AN ABSTRACT OF THE THESIS OF

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Abstract approved:

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One second GPS collars were deployed on cattle in three different pastures at three separate times during the year. In each riparian pasture the vegetative communities and stream bank edge were digitally mapped using low elevation aerial photographs and checked in the field for accuracy. A 5 m buffer zone was established on the outside of both stream banks to analyze steam bank edge. The Animal Movement Classification Tool (Johnson et al. 2009) was used to split the one second data into 24 hour periods and movement was determined by pre determined settings. The herd day (5 cattle) one second point files were overlaid with this map and amount of time spent was determined for each community or zone. Analysis was done to determine the type of movement done in each community (moving vs. stationary and 1st half vs 2nd half of trial). One typical day for each pasture was analyzed to show the movement of a cow for that day. Other descriptive analyses were used to explain cattle crossings.

In all three pastures the cattle did not move evenly throughout the pastures. Cattle always preferred to rest in areas that were dry and open. Cattle were stationary for more than 50% of the time in each pasture and had a consistent resting period from about dark until 4:00 a.m. Stationary locations (stationary > 10 minutes) were found to be relatively well distributed within these areas.

Interaction with the stream was found to be 1-2% of total occupancy. Cattle were either neutral in preference or avoided these areas relative to their acreage and a majority of the time spent in these areas was spent moving not resting. Cattle did not prefer to be in the stream bank zone in any pasture relative to their acreage. The stream bank zone was used as a travel corridor to get to and from the stream to drink or cross.

Distribution and Behavior of Cattle Grazing Riparian Pastures

by

Marie A. Wilson

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I understand my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Marie A. Wilson, Author

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Distribution and Behavior of Cattle Grazing Riparian Pastures

Introduction

Management of riparian systems in the western United States has and continues to be the subject environmental controversy. In the arid west a significant portion of rural economies is dependent on the water and forage derived from these systems. Conversely, environmental concerns about the management of these lands and the potential impact on endangered species have placed these lands under increased scrutiny. A literature review of this subject by the National Research Council (2002) indicated that:

> *"Traditional agriculture is probably the largest contributor to the decline of riparian areas…"*
>
> &
>
> *"The primary effects of livestock grazing include 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."*

However, other authors (Bryant 1982, Gillen et al. 1984, Roath and Krueger 1982a, Kauffman et al. 1983a, Wagnon 1968, Laliberte et al. 2001, Buckhouse et al. 1981, Ballard 1999, Wilson 2010) report results that indicate that cattle can graze rangelands containing riparian areas without harming these riparian areas and that managed grazing can maintain and improve riparian systems.

In the middle of this controversy cattle research in riparian areas has been evolving with improved technology. Collar tracking systems began using a combination of observation and telemetry in the1950s and 1960s and more recently Global Positioning Systems (GPS) to track animal movement. This transition to GPS and the development of increased memory storage capacity have allowed for the development of one second GPS collars. These collars have the ability to track cattle movement every second, allowing the researcher to know exactly where cattle are without disturbing them. The purpose of this study was to develop a data set of cattle movement in riparian pastures using the one second collar technology to help sort through the confusion of what cattle do or do not do in these riparian systems.

Literature Review

Riparian and stream health is a major issue facing public grazing land users today. It has been stated by the U.S. Forest Service, Bureau of Land Management and Environmental Protection Agency that stream systems in the western United States are being negatively affected by livestock grazing (Armour et al. 1994, U.S. GAO 1988). Concern over this issue has grown to the point that land managers actively seek methods of cattle distribution that will minimize negative impacts on sensitive areas like riparian zones (Coughenour 1991, Bailey et al. 1996). However scientific findings and the associated literature on this subject is not settled. For example, Ames (1977) states that water, shade, thermal cover and production of higher quality forage cause riparian areas to receive more use than uplands, while comparable studies indicate that upland areas receive more frequent use than riparian areas by free ranging cattle (Bryant 1982, Gillen et al. 1984, Roath and Krueger 1982a, Kauffman et al. 1983a, Wagnon 1968). In an effort to clarify this apparent discrepancy, Larsen et al. (1998) made an assessment of the scientific credibility of 428 articles evaluating grazing impacts on riparian communities. They found that only 89 articles contained experimental, replicated and statistically valid analyses. Given this range in literature quality, it is of little wonder that contradictory conclusions predominate our understanding of the behavior of cattle and the ecology of aquatic systems (Harris 2001).

Animal distribution

Meuggler (1965) reported that distance from water strongly influenced cattle distribution. Smith et al. (1992) concluded that preference for grazing areas may be partly based on succulent forage that grew in riparian areas with water. Conversely, a study in an Arizona Ponderosa Pine forest by Clary et al. (1978) found that there was no correlation between water and forage use by cattle. Still others have found that while distance to water was an important factor, no single environmental factor explained cattle use adequately (Cook 1966).

Miller and Krueger (1976) found that 71% of the forage consumed by livestock was associated with distance to water and salt. A study by Porath et al. (2002) on Milk Creek in Eastern Oregon found that cattle in the early part of the grazing period without any off stream water or salt ended up closer to the stream later in the day than cattle with off stream resources even though both groups of cattle generally started at the same distance from the stream. Canopy cover or shade was also found to be a determinant in establishing cattle distribution. In 1991, in a study conducted by Pinchak et al., 77% of cattle use was within 366 m of water while only 12% of vegetation use occurred on the 65% of the available land located 723 m or more from water. Roath and Krueger (1982b) observed that when moderately steep slopes were present, the vertical distance above the water was an important factor in determining vegetation use. They stated that when determining spatial and temporal grazing use of forested range, water and vegetation types were the most important factors. Similarly, a regression model developed in Texas to explain forage utilization found that water availability played an important role in the selection of grazing areas by livestock (Owens et al. 1991). Hart et al. (1993) observed that as the distance to water increased the distribution of forage use on a 207 ha pasture decreased. However, they also observed that this inverse relationship between distance to water and forage use did not hold true on smaller (24 ha) pastures, concluding that land managers need to recognize that both pasture size and distance to water influence livestock use. Smith et al. (1992) observed an avoidance of areas of upland forage in an allotment of 49,900 ha due to distance to drinking water. In a study conducted in eastern Oregon on 44,000 ha of the Wallowa-Whitman National Forest it was found that cattle did not use forage areas near running water more than uplands (Wilson 2010). This study (24 hour, GPS tracking) showed that cattle spent 96 to 99% of their time at least 60 m from either bank of perennial streams.

Senft et al. (1985a) observed that seasonal proximity to water and forage quality indicators is related to grazing distribution. Their study used a relative measure of forage quality and quantity to predict grazing distribution. A study done on Milk Creek in Eastern Oregon found that cattle were consistently observed further from the channel in the early part of the grazing period than in the later part, 161 and 99 m respectively (Parsons et al. 2003). DelCurto et al. (2000) also observed that season of use and water availability had a strong influence on animal distribution patterns on forested range.

Impact on water's edge

In an early study on Catherine Creek in Eastern Oregon, significant stream bank loss and erosion levels were reported to be associated with cattle grazing by indirect cattle measurements (Kauffman et al. 1983a). However, a subsequent study using precise ground measurements and remote sensing technology on the same stretch of Catherine Creek determined that topography and stream dynamics over the past twenty year period had greater influence on channel morphology than cattle grazing (Laliberte et al. 2001). Similarly, changes in channel morphology on Meadow Creek in Eastern Oregon were found to be more highly associated with high runoff and ice flows rather than cattle grazing (Buckhouse et al. 1981). This apparent contradiction in the literature regarding cattle impact was clarified at least in part on Catherine Creek in a direct cattle observation study conducted by Ballard (1999). Her direct observations determined that cattle were spending 94% of their time in terrestrial habitats away from water, 6% of their time in stream habitats, and less than 1% of their time in direct stream contact (wetted edge).

Rauzi and Hanson (1966) found that soil infiltration decreased with increased grazing intensity. In a study where grazing was contrasted against exclusion, a trend was identified in the top 4 inches of soil where large macropore space decreased and bulk density increased due to livestock trampling (Orr 1960). In the same study, however, it was reported that the soil recovery was relatively rapid (5 years) following livestock removal.

A number of factors have been found that influence the amount of time cattle spend in riparian zones. Streamside vegetation, stream channel morphology, shape and quality of the water column and the structure of the soil portion of the stream bank have all been found to be important (Kauffman and Krueger 1984). Kauffman and Krueger

(1984) noted that livestock impact can be reduced by simply distributing livestock more evenly over the watershed reducing livestock concentration.

Impact of channel activity

Concentration of manure in stream channels contributes organic matter, microbial populations and nutrients (nitrogen and phosphorous) to the water column that can reduce water quality (Ballard 1999). Free ranging cattle defecate on average 12 times per day (Larsen 1989) in a non-uniform distribution pattern (Hafez and Schein 1962). This amounts to about 0.5-0.75% of the cattle's body weight per day on a dry weight basis and the output contains on average 3.8 x 10^{10} fecal coliform (Larsen 1989). Tate et al. (2000) report that *Cryptosporidium parvum* oocysts contained in cattle fecal deposits tend to be moved approximately 1 m by diffuse overland flow. Atwill et al. (2002) reported that striped skunks, coyotes, ground squirrels and marmots all produce more oocysts per individual than adult beef cows and that calves with undeveloped rumens is the only beef cattle age group that yield comparable numbers of oocysts. In the study by Ballard (1999) cattle spent less than 1% of their time in stream. Half that time was spent drinking water and less than 0.01% of their time was spent defecating in the aquatic habitat (wetted edge). She reported that cattle typically enter the stream to either drink or cross the stream and that drinking cattle tended to enter the stream with their two front feet and then back away when finished. Sneva (1969) and McInnis (1985) observed drinking times to be 17 minutes and 26.6 minutes per day respectively. Ballard (1999) reported that cattle spent about 3 minutes in a drinking event and would have 1 to 2 drinking events per day. Wagnon (1963) observed drinking times of 3-4 minutes per event.

Vegetation impact

Plant communities and associations are influenced by a number of abiotic and biotic factors. Abiotic resources tend to determine the spatial arrangement of plant life that is dependent on those resources to complete their life cycle (Harper 1977). Within those abiotic resources, available moisture and nutrients typically tend to be most important (Brady 1990).

Vegetation patterns influence cattle distribution (Brock and Owensby 2000, Senft et al. 1987, Smith 1988, Wade et al 1998). Hein (1935) reported that grazing time was directly proportional to the quantity and quality of available forage. Cook et al. (1962) reported that animal utilization and daily intake on poor range was less than on range in good condition. Forage intake has also been found to decrease as plant material matures (Cordova et al. 1978). Ganskopp et al. (1993) observed that as the density of cured stems increased in plants, cattle grazing decreased to the point of avoidance.

Anderson and Kothmann (1980) found that forage species, particularly palatable forbs, was positively correlated with distanced traveled by cattle. Clary et al. (1978) determined that tree density and forage production were also associated with forage utilization. However, Havstad et al. (1983) found no difference in forage intake as availability of crested wheatgrass declined. Low et al. (1981b) observed little change in animal behavior in Australia even though cattle grazed more widely when forage became scarce. In southern New Mexico, Herbel and Nelson (1966) found no relationship between quantity of forage per unit area and grazing time.

Kauffman et al. (1983b) speculated that riparian succession was hindered due to heavy browsing found on willows located on gravel bars. However, McLean et al. (1963) reported that a reduction in grazing intensity was followed by an increase in plant biomass the following year. Roath and Krueger (1982a) report that grass and shrub communities in mountain riparian systems showed no evidence of long term effects from cattle grazing.

Resting location impacts

Senft et al. (1985b) observed that while cattle spend up to 50% of their time resting, studies often only concentrate on grazing and traveling behavior of the animals. They observed that for management purposes, resting sites and the environmental factors that accompany them are very important to understanding animal distribution.

Early studies tended to focus on grazing time during the spring and summer and were only conducted during daylight hours. Moorefield and Hopkins (1951) identified three distinct daylight grazing times with resting times located in between: early morning, mid-day and evening. A similar pattern was observed by Sneva (1970) in Eastern Oregon. He reported that animals typically withdraw to cover during nighttime hours in the spring and summer while daytime distribution seemed determined by forage location. Low et al. (1981a) reported that 72% of cattle that were observed at dawn, grazed in the same plant community during that day. This led to speculation that the locations of night time resting areas was a determinant for the day time grazing pattern. Bailey et al. (1990) observed that cattle rarely forage in the same area for two consecutive mornings even though they maybe grazing in a nearby area the following morning.

Marlow and Poganik (1986) found that cattle concentration was greater in August and September in riparian zones while uplands were utilized more heavily in June and July. They did not observe a distinction in resting areas during late July, August and September in either riparian or upland communities. Senft et al. (1985b) observed a similar pattern for night resting areas when they developed cool and warm season grazing models.

Daytime rest areas are strongly associated with water availability (Senft et al. 1985b). Body water management and energy budget relate to most cattle activities. During the hot part of the day, cattle tend to avoid higher temperatures and restrict movement by seeking a comfortable environment (Bennet et al. 1984, Bryant 1982, Reppert 1960, Roath and Krueger 1982a, Senft et al. 1985b). Heat that is felt by a cow comes from absorbed radiation (solar and atmospheric) that strikes the body of the cow (Harris 2001) and physiological functions that are necessary for life. Increased respiration rates (breathing), consumption of water, restriction of movement, seeking favorable environments and perspiring through apocrine sweat glands allow cattle to regulate their body temperature and deal with excessive heat (Bryant 1982). Bennett et al. (1984) noted a strong association with increased respiration rate of cattle when in the sun rather than the shade.

Observing behavior

GPS technology is a useful tool for evaluating the dynamics of space use and animal movement (Gaillard et al. 2010). Historically, observation has been the primary method of obtaining information on cattle behavior. In 1921, J.H. Sheppard published the first observational study (The Trail of the Shortgrass Steer) of cattle (Sneva 1970). Observers in these early studies followed animals to estimate animal activity and travel (Cory 1927). Hull et al. (1960) determined that 30 minute observation periods captured major behavioral patterns. Nelson and Furr (1966) observed that while 30 minute intervals detected coarse scale activities, fine scale activities of walking, nursing calves, defecation, urination and drinking could not be determined with certainty. Agouridis et al. (2004) listed four main problems associated with methods of animal observation: it is labor intensive, prone to error since the observer can alter cattle behavior, generally observations are too short to confidentially understand daily behavior and observer fatigue is a source of data bias.

Several authors evaluated methods of observation. Hull et al. (1960) noticed significant behavioral differences between individual cows and stated that in order to approximate behavior at least 4 animals needed to be observed during each observation period. Wagnon (1963) observed the grazing habitat of one animal continuously instead of interval observations. Herbel and Nelson (1966) selected a different animal in each observation period but observed the animal for an extended period of time. Ehrenreich and Bjugstad (1966) observed different animals over a 6 month grazing period selecting one individual for a 24 hour period at two week intervals. Reppert (1960) observed 20 freely grazing heifers, selecting individuals one at a time over a 48 hour period every month as they came into view. Individual animals were also observed by Martin and Bateson (1986) where two out of three randomly selected 4 hour periods were monitored in riparian pastures. This method was also used in a study conducted in Eastern Oregon on the Catherine Creek pasture by Ballard (1999).

Major advancements in tracking animals occurred as global positioning systems (GPSs) became available (Ungar et al. 2005). GPS tracking minimizes human interaction and can provide continuous (24/7) tracing of livestock movement. However, depending on the research questions being asked, the observation interval (GPS integration) can result in a variety of issues. Woodside (2010) observed that data rich spatial and temporal resolution can be achieved in large ungulate studies using one second observation intervals but that battery life becomes an issue. Her study determined that one second GPS locations were comparable to concurrent field observations made at one minute intervals.

In 2001 Ganskopp noted that a 20 minute GPS observation interval was not sufficient to detect coarse scale activities with certainty. Ganskopp and Bohnert (2006) later used 10 minute GPS intervals to determine cattle travel distances, velocities and treatment occupation of senescent verses conditioned areas in four pastures. In northern Montana, the effectiveness of using dehydrated molasses supplement as a technique to modify grazing distribution was determined using GPS collars monitoring cattle locations every 10 minutes (Bailey et al. 2001). Turner et al. (2000) observed that discrete events such as watering or interpreting animal activity are difficult to determine with GPS location intervals greater than 5 minutes where as attributes on the scale of pasture utilization were not. Brosh et al. (2006) was able to determine fine scale activities (lying down, standing and walking with and without grazing) by combining motion sensing with 5 minute GPS location data. Ganskopp and Johnson (2007) tested the sensitivity of GPS location intervals using 5 minute GPS collars with each animal being observed for a minimum of 8 daylight hours over fifteen days. They found that 81 to 92% of the resting events were successfully classified and that daily travel was overestimated by 15.2% if left unfiltered. They also observed that the undetected meanderings of animals were at least in part offset by the GPS error associated with displaced points (Ganskopp and Johnson 2007).

Current GPS technology contains horizontal bias. Decesare et al. (2005) found that under high canopy closure (> 40%), GPS horizontal error increased track lengths

27.5% compared to 8.5% under open environments using Trimble™ GPS units set at 2 second intervals, actual point dislocation deviated 7.98 m and 2.53 m respectively. Agouridis (2004) studied GPS technology in open fields, along fence lines, and under deciduous tree canopies to test horizontal error under static conditions (not moving). In open environments they observed a horizontal error of 3.93+0.86 m. Fence lines and deciduous trees canopies yielded errors of 6.21+1.66 m and 12.31+2.15 m respectively. A test of dynamic (moving) point locations under open field conditions yielded an error of 4.48+0.83 m. Given these results, he concluded that animal frequency studies should include a 4 to 5 m buffer zone around creeks. GPS location data will also contain occasional false records that are not physically possible. These false records are associated with false readings on inactive animals and should be removed from the datasets (Moen et al. 1997).

An acceptable level of error should be determined prior to undertaking a study so that consideration can be given to errors represented by individual animal behavior and the number of cows needed to represent the herd (Turner et al. 2000). A study using pedometers to monitor cow travel over arid rangelands concluded that a large number of animals were needed to capture herd behavior because of the individuality of cattle (Anderson and Urquhart 1986). Turner et al. (2000) suggests that collaring the dominant or social animals may be the easiest alternative for capturing represent herd locations in extensive grazing studies. Deployment of GPS collars on different animals every year was suggested by Hebblewhite and Haydon (2010) as a way to increase the sample size when studying resource selection or movement.

The controversy surrounding livestock distribution and behavior in riparian areas is reflected in the various and sometimes contradictory answers reported in the literature. The importance of riparian areas to society emphasizes the need for consistent answers that can be used for management. Current advances in Global Positioning System technology allow researchers to study the fine scale activities of cattle 24 hours a day. It is believed that this objective method of directly measuring cattle occupancy and activity will bring clarity and consistency to these issues.

Methods and Tools

Study objectives

The overall objective of this study was to quantify the pattern of occupancy by free ranging cattle in three different riparian pastures over a 2 year study period. Specific study objectives included determining:

1. The pattern of channel occupancy compared to other areas in the pasture.
2. The pattern of stream bank occupancy compared to other areas in the pasture.
3. The preference expressed by cattle toward different vegetative communities recognized in the riparian pastures.
4. The activity preference expressed by cattle within different communities and locations within the riparian pastures.

Study area

The riparian pastures used in this study are located in the Blue Mountain Province of northeastern Oregon (Anderson et al. 1998). Province elevation ranges between 900 and 1,500 m and is characterized by rugged mountains, steep canyons and large plateaus that are divided by dendritic drainages. Precipitation within the province occurs primarily as snow between November and March. The major province bedrock is basalt and soils that occur along major streams are typically composed of coarse (gravelly) alluvium.

Each of the riparian study pastures can generally be described as a meadow with a free flowing stream. However each is unique in terms of stream size and volume, vegetation and topographic characteristics. In general, flood plains in northeastern Oregon will contain four geomorphic surfaces (Laird 1987). The youngest (typically < 200 years BP) of these surfaces is called the Horseshoe surface and is inundated by stream bank full conditions. Most of this surface floods annually and can be described as the lowest surface of the flood plain in the valley. It includes the river or stream channel, point bars, channel fillings and abandoned meanders. The Horseshoe surface is the primary zone where scouring and coarse substrate deposition will occur and can reflect rapid landscape change, channel abandonment, lateral migration of meanders and the downstream movement of alluvial deposits. The floodplain surface immediately above the bank full elevation is called Ingram (approximately 400 – 4000 years BP). The Ingram surface is an undulating surface that is influenced by the channeling of flood water onto the flood plain and fine sediment deposition. Flooding is common on the lowest of these surfaces and fine sediment deposits tend to accumulate and are subject to seasonal saturation. The higher elevations on this surface flood less frequently and the depositional material will be subject to shorter periods of saturation. The oldest geomorphic surface associated with the current flood plain is called Winkle (approximately 4000 – 8000 years BP). When present, this surface forms benches and terraces that are remnants of abandoned flood plains and directly influence flooding patterns. Soils forming the Winkle surface will generally be the driest soils associated with the current flood plain surface. The Senecal surface is comprised of older alluvial terraces generally above the level of the current flood plain and is not associated with the current drainage system.

The Catherine Creek pasture is a 53 ha pasture unit located on the Hall Ranch of the Eastern Oregon Agriculture Research Center (EOARC) 15 km southeast of Union, Oregon. The channel of Catherine Creek is best described as a D channel (Rosgen 1994) reflecting the work being conducted during periods of high creek flow as the channel transitions from a steep upstream gradient to the riparian pasture gradient of 2-3% slope. Catherine Creek runs for 2 km through the pasture and is can be 1 m deep and approximately 25 m wide. As Catherine creek leaves the pasture unit the channel transitions into a B channel confined by mountainous landscape. Cattle typically graze this pasture in mid August and stay until early October. The primary vegetation communities (Table 1) in the unit include riparian shrub, dry meadow, hawthorne and pine community types. Soils in this pasture include the Veazie-Voats Complex and Hall Ranch soils (Table 2).

The Milk creek pasture is adjacent to the Catherine creek pasture and also contains 53 ha. Cattle typically enter this pasture in early October and stay into

November. Milk Creek is a shallow low gradient E Channel stream (Rosgen 1994) that averages 2 m wide and less than 1 m deep and runs through the pasture for approximately 1.5 km. The dominant vegetation communities (Table 1) of Milk Creek include wet, moist and dry meadow communities as well as upland communities of ponderosa pine. Soils in this pasture include the Veazie Voats Complex, Hutchinson Variant and Wilkins soils (Table 2).

The North Powder pasture contains 79 ha in Baker County in northeastern Oregon. Cattle typically enter the pasture in mid July and stay throughout the summer months. The Powder River flows through the pasture for approximately 2 km on a low gradient forming a sinuous E channel (Rosgen 1994). The river averages 10 m wide and over 1 m deep. The major vegetation communities (Table 1) in the North Powder pasture include willow, baltic rush, quackgrass and saltgrass community types. Soils in this pasture include the Baldock, Umapine, Haines and Baker soils (Table 2).

Table 1. Common and scientific names of major species located in the study area and their wetland species classification[1].

Common Name	**Scientific Name**	**Classification**[1]
peachleaf willow	*Salix amygdaloides* Andersson	Facultative wetland
Booth willow	*Salix boothii* Dorn	Obligate
coyote willow	*Salix exigua* Nutt.	Obligate
saltgrass	*Distichlis spicata* (Torr.) Rydb.	Facultative
Lemmon's alkaligrass	*Puccinellia lemmonii* (Vasey) Scribn.	Facultative
greasewood	*Sarcobatus vermiculatus* (Hook.) Torr.	Facultative
basin wildrye	*Elymus cinereus* (Scribn. & Merr.)	Facultative upland
baltic rush	*Juncus balticus* Willd.	Facultative wetland
alkali cordgrass	*Spartina gracilis* Trin.	Facultative wetland
tufted hairgrass	*Deschampsia cespitosa* (L.) Beauv	Facultative wetland
bentgrass	*Agrostis diegoensis* Vasey	Facultative
small panicle bulrush	*Scirpus microcarpus* J. Presl & C. Presl	Obligate
aquatic sedge	*Carex aquatilis* Wahlenb.	Obligate
Nebraska sedge	*Carex nebrascensis* Dewey	Obligate
quackgrass	*Elymus repens* (L.) Beauv	Facultative upland
bluegrass	*Poa agassizensis* Boivin & D. Love	Facultative upland
timothy	*Pheleum pretense* L.	Facultative upland
meadow foxtail	*Alopecurus pratensis* L.	Facultative wetland
bulbous bluegrass	*Poa bulbosa* L.	Facultative upland
blue wildrye	*Elymus glaucus* Buckl.	Facultative upland
Idaho fescue	*Festuca idahoensis* Elmer	Facultative upland
mountain brome	*Bromus marginatus* Nees ex steud.	Facultative upland
ponderosa pine	*Pinus ponderosa* Dougl.	Facultative upland
woolly sedge	*Carex lanuginose* Michx.	Obligate
small wing sedge	*Carex microptera* Mack.	Facultative
black hawthorne	*Crataegus douglasii* Lindl.	Facultative
intermediate wheatgrass	*Elymus hispidus* (P.Opiz) Melderis	Facultative upland
Bebb willow	*Salix bebbiana* Sarg.	Facultative wetland
mountain alder	*Alnus incana* (L.) Moench	Facultative wetland
snowberry	*Symphoricarpos albus* (L.) Blake	Facultative

[1] Obligate - wetland occurrence 99%; facultative wetland – wetland occurrence 67 to 99%; facultative - wetland occurrence 34 to 66%; facultative upland - wetland occurrence 1-33%; upland - plants that are almost exclusively found in upland settings (Larson et al. 2007).

Table 2. Series name and U.S. Taxonomic Classification name (family) of the soils found in the study pastures.

Series Name	Family Name
Veazie	Coarse-loamy over sandy or sandy skeletal, mixed, mesic Cumulic Haploxerolls
Voats	Sandy-skeletal, mixed, mesic Fluventic Haploxerolls
Hall Ranch	Fine-loamy, mixed, frigid Ultic Haploxerolls
Baldock	Fine-loamy, mixed (calcareous), mesic Typic Haplaquepts
Umapine	Coarse-silty, mixed (calcareous), mesic Typic Halaquepts
Haines	Coarse-silty, mixed (calcareous), mesic Typic Haplaquepts
Baker	Coarse-loamy, mixed, mesic Orthidic Durixerolls
Wilkins	Fine, montmorillonitic frigid, xeric Argialbolls
Hutchinson Variant	fine, monomorillonitic, frigid, frigid Argis Durixerolls

Technology

Since the mid 1990s animal behavorialist have been using Global Positioning Systems (GPS) to track where and how animals move. As these systems have developed the ability to track animal movements at one second intervals has been achieved. These collars have increased storage capacity and use removable memory cards to record longitude, latitude, date and time, amount and quality of satellite signals and velocity. The operational battery life of the collars set at one second intervals is approximately 6.25 days. Collar construction facilitates the interchange of replacement memory cards and batteries in the field to allow for extended periods of data collection. While using the same collars in a study done in 2010, Woodside found that the accuracy of the collars resulted in a mean x-y error of 1.4 m (SD = 0.83 m) and logged continuously when averaged across all trials. It was also found that the reference unit location error ranged from a minimum of 0.0 m to a maximum of 9.53 m across all trials.

Data collection

Data collection in the Catherine Creek pasture occurred in 2008 and 2009 for two weeks in mid-late August. Data collection in the North Powder and Milk Creek pastures occurred during 2009 and 2010 for two weeks in mid-late July and early-mid October, respectively. Ten mature cow/calf (Bos tuarus) pairs were randomly selected from different herds grazing each pasture and fitted with the one second collar. The collared cows were released into the pasture for 7 days and allowed to graze without interference. At the end of the 7 day trial the collared cows were placed in a retaining pen where collar batteries and memory cards were replaced before returning the cows back to the pasture. This potentially yielded 12.5 days (1,080,000 seconds) of data per cow per year. Each seasonal collar set is considered a single sample observation (Bailey et al. 2001) that is comprised of logging data that is auto-correlated.

Map development

On September 17, 2009 all three of the pastures had low elevation aerial photographs taken with a Canon EOS Rebel XSi 12.4 megapixel conventional color digital camera mounted in the belly of a Cessna 182 aircraft. The photos yielded 20 cm by 20 cm ground pixel (1:706 scale) photographs that was corrected for lens curvature and brought into ERSI ® ArcMap™ 10 to be geo referenced with the 2009 United States Department of Agriculture (USDA) National Agriculture Imagery Program (NAIP) photography that has a level of accuracy of ± 5 m.

Stream bank location was digitized using the low elevation aerial photographs. This yielded a stream channel defined at bank full that included gravel bars. The channel delineation was independent of the water level captured in the photos and the time period when the cattle were present in the pasture. Field checks of the digitized stream bank were conducted to validate the placement of the stream on the map. Using ArcMap, a 5 m buffer zone on the outside of the stream bank was established to analyze the time spent on the bank (Agouridis 2004).

Vegetation was digitized in ArcGIS 10 from the low elevation aerial photographs and field checked for accuracy using a handheld GPS unit. Each pasture was done individually with different community types recognized in each pasture. Soil maps (Natural Resource Conservation Service Soil Surveys) were utilized to assist with the delineation of community boundaries.

Data Management

Raw data taken from the removable memory cards was downloaded and processed to a comma separated value (CSV) excel file using a software program that formatted the data and partitioned it into 24 hour periods. The excel files were analyzed using an Animal Movement Classification Tool (Johnson et al. 2009) that allowed parameters to be established for the purpose of classifying animal movement. Animals were classified as moving if they moved faster than 0.001 kph for more than 3 consecutive seconds. Stationary classifications were upgraded to a resting location designation when a cow remained stationary for 10 minutes. Aggregated resting locations (groups) were mapped as centrally located points. Output files from the Animal Movement Classification Tool (AMCT) displayed information about velocity, velocity class, resting group number as well as the original data obtained from the collars.

Cow day output files from the AMCT were then merged into herd day files and processed by hand in Microsoft Office Excel 2007^{TM} to prepare for conversion into ArcCatalog^{TM}, allowing the CSV files to be transformed into shapefiles in ArcMap. Time displayed in Greenwich Mean was converted into Pacific Standard Time. Shapefiles were clipped to pasture boundaries to remove GPS error outside the pasture boundary.

The raw data set was examined to identify a balanced data set for analysis. The outcome of this examination created 5 complete cow data sets (10 days: 5 days the 1st half and 5 days in the 2nd half of the trial) for each pasture per year. Each data set was comprised of files that contained at least 98% of the potential GPS locations taken for that day. Merging the cow day sets in a given pasture yields herd day files where the herd is classified as 5 cattle (Hull et al. 1960). This process required the creation of a single dummy cow for two of the pastures. The dummy cow data set was created by using average values created from the other 4 cattle in the pasture. Each pasture analysis was based on 8,640,000 GPS locations (5 cattle for 10 days per year for two years).

Evaluation

Analysis using the AMCT determined how much herd time was spent moving verses being stationary in each pasture and whether the movement pattern changed during the 1st half of the trial vs. the 2nd. A single cow day was selected to illustrate the daily routine of a collared cow in each pasture. Resting locations, stream crossing and stream bank access were also determined using the AMCT.

ArcMap 10 was utilized to establish community preference based on the amount of time spent in each vegetation community and stream channel. Herd by day shapefiles were overlaid onto community boundaries to partition time and area attributes. A Relative Preference Index (RPI) was calculated to illustrate the relationship of animal preference. Stream crossing locations were identified using ArcMap and field checked to identify physical on-site attributes that would impact animal access.

The 5 m buffer zone used to establish the stream bank zone was used to provide an estimate of maximum cow access to the stream bank. The calculation incorporates potential horizontal GPS error into the occupancy estimate (Agouridis 2004).

Statistical analysis

Descriptive statistics in the form of percentages, averages and totals were used to describe the pattern of animal occupancy and activity. Relative preference indices (RPI), where appropriate, were utilized to assist in the description of animal preference (see Appendix A7). Chi-square assessments ($p < 0.05$) of occupancy and activity differences (see Appendix A7) were used to verify the statistical importance of mathematical differences (Snedecor and Cochran, 1973).

Results and Discussion

Catherine Creek (mid-late August)

Pasture usage

Within the Catherine Creek pasture, cattle spent nearly twice as much time being stationary compared to moving ($\geq$ 0.002 kph for at least 3 consecutive seconds). This pattern was maintained throughout the first and second half of each trial period.

The daily pattern of cattle activity is illustrated in (Figure 1). Cow 6220 was stationary for most of the night time period (10:00 p.m. –3:30 a.m. Pacific Standard Time). She began moving at 3:30 a.m. and was engaged in moving activity for approximately 6.5 hours. Observation of cattle movement would suggest that much of this time represented a grazing bout that had an average velocity of 0.9 kph. This moving period was followed by a short resting period lasting 1.5 hours. From 11:30 a.m. to 1:30 p.m. the cow again showed velocity, followed by another resting period lasting approximately 2 hours. During the evening hours (3:30 p.m. – 10:00 p.m.) the cow had another suggested grazing period. During the moving portions of the day the cow crossed or accessed the stream edge four times without stopping (6:00 a.m., 1:00 p.m., 4:00 p.m and 7 p.m.). There were two other times when the cow accessed the stream bank (5:30 a.m. and 12:00 p.m.) and remained stationary. These two events suggest that drinking was occurring and each event lasted 2 – 7 minutes.

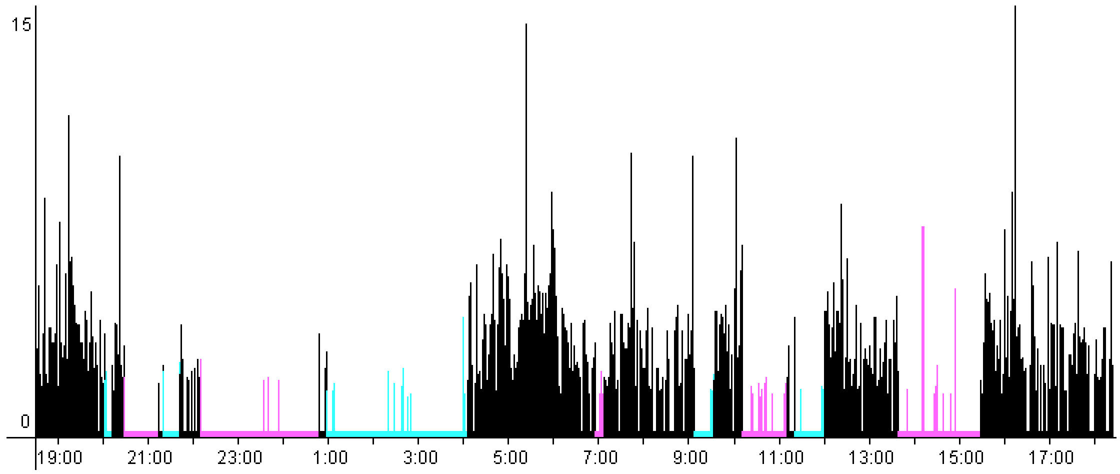

Figure 1. A typical day of a cow in the Catherine Creek pasture. The x axis is the time in Pacific Standard Time (PST) using military time. The y axis is in kilometer per hours. Resting locations are the pink and blue lines, done only to differentiate between resting periods. Velocity shown in the resting periods is due to stationary GPS error that occurs when the unit is not moving.

Community preference

Cattle did not occupy the plant communities within the Catherine Creek pasture equally relative to their acreage (Table 3). The dry meadow and hawthorne/baltic communities were selected and occupied at a rate that was greater ($P \leq 0.05$) than other communities in the pasture. Cattle avoided ($P \leq 0.05$) the channel, pine and riparian shrub communities given their relative acreage, while the hawthorne/dry community was used proportional to its acreage.

Table 3. Summary of cattle activities within the community types identified in the Catherine Creek pasture. Designation of No or Yes by community in the preference column indicate significance ($P \leq 0.05$). NS indicates non significance.

Catherine Creek		
Community	Preference	Relative Preference Index
Channel	No	0.2
Bank (5 m)	No	0.4
Dry Meadow	Yes	3.3
Hawthorne Baltic	Yes	2.8
Hawthorne Dry	NS	1.1
Pine	No	0.2
Riparian Shrub	No	0.5

Preferred communities

The dry meadow and hawthorne/baltic communities occupied 13.7 and 11.4% of the pasture. Cattle expressed a strong preference for both communities (45.8 and 31.5% of total time, respectively). Cattle spent 27% more time being stationary compared to moving in the dry meadow. The reverse was true in the hawthorne/baltic community where 20% more time was spent moving compared to being stationary.

The dry meadow and hawthorne/baltic communities occur in the Catherine Creek pasture on alluvial deposits that form a terrace, channel and gravel bar mosaic (Veazie-Voates soil complex). Depth to water table on these upper Ingram surfaces will typically range from 1.2 to 1.8 m. The dry meadow community (intermediate wheatgrass, timothy and bluegrass) tend to occupy areas of deep loam (up to 0.8 m) over gravelly sands (larger inclusions of Veazie soil). The hawthorne/baltic community occurs in areas of the landscape where the loam varies in depth from 0.4 m to exposed gravel and cobble. Within that mosaic, hawthorne is restricted to the deeper areas of loam with a bluegrass and baltic rush understory extending onto the shallower loam deposits.

A map (Figure 2) of resting locations (stationary for more than 10 minutes) shows that although the dry meadow was preferred for stationary activity the distribution of the resting locations was more or less evenly distributed in the open areas rather than being clustered at a few preferred sites.

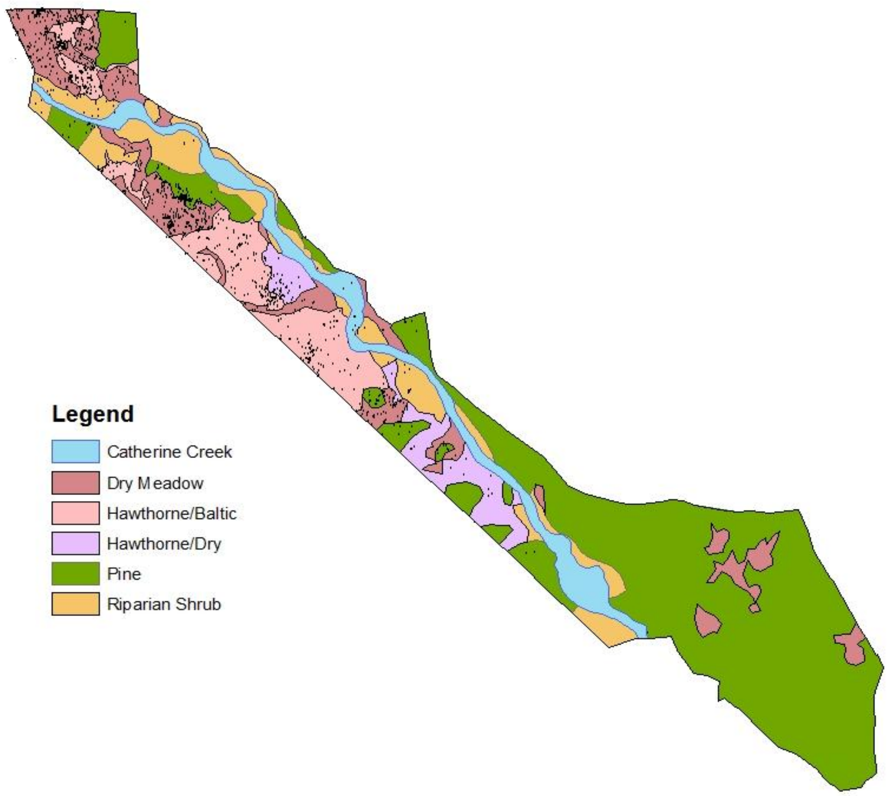

Figure 2. A map of Catherine Creek pasture with vegetative communities. The black dots represent resting locations where the GPS locations were stationary for longer than 10 minutes.

Neutral preference communities

The hawthorne/dry community contains 5.3% of the pasture area and was not selected or avoided during the grazing trials. Cattle using this area spent equal amounts of time (5.7% of total time) stationary and moving. This hawthorne community is on the same soil complex as above but in this case the understory vegetation was either minimal or nonexistent and the site was visibly drier. The source of this understory vegetation difference is speculated to be associated with a deposition pattern that increased the amount of coarse substrate in the surface loam deposit and the rate of internal drainage.

Non-preferred communities

The channel, pine and riparian shrub communities contain 9.2, 49.6 and 10.7% of the pasture. Cattle used these communities minimally (1.5, 10.3 and 5.4% of total time, respectively) relative to their size within the pasture and allocated their activities differently across these communities. Cattle spent 5Xs more time moving in the channel unit compared to being stationary, 56% more time being stationary compared to moving in the pine community and 3.3Xs more time spent moving in riparian shrub communities.

The primary use of the channel community by cattle was apparently to access water. The channel of Catherine Creek is dynamic having characteristics similar to the braided channel (channel type D) described by Rosgen (1994). Catherine creek enters the pasture along a steep gradient after draining mountainous terrain. This transition to a gradient of 2-3% naturally slows channel velocities, increases water depths and encourages the formation of braided channels with exposed cobble banks (riverwash). Cattle tended to access Catherine Creek to drink at locations where openings exist in the hawthorne and where the flood plain surface transitions to the channel at a gentle slope as opposed to an abrupt edge. Cattle stream crossing locations also tend to utilize riffle deposition patterns that minimize water depth. Overall most stream crossings occurred on less than 4% of the channel length.

The pine community was used primarily as a resting area. The pine community occurs on Hall Ranch soil and is delineated into areas having slopes of 2-35 and 35-65%. Cattle strongly avoided areas of this unit that occurred on slopes greater than 35%. A portion of the pine community extends onto the Veazie-Voats soil complex where it is restricted to deeper pockets of loam deposition. Stationary resting areas in the pine community tend to be clustered around individual trees and tree clusters, usually along the outside edge of open areas (Figure 3).

Figure 3. Aerial photograph with resting locations in the Catherine Creek pasture. The yellow polygon is the ponderosa pine community and the red dots represent resting locations. An orange circle has been place around the most preferred resting spot in this community.

Cattle activity within the riparian shrub community was dominated by activities associated with movement. These areas occur on the lower Ingram surfaces of the Veazie-Voats complex, having water table and flooding characteristics that favor the occurrence tall shrub community of Bebb willow and mountain alder which are facultative wetland species and a short shrub community of snowberry.

Stream bank zone

The stream bank zone consists of a 5 m zone on either side of Catherine Creek. The stream bank unit contains 3% of the area of the pasture. Cattle used (1% of total time) this area minimally ($P \leq 0.05$) relative to its size within the pasture and spent most of their time on activities associated with moving. Cattle spent 5Xs more time moving in the stream bank zone compared to being stationary and maintained that pattern throughout the 2 year study.

North Powder (mid-late July)

Pasture usage

Within the North Powder pasture, cattle spent 84% more time involved in stationary activities compared to moving. This pattern was maintained throughout the first and second half of each trial period.

The pattern of daily activity of the cattle is shown in Figure 4. During the nighttime period (9:00 p.m. – 3:30 a.m., Pacific Standard Time) Cow 42 remained stationary. At 3:30 a.m. the cow began moving around and it is assumed by the movement that grazing activity was occurring. A short resting period occurred between 8:00 a.m. and 9:00 a.m., followed by more movement from 9:00 a.m. until 9 p.m. with several short resting periods in between. Cow 42 accessed the stream several times during this day. Two events occurred when the cow crossed the stream (11:00 a.m., 2:30 p.m.). There were five events where the cow accessed the stream bank without crossing, but four of them were less than 1 minute (11:00 a.m., 2:00 p.m., 5:00 p.m., 5:30 p.m.) and one was substantially longer (9:30 a.m.). It is important to note that the North Powder pasture has water throughout the pasture and cattle access water at areas other than the Powder River.

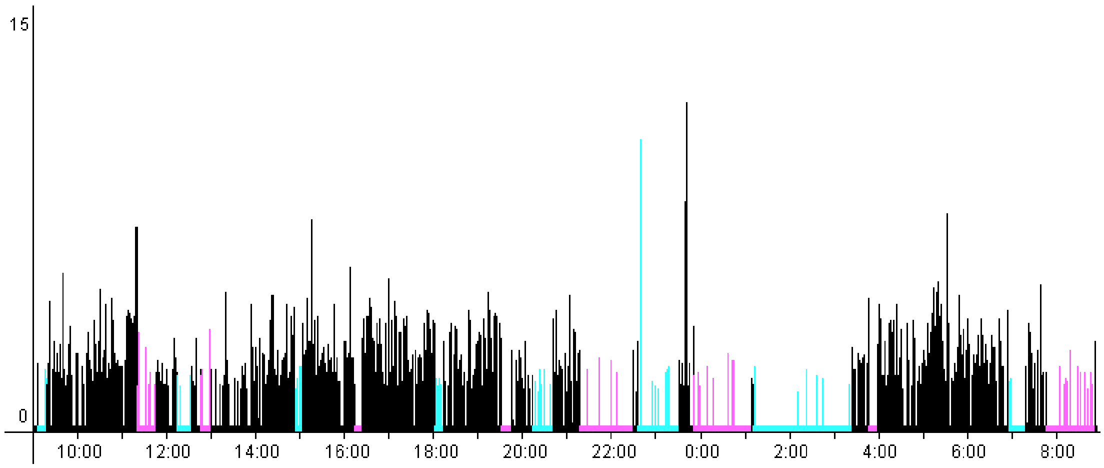

Figure 4. A typical day of a cow in the North Powder pasture. The x axis is the time in Pacific Standard Time (PST) using military time. The y axis is in kilometer per hours. Resting locations are the pink and blue lines, done only to differentiate between resting periods. Velocity shown in the resting periods is GPS error that occurs when the unit is not moving.

Community preference

The pattern of cattle occupancy within the pasture indicates that the collared cows expressed a preference in plant community occupation. The willow and saltgrass communities were selected and occupied at a rate that was greater ($P \leq 0.05$) than the other communities in the pasture. Cattle avoided ($P \leq 0.05$) the channel, baltic and small channel communities given their relative acreage within the pasture, while the quackgrass and areas of community complex were used proportionally to their acreage.

Table 4. Summary of cattle activities within the community types identified in the North Powder pasture. Designation of No and Yes by community in the preference column indicate significance ($P \leq 0.05$). NS indicates non significance.

North Powder		
Community	Preference	Relative Preference Index
Channel	No	0.4
Bank (5 m)	No	1.6
Willow	Yes	4.2
Baltic	No	0.2
Saltgrass	Yes	1.5
Small Channel	No	0.4
Quackgrass	NS	0.7
Complex	NS	1.0

Preferred communities

The willow and saltgrass communities occupy 3.5 and 21.5% of the pasture. Cattle expressed a stronger preference for the willow community than saltgrass. Cattle occupied the willow communities equally in terms of being stationary and moving while the saltgrass community was selected primarily for stationary activities (stationary was nearly 2Xs greater than moving activities). There was no preference in the 1st or 2nd half of the trial expressed in the willow community during the trials (total occupancy time = 14%). Cattle preferred to use the saltgrass community more during the 1st half of each trial (26% more) and occupied the community 32% of the study time. The resting location map (Figure 5) shows that while cattle occasionally rest in the same location, the resting sites have good distribution over the pasture.

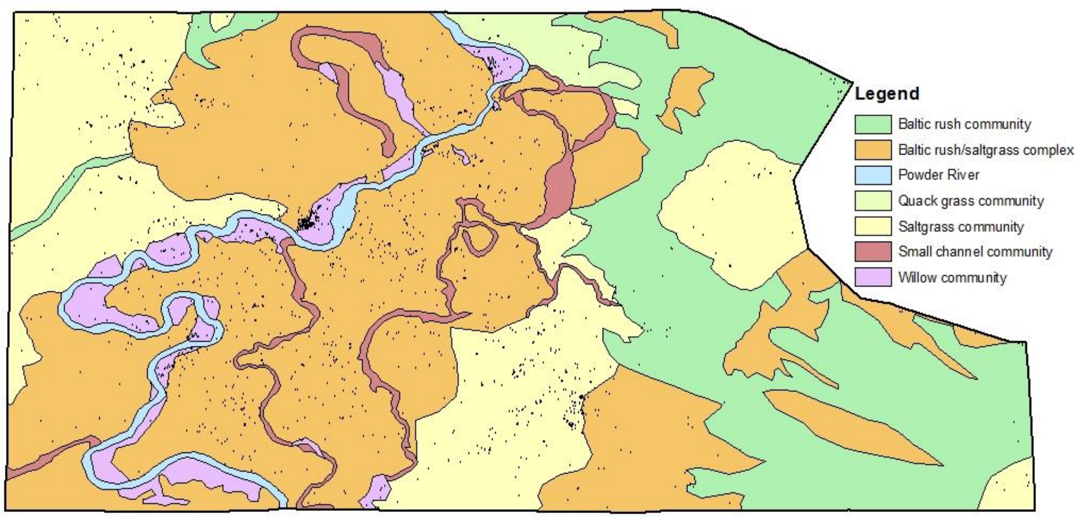

Figure 5. A map of North Powder pasture with vegetative communities. The black dots represent resting locations where the GPS locations were stationary for longer than 10 minutes.

The willow community occurs on mixed alluvial deposits of the lower Ingram surface that are influenced by flooding and high water table characteristics (Baldock soil). Depth to water on this soil typically ranges from 0 to 0.5 m. The willow community (peachleaf, Booth and coyote willows) is mature with most shrubs 2-3 m in height, well above the height of grazing cattle. The saltgrass community occurs on two soils, both of which are somewhat poorly drained with the depth to water table being 0.3 to 0.6 m.

Most of the soil in this community occur in the Winkle geomorphic surface and is saline to strongly saline (Umapine soil) with mixed alluvial and loess parent material. The remaining area of saltgrass community occurs within the Ingram surface, are slightly saline and are comprised of loess and mixed alluvial material (Haines soil). The vegetation in the saltgrass community is dominated by saltgrass, Lemmon's alkaligrass with scattered greasewood and basin wildrye.

Neutral preference communities

The quackgrass and baltic/saltgrass complex communities occupied 1.5 and 46% of the pasture. Though both communities were neutral in cattle preference activity preference did differ. The total amount of time spent in these communities was 1.1 (quackgrass) and 46.7% (complex). In the quackgrass community cattle showed no preference to moving or being stationary while in the complex they were 37% more likely to be moving. In both communities the cattle preferred to use the community during the first half of each trial (quackgrass=3.4Xs more time, complex=20% more time). The neutral preference of the quackgrass community is being biased by the location of the community next to the gate where cattle enter the pasture and spend time prior to dispersing throughout the pasture.

The quackgrass community occurs on the Baldock soil forming the upper Ingram surface. The vegetative species found in this community consists primarily of quackgrass, Lemmon's alkaligrass, bluegrass and timothy. The complex occurs on two soils, Baldock and Baker, and reflects a mosaic of undulating surfaces and community dominance that occurs in the pasture.

Non-preferred communities

The channel, small channel and baltic communities occur on 2.5, 3 and 22% of the pasture. The collared cattle had a total occupancy time in these communities of 0.9, 1.1, and 3.8%, respectively. Cattle expressed avoidance toward these areas. Collared cows showed no difference in the amount of time they spent stationary or moving in the baltic community. They spend greater amounts of time moving than stationary in the channel (4Xs) and small channel (3.6Xs) communities. In the first half of the trial, collared cows spent 35% more of their time moving in the channel community while they spent 85% more time in the second half of the trials in the baltic community. There was no preference in the amount of time cattle spent in the small channel community during each trial.

The channel and small channel communities occur in the North Powder pasture within the Baldock mapping unit. The Powder River is approximately 1.9 km long and 10 m wide with E channel characteristics. Cattle tended to access the Powder River to drink at locations where the flood plain surface transitions to the channel at a gentle slope as opposed to an abrupt drop. Cattle stream crossing locations also tend to utilize riffle deposition patterns that minimize water depth. Overall stream access occurred on less than 7% of the channel length.

The small channel vegetation is comprised primarily of thinleaf bentgrass, small panicle bulrush, aquatic sedge, baltic rush, Nebraska sedge and tufted hairgrass. It dissects the eastern portion of the pasture and occurs in abandoned channels. The baltic community occurs on the old alluvial deposits of the Senecal geomorphic surface (Baker soil). This well drained, moderate to saline soil support baltic rush, alkali cordgrass, sedge, Lemmon’s alkaligrass and trace amounts of tufted hairgrass and thinleaf bentgrass.

Stream bank zone

The stream bank buffer zone in the North Powder pasture occupies 2% of the pasture. The collared cattle had a total occupancy time in this zone of 3.2%. Cattle expressed no preference ($P \leq 0.05$) to this area compared to the usage of the remainder of the pasture. While the cattle showed no preference toward the first and second half of each trial, they did show that they were more likely to be moving in this zone (79% more likely) than being involved in stationary activities.

Milk Creek (early-mid October)

Pasture usage

Within the Milk Creek pasture unit, cattle spend 2.6X as much time being stationary compared to moving. This pattern was maintained throughout the first and second half of each trial period.

The daily activity pattern of the cattle is shown in Figure 6. Cow 7101 rested mostly through the night time hours (8:00 p.m. – 4:00 a.m.). At 4:00 a.m. she started a grazing bout that lasted until 9:30 a.m. followed by a short resting period. Velocity resumed at 10:30 a.m. and continued until a little after noon when another hour long resting location was recorded. From 1:30 p.m. until 8:00 p.m. Cow 7101 continued grazing with an average velocity of 0.24 kph. Milk Creek was crossed once (3:42 p.m.) and accessed twice (12:00 p.m. and 5:00 p.m.). It is assumed that Cow 7101 was accessing the stream to drink, each of these events lasted less than 3 minutes.

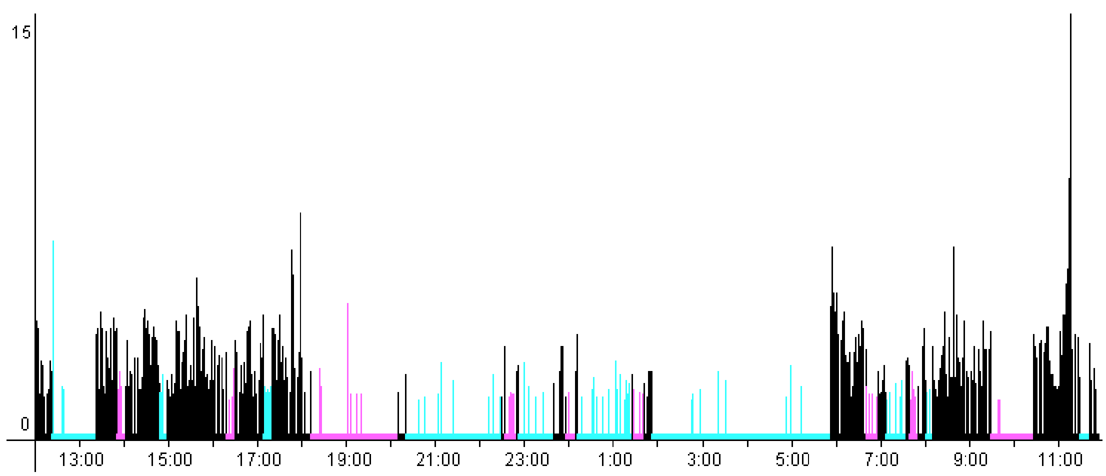

Figure 6. A typical day of a cow in the Milk Creek pasture. The x axis is the time in Pacific Standard Time (PST) using military time. The y axis is in kilometer per hours. Resting locations are the pink and blue lines, done only to differentiate between resting periods. Velocity shown in the resting periods is GPS error that occurs when the unit is not moving.

Community preference

Collared cows expressed a preference toward plant communities within the Milk Creek pasture relative to their acreage. The wet meadow, moist meadow, dry meadow and hawthorne communities were selected and occupied at a rate that was greater ($P \leq 0.05$) than the other communities in the pasture. Cattle avoided ($P \leq 0.05$) the pine/wheatgrass and pine/rye communities given their relative acreage within the pasture, while the channel and wet/moist meadow communities were used proportional to their acreage.

Table 5. Summary of cattle activities within the community types identified in the Milk Creek pasture. Designation of No and Yes by community in the preference column indicate significance ($P \leq 0.05$). NS indicates non significance.

Milk Creek		
Community	Preference	Relative Preference Index
Channel	NS	0.9
Bank (5 m)	No	1
Wet Meadow	Yes	1.6
Moist Meadow	Yes	1.7
Dry Meadow	Yes	1.5
Wet/Moist Meadow	NS	0.8
Wet/Moist Meadow w/ Hawthorne	Yes	1.4
Pine/Wheatgrass	No	0.4
Pine/Rye	No	0.2

Preferred communities

The wet meadow, moist meadow, dry meadow and hawthorne communities occupy 0.8, 16.0, 31.8 and 5.3% of the pasture. Cattle occupancy within the four communities was 1.3, 28.0, 48.0 and 7.3% of total time, respectively. Cattle expressed close to the same amount of preference for all the communities. In both the wet meadow and moist meadow the cattle had no preference for being stationary or moving, while in the hawthorne community they preferred to be moving 36% more of the time than stationary and in the dry meadow community they preferred to be stationary 12% more of the time. Both the moist meadow and hawthorne community were used more frequently in the first half of the trial than the second (63 and 89%), while in the dry meadow communities the cattle preferred to use the community during the second half of the trial rather than the first by 24%. Cattle within the wet meadow community didn't show any preference to either the first or second half of the trial.

The wet meadow, moist meadow, hawthorne and most of the dry meadow communities occur on alluvial deposits that form a terrace, channel and gravel bar mosaic (Veazie-Voats soil complex). The undulating surfaces of the Veazie-Voats soil complex (Ingram geomorphic surface) results in varying water table and surface flooding characteristics. The wet meadow (sedges and rushes) is the wettest vegetative area of the pasture and has water table and flooding characteristics that support obligate wetland species. The moist meadow (thinleaf bentgrass, meadow foxtail and baltic rush) occurs on moderately elevated and moderately drained areas where water table and flooding characteristics support facultative wetland species. The hawthorne community is drier and more drained than the previous communities and supports a mix of facultative and facultative wetland species (hawthorne, thinleaf bentgrass, meadow foxtail, baltic rush with inclusions of sedge, scattered Bebb willow and alder as well as scattered individuals of ponderosa pine (upland species) along the stream. The surface loam in the hawthorne community varies in depth from 0.4 m to exposed gravel and cobble. The dry meadow community included intermediate wheatgrass, timothy and bluegrass (upland species) with inclusions of very shallow rocky ground dominated by bulbous bluegrass. A second dry meadow is located at a higher elevation in the pasture on alluvial deposits with a mantle of loess and volcanic ash (Wilkins soil). This soil is somewhat poorly drained but is normally found outside the flood plain on elevated slopes.

A map (Figure 7) of stationary locations shows that while cattle avoided choosing resting locations on the steeper slopes of the pasture. Cattle tended to select resting areas throughout the pasture.

Figure 7. A map of Milk Creek pasture with vegetative communities. The black dots represent resting locations where the GPS locations were stationary for longer than 10 minutes.

Neutral preference communities

The channel and wet/moist complex were occupied during the grazing trials at a rate comparable to the 0.8 and 3% of the pasture that they occupy. Occupancy of these communities during the study represented 0.7 and 2.3% of total time, respectively. In both communities the cattle preferred to be moving rather than stationary; channel by 2.7Xs more time and wet/moist complex by 89% more. Cattle used the wet/moist complex and channel communities equally during both the first and the second half of the trial. Both communities occur within the Veazie-Voates soil complex. Vegetation on the wet/moist meadow complex included thinleaf bentgrass, meadow foxtail, baltic rush and scattered sedge. Milk Creek is a shallow E channel that is inaccessible in many areas due to the excessive hawthorne growth. As a result, cattle tended to access Milk Creek to drink at locations where openings exist in the hawthorne and where the flood plain surface transitions at a gentle slope as opposed to an abrupt drop. Since Milk Creek is relatively narrow and shallow, cattle crossings tend to reflect access constraints over water depth. Overall stream access occurred on less than 8.0% of the channel length.

Non-preferred communities

The pine/wheatgrass and pine/rye communities contain 11.4 and 31% of the pasture. They were occupied 4.9 and 7.5% of total time. Cattle used these communities minimally. Cattle preferred to be moving 89% more of the time than stationary in the pine/wheatgrass community while in the pine/rye community the cattle spent equal amounts of time moving and stationary. It was interesting to note that the cattle preferred to use the pine/wheatgrass community in the 1st half of the trial while they preferred to use the pine/rye community in the 2nd half of the trial.

Both of the pine communities occur on alluvial fans that are comprised of mixed alluvium with loess and volcanic ash in the surface layer (Hutchinson soil variant). These communities typically occur on slopes of 12 to 35%, the depth to water table is more than 2 m and are well drained. The lower elevation, more gently sloping pine community is made up of ponderosa pine and intermediate wheatgrass. As the elevation increases and the slope increases, the community changes to a ponderosa pine overstory with blue wildrye, Idaho fescue and mountain brome understory. It is assumed that the cattle spent more time stationary in the pine/wheatgrass because of the gentle slope while more time was spent moving in the steeper pine/rye community.

Stream bank zone

The stream bank zone consists of a 5 m zone on either side of Milk Creek. The stream bank unit contains 2.3% of the area of the pasture and the collared cows occupied the zone 2.4% of total time. The collared cows were neutral in their selection of this area and spent nearly 95% more of their time moving rather than being stationary during both the first and second half of the trial periods.

Conclusions

Activity

Cattle spent at least 50% of their time being stationary. This result is similar to observations reported by Senft et al. (1985), who suggested that knowledge about resting locations was important for management because of the prominence of the activity in the animal's daily routine. In this study, the amount of time resting was similar regardless of pasture location, time of year or differences among cattle. Cattle tended to bed down around dark and remain relatively still until about 4:00 a.m. PST, which is consistent with results reported by Reppert (1960) and Sneva (1970). By contrast, daytime resting periods occurred throughout the day, but did not follow an established pattern. Daytime resting generally appeared to be influenced by factors such as thermal conditions, weather, pasture topography and vegetation, grazing locations and individual cattle preference.

Cattle tended to prefer resting locations in the drier community types. In general these locations reflect shared characteristics of good visibility, higher (drier) elevation and deeper soil. It is assumed that these attributes provide comfort against predation and insects and favorable bedding. Although the cattle preferred to be stationary in these communities they also tended to begin grazing periods in these same areas. This result supports observations by Low et al. (1981a) that cattle begin grazing in the same area where they rest. Some stationary locations were observed around trees but tended to occur on the edge of an open community.

The dry meadow communities were selected in all pastures for both grazing and resting activities. The hawthorne and willow communities that had sufficient soil and moisture characteristics to support palatable understory vegetation were preferred in all pastures for grazing activity. Cattle in these communities preferred to be moving or were neutral in their preference suggesting that grazing was occurring in these communities. Shrub height was well passed the grazing height of cattle in all pastures so the preference for grazing these areas may be related to the greenness of vegetation found beneath the shrubs. This observation is supported when the dry pine communities are studied in the Milk Creek and Catherine Creek pastures. Cattle strongly avoided these areas and mostly used them for stationary locations. Vegetation beneath these shaded areas tend to be drier leading to the conclusion that cattle prefer vegetation that is found in shaded areas with deeper soils that have more moisture available.

Channel interaction

Cattle tended to be indifferent or avoided the channel area of pastures. Overall cattle spent 1-2% of their time within the channel area, which is comparable to the <1% channel and 5% in riparian habitat (gravel bar) reported by Ballard (1999). Most of this time was dedicated to drinking or crossing the stream. Similarly the amount of time drinking (3-4 minutes/event) was consistent with numbers reported by Ballard (1999) and Wagnon (1963).

Cattle occasionally rest near the stream in areas associated with shade and/or dry ground. However, cattle were more likely to avoid streams as resting locations and select stream crossings where the stream banks were gently sloped and avoid crossing where steep banks and deeper channel water occur.

Bank interaction

Cattle spent a minimal amount of time (2%) in the bank buffer zone that was 5 m (15 ft) on the outside of both banks of the channel and consistently had no preference for this zone. These areas were used primarily as travel corridors to get to the stream for water or to reach a crossing location. The cattle occupancy data (a direct measure) indicate that cattle do not prefer theses areas. These results are in contrast to the general belief that cattle are a primary occupant of this area and a source of significant bank alteration. This discrepancy indicates that additional research needs to be undertaken to determine if the indirect measures currently being used to measure cattle impact on bank alteration are providing an accurate measure of cattle contribution.

Technology

The technology used in this study yielded millions of data points without requiring direct human interaction once the cattle were released into the pasture. The analysis reported in this study only utilized a portion of the information contained in the data set.

Understanding the influence of GPS and map error on data analysis is critical to the successful application of this technology in research. Wilson (2010) noted that the large volume of data being collected with this technology had a beneficial effect of reducing GPS error but placed greater emphasis on the need to minimize mapping error. Overall the value of this technology to management is obvious but is dependent on the accurate location of landscape attributes.

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Appendix

A1

Complete dataset for Catherine Creek pasture **pg 1**

Catherine Creek Data 2008											
	8/11/2008 (seconds)	% Moving	8/11/2008 (seconds)	% Stationary	Total (seconds)	% Total	8/12/2008 (seconds)	% Moving	8/12/2008 (seconds)	% Stationary	Total (seconds)
Channel	4003	2.7%	1015	0.4%	5018	1.2%	2803	1.7%	1693	0.6%	4496
Dry Meadow	73010	49.2%	179553	69.0%	252563	61.8%	45115	27.3%	122101	45.9%	167216
Hawthorne_Baltic	38183	25.7%	55795	21.4%	93978	23.0%	75176	45.5%	113088	42.5%	188264
Hawthorne_Dry	755	0.5%	42	0.0%	797	0.2%	14451	8.7%	13605	5.1%	28056
Pine	9020	6.1%	16373	6.3%	25393	6.2%	13020	7.9%	19085	7.2%	32105
Riparian Shrub	24148	16.3%	8014	3.1%	32162	7.9%	15383	9.3%	4874	1.8%	20257
Moving vs Stationary	149119	36.5%	260792	63.8%	409911	100.2%	165948	38.5%	274446	63.7%	440394
Stream Bank (5m)*	3498	2.4%	1313	0.5%	4811	1.2%	3334	2.0%	3424	1.3%	6758

Catherine Creek 2009 Data											
	8/12/2009 (seconds)	% Moving	8/12/2009 (seconds)	% Stationary	Total (seconds)	% Total	8/13/2009 (seconds)	% Moving	8/13/2009 (seconds)	% Stationary	Total (seconds)
Channel	1827	1.1%	1324	0.5%	3151	0.7%	1070	0.6%	349	0.1%	1419
Dry Meadow	69497	41.5%	115212	44.7%	184709	43.4%	86382	48.2%	170476	68.6%	256858
Hawthorne_Baltic	59379	35.4%	45132	17.5%	104511	24.6%	68248	38.1%	50166	20.2%	118414
Hawthorne_Dry	6499	3.9%	2296	0.9%	8795	2.1%	3876	2.2%	1207	0.5%	5083
Pine	13440	8.0%	76740	29.7%	90180	21.2%	5391	3.0%	23503	9.5%	28894
Riparian Shrub	17061	10.2%	17316	6.7%	34377	8.1%	14239	7.9%	3062	1.2%	17301
Moving vs Stationary	167703	39.4%	258020	60.6%	425723	100.0%	179206	41.9%	248763	58.2%	427969
Stream Bank (5m)*	1555	0.9%	2134	0.8%	3689	0.9%	1580	0.9%	348	0.1%	1928

* Stream bank was analyzed separately from the in stream and vegetative communities .

A1

Complete dataset for Catherine Creek pasture

pg 2

Catherine Creek Data 2008												
% Total	8/13/2008 (seconds)	% Moving	8/13/2008 (seconds)	% Stationary	Total (seconds)	% Total	8/14/2008 (seconds)	% Moving	8/14/2008 (seconds)	% Stationary	Total (seconds)	% Total
1.0%	6395	3.8%	4699	1.8%	11094	2.6%	1786	1.7%	92	0.0%	1878	0.5%
38.8%	37519	22.2%	106593	41.1%	144112	33.6%	52014	48.7%	150770	58.9%	202784	55.9%
43.7%	63603	37.7%	59406	22.9%	123009	28.7%	36443	34.1%	82848	32.4%	119291	32.9%
6.5%	18553	11.0%	12085	4.7%	30638	7.1%	2620	2.5%	1634	0.6%	4254	1.2%
7.4%	22464	13.3%	62604	24.1%	85068	19.8%	5100	4.8%	18946	7.4%	24046	6.6%
4.7%	20635	12.2%	14484	5.6%	35119	8.2%	8777	8.2%	1600	0.6%	10377	2.9%
102.1%	169169	39.5%	259871	60.6%	429040	100.1%	106740	29.4%	255890	70.6%	362630	100.0%
1.6%	5398	3.2%	0	0.0%	5398	1.3%	2527	2.4%	387	0.2%	2914	0.8%

Catherine Creek 2009 Data												
% Total	8/14/2009 (seconds)	% Moving	8/14/2009 (seconds)	% Stationary	Total (seconds)	% Total	8/15/2009 (seconds)	% Moving	8/15/2009 (seconds)	% Stationary	Total (seconds)	% Total
0.3%	10031	6.4%	1836	0.7%	11867	2.8%	9207	5.4%	3726	1.4%	12933	3.0%
60.1%	33917	21.6%	146003	53.4%	179920	41.8%	53607	31.2%	158522	61.4%	212129	49.3%
27.7%	78498	50.0%	80760	29.5%	159258	37.0%	73033	42.5%	37396	14.5%	110429	25.7%
1.2%	10230	6.5%	5179	1.9%	15409	3.6%	5671	3.3%	2463	1.0%	8134	1.9%
6.8%	4870	3.1%	25902	9.5%	30772	7.1%	17852	10.4%	46996	18.2%	64848	15.1%
4.0%	19753	12.6%	14347	5.2%	34100	7.9%	12932	7.5%	8940	3.5%	21872	5.1%
100.1%	157299	36.5%	274027	63.7%	431326	100.2%	172302	40.1%	258043	60.0%	430345	100.1%
0.5%	3991	2.5%	1038	0.4%	5029	1.2%	4618	2.7%	2809	1.1%	7427	1.7%

A1

Complete dataset for Catherine Creek pasture

pg 3

Catherine Creek Data 2008												
8/15/2008 (seconds)	% Moving	8/15/2008 (seconds)	% Stationary	Total (seconds)	% Total	8/27/2008 (seconds)	% Moving	8/27/2008 (seconds)	% Stationary	Total (seconds)	% Total	8/28/2008 (seconds)
3706	2.5%	2162	0.8%	5868	1.4%	5525	4.1%	1850	0.6%	7375	1.7%	2172
52165	35.8%	150238	53.2%	202403	47.3%	22188	16.6%	77032	26.0%	99220	23.1%	27239
54478	37.4%	100260	35.5%	154738	36.2%	54005	40.3%	71507	24.1%	125512	29.2%	65748
2511	1.7%	6051	2.1%	8562	2.0%	20012	14.9%	52000	17.6%	72012	16.7%	8593
11761	8.1%	6502	2.3%	18263	4.3%	16434	12.3%	86386	29.2%	102820	23.9%	16097
20976	14.4%	16993	6.0%	37969	8.9%	16307	12.2%	8118	2.7%	24425	5.7%	5254
145597	34.0%	282206	66.0%	427803	100.0%	134471	31.3%	296893	69.0%	431364	100.3%	125103
3284	2.3%	3301	1.2%	6585	1.5%	2521	1.9%	750	0.3%	3271	0.8%	1453

Catherine Creek 2009 Data												
8/16/2009 (seconds)	% Moving	8/16/2009 (seconds)	% Stationary	Total (seconds)	% Total	8/19/2009 (seconds)	% Moving	8/19/2009 (seconds)	% Stationary	Total (seconds)	% Total	8/20/2009 (seconds)
3571	2.2%	972	0.4%	4543	1.1%	21161	14.0%	8570	3.2%	29731	7.2%	3184
25556	15.6%	60420	22.8%	85976	20.0%	30191	20.0%	19536	7.4%	49727	12.0%	76257
94984	58.0%	101603	38.3%	196587	45.8%	36370	24.1%	68623	26.0%	104993	25.3%	44221
24166	14.8%	93178	35.1%	117344	27.4%	30301	20.1%	109689	41.5%	139990	33.7%	8327
9846	6.0%	7177	2.7%	17023	4.0%	18102	12.0%	52849	20.0%	70951	17.1%	10689
6088	3.7%	2095	0.8%	8183	1.9%	15419	10.2%	5249	2.0%	20668	5.0%	12806
164211	38.3%	265445	61.9%	429656	100.1%	151544	36.5%	264516	63.7%	416060	100.2%	155484
2999	1.8%	953	0.4%	3952	0.9%	6745	4.5%	3225	1.2%	9970	2.4%	1713

A1

Complete dataset for Catherine Creek pasture

pg 4

Catherine Creek Data 2008												
% Moving	8/28/2008 (seconds)	% Stationary	Total (seconds)	% Total	8/29/2008 (seconds)	% Moving	8/29/2008 (seconds)	% Stationary	Total (seconds)	% Total	8/30/2008 (seconds)	% Moving
1.7%	392	0.1%	2564	0.6%	514	0.5%	553	0.2%	1067	0.3%	854	0.9%
21.9%	125389	41.7%	152628	35.9%	64274	68.1%	227265	69.5%	291539	69.2%	55813	58.9%
52.9%	77866	25.9%	143614	33.8%	15124	16.0%	85636	26.2%	100760	23.9%	12596	13.3%
6.9%	9442	3.1%	18035	4.2%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
13.0%	86218	28.6%	102315	24.1%	833	0.9%	627	0.2%	1460	0.3%	12165	12.8%
4.2%	1695	0.6%	6949	1.6%	13694	14.5%	13402	4.1%	27096	6.4%	13450	14.2%
29.4%	301002	70.8%	426105	100.2%	94439	22.4%	327483	77.8%	421922	100.2%	94878	24.0%
1.2%	387	0.1%	1840	0.4%	1477	1.6%	898	0.3%	2375	0.6%	2046	2.2%

Catherine Creek 2009 Data												
% Moving	8/20/2009 (seconds)	% Stationary	Total (seconds)	% Total	8/21/2009 (seconds)	% Moving	8/21/2009 (seconds)	% Stationary	Total (seconds)	% Total	8/22/2009 (seconds)	% Moving
2.0%	1037	0.4%	4221	1.0%	3459	2.4%	1112	0.4%	4571	1.1%	522	0.4%
49.1%	190208	70.3%	266465	62.5%	76936	52.3%	124200	44.2%	201136	47.0%	87951	64.3%
28.4%	51284	18.9%	95505	22.4%	49439	33.6%	143908	51.2%	193347	45.2%	36402	26.6%
5.4%	3687	1.4%	12014	2.8%	31	0.0%	0	0.0%	31	0.0%	0	0.0%
6.9%	15759	5.8%	26448	6.2%	2613	1.8%	750	0.3%	3363	0.8%	569	0.4%
8.2%	8678	3.2%	21484	5.0%	14702	10.0%	10918	3.9%	25620	6.0%	11709	8.6%
36.5%	270653	63.5%	426137	100.0%	147180	34.4%	280888	65.7%	428068	100.1%	137153	32.2%
1.1%	873	0.3%	2586	0.6%	3190	2.2%	1004	0.4%	4194	1.0%	1190	0.9%

A1

Complete dataset for Catherine Creek pasture

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Catherine Creek Data 2008									
8/30/2008 (seconds)	% Stationary	Total (seconds)	% Total	8/31/2008 (seconds)	% Moving	8/31/2008 (seconds)	% Stationary	Total (seconds)	% Total
145	0.0%	999	0.3%	1169	1.5%	271	0.1%	1440	0.4%
227190	75.7%	283003	71.7%	32082	40.1%	115341	43.1%	147423	42.4%
45417	15.1%	58013	14.7%	27092	33.9%	131321	49.1%	158413	45.6%
0	0.0%	0	0.0%	1305	1.6%	4133	1.5%	5438	1.6%
19874	6.6%	32039	8.1%	8621	10.8%	7914	3.0%	16535	4.8%
10171	3.4%	23621	6.0%	9766	12.2%	8406	3.1%	18172	5.2%
302797	76.7%	397675	100.7%	80035	23.0%	267386	77.0%	347421	100.0%
2064	0.7%	4110	1.0%	1212	1.5%	499	0.2%	1711	0.5%

Catherine Creek 2009 Data									
8/22/2009 (seconds)	% Stationary	Total (seconds)	% Total	8/23/2009 (seconds)	% Moving	8/23/2009 (seconds)	% Stationary	Total (seconds)	% Total
103	0.0%	625	0.1%	8795	6.5%	3438	1.2%	12233	2.9%
179200	61.9%	267151	62.7%	62327	46.4%	95307	32.5%	157634	36.9%
102129	35.3%	138531	32.5%	31014	23.1%	108774	37.1%	139788	32.7%
0	0.0%	0	0.0%	4381	3.3%	1293	0.4%	5674	1.3%
20	0.0%	589	0.1%	14745	11.0%	79827	27.2%	94572	22.1%
8044	2.8%	19753	4.6%	13411	10.0%	6274	2.1%	19685	4.6%
289496	67.9%	426649	100.1%	134673	31.4%	294913	68.6%	429586	100.4%
693	0.2%	1883	0.4%	2312	1.7%	1265	0.4%	3577	0.8%

A2

Catherine Creek data for 2008 and 2009

2008 Catherine Creek			
	1st half	2nd half	Average
Channel	1.3%	0.6%	1.0%
Dry Meadow	47.5%	48.5%	48.0%
Hawthorne_Baltic	32.9%	29.4%	31.2%
Hawthorne_Dry	3.4%	4.5%	4.0%
Pine	8.9%	12.2%	10.6%
Riparian Shrub	6.5%	5.0%	5.7%
Moving	35.6%	26.0%	30.8%
Resting	64.9%	74.2%	69.6%
Stream Bank (5 m)	1.3%	0.7%	1.0%

2009 Catherine Creek			
	1st half	2nd half	Average
Channel	1.6%	2.4%	2.0%
Dry Meadow	42.9%	44.2%	43.6%
Hawthorne_Baltic	32.2%	31.6%	31.9%
Hawthorne_Dry	7.2%	7.6%	7.4%
Pine	10.8%	9.3%	10.0%
Riparian Shrub	5.4%	5.0%	5.2%
Moving	39.2%	34.2%	36.7%
Resting	60.9%	65.9%	63.4%
Stream Bank (5 m)	1.0%	1.1%	1.0%

A3

Complete dataset for North Powder pasture

pg 1

North Powder Data 2009											
	7/21/2009 (seconds)	% Moving	7/21/2009 (seconds)	% Stationary	Total (seconds)	% Total	7/22/2009 (seconds)	% Moving	7/22/2009 (seconds)	% Stationary	Total (seconds)
Channel	6549	3.3%	4877	2.1%	11426	2.7%	3888	2.4%	795	0.3%	4683
Willow	21336	10.7%	11472	4.9%	32808	7.6%	26359	16.6%	42856	15.8%	69215
Baltic	11272	5.7%	3195	1.4%	14467	3.4%	8642	5.4%	19396	7.1%	28038
Salt Grass	28459	14.3%	51824	22.4%	80283	18.6%	31266	19.7%	81904	30.1%	113170
Small Channel	3917	2.0%	1383	0.6%	5300	1.2%	2693	1.7%	747	0.3%	3440
Quack Grass	5000	2.5%	1140	0.5%	6140	1.4%	5694	3.6%	4228	1.6%	9922
Complex	122523	61.6%	157925	68.1%	280448	65.1%	80230	50.5%	121994	44.9%	202224
Moving vs Resting	199056	46.2%	231816	53.8%	430872	100.0%	158772	36.9%	271920	63.1%	430692
Stream Bank (5m)*	11640	5.8%	4539	2.0%	16179	3.8%	9638	6.1%	6059	2.2%	15697

North Powder 2010 Data											
	716/2010 (seconds)	% Moving	7/16/2010 (seconds)	% Stationary	Total (seconds)	% Total	7/17/2010 (seconds)	% Moving	7/17/2010 (seconds)	% Stationary	Total (seconds)
Channel	3169	1.6%	303	0.1%	3472	0.8%	3925	2.1%	1258	0.5%	5183
Willow	35094	17.9%	49712	21.1%	84806	19.6%	40991	22.4%	42320	17.0%	83311
Baltic	881	0.5%	1814	0.8%	2695	0.6%	6272	3.4%	2419	1.0%	8691
Salt Grass	33385	17.1%	102278	43.3%	135663	31.4%	42005	22.9%	70471	28.3%	112476
Small Channel	3365	1.7%	1189	0.5%	4554	1.1%	195	0.1%	1	0.0%	196
Quack Grass	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0
Complex	119854	61.2%	80751	34.2%	200605	46.5%	89731	49.0%	132280	53.2%	222011
Moving vs Resting	195748	45.3%	236047	54.7%	431795	100.0%	183119	42.4%	248749	57.6%	431868
Stream Bank (5m)*	5515	2.8%	5148	2.2%	10663	2.5%	10253	5.6%	8863	3.6%	19116

* Stream bank was analyzed separate from in stream and vegetative communities.

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Complete dataset for North Powder pasture

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North Powder Data 2009												
% Total	7/23/2009 (seconds)	% Moving	7/23/2009 (seconds)	% Stationary	Total (seconds)	% Total	7/24/2009 (seconds)	% Moving	7/24/2009 (seconds)	% Stationary	Total (seconds)	% Total
1.1%	4644	2.9%	905	0.3%	5549	1.3%	2151	1.4%	1336	0.5%	3487	0.8%
16.1%	23084	14.4%	40558	14.9%	63642	14.7%	8983	6.1%	26062	9.2%	35045	8.1%
6.5%	218	0.1%	0	0.0%	218	0.1%	3424	2.3%	719	0.3%	4143	1.0%
26.3%	22351	14.0%	59217	21.8%	81568	18.9%	25769	17.4%	132131	46.6%	157900	36.6%
0.8%	2717	1.7%	1102	0.4%	3819	0.9%	5291	3.6%	2583	0.9%	7874	1.8%
2.3%	3509	2.2%	599	0.2%	4108	1.0%	0	0.0%	0	0.0%	0	0.0%
47.0%	103362	64.7%	169739	62.4%	273101	63.2%	102857	69.3%	120694	42.6%	223551	51.8%
100.0%	159885	37.0%	272120	63.0%	432005	100.0%	148475	34.4%	283525	65.6%	432000	100.0%
3.6%	8520	5.3%	9112	3.3%	17632	4.1%	5014	3.4%	4268	1.5%	9282	2.1%

North Powder 2010 Data												
% Total	7/18/2010 (seconds)	% Moving	7/18/2010 (seconds)	% Stationary	Total (seconds)	% Total	7/19/2010 (seconds)	% Moving	7/19/2010 (seconds)	% Stationary	Total (seconds)	% Total
1.2%	3151	1.8%	1083	0.4%	4234	1.0%	2406	1.3%	970	0.4%	3376	0.8%
19.3%	13389	7.5%	24689	9.8%	38078	8.8%	30438	16.3%	29797	12.2%	60235	14.0%
2.0%	7377	4.1%	4963	2.0%	12340	2.9%	4413	2.4%	25968	10.6%	30381	7.0%
26.0%	22967	12.9%	94855	37.5%	117822	27.3%	24320	13.0%	73910	30.2%	98230	22.8%
0.0%	3081	1.7%	733	0.3%	3814	0.9%	4184	2.2%	2823	1.2%	7007	1.6%
0.0%	12766	7.1%	13284	5.2%	26050	6.0%	2138	1.1%	5234	2.1%	7372	1.7%
51.4%	116002	64.9%	113539	44.9%	229541	53.2%	118992	63.7%	105764	43.3%	224756	52.1%
100.0%	178733	41.4%	253146	58.6%	431879	100.0%	186891	43.3%	244466	56.7%	431357	100.0%
4.4%	7807	4.4%	4247	1.7%	12054	2.8%	8391	4.5%	14337	5.9%	22728	5.3%

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Complete dataset for North Powder pasture **pg 3**

North Powder Data 2009												
7/25/2009 (seconds)	% Moving	7/25/2009 (seconds)	% Stationary	Total (seconds)	% Total	7/29/2009 (seconds)	% Moving	7/29/2009 (seconds)	% Stationary	Total (seconds)	% Total	7/30/2009 (seconds)
3228	2.1%	1363	0.5%	4591	1.1%	538	0.5%	1007	0.3%	1545	0.4%	2603
13134	8.6%	35354	12.7%	48488	11.2%	11766	10.0%	31796	10.1%	43562	10.1%	16815
2414	1.6%	1107	0.4%	3521	0.8%	1043	0.9%	12	0.0%	1055	0.2%	2853
34620	22.6%	139934	50.2%	174554	40.4%	15546	13.3%	142798	45.4%	158344	36.7%	26918
4240	2.8%	1718	0.6%	5958	1.4%	4118	3.5%	2465	0.8%	6583	1.5%	3432
9037	5.9%	2580	0.9%	11617	2.7%	0	0.0%	0	0.0%	0	0.0%	0
86370	56.4%	96549	34.7%	182919	42.4%	84251	71.9%	136421	43.4%	220672	51.1%	68555
153043	35.5%	278605	64.6%	431648	100.0%	117262	27.2%	314499	72.8%	431761	100.0%	121176
6544	4.3%	8696	3.1%	15240	3.5%	2903	2.5%	7288	2.3%	10191	2.4%	2411

North Powder 2010 Data												
Dummy (seconds)	% Moving	Dummy (seconds)	% Stationary	Total (seconds)	% Total	7/25/2010 (seconds)	% Moving	7/25/2010 (seconds)	% Stationary	Total (seconds)	% Total	7/26/2010 (seconds)
3163	1.7%	904	0.4%	4066	0.9%	2775	1.8%	1280	0.5%	4055	0.9%	1910
29978	16.1%	36630	14.9%	66608	15.4%	39247	26.2%	66563	23.7%	105810	24.5%	15669
4736	2.5%	8791	3.6%	13527	3.1%	2011	1.3%	3401	1.2%	5412	1.3%	15478
30669	16.5%	85379	34.8%	116048	26.9%	45419	30.3%	136956	48.7%	182375	42.3%	36298
2706	1.5%	1187	0.5%	3893	0.9%	404	0.3%	64	0.0%	468	0.1%	2006
3726	2.0%	4630	1.9%	8356	1.9%	0	0.0%	0	0.0%	0	0.0%	4134
111145	59.7%	108084	44.0%	219228	50.8%	60207	40.1%	73085	26.0%	133292	30.9%	75551
186123	43.1%	245602	56.9%	431725	100.0%	150063	34.8%	281349	65.2%	431412	100.0%	151046
7991.5	4.3%	8148.75	3.3%	16140.25	3.7%	12784	8.5%	13773	4.9%	26557	6.2%	6247

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Complete dataset for North Powder pasture

pg 4

North Powder Data 2009												
% Moving	7/30/2009 (seconds)	% Stationary	Total (seconds)	% Total	7/31/2009 (seconds)	% Moving	7/31/2009 (seconds)	% Stationary	Total (seconds)	% Total	8/1/2009 (seconds)	% Moving
2.1%	1517	0.5%	4120	1.0%	1177	1.1%	305	0.1%	1482	0.3%	1832	1.7%
13.9%	55028	17.7%	71843	16.6%	18200	16.5%	69848	21.7%	88048	20.4%	20598	18.7%
2.4%	842	0.3%	3695	0.9%	5104	4.6%	30003	9.3%	35107	8.1%	265	0.2%
22.2%	138653	44.6%	165571	38.3%	21216	19.3%	99179	30.8%	120395	27.9%	27650	25.1%
2.8%	2609	0.8%	6041	1.4%	2255	2.0%	557	0.2%	2812	0.7%	1788	1.6%
0.0%	0	0.0%	0	0.0%	405	0.4%	169	0.1%	574	0.1%	0	0.0%
56.6%	112040	36.1%	180595	41.8%	61728	56.1%	121701	37.8%	183429	42.5%	57788	52.6%
28.1%	310689	72.0%	431865	100.0%	110085	25.5%	321762	74.5%	431847	100.0%	109921	25.4%
2.0%	2826	0.9%	5237	1.2%	2228	2.0%	3431	1.1%	5659	1.3%	3282	3.0%

North Powder 2010 Data												
% Moving	7/26/2010 (seconds)	% Stationary	Total (seconds)	% Total	7/27/2010 (seconds)	% Moving	7/27/2010 (seconds)	% Stationary	Total (seconds)	% Total	7/28/2010 (seconds)	% Moving
1.3%	341	0.1%	2251	0.5%	1487	1.1%	925	0.3%	2412	0.6%	2978	2.1%
10.4%	41191	14.7%	56860	13.2%	11275	8.3%	17047	5.8%	28322	6.6%	12087	8.7%
10.2%	10017	3.6%	25495	5.9%	24685	18.2%	67727	22.9%	92412	21.4%	15504	11.1%
24.0%	82127	29.3%	118425	27.5%	16303	12.0%	94305	31.9%	110608	25.7%	19546	14.0%
1.3%	785	0.3%	2791	0.6%	6770	5.0%	7703	2.6%	14473	3.4%	3479	2.5%
2.7%	4555	1.6%	8689	2.0%	5205	3.8%	8000	2.7%	13205	3.1%	128	0.1%
50.0%	141102	50.4%	216653	50.2%	70484	52.0%	101389	34.3%	171873	39.9%	85902	61.5%
35.0%	280118	65.0%	431164	100.0%	136209	31.5%	297096	68.5%	433305	100.6%	139624	32.4%
4.1%	8825	3.2%	15072	3.5%	5713	4.2%	7035	2.4%	12748	3.0%	4121	3.0%

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Complete dataset for North Powder pasture **pg 5**

North Powder 2009 Data									
8/1/2009 (seconds)	% Stationary	Total (seconds)	% Total	8/2/2009 (seconds)	% Moving	8/2/2009 (seconds)	% Stationary	Total (seconds)	% Total
842	0.3%	2674	0.6%	2476	2.2%	1103	0.3%	3579	0.8%
74917	23.3%	95515	22.1%	14221	12.7%	39274	12.3%	53495	12.4%
204	0.1%	469	0.1%	4348	3.9%	2296	0.7%	6644	1.5%
159767	49.6%	187417	43.4%	26931	24.1%	151647	47.4%	178578	41.4%
876	0.3%	2664	0.6%	2974	2.7%	1949	0.6%	4923	1.1%
0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
85296	26.5%	143084	33.1%	60887	54.4%	123658	38.6%	184545	42.7%
321902	74.5%	431823	100.0%	111837	25.9%	319927	74.1%	431764	100.0%
4309	1.3%	7591	1.8%	6030	5.4%	5567	1.7%	11597	2.7%

North Powder 2010 Data									
7/28/2010 (seconds)	% Stationary	Total (seconds)	% Total	7/29/2010 (seconds)	% Moving	7/29/2010 (seconds)	% Stationary	Total (seconds)	% Total
2311	0.8%	5239	1.2%	2132	1.6%	839	0.3%	2971	0.7%
19307	6.6%	31394	7.3%	17565	12.9%	47937	16.3%	66502	15.4%
17897	6.1%	33401	7.8%	2704	2.0%	1774	0.6%	4478	1.0%
135440	46.5%	154986	36.0%	50812	37.4%	166641	56.5%	217453	50.5%
2969	1.0%	6448	1.5%	2021	1.5%	968	0.3%	2989	0.7%
0	0.0%	128	0.0%	0	0.0%	0	0.0%	0	0.0%
113151	38.9%	199053	46.2%	60782	44.7%	76637	26.0%	137419	31.9%
291075	67.6%	430649	100.0%	136016	31.6%	294796	68.4%	431812	100.2%
5585	1.9%	9706	2.3%	8443	6.2%	6970	2.4%	15413	3.6%

A4

North Powder data for 2009 and 2010

2009 North Powder			
	1st half	2nd half	Average
Channel	1.4%	0.6%	1.0%
Willow	11.6%	16.3%	13.9%
Baltic	2.3%	2.2%	2.3%
Salt Grass	28.2%	37.5%	32.8%
Small Channel	1.2%	1.1%	1.1%
Quack Grass	1.5%	0.0%	0.8%
Complex	53.9%	42.3%	48.1%
Moving	38.0%	26.4%	32.2%
Resting	62.0%	73.6%	67.8%
Stream Bank (5 m)	3.4%	1.9%	2.6%

2010 North Powder			
	1st half	2nd half	Average
Channel	0.9%	0.8%	0.9%
Willow	15.4%	13.4%	14.4%
Baltic	3.1%	7.5%	5.3%
Salt Grass	26.9%	36.4%	31.6%
Small Channel	0.9%	1.3%	1.1%
Quack Grass	1.9%	1.0%	1.5%
Complex	50.8%	39.8%	45.3%
Moving	43.1%	33.1%	38.1%
Resting	56.9%	66.9%	61.9%
Stream Bank (5 m)	3.7%	3.7%	3.7%

A5

Complete dataset for Milk Creek pasture

pg 1

Milk Creek Data 2009											
	10/8/2009 (seconds)	% Moving	10/8/2009 (seconds)	% Stationary	Total (seconds)	% Total	10/9/2009 (seconds)	% Moving	10/9/2009 (seconds)	% Stationary	Total (seconds)
Channel	1310	1.0%	1469	0.5%	2779	0.6%	2807	2.5%	2061	0.6%	4868
Wet Meadow	260	0.2%	168	0.1%	428	0.1%	321	0.3%	118	0.0%	439
Moist Meadow	57084	45.2%	139379	45.7%	196463	45.6%	61110	53.8%	165073	51.9%	226183
Dry Meadow	50570	40.1%	120312	39.5%	170882	39.7%	20864	18.4%	61041	19.2%	81905
W/M Meadow	2392	1.9%	290	0.1%	2682	0.6%	3337	2.9%	9422	3.0%	12759
W/M Meadow w/ Haw	2840	2.3%	505	0.2%	3345	0.8%	5126	4.5%	5317	1.7%	10443
Pine/Wheatgrass	11716	9.3%	42557	14.0%	54273	12.6%	19983	17.6%	74901	23.6%	94884
Pine/Rye	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0
Moving vs Resting	126172	29.3%	304680	70.7%	430852	100.0%	113548	26.3%	317933	73.7%	431481
Stream Bank (5m)*	4581	3.6%	2822	0.9%	7403	1.7%	6887	6.1%	5367	1.7%	12254

Milk Creek 2010 Data											
	10/5/2010 (seconds)	% Moving	10/5/2010 (seconds)	% Stationary	Total (seconds)	% Total	10/6/2010 (seconds)	% Moving	10/6/2010 (seconds)	% Stationary	Total (seconds)
Channel	3567	2.5%	1094	0.4%	4661	1.1%	1009	0.9%	774	0.2%	1783
Wet Meadow	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0
Moist Meadow	24304	16.8%	37994	13.2%	62298	14.4%	39861	35.5%	58570	18.3%	98431
Dry Meadow	70254	48.4%	166563	58.1%	236817	54.8%	42348	37.7%	164639	51.5%	206987
W/M Meadow	662	0.5%	1595	0.6%	2257	0.5%	1124	1.0%	868	0.3%	1992
W/M Meadow w/ Haw	45565	31.4%	79137	27.6%	124702	28.9%	26852	23.9%	93846	29.4%	120698
Pine/Wheatgrass	672	0.5%	399	0.1%	1071	0.2%	1239	1.1%	703	0.2%	1942
Pine/Rye	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0
Moving vs Resting	145024	33.6%	286782	66.4%	431806	100.0%	112433	26.0%	319400	74.0%	431833
Stream Bank (5m)*	9294	6.4%	5517	1.9%	14811	3.4%	3860	3.4%	6685	2.1%	10545

* Stream bank was analyzed separately from in stream and vegetative communities.

A5

Complete dataset for Milk Creek pasture **pg 2**

Milk Creek Data 2009												
% Total	10/10/2009 (seconds)	% Moving	10/10/2009 (seconds)	% Stationary	Total (seconds)	% Total	10/11/2009 (seconds)	% Moving	10/11/2009 (seconds)	% Stationary	Total (seconds)	% Total
1.1%	1184	1.2%	447	0.1%	1631	0.4%	2239	1.8%	634	0.2%	2873	0.7%
0.1%	2264	2.3%	6843	2.1%	9107	2.1%	2916	2.3%	6050	2.0%	8966	2.1%
52.4%	56042	57.5%	186686	56.0%	242728	56.4%	35847	28.5%	120714	39.9%	156561	36.5%
19.0%	22779	23.4%	48009	14.4%	70788	16.4%	56724	45.1%	159642	52.7%	216366	50.5%
3.0%	7072	7.3%	12834	3.9%	19906	4.6%	12151	9.7%	7084	2.3%	19235	4.5%
2.4%	2928	3.0%	2759	0.8%	5687	1.3%	11774	9.4%	6841	2.3%	18615	4.3%
22.0%	5262	5.4%	75761	22.7%	81023	18.8%	4227	3.4%	1759	0.6%	5986	1.4%
0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
100.0%	97531	22.6%	333339	77.4%	430870	100.0%	125878	29.4%	302724	70.6%	428602	100.0%
2.84%	4124	4.2%	2836	0.9%	6960	1.6%	5276	4.2%	2488	0.8%	7764	1.8%

Milk Creek 2010 Data												
% Total	10/7/2010 (seconds)	% Moving	10/7/2010 (seconds)	% Stationary	Total (seconds)	% Total	10/8/2010 (seconds)	% Moving	10/8/2010 (seconds)	% Stationary	Total (seconds)	% Total
0.4%	1406	1.1%	509	0.2%	1915	0.4%	1156	1.0%	398	0.1%	1554	0.4%
0.0%	3895	3.2%	1907	0.6%	5802	1.3%	3168	2.7%	7969	2.5%	11137	2.6%
22.8%	34687	28.3%	61564	19.9%	96251	22.3%	20259	17.2%	57365	18.3%	77624	18.0%
47.9%	53203	43.4%	213974	69.3%	267177	61.9%	65963	56.0%	175173	55.9%	241136	55.9%
0.5%	5086	4.2%	3077	1.0%	8163	1.9%	1358	1.2%	734	0.2%	2092	0.5%
27.9%	13197	10.8%	20867	6.8%	34064	7.9%	7013	6.0%	10619	3.4%	17632	4.1%
0.4%	11053	9.0%	6989	2.3%	18042	4.2%	5638	4.8%	6280	2.0%	11918	2.8%
0.0%	0	0.0%	0	0.0%	0	0.0%	13343	11.3%	54882	17.5%	68225	15.8%
100.0%	122527	28.4%	308887	71.6%	431414	100.0%	117898	27.3%	313420	72.7%	431318	100.0%
2.4%	5971	4.9%	10909	3.5%	16880	3.9%	2224	1.9%	795	0.3%	3019	0.7%

A5

Complete dataset for Milk Creek pasture

pg 3

Milk Creek Data 2009												
10/12/2009 (seconds)	% Moving	10/12/2009 (seconds)	% Stationary	Total (seconds)	% Total	10/16/2009 (seconds)	% Moving	10/16/2009 (seconds)	% Stationary	Total (seconds)	% Total	10/17/2009 (seconds)
1149	0.88%	721	0.2%	1870	0.4%	427	0.3%	123	0.0%	550	0.1%	872
2350	1.81%	6829	2.3%	9179	2.1%	0	0.0%	0	0.0%	0	0.0%	1040
44462	34.17%	215200	72.4%	259662	60.8%	18035	14.4%	12400	4.1%	30435	7.1%	36658
53213	40.90%	56210	18.9%	109423	25.6%	68038	54.5%	213508	69.8%	281546	65.3%	63966
6516	5.01%	3850	1.3%	10366	2.4%	1478	1.2%	646	0.2%	2124	0.5%	4673
5767	4.43%	5711	1.9%	11478	2.7%	3776	3.0%	975	0.3%	4751	1.1%	4200
5771	4.44%	3503	1.2%	9274	2.2%	493	0.4%	25	0.0%	518	0.1%	6338
10881	8.36%	5327	1.8%	16208	3.8%	32782	26.3%	80741	26.4%	113523	26.3%	8836
130109	30.44%	297351	69.6%	427460	100.0%	125029	29.0%	308418	71.0%	433447	100.6%	126583
2862	2.20%	4842	1.6%	7704	1.8%	2210	1.8%	826	0.3%	3036	0.7%	3550

Milk Creek 2010 Data												
Dummy (seconds)	% Moving	Dummy (seconds)	% Stationary	Total (seconds)	% Total	10/12/2010 (seconds)	% Moving	10/12/2010 (seconds)	% Stationary	Total (seconds)	% Total	10/13/2010 (seconds)
1784.5	1.4%	693.75	0.2%	2478.25	0.6%	2193	1.8%	1860	0.6%	4053	1.0%	1033
1765.75	1.4%	2469	0.8%	4234.75	1.0%	965	0.8%	151	0.0%	1116	0.3%	0
29777.75	23.9%	53873.25	17.5%	83651	19.4%	31195	25.4%	29614	9.8%	60809	14.3%	26696
57942	46.6%	180087.25	58.6%	238029.3	55.1%	53273	43.4%	170879	56.5%	224152	52.7%	75558
2057.5	1.7%	1568.5	0.5%	3626	0.8%	13484	11.0%	49910	16.5%	63394	14.9%	69
23156.75	18.6%	51117.25	16.6%	74274	17.2%	3849	3.1%	5935	2.0%	9784	2.3%	14015
4650.5	3.7%	3592.75	1.2%	8243.25	1.9%	17447	14.2%	43940	14.5%	61387	14.4%	4389
3335.75	2.7%	13720.5	4.5%	17056.25	4.0%	526	0.4%	237	0.1%	763	0.2%	11143
124470.5	28.8%	307122.25	71.2%	431592.8	100.0%	122932	28.9%	302526	71.1%	425458	100.1%	132903
5337.25	4.3%	5976.5	1.9%	11313.75	2.6%	9426	7.7%	12031	4.0%	21457	5.0%	3613

A5

Complete dataset for Milk Creek pasture

pg 4

Milk Creek Data 2009												
% Moving	10/17/2009 (seconds)	% Stationary	Total (seconds)	% Total	10/18/2009 (seconds)	% Moving	10/18/2009 (seconds)	% Stationary	Total (seconds)	% Total	10/19/2009 (seconds)	% Moving
0.7%	261	0.1%	1133	0.3%	1166	0.9%	1190	0.4%	2356	0.5%	1405	1.3%
0.8%	254	0.1%	1294	0.3%	82	0.1%	65	0.0%	147	0.0%	367	0.3%
29.0%	101071	33.2%	137729	32.0%	37736	30.7%	95760	31.1%	133496	31.0%	24544	21.9%
50.6%	159539	52.5%	223505	51.9%	48154	39.2%	148740	48.3%	196894	45.7%	68918	61.6%
3.7%	6671	2.2%	11344	2.6%	1601	1.3%	1785	0.6%	3386	0.8%	1321	1.2%
3.3%	1513	0.5%	5713	1.3%	1514	1.2%	862	0.3%	2376	0.6%	7412	6.6%
5.0%	21105	6.9%	27443	6.4%	8524	6.9%	5426	1.8%	13950	3.2%	851	0.8%
7.0%	13902	4.6%	22738	5.3%	23985	19.5%	53917	17.5%	77902	18.1%	7025	6.3%
29.4%	304316	70.6%	430899	100.1%	122762	28.5%	307745	71.5%	430507	100.0%	111843	25.9%
2.8%	1920	0.6%	5470	1.3%	4663	3.8%	4631	1.5%	9294	2.2%	3708	3.3%

Milk Creek 2010 Data												
% Moving	10/13/2010 (seconds)	% Stationary	Total (seconds)	% Total	10/14/2010 (seconds)	% Moving	10/14/2010 (seconds)	% Stationary	Total (seconds)	% Total	10/15/2010 (seconds)	% Moving
0.8%	2742	0.9%	3775	0.9%	1274	1.1%	9310	3.0%	10584	2.5%	667	0.6%
0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	6536	6.3%
20.1%	33903	11.5%	60599	14.2%	20472	17.2%	86356	27.7%	106828	24.8%	18214	17.5%
56.9%	206413	70.0%	281971	65.9%	49559	41.6%	122448	39.2%	172007	39.9%	51497	49.4%
0.1%	0	0.0%	69	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
10.5%	26187	8.9%	40202	9.4%	30926	26.0%	49161	15.7%	80087	18.6%	4034	3.9%
3.3%	1354	0.5%	5743	1.3%	215	0.2%	0	0.0%	215	0.0%	1522	1.5%
8.4%	24380	8.3%	35523	8.3%	16581	13.9%	45124	14.5%	61705	14.3%	22155	21.2%
31.1%	294979	68.9%	427882	100.0%	119027	27.6%	312399	72.4%	431426	100.1%	104625	24.4%
2.7%	16389	5.6%	20002	4.7%	4699	3.9%	15421	4.9%	20120	4.7%	2831	2.7%

A5

Complete dataset for Milk Creek pasture **pg 5**

Milk Creek Data 2009									
10/19/2009 (seconds)	% Stationary	Total (seconds)	% Total	10/20/2009 (seconds)	% Moving	10/20/2009 (seconds)	% Stationary	Total (seconds)	% Total
560	0.2%	1965	0.5%	585	0.5%	932	0.3%	1517	0.4%
511	0.2%	878	0.2%	4362	3.9%	15731	5.0%	20093	4.7%
75474	23.6%	100018	23.2%	37374	33.7%	113994	36.3%	151368	35.6%
202009	63.2%	270927	62.8%	46550	42.0%	112474	35.8%	159024	37.4%
586	0.2%	1907	0.4%	5886	5.3%	2822	0.9%	8708	2.1%
7678	2.4%	15090	3.5%	4146	3.7%	20244	6.5%	24390	5.7%
969	0.3%	1820	0.4%	4508	4.1%	1085	0.3%	5593	1.3%
31741	9.9%	38766	9.0%	7485	6.8%	47801	15.2%	55286	13.0%
319528	74.1%	431371	100.0%	110896	26.1%	315083	73.9%	425979	100.3%
3531	1.1%	7239	1.7%	2238	2.0%	5600	1.8%	7838	1.8%

Milk Creek 2010 Data									
10/15/2010 (seconds)	% Stationary	Total (seconds)	% Total	10/16/2010 (seconds)	% Moving	10/16/2010 (seconds)	% Stationary	Total (seconds)	% Total
3829	1.2%	4496	1.1%	905	0.7%	201	0.1%	1106	0.3%
26354	8.2%	32890	7.7%	4215	3.1%	3275	1.1%	7490	1.8%
77941	24.1%	96155	22.5%	15540	11.4%	8587	3.0%	24127	5.7%
141628	43.8%	193125	45.2%	64268	47.2%	219517	76.2%	283785	66.9%
331	0.1%	331	0.1%	13947	10.2%	7790	2.7%	21737	5.1%
16189	5.0%	20223	4.7%	5676	4.2%	1995	0.7%	7671	1.8%
693	0.2%	2215	0.5%	9427	6.9%	7606	2.6%	17033	4.0%
56893	17.6%	79048	18.5%	22143	16.3%	39107	13.6%	61250	14.4%
323858	75.6%	428483	100.2%	136121	32.1%	288078	67.9%	424199	100.0%
9042	2.8%	11873	2.8%	3311	2.4%	1521	0.5%	4832	1.1%

A6

Milk Creek data for 2009 and 2010

2009 Milk Creek			
	1st half	2nd half	Average
Channel	0.7%	0.4%	0.5%
Wet Meadow	1.3%	1.1%	1.2%
Moist Meadow	50.3%	25.8%	38.1%
Dry Meadow	30.2%	52.6%	41.4%
W/M Meadow	3.0%	1.3%	2.2%
W/M Meadow w/ Haw	2.3%	2.4%	2.4%
Pine/Wheatgrass	11.4%	2.3%	6.8%
Pine/Rye	0.8%	14.3%	7.6%
Moving	27.6%	27.8%	27.7%
Resting	72.4%	72.2%	72.3%
Stream Bank (5 m)	2.0%	1.5%	1.7%

2010 Milk Creek			
	Trial 1	Trial2	Average
Channel	0.6%	1.1%	0.8%
Wet Meadow	1.0%	1.9%	1.5%
Moist Meadow	19.4%	16.3%	17.8%
Dry Meadow	55.2%	54.1%	54.6%
W/M Meadow	0.8%	4.0%	2.4%
W/M Meadow w/ Haw	17.2%	7.4%	12.3%
Pine/Wheatgrass	1.9%	4.1%	3.0%
Pine/Rye	4.0%	11.1%	7.5%
Moving	28.8%	28.8%	28.8%
Resting	71.2%	71.2%	71.2%
Stream Bank (5 m)	2.6%	3.7%	3.1%

A7

Chi-Square Assessment

Chi-Square assessment is used to evaluate the goodness-of-fit between observed data and a theoretical model (Mosteller and Rourke 1973). In this thesis Chi-Square assessment was used to assess the goodness-of-fit between observed cattle occupancy and the area extent of attribute categories on a landscape.

Where: $(x)^2 = \sum_{i=1}^{c} \left(\frac{O-E}{E}\right)^2$ and df = c - 1

X^2 = Calculated Chi-Square value

C = Categories of a landscape attribute

i = Categories 1 through C

O = The proportion of cattle occupancy

E = The proportion of the area located in the test area that is contained in category i.

A sequence of Chi-Square tests was performed on each landscape attribute. An initial assessment was used to test across all categories to determine the overall goodness-of-fit. The initial test was then supplemented with tests (df=1) targeted against the alternative hypothesis (Snedecor and Cochran, 1971).

Relative Preference Index

Where: $x = \frac{O}{A}$

X = Relative Preference Index

O = The percentage of occupation of cattle in each community

A = The percentage of community area compared to the pasture