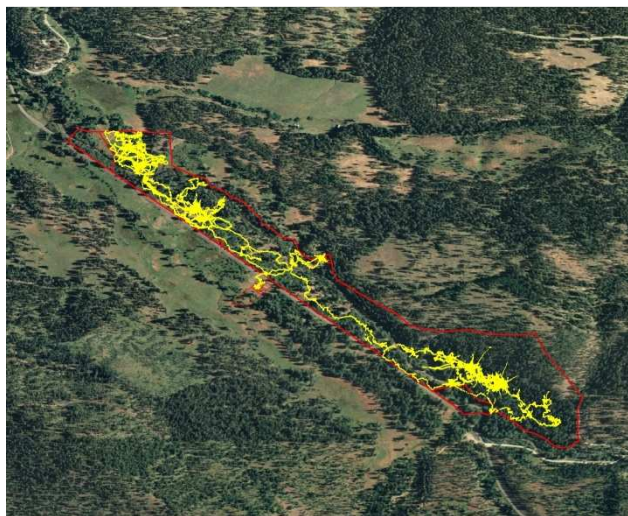
The aerial photographs of the study pastures taken in September are being geo-rectified and as soon as this work is completed we will map vegetative communities on each site. One riparian pasture, pasture “C” on the Hall Ranch, was mapped last fall and is complete (Figure 4). We will, however, verify that the stream channel has not shifted since September 2008.

The GPS collar data from both the first and second trials at the first 3 sites has been collected, downloaded, and processed using GGS Logger Conversion (Johnson 2009). These files can now be loaded into the GIS programs and shapefiles constructed (Figure 5). We have noticed considerable change in the grazing patterns recorded during 2008 and 2009 in the Catherine Creek Pasture on the Hall Ranch. We are also in the process of analyzing GPS track logs of cattle to determine times when animals were moving and stationary. The Animal Movement Classifier (Johnson et al. 2009) was reprogrammed this summer to facilitate the tasks of processing and output tabulation. This program automatically appends the movement class on the comma separated values file with position data. The modification streamlines and speeds analysis considerably.



**Figure 4.** Cow track logs from the Catherine Creek pasture (Pasture "C") on the Hall Ranch, Union County, OR. This data was collected in August 2008 during a preliminary investigation for this project.

Ms. Marie Wilson has been employed as a Graduate Research Assistant on the project and is collecting and processing data. She is a recent graduate of the Eastern Oregon University OSU Ag Program with a degree in Range Ecology and Management. After graduation she worked for the BLM in Idaho. She brings considerable intellect, energy and dedication to the project and has a good start on a Master of Science degree.



**Figure 5.** Cow (Unit 29) movement on Catherine Creek during the 2009 grazing season.

### Conclusions

Even though we have collected much GPS data on cows and assembled many GIS data layers for study sites, it is premature to suggest conclusions. We expect that data collection for 2009 will be completed by the end of November and analysis should be complete for this year's data by June 2010.

### Acknowledgments

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Research Service, Oregon State University, or the Oregon Agricultural Experiment Station of any product or service to the exclusion of others that may be suitable.

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Beef Cattle Sciences

# Oregon Beef Council Report

## Evaluation of Wolf Impacts on Cattle Productivity and Behavior <sup>1</sup>

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### Synopsis

This project has initiated and employed an Adaptive Management System (AMS) with its planning, action, monitoring, and evaluation components to define and document the effects of the reintroduction of the gray wolf on livestock production systems and ecosystem services in Idaho and Oregon.

areas which are being used to define livestock preference for vegetative communities and landscape classes. Economic analysis has begun of ranching systems on paired sites to document wolf effects on the cattle productivity and profitability.

### Summary

We have initiated and employed an Adaptive Management System (AMS) to document the effects of gray wolves on cattle production systems in Oregon and Idaho. The project has collected information on cattle movement on land in both wolf common and wolf rare areas with GPS collars that record positions every 5 minutes. Sixty cow collars were deployed in 2008 and 65 in 2009. We have also documented wolf presence using scat/sign surveys, sighting reports, and depredation reports filed by cooperating ranchers and APHIS Wildlife Services. The project has collared one wolf and will retrieve the collar in winter 2009. The GIS data layers have been collected or made for

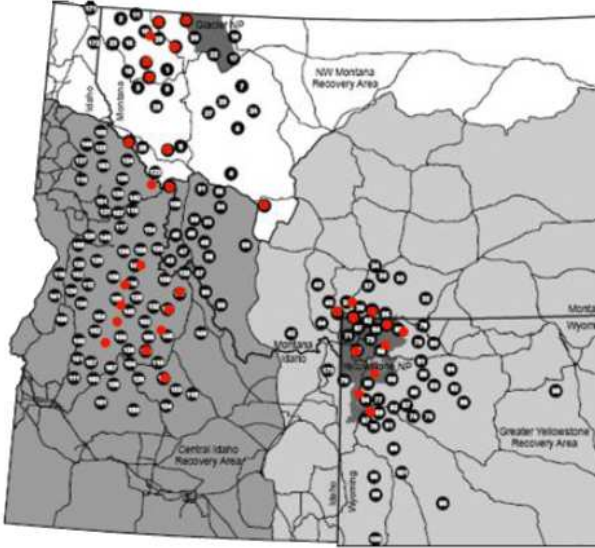
### Introduction

In 1995 and 1996, 66 wolves were captured in Alberta and British Columbia, Canada, and reintroduced into Yellowstone National Park (31 individuals) and central Idaho (35 individuals). Today these populations have grown to more than 1,500 with more than 700 in Idaho (Figure 1) and their range has expanded considerably with individuals or packs commonly found in adjacent states (US Fish and Wildlife Service 2006). As wolf populations have grown, so has predation on livestock (Figures 2 and 3). When wolves expand into areas with established livestock production systems, losses increase complicating animal management and reducing ranch profit. In order to meet this challenge, ranchers need to have techniques to minimize cattle and other domestic

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animal losses. They and the public will benefit from a scientific examination of wolf effects on the economic and ecological systems. Information from these studies can also be used to formulate rational managerial strategies.



**Figure 1.** The location of wolf packs in 1999 (red dots) and 2005 (black numbered dots) in the Northern Rocky Mountains (From US Fish and Wildlife Service 2006).

The goal of this project was to create an Adaptive Management System (AMS) with its planning, action, monitoring, and evaluation components (Figure 4) that will define and document the effects of the reintroduction of the gray wolf on livestock production systems and ecosystem services in both range and forest lands in the Pacific Northwest and the Northern Rocky Mountains.

Specific questions were being asked by researchers associated with the project at the direction of the Adaptive Management Committee. These questions are:

1. What is the cattle mortality and age structure of animals killed by wolves?
2. How similar is weight gain for cattle that are under the threat of wolf predation versus those who are not?
3. Are cow conception rates similar with and without the threat of wolf predation?
4. Do cattle ranches in areas with wolves have similar production costs and profitability?

5. Is predation season-dependent? Are there specific times with greater risk?
6. Do cattle change their landscape grazing patterns in response to wolf presence?
7. Do livestock form more concentrated herds when wolves are present?
8. Do livestock prefer specific landscape areas when wolves are present?
9. Do riparian areas (or any other identifiable vegetation association) get less use by livestock when wolves are present?
10. Do any landscape areas demonstrate vegetation or ecosystem improvement?



**Figure 2.** Calf killed on a project study area by wolves.

We realize that it is extremely ambitious to attempt to answer all these questions with a single project but believe that it is imperative that we begin the process, for the consequences of inaction are unacceptable. We further believe that a scientific investigation will lead to insight concerning the effects of wolves on both the cattle production system and the ecological/environmental system suggesting mitigation strategies that reduce conflict.

## Results to Date

### Establishment of an Adaptive Management System with an Advisory Committee

Holling (1978) and Walters (1986) suggested the adaptive management process should integrate the existing interdisciplinary experience and scientific information into dynamic

management. An AMS should be used as a formalized, yet flexible approach to natural resource management which clarifies the problem and enhances communication between stakeholders and managers. In 2008, the project established an Adaptive Management System (AMS) and an Advisory Committee (AC). Our AC acted to establish the framework for the active AMS and formulated questions that were central to the wolf/livestock production issue. The committee consists of a group of livestock producers, consulting range and wildlife scientists, a statistician, and a chairman/facilitator. Several members of the committee have extensive experience rearing livestock in areas where wolves are common. The AC also has access to experts at the Oregon State University, University of Idaho, Idaho Fish and Game, Oregon Department of Fish and Wildlife, USDA APHIS Wildlife Services, or other institutions if they need additional information or consultants.

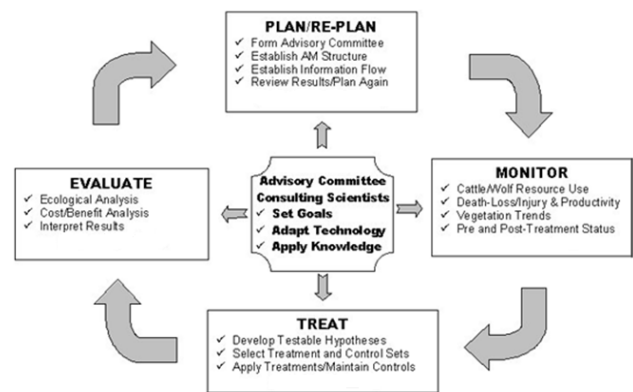


**Figure 3.** A 400 lb. (180 kg) calf that was severely injured during a wolf attack on a project study area

The committee suggested identifying an experienced meeting chair/facilitator from the University Extension Service to encourage open communication and the exchange of thoughts and experience among stakeholders. The facilitator selected was Mr. John Williams of Wallowa County, Oregon. He receives and distributes information to and from the project to Advisory Committee members and chairs the AC meetings.

We conduct our research and extension activities under the auspices of the AC in all four components of the AMS activity cycle: Planning, Monitoring, Treatment, and Evaluation (Figure 4). As such, our stakeholders play crucial roles in problem identification, objective formulation,

project implementation, evaluation and application of project results. We followed the logic model outlined by Possingham et al. (2000) for decision making by first clarifying the problem(s) identifying knowledge gaps, and defining the objectives for the AMS. From this basis, the Advisory Committee has approved a list of possible experimental actions to provide the committee with unbiased, scientific information on which to build the AMS framework. The project has also identified cooperating stock growers in both Idaho and Oregon that assist project scientists in the collection of necessary field and economic data. The last meeting of the advisory board was on 29 October 2009 at Eastern Oregon University in La Grande, OR. Four Committee members joined us via Polycom Video Conferencing from the OSU Extension Office in Ontario, Oregon and one from Corvallis, Oregon.



**Figure 1.** The Adaptive Management Process utilized by the Wolf/Cattle Interaction Study to define the changes in the livestock production system induced by wolf reintroduction and find mitigation strategies to reduce losses.

**Additional Project Funding from USDA CSREES NRI Managed Ecosystems Grants Program**

We secured two grants from the USDA CSREES AFRI Managed Ecosystems program for broadening the scope of our on-going Oregon Beef Council wolf/cattle project. In June 2009, we received \$54,839 to refine our existing experimental and sampling designs, support the vegetation and wolf-presence monitoring field work on the existing study areas, enhance the reliability and functionality of the GPS tracking collar design, and to expand cattle distribution data collection efforts on additional study areas. Work has begun in all 4 of these focus areas and details of this newly-funded work are included below. In September 2009, we were notified of an additional \$99,968 grant to be received in January 2010 to expand economic



analysis of wolf impacts on ranching systems and to continue data collection within the AMS system for 1 year. This grant is divided between University of Idaho and Oregon State University.

### **Measurement of Wolf Presence/Movement**

#### ***Wolf Collaring***

Collaring wolves is challenging because of the multiple levels of agencies involved and the technical complexity of the action. On May 2009, the USDA APHIS Wildlife Services (USDA-APHIS-WS) was able to deploy one of our recording GPS collars on a 90 pound, gray male sub-adult wolf on one of our Idaho study areas. This wolf is running with a VHF-radio collared wolf and both appear to be members of a pack of up to 12 individuals. Ranch personnel have sighted wolves from this pack on several occasions and research team members have heard their howls. This pack has killed calves and are operating in the areas where there are cows carrying OBC collars. Confirmed wolf depredation was continuing as of October 2009 and USDA-APHIS-Wildlife Services is attempting to control this pack. A wolf hunting season occurred this fall (2009) in Idaho (Idaho Fish and Game 2009). Wolf-take quotas have been assigned and include animals on our research areas. Hunters, however, were asked not to take collared wolves.

In addition to these collars, USDA/APHIS Wildlife Services and the Oregon Department of Fish and Wildlife are monitoring other animals on our study areas via VHF-radio broadcasts and have shared this data with the project. This winter we will activate the radio drop-off device and hopefully retrieve the wolf GPS collar and the 15 minute data it contains. We should note that wolves are very hard on GPS tracking collars and failure rates can approach 50%. If we are successful in retrieving GPS data from this animal it will yield extremely valuable information about wolf/cattle interactions.

#### ***Wolf Scat /Sign Survey***

Wolf scat and sign are being monitored by project personnel in an effort to document the relative wolf presence (high vs. low) on study areas. We cannot use this data as a census of wolf population but it does indicate the relative degree that wolves are present on sites. We have established survey routes on each of the study sites. These routes are driven slowly and examined for wolf scat or sign using criteria provided by ODFW (ODFW 2009) and individuals with experience in wolf detection.

Each probable scat or sign found is positioned with a hand-held GPS, photographed at high resolution with a ruler in the image, dated, and logged into a GIS database (Figures 5 and 6) (ESRI 2009, Global Mapper LLC 2009). In addition to survey routes sampled by project personnel, volunteers that live on or near experimental areas also record scat and sign following the same protocol.



**Figure 5.** Wolf scat is positioned with a GPS unit, dated, and photographed to document generalized wolf presence. Positions are mapped as a GIS data layer



**Figure 2.** Wolf track on the study area are positioned using a handheld GPS and photographed. They become part of the GIS data set that maps wolf presence.



Tables 1 and 2 give results of a survey done on a high-wolf presence site in Idaho and a low-wolf presence site in Oregon. The density of probable wolf scat is nearly 10 times higher on the high-wolf presence site than on the low-wolf presence area. We should note that positive identification of wolf feces could be accomplished by DNA sampling, but this was deemed unnecessary by the committee.

from aircraft. These sightings are not done on regular intervals but rather when depredation reports are received or when wolves are being tracked. Several agencies provided this type of information to the project and we have assembled a GIS database that records the date, time, place and number of wolves sighted. These sightings often record the presence of more than 1 individual and our database includes the number sighted, date, and notes.

**Table 1.** Summary of preliminary wolf scat survey for a high density wolf presence site in Idaho.

Survey Route	Length (km)	Length (miles)	Wolf Scat or Sign Locations	Linear Density (No./km)	Linear Density (No./mile)
Survey Route 1	28.9	17.96	45	1.56	2.51
Survey Route 2	17.3	10.75	16	0.92	1.49
Survey Route 3	1.4	0.87	8	5.71	9.20
Survey Route 4	8.69	5.40	12	1.38	2.22
Survey Route 5	14.2	8.82	14	0.99	1.59
Survey Route 6	0.305	0.19	6	19.67	31.66
Survey Route 7	3.44	2.14	2	0.58	0.94
	<b>74.235</b>	<b>46.13</b>	<b>103</b>	<b>1.39</b>	<b>2.23</b>

**Table 2.** Summary of preliminary wolf scat survey for a low density wolf presence site in Oregon.

Survey Route	Length (km)	Length (miles)	Scat/Sign No.	No./km	No./mile
Survey Route 1	1.99	1.24	0	0.00	0.00
Survey Route 2	5.57	3.46	1	0.18	0.29
Survey Route 3	15.60	9.69	2	0.13	0.21
Survey Route 4	5.80	3.60	6	1.03	1.66
Survey Route 5	14.00	8.70	3	0.21	0.34
Survey Route 6	10.70	6.65	0	0.00	0.00
Survey Route 7	8.01	4.98	1	0.12	0.20
Survey Route 8	11.80	7.33	0	0.00	0.00
Survey Route 9	2.35	1.46	0	0.00	0.00
Survey Route 10	5.21	3.24	0	0.00	0.00
Survey Route 11	1.71	1.06	0	0.00	0.00
	<b>82.74</b>	<b>51.41</b>	<b>13</b>	<b>0.16</b>	<b>0.25</b>

**Sighting Reports**

Wolves are not regularly seen by people going about their work on ranches and farms; several ranch employees have reported only seeing wolves once or twice a year. This is probably because work usually involves machinery or activity that makes noise and wolves are naturally surreptitious. Bird watchers, hunters scouting game, and nature photographers see wolves more regularly. Wolves are often heard by campers and people outdoors in the evening and at night.

The APHIS Wildlife Services’ and Game Department personnel have the advantage of VHF radio collars that are placed on some wolves which allow them to locate animals either on the ground or

Sighting reports do not take the place of GPS collar information, thus we will continue efforts to collar wolves with units of advanced design. Idaho Fish and Game and USDA Wildlife Services have been very helpful over the last two years and continue to assist the project in our wolf-collaring endeavors.

**Development of a Howlbox for Automated Wolf Survey**

We are currently developing an improved version of the Howlbox originally designed by researchers at the University of Montana Cooperative Wildlife Research Unit in Missoula.

The Howlbox is an electronic device designed to play electronic recordings of wolves howling and then record audible responses to the howlings. Spectral analysis of the audible responses provides information on wolf presence, minimum number of individuals responding, and estimates of distance and direction to the responding wolves. The Howlbox is intended to be a device that can be deployed in the field and collect wolf presence data unattended for an extended sampling period. The original Montana design is however, quite large, heavy, and power-hungry. Our Howlbox design would substantially reduce size and weight, greatly improve power efficiency, and enable the device to intelligently react to detected wolf responses (e.g., increase sampling interval, alter volume levels, etc.). These improvements would make the Howlbox more suitable for remote deployments in roadless areas and would more effectively sample wolf presence levels.

### ***Wolves Controlled by AHPIS Wildlife Services or Under Permit by Ranchers***

The APHIS Wildlife Services can implement control actions for wolves suspected to be involved in livestock depredations and to capture non-depredating wolves for collaring and re-collaring with radio transmitters as part of ongoing wolf monitoring and management efforts. We are recording information about wolves controlled by Wildlife Services or ranchers operating under a control permit. We record location, date, gender, age class and number. Removal of wolves occurs after depredation on livestock and several of our study sites have documented cattle depredation which resulted in wolf removal.

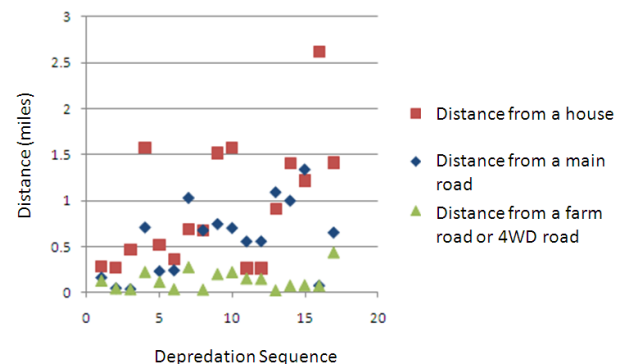
### ***Cattle Killed by Wolves***

It is difficult to document wolf predation on cattle on our study areas because the topography is rough and the land is often covered with trees and shrubs. Animals are consumed quickly, especially small calves, and detection is difficult unless a person's daily work takes them to the kill site. Ranchers indicate that they believe that they find only 10 to 20% of calves killed by wolves. In spite of these limitations there have been numerous confirmed wolf depredations on our study areas.

Locations of known attacks on livestock for one of our sites were plotted in a GIS to see if a pattern emerged. Known depredations were typically near roads, habitations, or work sites ostensibly

because of the increased likelihood of detection. Several depredation sites are visible from houses occupied by ranch personnel or other rural dwellers. As was mentioned previously wolves are surreptitious and ranchers have indicated that animals are lost at all times of the day and may be lost close to homes or worksites in daylight. Figure 7 is a plot of known 2009 depredation sites in relation to houses and roads. It is obvious that predation can take place close to human activity.

Wolf depredation on cattle on study sites varies from none to very heavy for the 2009 grazing season. One ranch has nearly 20 confirmed or probable attacks on cattle and has estimated that they may have lost as many as 60 calves this year. The actual number of animals not returning from the pastures and allotments will be determined in November and December when animals are gathered and counted. This loss will be compared to the number of animals missing in previous years to see if the presence of wolves increased the number of missing animals. The project will count bulls, cows and calves when animals are gathered this November or December.



**Figure 3.** The distance of confirmed or probable wolf depredation sites from houses, main roads and farm roads on Idaho Study Site 1 during the 2009 grazing season.

### ***Cattle Movement determined by GPS Collaring***

The spatial behavior of cattle is reflective of their need for food, water, security, and thermal and environmental protection (Stuth 1991). Sixty cow GPS collars were deployed on 6 study areas during the 2008 field season that recorded data at 5 minute intervals. Each point is tagged with the animal number, position in latitude and longitude, date, time, velocity, quality of the fix, battery voltage, and other information. This data can be used to determine where animals go and how long they spend in certain locations. Several facts become

obvious when this information is plotted. First, collared animals are moving through the pastures in an independent fashion, not as individuals in one herd. They may enter the pastures at the same location and be moved in a similar direction throughout the grazing season, but considerable variation exists from one collared cow to the next. We have observed that a large herd breaks into a series of smaller groupings of a few to perhaps 20 individuals which move as a group. These subgroups function independently in choosing grazing areas and travel routes. We also noticed that animals seem to prefer sites on the landscape with deeper soils and more forage; treed sites in these areas typically have deeper soils which allow trees to establish and grow.

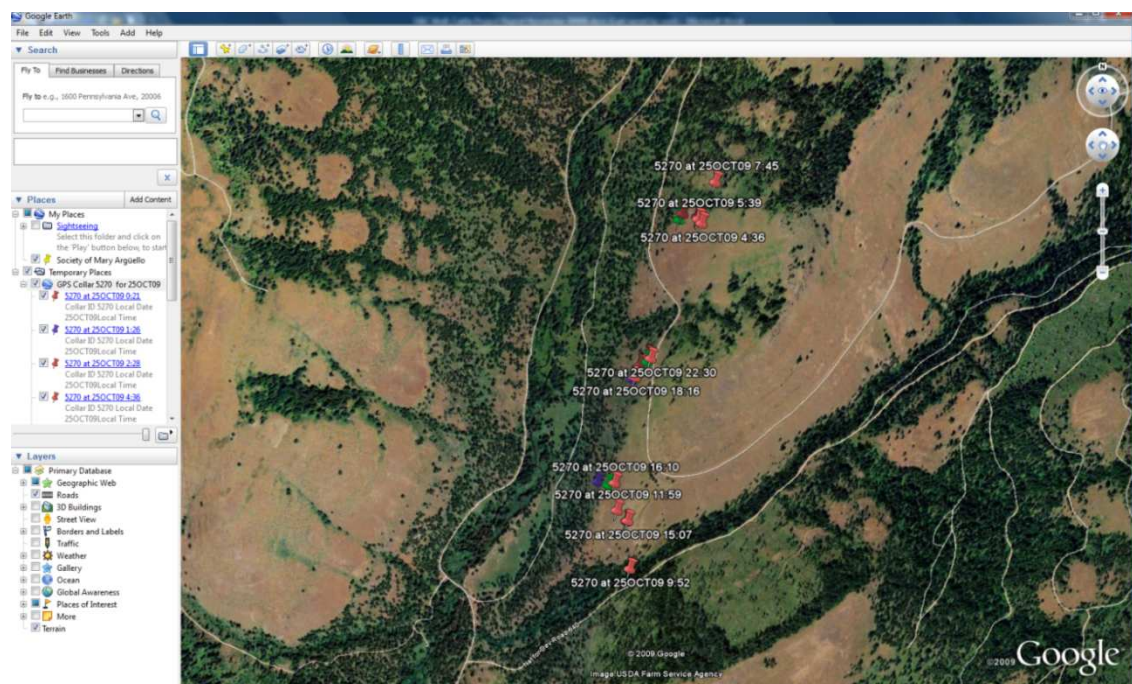
Data is being analyzed in a spatial context and the relative number of cow positions recorded on various range/ecological sites is being tallied, interpreted and compared between sites.

Sixty eight GPS collars were deployed in spring of 2009 and are still collecting data in the field. They will be retrieved in November and December 2009. These collars are set to record positions at 5 minute intervals and are divided between areas that had heavy wolf presence in the past (35) and areas with low or no wolf presence (30). The position data being collected by these GPS units will allow us to document which range/ecological sites cattle are using and to quantify the intensity of use.

We can also determine the relative number of positions on or near streams or any other features on the landscape.

### Satellite Broadcast Collars

A field-prototype of the Clark GPS-SATCOMM tracking collar has been prepared and was deployed in late summer 2009 on a cow from one of the Idaho study areas (Figure 8). Originally developed from support from the USDA ARS, Boise State University Engineering, Idaho National Laboratory, and University of Alaska Fairbanks, this collar is similar to the 66 storage-only GPS collars currently deployed on the OBC study areas but it also includes a satellite data modem. The modem allows two-way communication between collar and user such that location data can be remotely downloaded and configuration commands uploaded in real-time. The satellite communication system provides the user with true global 24/7 access to the collars via email. Ten other field-prototypes have previously been deployed during another tracking project in Alaska and these collars have proved to be both powerful and reliable for real-time tracking of extensively ranging animals. The physical size of the GPS-SATCOMM collars, however, limits its application to larger animals and currently cannot be used on wolves.



**Figure 8.** Positions from the Clark broadcast GPS collar which is monitoring a free-roaming cow (Number 5270) on an Idaho Study Site in October 2009. The cow positions are shown in Google Earth, a free software package linked to maps and aerial/satellite images delivered over the internet.



Using USDA-CSREES-NRI funds, revisions of the storage-only GPS and the GPS-SATCOMM tracking collar designs have been developed and are currently being lab tested. These revisions provide additional improvements in the reliability of both the hardware and software of the tracking collars and considerably reduce the physical size of the electronics hardware. Depending on lab testing results, field-prototypes of the revised collar designs may be available for test deployment in the 2010 field season.

### **Software Development**

We have just completed an updated Animal Movement Classifier Program and continue to work on modules in the KRESS Modeler that facilitate data handling and analysis. These programs allow us to handle and summarize very large data sets that contain not only cattle and wolf positions but multiple GIS layers for the landscapes being studied. For example, we can attribute positions with information from GIS Data layers or subset information to determine activity at night. We have also just completed a revision of the VegMeasure Program. The new version, VegMeasure 2, is facilitating classification of the ground-level quadrat samples of vegetation as well as aerial photos (Johnson et. al. 2008).

We are also developing a user interface for use by cooperating ranchers to obtain and display incoming cattle location data from Clark GPS-SATCOMM tracking collars in real-time. The system would enable the cooperator to download location data and plot them on maps or remote sensing imagery using Google Earth (freeware) or other spatial tools (e.g., Global Mapper 11.0). Our intention is to design the interface such that it will be effective for users of all levels of technical expertise. Once equipped with this tool, we expect our cooperators will be able to play an even larger role by alerting the science team to anomalous cattle behavior in near-real time.

### **Economic Impacts**

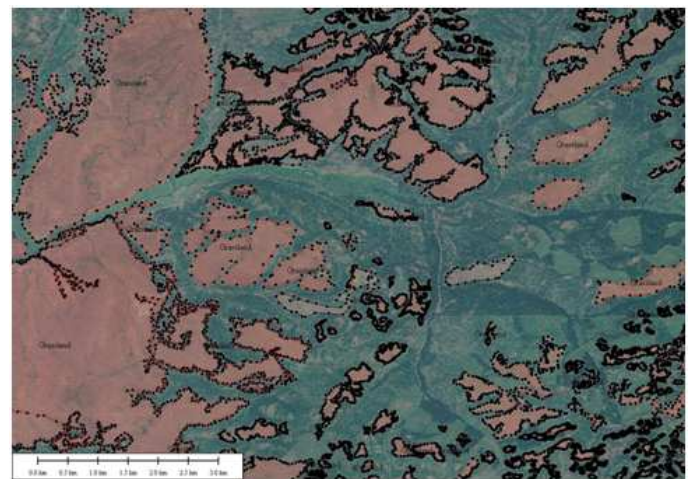
Dr. Neil Rimbey (University of Idaho) has begun collecting economic data from ranches in areas where wolves are common and areas where they are rare. This effort is examining changes in the production system both longitudinally through time on those ranches with detailed records going back to periods when wolves were rare and cross comparison between sites and allotments (with wolf

and without). The funding from the USDA-AFRI will support this effort.

### **Vegetation Community Mapping**

Vegetative community maps, based on Fred Hall's and Charlie Johnson's classification, exist in rough form for the Wallowa Whitman National Forest lands. We are updating these GIS layers and using these maps to determine the plant communities and locations most preferred by cattle. Unfortunately, similar maps do not exist for the 3 study areas on the Payette National Forest in Idaho. The vegetative community maps that the Payette do have in GIS format are much coarser (maximum resolution 1 km<sup>2</sup>) and are based on A.W. Kuchler's Potential Native Vegetation map (Kuchler 1964) but these are not appropriate for our analysis.

We obtained and digitally scanned some hard-copy (paper) maps of the plant communities on the Idaho study areas that had been drawn in the early 1970s by USFS personnel. Even after these maps were geo-corrected they were of limited use because of their age and cartographic errors in the original paper base maps. Thus, we have been forced to create electronic vegetation maps from USDA NAIP 2004 color aerial photographs for the Idaho study areas (Figure 9). This is a tedious, time-consuming job and we are nearing completion of the maps for the first 2 of the 3 areas. The last area will be digitized December through March 2010. These new maps will have to be field-verified and errors corrected during site visits before they can be accepted.



**Figure 4.** Digitization of vegetative communities on OBC Study areas on the Payette National Forest of Idaho. These maps are being classified in accordance with units identified by Dr. Fred Hall and Charles Johnson of the USFS.

Data on the relative productivity and degree of utilization of rangelands within the study areas is being collected for the 2009 field season. For each of the major vegetation types, i.e. wet meadow, dry meadow, open grassland, ponderosa pine savanna, etc., both plant height (for use with Dr. Larry Larson’s height/weight curves) and a straight down photograph were taken. Each of the samples (quadrats) was positioned with a GPS and logged with a date and time. Vertical photography from 1.5 m above the ground documents the percentage cover of green leaves, litter and bare soil. These photos can also be used to estimate range condition, plant production, plant species diversity, and grazing intensity (Johnson et al. 2008).

**Streams and Water Development GIS Layers**

Livestock use of riparian areas and streams within the study area is being evaluated because hypotheses have been proposed that suggest that large ungulates will shift their foraging away from riparian areas or other areas with shrubby, concealing vegetation to open areas where approaching wolves can be seen. We obtained USGS stream layers that positioned streams with either seasonal or perennial flow. These layers seemed to overestimate the extent of live water on the study sites based on our field visits so several other data sets for streams were examined.

We also interviewed cooperators and range riders as to the location of live water on the allotments and asked them to mark which stream segments contained running water during the times that cattle were in the allotments. Their information indicates substantially less linear extent of live water in the study pastures. All stream layers (USGS, USFS, ODFW and range users) were included in the project GIS database. The relative proximity of collared cows to streams (reported as % of all cow locations) for each of the classifications is given in Figure 10. Differences in values are the result of differences in extent of underlying stream layers. We will continue to examine the landscapes used in the study to verify the extent of live water and riparian areas and the relative cattle use.

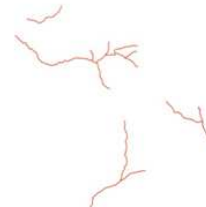
**Topography Usage by Cattle & Topographic Range Sites**

Slope and aspect maps were derived from USGS Digital Elevation Models based upon USDA Natural Resource Conservation Service classes. Each study area was masked and underlying values for elevation, slope and aspect extracted to characterize each study site (Table 3). As with proximity to streams, the relative cow usage of each class was determined (Table 4).

USGS Stream Layer	Herd 1	Herd 2
5 meters (16.4 ft)	4.03 %	4.32 %
10 meters (32.8 ft)	8.16 %	8.55 %
20 meters (65.6 ft)	16.07 %	16.06 %
30 meters (98.4 ft)	22.85 %	22.54 %
40 meters (131.2 ft)	28.54 %	27.94 %
50 meters (164 ft)	33.33 %	32.60 %



OSU/Operator Corrected	Herd 1	Herd 2
5 meters	.08 %	.53 %
10 meters	.18 %	1.07 %
20 meters	.33 %	2.09 %
30 meters	.50 %	2.89 %
40 meters	.66 %	3.57 %
50 meters	.81 %	4.10 %



**Figure 10.** Comparison of proximity of cows to USGS streams and the operator corrected running water stream layers for 2 herds grazing during 2008. Values are the percentage of cow positions that were within a specified buffer centered on the stream channel. Substantial differences result from differences in the extent of live streams mapped by USGS and by cooperators.

**Table 3.** Summary of the topographic characteristics of the three Oregon Study Sites used in the OBC Wolf Cattle Interaction Study.

Slope	Oregon Site 1	Oregon Site 2	Oregon Site 3
0-4%	3.88%	3.91%	2.85%
4-12%	18.42%	10.91%	14.14%
12-35%	50.03%	22.27%	53.69%
>35%	27.68%	62.91%	29.32%
<b>Aspect</b>			
None	0.07%	0.08%	0.17%
North	45.31%	52.21%	43.92%
South	54.62%	47.71%	55.90%

**Table 4.** Summary of the percentage of cow positions on each slope class and aspect class for animals using the three Oregon Study Sites.

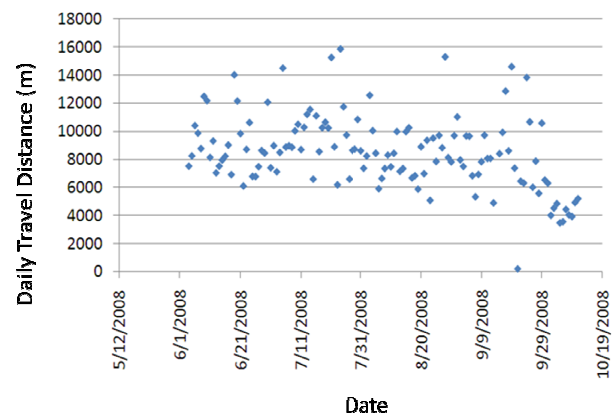
Slope	Herd 1	Herd 2
0-4%	7.78%	8.29%
4-12%	31.09%	34.85%
12-35%	51.70%	45.45%
>35%	9.42%	11.41%
<b>Aspect</b>		
None	0.28%	0.13%
North	45.35%	38.32%
South	54.36%	61.55%

We have also classified the topography of all study areas into a series of Topographic Range Sites using the following classes: 1) land with less than 5° slope, 2) North slopes between 5° and 15°, 3) East slopes between 5° and 15°, 4) South slopes between 5° and 15°, 5) West slopes between 5° and 15°, 6) North slopes between 15° and 30°, 7) East slopes between 15° and 30°, 8) South slopes between 15° and 30°, 9) West slopes between 15° and 30°, 10) North slopes greater than 30°, 11) East slopes greater than 30°, 12) South slopes greater than 30°, 13) West slopes greater than 30°. We will analyze site preference for these sites in a similar fashion to what was done for NRCS slope and aspect classes.

**Animal Spatial Behavior**

Travel distance was calculated for collared animals during the 2008 grazing season. Figure 11 gives an example of this type of data. Some of the days with long travel distances are probably the result of herding by range riders when animals are moved within the allotment or they may result from compounded GPS errors if an animal is resting near

an obstruction which blocks GPS satellites. We will examine the recorded velocity of the positions (GPS velocity is more precisely measured than GPS position) to determine if animals were truly moving on these days.



**Figure 11.** Calculated travel distance for an Oregon cow carrying GPS Unit 027 during the summer of 2008.

A summary of the travel distance recorded for the cow carrying GPS unit 027 during the summer of 2008 is given in Table 5.

**Table 5.** Calculated travel distance for Oregon cow carrying GPS Unit 027 on one of our Oregon Study Sites.

Parameter	Daily Travel Distance (km)	Daily Travel Distance (miles)
Mean	8.51 km	5.29 miles
Standard Deviation	2.61 km	1.62 miles
Maximum	15.84 km	9.85 miles
Minimum	0.193 km	0.120 miles

Grouping or bunching of cows may also result from wolf predation. Since we had no wolf collars deployed in 2008, we were not able to examine this question in detail. Information gathered in 2009, with heavy wolf depredation and a GPS collared wolf, should allow us to answer some of the questions about hazing of cattle by wolves and cow response to predation threat. We have also begun to explore other experiments that will provide more detailed and temporally and spatially precise information on wolf-cattle interactions.

### Project Publications

Several publications have resulted from this project to date. They are listed below:

**Johnson, M.D., M. Louhaichi, N.R. Harris, A.L. Wörz, and D.E. Johnson. 2008.** A protocol for monitoring vegetation, bare ground and litter in scaled globally-positioned ground-level imagery. American Society of Photogrammetry and Remote Sensing Proceedings, 2008 Annual Conference. Bridging the Horizons - New Frontiers in Geospatial collaboration. Portland Oregon, USA.  
[http://www.ars.usda.gov/resarch/publications/publications.htm?SEQ\\_NO\\_115=220820](http://www.ars.usda.gov/resarch/publications/publications.htm?SEQ_NO_115=220820)

**Clark, P.E., D. Spencer, D.E. Johnson, & F. Pierson. 2009.** Cutting-edge Technologies: GPS/Satellite Communications-based Tracking System. Abstr. of Papers, 62nd annual meeting Soc. for Range Manage., Albuquerque, New Mexico, USA. (Invited)

**Clark, P.E., and D.E. Johnson. 2009.** Wolf cattle interactions in the northern Rocky Mountains. Range field day progress report. Oregon Agricultural Experiment Station, Special Report 1092. Corvallis, OR  
[http://ir.library.oregonstate.edu/jspui/bitstream/1957/12263/1/SR\\_no.1092\\_ocr.pdf](http://ir.library.oregonstate.edu/jspui/bitstream/1957/12263/1/SR_no.1092_ocr.pdf)

**Wilson, K.D., P.E. Clark, L.L. Larson, J. Williams, M.D. Johnson, M. Louhaichi, D.E. Johnson. (Submitted 2010).** Cattle site preference in response to wolf presence in northeastern Oregon and western Idaho. Abstr. of Papers, 63rd annual meeting Soc. for Range Manage., Denver, Colorado, USA.

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Beef Cattle Sciences

# Oregon Beef Council Report

## Relationships Between Insect Abundance and Plant Community Characteristics for Sage-Grouse Brood-Rearing Habitat <sup>1</sup>

Erica A. Freese<sup>2</sup>, Tamzen K. Stringham<sup>3</sup>, and Jeffrey C. Miller<sup>4</sup>

### Synopsis

Insects consumed by sage-grouse chicks show correlation to some plant community characteristics. Plant community characteristics can be manipulated by management.

### Summary

The objective of this study was to link the abundance of insects found in the diet of sage-grouse chicks (caterpillars, ants, grasshoppers, darkling and scarab beetles) with plant community characteristics in sagebrush steppe ecosystems. Two sites were located within mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) dominated communities under spring and winter cattle grazing management. Two other sites were split between a rabbitbrush (*Chrysothamnus* sp. or *Ericameria* sp.) dominated upland and meadow. Line-point intercept, plant height and basal gap intercept were used to measure plant community structure and composition. Insect abundance was measured using pitfall traps. The rabbitbrush sites provided more caterpillars throughout May and June than the sagebrush sites. Compared to the spring grazed sagebrush site, the winter grazed site exhibited greater darkling beetle and grasshopper abundance and less sagebrush and

shrub cover, taller grasses and shrubs, and smaller basal gaps. Basal gaps are the distance between the bases of perennial plants at the soil surface. Caterpillars were negatively associated with percent basal gap, mean basal gap size, and sagebrush cover and positively associated with perennial grass cover, rabbitbrush cover, shrub height, and total vegetative cover. Overall, the rabbitbrush dominated meadow provided the most forb cover and caterpillars, suggesting that inclusions of this community type within the landscape would provide quality sage-grouse brood-rearing habitat.

### Introduction

Greater sage-grouse (*Centrocercus urophasianus*) populations have been declining over the past half century, in part due to low annual recruitment, which has been attributed to poor quality brood-rearing habitat (Connelly and Braun 1997). Sage-grouse population decline is concurrent with a decline in the extent and quality of the sagebrush biome (Connelly et al. 2004). Habitat loss is multifaceted including urbanization, fragmentation, and invasion by exotic and native species, increased occurrence of wildfires, and energy development (Connelly et al. 2004). However, current research has shown a positive

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relationship between sage-grouse brood and chick survival and the abundance of caterpillars (larva of Lepidoptera or moths and butterflies) (Gregg and Crawford 2009).

It has been well documented that sage-grouse chicks need insects during early brood-rearing to enhance diet quality and increase chances of survival. Numerous studies show ants and beetles to be the majority of insects consumed by sage-grouse chicks during early brood-rearing (Drut et al. 1994, Klebenow and Gray 1968, Peterson 1970, Rasmussen and Griner 1938). Less commonly reported in the diet, caterpillars are high in protein and fats and, when available, are high-quality components in sage-grouse chick diets. Research by Gregg and Crawford (2009) reported evidence directly linking sage-grouse chick survival with caterpillar abundance.

Identifiable relationships between the plant community and insects may have a significant impact on habitat management for sage-grouse as well as affecting policies regarding a variety of land use activities, such as off-road vehicle use, livestock grazing, and public recreation. Managing for factors that can increase the chance of survival, such as structural habitat diversity, food quality and availability, is critical for keeping sage-grouse populations stable. Therefore, if plant community structure and composition can be related to food resources land managers will have more information to make decisions concerning management of sage-grouse habitat.

The focus of this study was to investigate correlations between 19 vegetation measurements and insect abundance. To accomplish this, plant community composition and structure in mountain big sagebrush dominated sites under winter and spring grazing management as well as in rabbitbrush dominated dry meadow and upland type communities were quantified. In addition, within each of these plant community types we determined the abundance of insect taxa that sage-grouse chicks consume: 1) ants, 2) darkling beetles, 3) scarab beetles, 4) grasshoppers, and 5) caterpillars.

## Materials and Methods

This two-year study used a completely randomized design to test insect, vegetation, and year differences between two seasons of cattle grazing on the four sites dominated by mountain big sagebrush. Additionally, the same effects were tested on the upland and meadow rabbitbrush dominated

sites. Sixteen randomly located plots were established in the spring of 2007 within two winter grazed pastures and two spring grazed pastures; eight plots were winter grazed and eight plots were spring grazed. Eight additional plots were randomly located in the rabbitbrush dominated sites within two pastures; four each in the meadow and upland plant communities.

Plant foliar and basal cover and community composition were measured using line-point intercept along five transects at each plot for two years. Foliar cover is the area covered by the aerial portion of a plant. Basal cover is the area of a plant that extends into the soil. To account for rare species, a species survey was conducted within each plot after the line-point intercept was completed. Plant height and basal gap intercept were used to measure plant community structure. Average heights of shrubs (live and dead) and perennial grasses (vegetative and reproductive) were measured along transects each year. Basal gap intercept was measured between perennial plant species only during 2008 because it was hypothesized that gap size may affect the abundance of ground-crawling insects.

Insect abundance was measured using pitfall traps. Although pitfall traps are not the standard for capturing caterpillars, sampling efforts were focused on insects available for sage-grouse chicks. Six traps per plot were located using a randomly chosen point along the vegetation transects. Traps were set out for a 10 week period, beginning the first week of May each year. This time period corresponds with probable sage-grouse brood rearing in central Oregon. Traps were collected and reset every two weeks. After collection, each 6-trap sample was combined and specimens of interest were sorted by group and counted for each sampling period. Being the focal point of this study, caterpillars were counted for both years while grasshoppers, ants, and beetles were only counted in 2007.

Two-way analysis of variance (ANOVA) was used to test differences in: 1) insect abundance and vegetation characteristics between winter and spring grazed sagebrush sites by year, and 2) insect abundance and vegetation characteristics between meadow and upland rabbitbrush sites by year. Correlations between insect abundance and vegetation characteristics were tested using Pearson's product moment correlation. Significant effects were tested at the 0.05  $\alpha$ -level.

## Results

Several vegetation measurements were significantly different between the winter and spring grazed sagebrush sites (Table 1). Sites under spring grazing management had higher total shrub cover ( $P < 0.01$ ) and sagebrush cover ( $P < 0.05$ ) than winter grazed sites. Mean plant basal gap was only measured during 2008, but was different between seasons of grazing ( $P < 0.05$ ). Spring grazed plots had an average gap size of  $127.8 \pm 8.0$  cm compared to an average gap size of  $103.7 \pm 4.8$  cm for winter grazed plots. Reproductive shoot height for grasses was greater under winter grazing management ( $P = 0.01$ ).

Among the 19 measured vegetation characteristics, 10 were different between the two rabbitbrush sites (Table 1). In the meadow site, total shrub cover was greater ( $P < 0.05$ ) than in the upland site. Total vegetation cover ( $P < 0.01$ ), plant basal cover ( $P < 0.01$ ) and shrub height ( $P < 0.01$ ) were all greater in the meadow site. Not surprisingly, the upland site had greater basal gap size ( $P < 0.01$ ) than the meadow site. The only significant year affect for the rabbitbrush sites was annual forb cover ( $P < 0.01$ ), with 2007 having more cover than 2008 ( $2007 = 6.5\% \pm 1.9$  and  $2008 = 1.8\% \pm 0.6$ ).

Caterpillar abundance was different between years ( $P < 0.01$ ) in the sagebrush sites with more in 2007 than 2008 (plot average = 6 vs. 2, respectively). However, there were no significant differences between caterpillar abundance by season of grazing when both years were combined, or when tested individually. Caterpillar abundance was different between rabbitbrush sites ( $P < 0.01$ ), with meadow plots having, on average, almost four times more caterpillars than upland plots. Unlike the sagebrush sites, caterpillar abundance showed no differences between years in the rabbitbrush dominated areas.

No year effects were tested for other insects because they were only counted during 2007. Grasshopper, scarab beetle, and darkling beetle abundance showed differences between seasons of grazing ( $P = 0.05, 0.04$  and  $0.04$ , respectively; Table 2). Winter grazed areas exhibited a greater abundance of grasshoppers and darkling beetles, while the spring grazed areas had greater, though relatively low, scarab beetle abundance. Grasshopper abundance was different between meadow and upland rabbitbrush sites ( $P < 0.01$ ). Upland plots had, on average, almost three times more grasshoppers per plot than meadow plots.

**Table 1.** Vegetation parameters (mean  $\pm$  SE / plot) of sagebrush sites by season of grazing (spring/winter) and rabbitbrush sites. Sagebrush sites analyzed separate from rabbitbrush sites. Shrub category = rabbitbrush and sagebrush combined. Brothers, OR. <sup>1</sup>

Variable	Season		Site	
	Spring	Winter	Meadow	Upland
<b>Cover (%)</b>				
Annual Forb	1.4	1.4	4.8	3.6
Perennial Forb	2.5	2.3	4.3	2.9
Food Forb	2.9	2.4	6.0	3.8
Perennial Grass	22.5	26.0	44.0	15.4
Rabbitbrush	5.7	3.8	29.9 <sup>a</sup>	11.2 <sup>b</sup>
Sagebrush	10.1 <sup>a</sup>	5.9 <sup>b</sup>	0.4 <sup>a</sup>	5.1 <sup>b</sup>
Total Shrub	19.6 <sup>a</sup>	11.7 <sup>b</sup>	30.7 <sup>a</sup>	19.1 <sup>b</sup>
Total Basal	6.9	7.7	11.1 <sup>a</sup>	4.0 <sup>b</sup>
Total Vegetative	45.9	41.4	86.6 <sup>a</sup>	41.0 <sup>b</sup>
<b>Height (cm)</b>				
Reproductive Grass	22.8 <sup>a</sup>	27.7 <sup>b</sup>	23.0	24.3
Vegetative Grass	12.2	13.2	15.5	12.5
Live Shrub <sup>2</sup>	30.6	23.5	42.8 <sup>a</sup>	29.4 <sup>b</sup>
Total Shrub <sup>2</sup>	32.1	24.5	44.3 <sup>a</sup>	28.2 <sup>b</sup>
<b>Other</b>				
Basal Gap (cm)	127.8 <sup>a</sup>	103.7 <sup>b</sup>	64.0 <sup>a</sup>	141.3 <sup>b</sup>
Percent Basal Gap	85.8	85.0	45.7 <sup>a</sup>	88.0 <sup>b</sup>

<sup>1</sup> Within season and site rows, values with different superscripts (a or b) differ at 0.05  $\alpha$ -level.

<sup>2</sup> Total and live shrub height were significantly taller in spring grazed sites when years were analyzed separately

When all the sagebrush and rabbitbrush sites were combined, several vegetation parameters correlated with caterpillar abundance. The strongest correlations were with total vegetative cover (coefficient = 0.78,  $P < 0.01$ ) and percent basal gap

(coefficient = -0.79,  $P < 0.01$ ) (Table 3). Therefore, caterpillars were more abundant in areas with greater vegetative cover and less distance between perennial plant bases.

**Table 2.** Ant, grasshopper, darkling and scarab beetle abundance per plot (mean  $\pm$  SE) for 2007 and caterpillar abundance per plot for 2007 and 2008 in sagebrush sites and rabbitbrush sites. Brothers, OR.

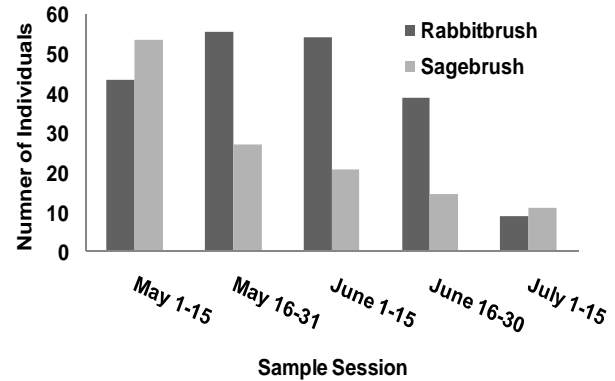
Variable	Season		Site	
	Spring	Winter	Meadow	Upland
Ants	1577.2	1850.3	3311.7	1591.3
Caterpillars	4.2	3.5	20.1 <sup>a</sup>	5.0 <sup>b</sup>
Darkling Beetles	10.0 <sup>b</sup>	16.5 <sup>a</sup>	22.3	23.3
Grasshoppers	10.2 <sup>b</sup>	19.3 <sup>a</sup>	7.5 <sup>a</sup>	18.8 <sup>b</sup>
Scarab Beetles	3.5 <sup>b</sup>	0.2 <sup>a</sup>	2.7	0

<sup>1</sup> Within season and site rows, values with different superscripts (a or b) differ at 0.05  $\alpha$ -level. Sagebrush sites were analyzed separately from rabbitbrush sites.

Although not statistically analyzed, it is apparent that caterpillar abundance, by 2-week sample session, between the sagebrush and rabbitbrush sites, the rabbitbrush sites provided a noticeably greater abundance longer in the season than the sagebrush sites (Figure 1). This has implications for sage-grouse broods that are from a second or third nest attempt. As the summer progresses insect supply dwindles, therefore having areas that provide these resources later in the season may be critical for broods of sage-grouse hens that fail at their initial nest.

**Table 3.** Significant (0.05  $\alpha$ -level) Pearson's product moment correlations [ $\geq$  ( $\pm 0.6$ )] between total caterpillar abundance and vegetation variables across all sites. 2007 and 2008 combined. Brothers, OR.

Variables	All Sites	
	P-value	Coefficient
Percent Basal Gap	<0.0001	-0.79
Perennial Grass Cover	<0.0001	0.61
Rabbitbrush Cover	<0.0001	0.64
Total Shrub Height	<0.0001	0.61
Total Vegetation Cover	<0.0001	0.78



**Figure 1.** Total caterpillar abundance for sagebrush and rabbitbrush sites, 2007 and 2008 combined. Brothers, OR.

### Conclusions

Consistent with other studies (Connelly et al. 2000, Connelly et al. 2004, Schroeder et al. 1999), the meadow location provided the greatest abundance of insects, especially caterpillars, and the most forb cover compared to all other sites. Although this is a rabbitbrush dominated meadow, it is surrounded by mountain big sagebrush communities and western juniper woodlands. The resulting landscape heterogeneity may be necessary to provide the complex and diverse habitats needed by sage-grouse. This research suggests that having this community type represented within the landscape may provide high-quality brood-rearing habitat for sage-grouse. However, these results are not promoting the deterioration of mesic meadows that are in good condition, but if the area is already dominated by rabbitbrush, management may chose to maintain this type of plant community for sage-grouse brood-rearing. The upland rabbitbrush site also had greater forb cover than any of the sagebrush sites, suggesting that having patches with rabbitbrush dominance may provide good quality foraging habitat for sage-grouse broods within broader sagebrush dominated landscapes. As a vital component of sage-grouse chick survival, inclusions of plant community types that support a diversity and high abundance of forbs and insects should be added to monitoring plans or assessments of current or potential sage-grouse brood-rearing habitat.

### Acknowledgements

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Beef Cattle Sciences

# Oregon Beef Council Report

## VegMeasure 2: a Software Package that Facilitates Measurement of Foliar Cover, Litter, and Bare Ground on Rangelands <sup>1</sup>

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M. D. Johnson<sup>2</sup>, P. Clark<sup>3</sup>, M. Louhaichi<sup>4</sup>, A. Wörz<sup>5</sup>, S. K. Ndzize<sup>6</sup>, and D.E. Johnson<sup>6</sup>

### Synopsis

We describe a photographic monitoring protocol and software program (VegMeasure 2) that can be used to quantify vegetative cover in quadrats.

### Summary

One of the most important indicators of rangeland condition and health is the percentage of the soil that is covered and protected from raindrops and overland flow of water by plants and litter. Sequential measurements of cover at seasonal or yearly intervals can indicate range trend. Unfortunately, plant foliar and litter cover is generally not measured but rather estimated by technicians using the quadrat method because quantitative measurement via intercept or point methods is tedious and time consuming. Differences in experience and judgment lead to substantial differences in cover estimates between technicians and from one sampling period to the next. We have been developing quantitative methods for estimating cover using globally positioned digital imaging coupled with image analysis for several years and have developed software and protocols that are repeatable and technician independent. These protocols employ a continuously recording Global

Positioning System (GPS) device, a digital camera, and a computer to acquire and manage information. Specialized software links an image of the ground to a specific location, rotates and scales the image, and processes it into meaningful classes such as foliar cover, litter, and bare ground. Original images, processed images, track logs, and photo locations are stored on the computer or a DVD for reference and archiving. Because both positioned and processed images are tagged with GPS coordinates, they can be viewed in a Geographical Information System (GIS).

### Introduction

Ecologists and managers have been challenged to develop cost-effective methods of measuring changes in vegetation that are reliable and repeatable (Stoddard and Smith 1943; Floyd and Anderson 1987; Brady et al. 1995; Bråkenhielm and Quighong 1995; Seefeldt and Booth 2006). Cost of vegetative inventories is high primarily because the labor required to sample is high and quantitative methods of measurement rely heavily on line intercept or point frame estimation which is slow. Recent developments in digital imaging, GPS technology, and computer technology have provided

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  4. International Center for Agricultural Research in the Dry Areas, Aleppo, Syria
  5. Global Geomatic Solutions, Muhlheim, Germany
  6. Rangeland Ecology & Management, Oregon State University, Corvallis, OR

new opportunities to speed the collection, processing, and storage of field data. The principles underlying this process are quite simple:

1. Digital cameras record the date and time when photographs are taken to the nearest second.
2. GPS receivers record both the location and time of the antenna with great accuracy.
3. A continuously recording GPS is coupled with a digital camera to determine the time, position and camera settings of the photograph. If the camera is pointed vertically downward and the directional orientation is known, the image can be rotated so that north is identified as the top of the image as in a map. We only have to scale the image to be able to produce an image map in which objects can be measured and positions quantified. If all photographs are taken with the same camera settings at the same height above the ground, the scaling will be the same.

This process is similar to photographic charting work done by early plant ecologists (Weaver and Clements 1938); thus, we have dubbed the process digital charting.

It also follows that the colors from the digital camera, which represent intensities of red, green and blue light striking the sensor, can be interpreted by computer to make meaningful classes. For example dark brown colors could be classed as soil, green hues as leaves and whitish colors as litter. In this fashion surface areas could be quantified and measured provided that the colors are sufficiently distinctive. Since the field of view of the camera is fixed, it can be used as a virtual plot frame that defines the sample area or quadrat. We suggest that data acquisition is faster and more uniform using these technique and information is more easily handled because the process is digital from start to finish and products can be stored in digital format. Other parameters such as presence or absence of distinctive species, plant vigor or plant health can also be evaluated in geo-referenced, time-stamped, high resolution images.

Our goal for this project was to update the VegMeasure software package (Johnson et al. 2004) and to develop algorithms and protocols within a software package, VegMeasure 2 (Johnson et al. 2009) which can be used to measure the percent cover of foliage, litter, and bare ground or other parameters of interest in electronically positioned and defined quadrats. The specific objectives were to:

1. Rapidly classify ground-level photographs into meaningful groups based on color.
2. Save classification parameters so they can be applied to other images taken under similar conditions.
3. Automatically classify all photographs selected or all photographs in a directory folder.
4. Export Images as either classified ASCII Raster maps or bitmaps with world files and projection information so they can be saved as GIS data layers.
5. Output summary tables with results of the classification for each image.

## Materials and Methods

Our technique for measuring cover requires a staff-mounted digital camera that is positioned to take a digital photograph vertically downward from a fixed height when the platform holding the camera is level (Figure 1). It consists of a Bogen Manfrotto 676B Monopod and a Bogen Manfrotto 3025/056 3D Junior Head to which a 5 by 8 inch (13 by 20 cm) platform has been mounted (Booth et al. 2004, Johnson et al. 2008). Attached to the platform is a bubble level, magnetic compass, continuously recording GPS unit, and the digital camera. The staff upon which the camera head is mounted can be either a pole of a fixed height or a variable height monopod, as long as the height does not change during a photo shoot (Figure 2).

The GPS positions are continuously monitored with a US Globalsat EM-406 GPS module, which employs a SiRF Star III chipset, and an embedded antenna attached to a SFE data logger. This provides a continuous breadcrumb log of positions for approximately 8 hours when powered by 4 AA batteries. We evaluated GPS accuracy using a fixed position test over 2.76 days (239,190 positions). Mean error was 6.33 ft., std. dev. = 4.76 ft. (1.93 m, std. dev. = 1.45 m) and 24.45% of points were within 3.3 ft. (1 m), 63.68% within 6.56 ft. (2m), 84.73% within 9.84 ft. (3 m). Only 616 points had errors greater than 32.8 ft. (10m; 0.26%).

Digital images were geographically positioned, scaled, and oriented using Geoalbum software (Johnson et al. 2007). These images were used to evaluate VegMeasure 2 and classification algorithms of the updated software.





**Figure 1.** Apparatus used to obtain digital images of quadrats that are positioned with GeoAlbum software and classified using VegMeasure 2.

## Results

VegMeasure 2 software was written in Qt, a cross platform computer language, and C++. It runs on all major platforms. After VegMeasure 2 is installed and the license file prepared it can be run from the start menu. The initial program window will look like Figure 3.



**Figure 2.** Acquisition of digital images in the field using a staff-mounted camera and a continuously recording GPS unit.

Users can load images by clicking the “Set Folder” button to specify the directory which contains the photos you would like to process. The photo names should now be listed in the box in the upper-left of the program window (Figure 4). Below the box are checkboxes to specify the types of images you would like to process. When you click an image, a preview should appear. Images can then be analyzed via a number of available processes.

### Red, Green, and Blue Band Algorithms

Each pixel in the original image has color information stored in the RGB format. There is a red, green, and blue index, and each runs from 0 to 255. Thus, (0, 0, 0) represents black, (255,0,0) represents pure red, etc. Selecting the “Red Band” algorithm will replace the original RGB color (r, g, b) at each pixel with its filtered red value (r, 0, 0). The raster output will contain with red value r at each pixel. Green and blue bands can also be similarly partitioned into a monochromatic image. Once the image is monochromatic, the relative intensity of the color can be used to divide the image into 2 classes representing objects of interest. We have used this to separate flowers from background and, on photographs taken vertically upward, sky from vegetation canopy.

### Green Leaf Algorithm

The green leaf algorithm selects pixels that correspond to green living vegetation from conventional color digital photography. It uses a formula that ratios the digital numbers for each of the three color channels (Louhaichi et al. 2001) then sets a threshold to separate classes (Booth et al. 2005). The digital numbers are ratioed using the following formula:

$$\frac{(G - R) + (G - B)}{G + R + G + B}$$

where:

G = digital number of the green channel (0 to 255)

R = digital number of the red channel (0 to 255)

B = digital number of the blue channel (0 to 255)

### Brightness Algorithm

The brightness of a pixel with RGB values (r, g, b) is determined by the formula:

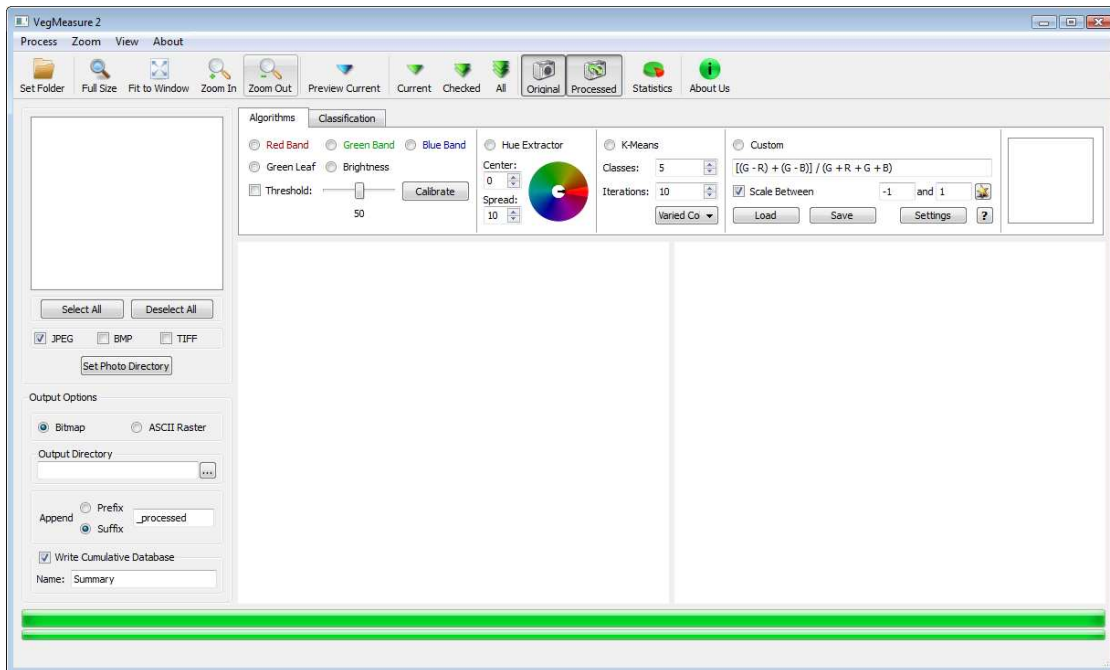
$$brightness = 0.299r + 0.587g + 0.144b$$

The values range from 0 to 255.

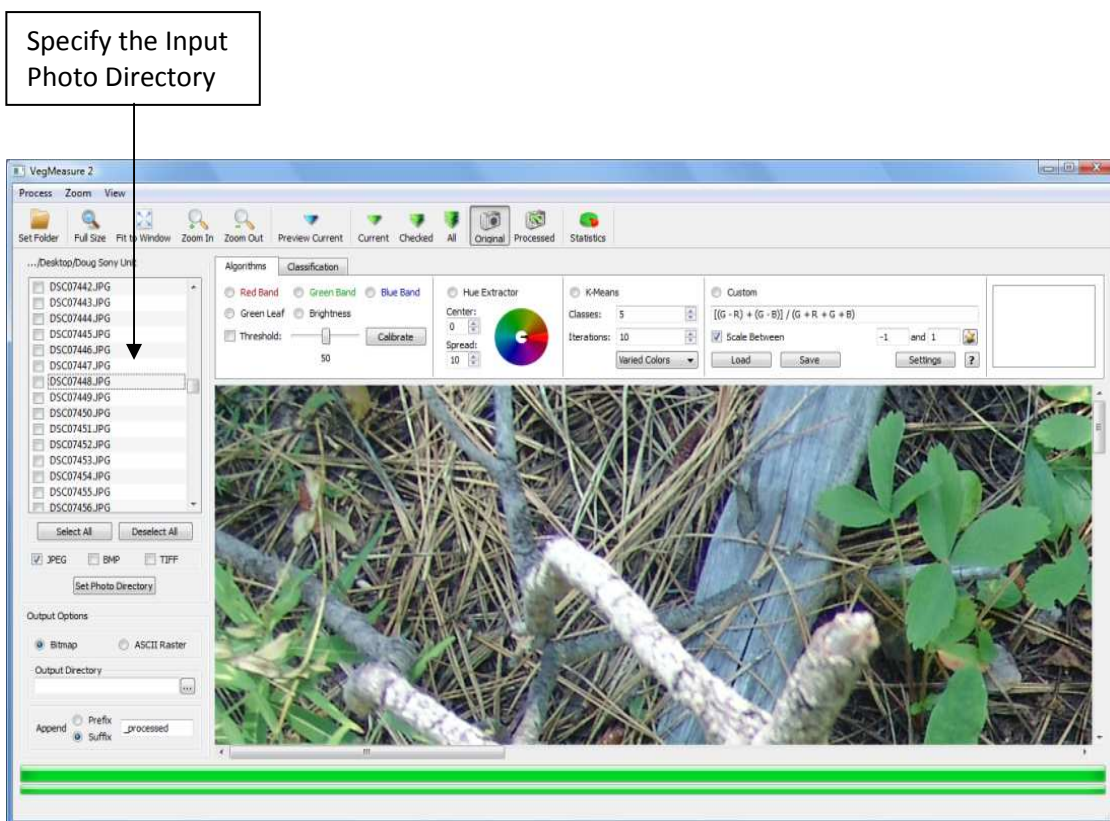
### Using a Threshold

A threshold can also be applied which segments the data into two classes: above or below the threshold. The threshold value ranges from 0 to 100, so a threshold of 50 applied to the red band will classify each pixel as 0 or 1 depending on whether or not its red value is below or above  $255 \times 0.5$ .





**Figure 3.** Initial program window of VegMeasure 2 software before the default folder is set and files are selected. The toolbar includes buttons that provide access to the analysis algorithms and program settings.



**Figure 4.** Once the input photo directory is specified, the user can select images to be processed and the output directory for classified images.

### **Calibrating a Threshold**

To calibrate the threshold, click the “Calibrate” button next to the threshold slider. You should see a window that looks like Figure 5. In this example (Figure 5), the number of points is 50, which means that 50 random points have been selected in the image. The user can press “Reset” to generate a new set of points. Circles are shown on the original image to indicate the locations. Each circle is blue, green, or red to indicate whether it is unclassified, above the threshold, or below the threshold. The currently selected point is shown in yellow. The current view will automatically zoom to the region with the currently selected point so the user can classify the point as either class 1, above the threshold, or class 2, below the threshold.

Colors may be dragged into the appropriate location (above or below the threshold). Several features make this quicker. Clicking the “Sort” button will arrange them in order of their current threshold value. Clicking the “Auto-Fill with Current Threshold” button will take the currently assigned threshold and apply it to assign each point to the appropriate box (Figure 6).

Once you have finished sorting colors, the user can click the “Calculate Threshold” button. The program will determine the best threshold to fit your criteria. You will then receive a dialog informing you of the calculated threshold and asking whether you would like to set it as the correct one.

### **Hue Extraction Algorithm**

In addition to the RGB color classification, colors may be described in the HSV (Hue-Saturation-Value) system. Figure 7 illustrates the various components.

The Hue extraction allows you to filter for colors whose hue lies in a particular color range. Hue values lie on a circle and range from 0-359. Thus, a hue of 0 is the same as a hue of 360. To use the algorithm, simply specify the hue range to classify based on a center value and a spread (Figure 8). The preview wheel shows the specified region as a lighter color.

This algorithm is useful when a particular plant has a specific and diagnostic color that is different from associated vegetation. For example, we have classified the cover of medusahead [*Taeniatherum caput-medusae* (L.) Nevski] in quadrats.

### **K-Means Classification Algorithm**

Often it is important to separate images into more than two classes. The K-Means Algorithm (MacQueen 1967) will automatically find groups of similar colors. The process is iterative, and convergence may take many steps. The program will run until a specified number of steps are completed or convergence is reached, whichever comes first. The program will also indicate whether or not convergence was reached. You must specify the number of color classes to identify, and the maximum number of iterations.

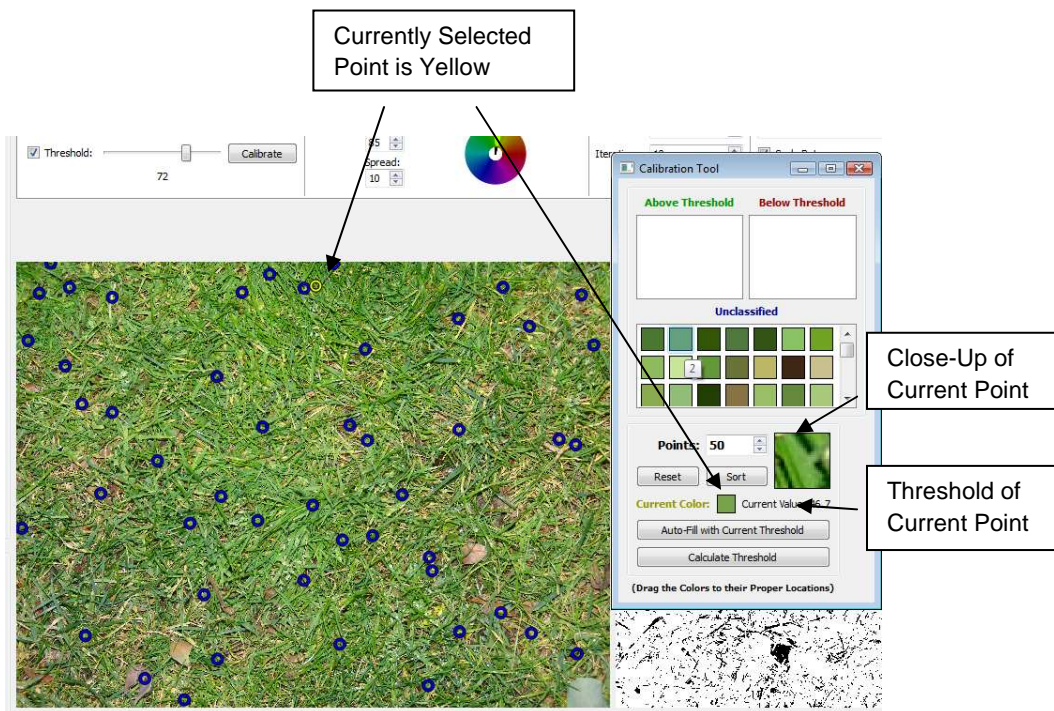
There are several options for the output image coloring scheme. Choosing “Varied colors” will assign colors to each group which is as different as possible from other display colors to emphasize grouping (Figure 9). “Monochrome” generates a grayscale image where the classes are evenly spaced between white and black. “Group Average” will give each group the average color in it, and is a good characterization of the quality of classification. If a raster map is chosen for the output, then cell values will simply be the group number.

### **Custom Formula**

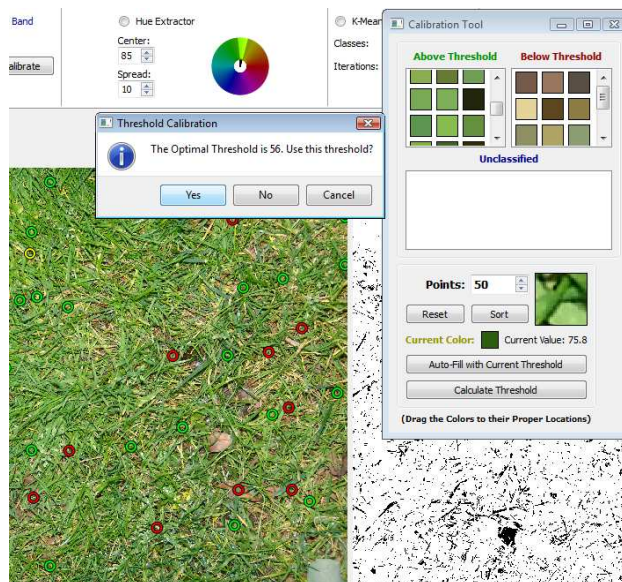
To allow for maximum flexibility, VegMeasure 2 allows the user to specify a custom formula by simply typing any formula in the equation box. It can be anything involving the usual symbols ( ) [ ] { } + - \* / ^ %. In addition, you can use the variables R, G, B, H, S, and V, which represent the red band, green band, blue band, hue, saturation, and value of the current color. Each cell in the original image will be processed with the specified formula.

The scale bounds determine the range of output values so that the output image may be properly colored (after proper scaling, output values range from 0-255). To automatically calculate these bounds, press the button with a star next to the scale bounds and the program will calculate the minima and maxima of your formula.

To see specific examples of your formula and ensure that it is correctly interpreted, the user can click the “Settings” button. A window will appear which allows you to specify RGB or HSV values (both will adjust when either is specified) (Figure 10). You can then see the value calculated using your formula, and the scaled value. This window also allows you to determine how the program handles non-numeric values, such as division by zero.

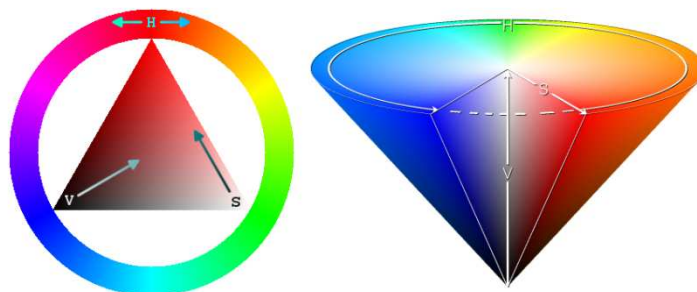


**Figure 1.** Threshold can be calculated by inserting random points on the image, then manually classifying each point. We suggest that 50 or more points be used in threshold calculation.



**Figure 6.** Once all points are classified, VegMeasure 2 calculates the threshold that fits the classification.

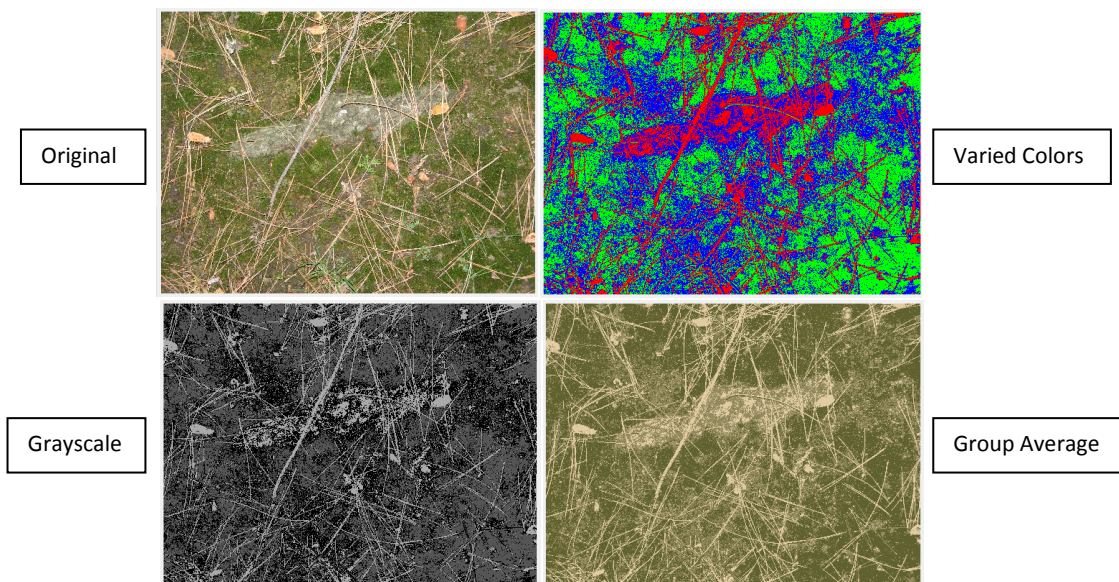




**Figure 7.** Graphical representation of the Hue-Saturation-Value color classification. Image Courtesy Wikipedia 2009.



**Figure 8.** The Hue Extractor allows users to identify both the hue and the range used in classification.



**Figure 9.** Output from the K-means classification can be color coded as varied colors, grayscale tones or the color of the group average.

As an example, the custom formula corresponding to the red band is just 'R' and must be scaled from 0 to 255. The custom formula corresponding to the Green Leaf algorithm is:  $[(G - R) + (G - B)] / (G + R + G + B)$ , and must be scaled from -1 to 1. Custom formulas may be saved and loaded for future use. The custom classification algorithm uses a significant amount of RAM. For complicated formulas and large images, it can require more than a gigabyte and may require long processing times.

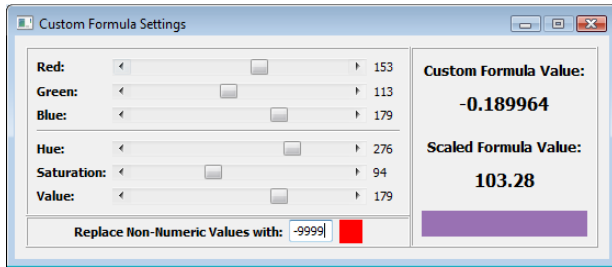


Figure 10. Value calculator for the "Custom Formula" algorithm.

### Custom User Supervised Classification Algorithm

#### Basics

VegMeasure 2 also allows you to create a custom classification scheme. Each pixel in the input image will be classified into user specified groups. To begin creating a scheme, click the "Classification" tab:

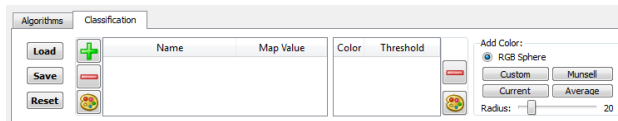


Figure 11. User supervised classification of colors in the image into meaningful classes using selected red, green, and blue values and a threshold around selected colors.

#### Adding Categories

The next step is to add the categories into which your image will be classified (Figure 11). To add a category, the user can click the green plus button. A new category will be added to the list and if necessary, you can modify the name and category value by double clicking the items in the table. Users can also change the category color by selecting the pertinent category and then clicking the palette button.

The next step is to add colors to each category with respective thresholds. The threshold represents the maximum distance in RGB color

space for a point to be classified in the category. For example, suppose you add a color with RGB values (100, 150, 50) to the category with threshold 20. Then any point with RGB values (r, g, b) will be classified as part of the category if the following is satisfied:

$$\sqrt{(r - 100)^2 + (g - 150)^2 + (b - 50)^2} \leq 20$$

There are several ways to add colors to a category. The most basic is by clicking the "Custom" button. A dialog will appear prompting for a color which will then be added to the current category. You may add as many colors to each category and a point will be classified as part of that category if it falls within the threshold of any of them. This algorithm is particularly useful for classifying green leaf, litter, and bare ground. The user classifies the colors of each category in the first image, testing periodically to determine if all portions of the image are classified. The user then saves the classification parameters so they can be applied to other images in the same data set. To save a custom classification for later use, simply click the "Save" button on the right side of the screen. The "Load" button allows you to open a previously saved classification.

### Utilities to Assist Custom Classification

#### Getting Colors from the Image

In addition to the preview, several utilities have been written to assist creation of a custom classification scheme. Once categories have been added with colors, moving the mouse over the input image will cause the color box on the right to update with the current color under the cursor (Figure 12). It also displays which category, if any, the point is classified in and the distance to the closest category. You can set this as the "Current Color" simply left-click with the mouse. If you click the "Current" button then this color will be added to the currently selected category.

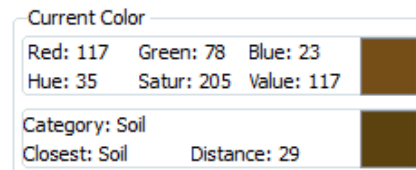


Figure 12. Information is displayed as the cursor is moved over the image which identifies the characteristics of the color, the closest classification and the Euclidian distance to the classified color space.

### Getting the Average Color of a Region

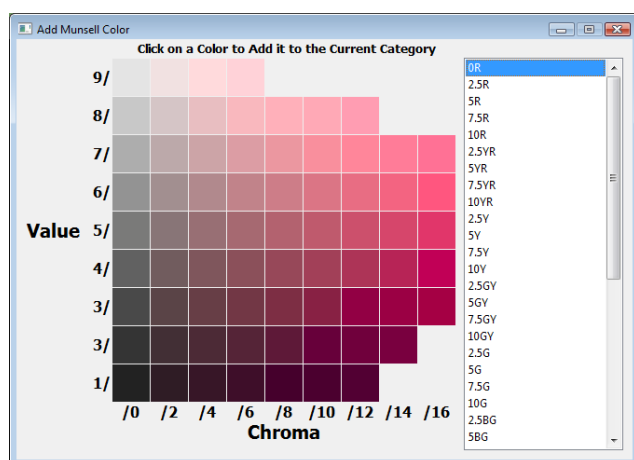
In some cases, it is useful to add the average color of a region. To do so, simply left click and drag a box around the desired region – the color preview will display the average as you drag. Then the average color can be added by clicking the “Current” button.



**Figure 13.** An Average color can be calculated by drawing a box on the image.

### Adding a Munsell Color

The Munsell color system (Cleland 1921) is widely used for classifying soils and vegetation (Simonson 1993, Schoeneberger et al. 1998). If the Munsell colors of a particular class have been ascertained, VegMeasure 2 has a built-in table of Munsell colors which can also be used by clicking on the “Munsell” button to see Figure 14. This feature was included because soil classification in the United States employs Munsell color classification for both wet and dry conditions. Plant scientists also use Munsell color charts when describing variations brought about by disease or nutrient deficiencies. Clicking a colored box will add that color to the current category with whatever the current threshold is set to.



**Figure 14.** Specific colors identified using the Munsell Color Charts the selecting the appropriate color in VegMeasure 2.

### Summary Table Output

A summary table that includes values for each class is compiled when users carry out operations on all files in a folder or a series of selected files. This summary table is output as a comma separated values (CSV) file which can be opened in word processors, spreadsheets, or text editors. The file contains the original image name, analysis algorithm performed, the threshold level used, percentage of the image above the threshold, and the percentage of the image below the threshold in tabular format.

Since its creation, VegMeasure 2 has been used to quantify rangeland vegetation, effects of wildfire on understory vegetation, and pattern of weeds by capturing distinctive flower or leaf color. We added specific algorithms for these applications.

We also are using VegMeasure 2 on permanent quadrats to document change through time, such as spring plant growth or reduction of leaf area by grazing. Charting of vegetation across several years with VegMeasure 2 should allow us to quantify the increase or decrease of specific bunchgrass or forb cover and to measure annual variability. Individual plant persistence and behavior can also be measured via VegMeasure2 in vegetative communities.

## Conclusions

VegMeasure 2 can transform a series of conventional color digital photographs into a valuable quantitative data set providing a strict protocol is followed during the process of collecting and handling images. We have used VegMeasure 2 to classify bare ground, litter and green foliage as well as the presence of plant species with distinctive hues. More rigorous testing is in progress as is evaluation of error as compared to traditional techniques of measuring cover. The original images, geo-referenced images, and classified images become a valuable data set that records and characterizes the condition of the range at a specified location at a specified time. These data sets are extremely valuable to document change and range trend.

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Beef Cattle Sciences

# Oregon Beef Council Report

## Progress Reports – Rangeland Ecology and Management

### **Development and Evaluation of Rangeland Vegetation and Sediment Monitoring: Phases I and II**

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**Project Objectives:** The overall objective of this study is to develop and test methodologies for monitoring forage utilization on grazing allotments and detecting change in streambed sediments associated with cattle use in riparian areas. This effort addresses two major areas of concern: 1) The development of quantitative data bases for allotment management and 2) The development of sampling methodology to facilitate the refinement of stubble height standards for riparian and upland grazing. Training would be provided to landowners/permittees and agency personnel.

**Project Start Date:** Phase I – June 2007; Phase II – June 2008

**Expected Project Completion Date:** June 2011

**Project Status:** Meetings are being held with national, regional, state, forest and district range staff from both the Forest Service (USFS) and Bureau of Land Management (BLM). Inventory issues associated with scale, statistical rigor and data accuracy have been discussed in detail. A pilot project on forested allotments in northeastern Oregon has been successfully completed. Similar inventory techniques were extended to the Snake River Province Sagebrush Steppe (BLM). In both cases (BLM and USFS), the adoption of the methodology occurred on a case by case basis.

Allotment inventory needs to provide data that can address allotment questions while at the same time provide compatible information for the vegetation classification units associated with larger landscape management. The ecological site classification utilized by the BLM and the Plant Community/Association classification utilized by the USFS represents a scale of vegetation classification that is used in allotment management that is also suitable for integration into most landscape inventories. The BLM and USFS are currently working to adopt a common system of ecological site classification. The foundation for that effort is the Ecological Site Inventory which was developed and is maintained by the Natural Resources Conservation Service. To expand the acceptance of the monitoring methodology developed in this project a document needs to be developed that supports the Ecological Site Inventory system, providing guidance on the measurement of forage utilization and stream sedimentation.

Forest community types used in the project include Ponderosa Pine-Douglas Fir-Elk Sedge, Ponderosa Pine-Fescue, Ponderosa Pine-Wheatgrass, Mixed Conifer-Pinegrass, Juniper-Big Sagebrush, Big Sagebrush-Bunchgrass, Low Sagebrush-Bunchgrass, Bunchgrass on Shallow Soil, Dry Phase Moist Meadow, Moist Meadow and Wet Meadow. Ecological sites used in the sagebrush steppe include sites having soil depth >20'', slopes <12% , no aspect and elevations either less than or greater than 3800 ft (<3800 Clayey 9-12; <3800 Mtn Clayey 9-12; >3800 Mtn Clayey 12-16; <3800 Loamy 9-12; <3800 Mtn Loamy 9-12; >3800 Mtn Loamy 12-16)



and sites with soil depths >20'', slopes >12%, north or south aspect and variable elevation (<4500 Clayey South 9-12; >4500 Mtn South 12-16; >3000 Mtn North 9-12; >3000 Mtn North 12-16).

The application of the inventory techniques and the testing of project products will continue as part of agency and land manager training. We are currently exploring ways to compile project products into a document or documents that support their application to the description of ecological sites. No additional funding is needed to complete the project.

## **The potential of DNA analysis for accurate cattle diet determination in sagebrush rangelands**

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**Project Objectives:** A controlled feeding trial with cattle will be conducted to determine the recovery of DNA in feces from a known diet. The objective is to evaluate the use of DNA fingerprinting to determine cattle diet composition. Particularly, in this study we attempt to determine if fecal DNA analysis can accurately determine the presence and proportion of sagebrush in cattle diets in areas where sage-grouse is a species of concern.

**Project Start Date:** June 2009

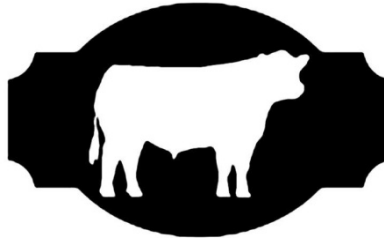
**Expected Project Completion Date:** May 2010

**Project Status:** This study will include three phases: 1) determination of sagebrush DNA barcodes, 2) controlled feeding trial and recovery of sagebrush in feces, and 3) field analysis to determine the potential presence of sagebrush in cattle diets. Phase 1 includes laboratory DNA extraction and base sequence determination for portions of the sagebrush genome that can be used as markers for the species. This phase has been initiated and will be completed in January of 2010. Phase 2 is the feeding trial experiment in which cattle will be fed a controlled diet including variable proportions of sagebrush. Feces will be collected and analyzed for the presence and proportion of sagebrush using its previously-determined DNA barcodes. This phase will start in November of 2009 and will be completed in January of 2010. Phase 3 will involve collection of cattle fecal samples in rangeland areas where sage-grouse is a species of concern. Phase 3 is ongoing and will be completed in May of 2010. Results will be summarized and presented at workshops and technical seminars.

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**A Vision for Rangeland  
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