Spatial Occupancy Patterns and Activity of Arid Rangeland Cattle Grazing Small Riparian Pastures

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Abstract

The spatial occupancy patterns and activity of cattle grazing three riparian pastures was investigated in northeastern Oregon using Global Positioning System (GPS) collars logging at one second intervals. Cattle consistently selected plant communities as grazing areas that had forage in sufficient volume to meet their requirements and favored communities as resting areas that were dry and open. Cattle were stationary for more than 50% of the time in each pasture and consistently rested between dark and 04:00 hours. Interaction with stream channels was found to be 1-2% of total occupancy time and occurred on less than 10% of channel length. Cattle were indifferent or avoided channel areas relative to their area and, when in this zone, they spent most of their time moving not resting. Cattle did not prefer the stream bank zone and spent only 2% of their time in that zone. When occupied, the stream bank zone was used as a travel corridor to gain access to water or cross the channel to access other pasture areas. These Results are in contrast with the general belief that cattle are a primary occupant of the stream bank/channel area, additional research is needed to define factors influencing cattle occupancy.

Key words: arid rangeland, cattle activity, GPS collars, riparian grazing, stream

Introduction

Management of riparian systems in the western United States is the subject of 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 contributing to the decline of riparian areas and that the long-term cumulative effects of livestock grazing result in the degradation of the structure, composition, and production of plants and animals at community, ecosystem, and landscape scales. However, other authors (Wagnon 1968; Buckhouse *et al.* 1981; Bryant 1982; Roath & Krueger 1982; Kauffman *et al.* 1983; Gillen *et al*. 1984; Laliberte *et al*. 2001; Ballard & Krueger 2005a, 2005b; Wilson 2010) report research results that indicate cattle can graze rangelands containing riparian areas without excessive concentration and that managed grazing can maintain or improve riparian systems.

Cattle research in riparian areas has evolved with improved technology, progressing from observation and telemetry in the 1950s and 1960s to include Global Positioning Systems (GPS) that can provide a periodic or continuous track of cattle movement. These advances allow researchers to track cattle movement without disturbing the tracked animal. The objective of this case study was to develop a data set of cattle movement in riparian pastures. The riparian pastures used in these studies are typically grazed for relatively short durations (2 to 5 weeks) in the summer or early autumn as part of a grazing system that includes mountain pastures and crop aftermath.

The study employed one-second GPS collar technology and created a continuous track of cattle position and activity and, when coupled with GIS maps of vegetative communities derived from high resolution aerial imagery, plant community selection by cows. The working hypothesis was that cattle would demonstrate site preference via occupation time within available plant communities.

Materials and Methods

Study *Area*

The riparian pastures (floodplain topography $\leq$ 5% slope) used in this study are located in the Blue Mountain Province of northeastern Oregon, USA (Anderson *et al*. 1998). Precipitation within the province occurs primarily as snow between November and March. The Catherine Creek pasture is a 47 ha pasture unit located at the Eastern Oregon Agriculture Research Center 15 km southeast of Union, Oregon. Catherine Creek runs for 1.9 km through the pasture and can be 1 m deep and approximately 25 m wide. Cattle typically graze this pasture in mid-August and can remain until mid-September in some years. The primary plant communities in the unit include riparian shrub (*Alnus incana* (L.) Moench or *Salix bebbiana* Sarg. dominant), dry meadow (*Elymus* spp., *Bromus* spp. and *Poa* spp. dominant), black hawthorn (*Crataegus douglasii* Lindl.) and ponderosa pine (*Pinus ponderosa* Dougl.). Herbaceous production varies greatly between communities and their topographic position (Table 1). The Milk Creek pasture is adjacent to the Catherine Creek pasture and contains 50 ha. Cattle enter the Milk Creek pasture in early October and remain until forage is judged to be used to an appropriate level, which can extend grazing to as late as early November. Milk Creek averages 2 m wide is less than 1 m deep and runs through the pasture for approximately

1.6 km. The dominant plant communities of Milk Creek include wet (*Carex* spp.*, Scirpus microcarpus* Presl. and *Juncus* spp. dominant), moist (*Alopecurus pratensis* L.*, Deschampsia cespitosa* (L.) Beauv.*, Poa* spp.and *Juncus* spp. dominant) and dry meadow communities as well as upland communities of ponderosa pine. The North Powder pasture contains 73.6 ha in Baker County in northeastern Oregon. Cattle typically enter the pasture in mid-July and remain until early September. The North Powder River flows through the pasture for approximately 1.9 km and averages 10 m wide and over 1 m deep. The major plant communities in the North Powder pasture include willow (*Salix* spp.), rush (*Juncus* spp.), quackgrass (*Elymus repens* (L.) Gould) and saltgrass (*Distichlis stricta* (Torr.) Rydb.). Long-term herbaceous production estimates (Hall 1973) for plant communities found on the study sites is provided in Table 1. Pastures used in this study differ in the plant communities present and in the relative proportion of communities but are representative of riparian pastures in the region with close juxtaposition of xeric and mesic growing conditions. Growing conditions on each site during the study were categorized by comparison to 30-year average conditions for precipitation and temperature using the PRISM data set (Prism Climate Group 2012). 30-year normal precipitation and mean temperature (1981-2010) for Catherine Creek and Milk Creek sites were 657 mm and 7.4 °C while North Powder received 349 mm and 8.0 °C. Catherine Creek and Milk Creek sites were classified for precipitation as typical for 2009 (675 mm) and wet for 2010 (785 mm). Mean temperature for the Catherine Creek and Milk Creek sites was classed as cool in 2009 (7.1 °C) and typical for 2010 (7.4 °C). The North Powder site was also classified for precipitation as typical for 2009 (401 mm) and wet for 2010 (424 mm). Mean temperature for the North Powder site was classed as cool in 2009 (7.2 °C) and typical for 2010 (7.7 °C).

All pastures are managed for sustained yield and rangeland health with both animal numbers and the duration of grazing is adjusted to account for differences in year-to-year forage production. All study sites are managed using a late summer short term grazing strategy and are stocked at 0.82 ha/aum. Monitoring occurs while cattle are present and, if standing forage falls below the desired utilization level of 60% on key forage species the livestock are removed.

Pastures were delineated into plant communities based on the classification of Hall (1973) using aerial photography that was taken on 17 September 2009 combined with site visits that verified plant species composition, soil depth, and boundaries. Aerial images were acquired at high resolution (20 cm by 20 cm ground pixel size or 1:706 scale) using a Canon EOS Rebel XSi 12.4 megapixel digital color camera mounted in the belly of a Cessna 182 aircraft. Images were corrected for lens curvature and geographically registered to USDA National Agriculture Imagery Program (NAIP) 2009 imagery using a minimum of 20 ground control points within the study pastures. The high resolution image was then visually inspected for conformity to the 2009 NAIP imagery (accuracy ± 5m). If portions of the image did not match the reference image, additional control points were added and the image was re-rectified. Pasture mosaics were developed to delineate plant communities and stream position. The GIS layers for plant communities, stream boundaries and fences in each pasture were verified using a Garmin GPS Map 76S unit with a manufacturer's specified accuracy of 3 m. All pasture data layers (aerial photographs, plant communities, streams and boundaries) were entered into a GIS database for use in ArcGIS 10 (ESRI 2010). A buffer zones on the outside of the stream bank was established using ArcMap to analyze the time spent on the bank (Agouridis *et al*. 2004).

Animals and GPS Collars

Ten randomly selected lactating cows from 3 different commercial herds (Angus/Hereford mix) were collared before grazing the three riparian pastures. The riparian pastures are grazed each year as part of the annual rotation for each individual herd. Thus, each herd had prior experience in their respective pastures. In each pasture, two sequential grazing periods of 6 d were established that reflect the physical limitation of the GPS data loggers to record for approximately 6.25 d on a set of batteries. After the first period of 6 d, cattle were gathered as soon as possible, collar batteries and digital cards replaced, and returned to the pasture to complete a second grazing period. Upon completion of the second period cattle were gathered and collars removed. Thus, each collared cow had the potential for 2 periods of 6 d of track logging per pasture per year (2009 and 2010) which were separated by between 1 and 7 d. Grazing trials in the North Powder pasture were conducted between 21 July -8 August 2009 and 16 July-31 July 2010. Grazing trials in the Catherine Creek pasture began on 11 August 2009 and 20 August 2010 and were completed on 24 Aug 2009 and 5 September 2010. Grazing trials in the Milk Creek pasture were conducted between 8 October -22 October 2009 and 5 October-17 October 2010.

Collars recorded latitude, longitude, elevation, GPS date/time, velocity, bearing, number of satellites used for the positional fix and fix quality on a 1-second interval. Data points before the cattle entered the pasture were removed from the data set. Only days with complete data sets (>98% potential positions recorded) were used in subsequent analyses. Collar recording was continuous and recorded a mean of 6 satellites per fix (SD = 1.1) with less than 1% of recorded fixes based on 4 or fewer satellites. A stationary GPS collar in the center of the Catherine Creek Pasture was used to assess location accuracy. Analysis of over 1 million GPS locations had an x-y error of 1.4 m (SD = 0.83 m).

Data retrieved from the collars were converted into ASCII text format, read into Microsoft Excel and ESRI ArcMap and split into 24 h periods. To make an even data set, five cattle were merged into herd by day shapefiles for 10 d in each pasture each year. An Animal Movement Classification Tool (Johnson *et al.* 2009) was used to determine if the cattle were stationary or moving (> 0.001 kph for more than 3 consecutive seconds) in each community. Stationary positions (those with 0 velocity for 10 min or longer) were located as a central point.

Descriptive statistics in the form of percentages, averages and totals were used to describe the pattern of animal occupancy and activity. Each pasture occupancy (percent time spent) and activity (movement classification) analysis was based on 8,640,000 GPS locations (5 cattle for 10 $d \cdot y^{-1}$ for 2 yr). X^2 tests ($P < 0.05$) of occupancy and activity differences were used to verify the statistical importance of mathematical differences (Snedecor & Cochran 1973). Relative occupancy by cattle of each plant community was indexed by dividing the % of all livestock positions occurring in that community by the plant community's area in the pasture as a percentage. Sites with relative occupancy values near 1 were assumed to be preferentially neutral, those below 1 were considered avoided and those above 1 were selected for. It is important to note that the position of plant communities in the pasture can influence the intensity of use i.e. a community type normally only infrequently used may be heavily used if it is positioned between desirable communities or is found on frequently use travel corridors.

Results and Discussion

Community Occupancy and Activity

Cattle spent at least 50% of their time stationary (data not shown) which is similar to results reported by Senft *et al*. (1985). Resting was a prominent activity in the daily routine of cattle regardless of pasture, period of grazing or differences among cow/calf herds. Cattle in this study tended to bed down around dark and remain relatively still until about 4:00 a.m. PST (data not shown), which is consistent with results reported by Reppert (1960) and Sneva (1970). Daytime resting periods occurred throughout the day and did not follow a well-defined pattern. We assume that daytime resting was the result of the individual response of cows to thermal conditions, weather, pasture topography, vegetation and grazing location.

Cattle preferred to rest in the drier plant communities of dry meadow, hawthorn/rush, willow and saltgrass (Table 2). In general these communities share characteristics of good visibility, a drier surface (higher elevation above water table) and deeper (less rocky) soil. It is assumed that these plant communities provided comfort against insects, predation, and favorable bedding. Cattle tended to be stationary at night and then began their morning grazing period in the same areas. This observation supports observations reported by Low *et al.* (1981). Some stationary locations were positioned under the canopy of trees but most were near or on the edge of open areas.

Meadow communities were selected in all pastures for grazing and resting activities (Table 2). Hawthorn and willow communities that had sufficient openness, soil depth and moisture characteristics that supported palatable understory vegetation were also preferred in all pastures. The dominant travel activity of cattle in these communities tended to be a slow moving walk (average of 1 kph) which suggested grazing activity. Shrub height in hawthorn and willow communities was generally above the grazing height of cattle in all pastures and the shrub biomass was not considered to be a significant source of forage. Selection of these areas for grazing activity appeared to be related to a sustained level of soil moisture, resulting in active forage growth throughout the grazing period. By contrast, the dry pine communities studied in the Milk Creek and Catherine Creek pastures received limited usage for grazing and resting by cattle. The pine communities occurred on soil surfaces that are elevated above groundwater sources and were composed of upland forage species that are dormant by mid-summer.

Channel Interaction

Cattle positions were mapped to show the relative level of occupancy in relation to the stream (Figure 1). Cattle were indifferent to or avoided the channel area of pastures (Table 2). Overall cattle spent 1-2% of their time within the channel area. Most of this time was dedicated to drinking or crossing the channel rather than resting or grazing for extended periods. The amount of time drinking was approximately 3-4 min/event and occurred one or two times per day. These results support numbers reported by Ballard and Krueger (2005a, 2005b) and Wagnon (1968). Cattle tended to select stream drinking and crossing locations in open areas where the stream banks were gently sloped and avoided areas with dense shrub, steep banks and deeper channel water. Channel access by cattle was limited to less than 10% of the channel length in all pastures.

Stream Bank Interaction

Cattle spent a minimal amount of time (2%) in the stream bank buffer zone that was 5 m on the outside of both banks of the channel and consistently had no preference for this zone (Table 2). While each pasture is unique, major sections of these stream banks have limited forage availability and access due to the occurrence of areas of dense woody vegetation, rocky surfaces with minimal soil development, saline soils, and/or elevated channel bank areas that commonly occur within undulating floodplain surfaces. As a result, pathways were selected within the stream bank zone as travel corridors to and from the stream for water or for crossing. This observation is supported by the dominance of travel activity (speeds > 1 kph) within the stream bank zone and the minimal usage of these areas for stationary activities.

Implications

The plant communities selected by cattle for grazing activity in this study had common characteristics of active forage growth and sufficient forage biomass to allow cattle to maintain rumen function with limited effort. Selected resting areas may or may not have active forage growth, but consistently reflect characteristics of being a dry, open and/or less rocky. All cattle utilized nighttime hours as a resting period, showing minimal movement with limited localized grazing around the nighttime resting area.

Cattle were either neutral in preference or avoided the channel and stream bank areas of the riparian pastures. In all cases, cattle occupancy in these areas was 1-2% with channel access occurring on less than 10% of the available channel length in each pasture. In temporal terms, a cow could be expected to spend 6 to 8 min drinking within the 15 to 20 min travel activity that occurred within the stream bank zone on a daily basis. These results are in contrast with the general belief that cattle are a primary occupant of the stream bank/channel area and a primary source of stream bank/channel deterioration. Our results suggest that additional research needs to be undertaken to define factors influencing cattle occupancy of stream bank/channel areas and the impact of that occupancy. Previous research was influenced by limited observation periods, observer accuracy and observer/cattle interaction as compared to new technologies that allow 24 hour observation, greater data accuracy and eliminate the need for an on-site observer. We suggest that additional studies be conducted to clarify the relationship between cattle distribution and site use under longer residence times in riparian pastures and across years with low forage production versus high forage production to further define resource selection and animal activity.

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Figure 1. This is an example of an occupancy map for one grazing trial on the Milk Creek Pasture in late summer 2009. For clarity, we have reduced the number of cows mapped to 3. The pasture was divided into 10 by 10 m grid cells, and then attributed with the number of cow positions found in each cell. Cell that are white have no or very few collared cow locations, black squares have up to 32 767 cow positions. The pasture boundary is in black and milk creek is shown in dark gray.

Table 1. Long-term herbaceous production† values (kg/ha) for selected plant communities contained within the study area. Climatic conditions during the study were determined for each site based on 30-year normal precipitation and temperature values (Prism 2012). Catherine Creek and Milk Creek Sites were classified for precipitation as typical for 2009 and wet for 2010. Temperature for the Catherine Creek and Milk Creek sites was classed as cool in 2009 and typical for 2010. The North Powder Site was also classified for precipitation as typical for 2009 and wet for 2010. Temperature for the North Powder Site was classed as cool in 2009 and typical for 2010.

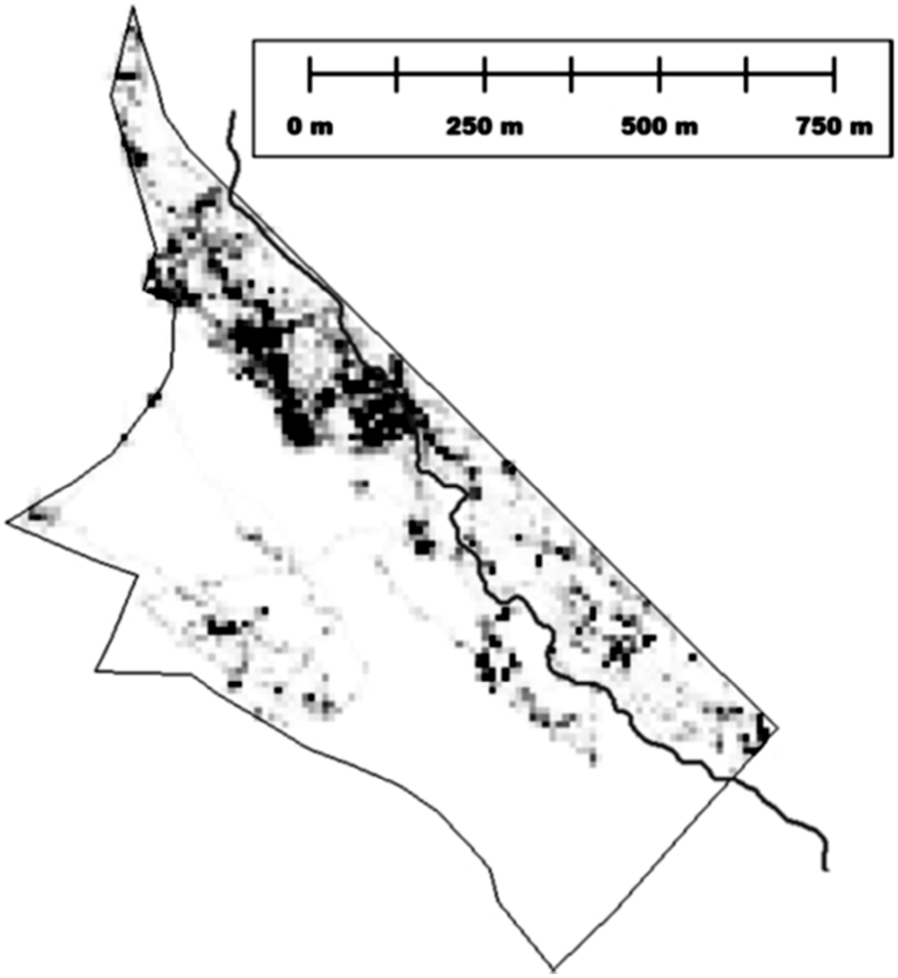
Plant Community	Production Range	Catherine Creek (ha)	Milk Creek (ha)	North Powder (ha)
Wet Meadow	2000 - 2500		0.2	
Moist Meadow	1000 - 1800		8.3	
Willow / Moist Meadow	1000 - 1800			2.7
Dry Meadow	500 - 1100	7.1	16.5	
Saltgrass	500 - 1000			16.8
Rush / Saltgrass	500 – 1000			35.9
Quackgrass	500 - 1000			1.1
Hawthorne / Rush	500 - 1000	5.9	3.0	
Hawthorne / Dry	100 - 200	2.7		
Pine / Snowberry	300 - 500	25.8	5.9	
Pine / Wheatgrass	400 - 800		16.1	
Rush	100 / 200			17.1
Riparian Shrub	100 - 200	5.5		

† Production estimates derived from Hall (1973) and Crowe and Clausnitzer (1997).

Table 2. Cattle occupancy, preference, activity pattern (%) and, in parentheses, the percent of time in each community spent moving or stationary for Catherine Creek, Milk Creek and North Powder pastures during 2009 and 2010.

Pasture	Community	Area (%)†	Occupancy (%)	P	Moving	P	Stationary	P
Catherine Creek	Dry Meadow	13.7	45.3	0.01	20.2 (44.1%)	0.01	25.6 (55.9%)	0.01
	Hawthorne/ Rush	11.4	31.1	0.01	17.2 (54.6%)	0.01	14.3 (45.4%)	0.01
	Hawthorne / Dry	5.3	5.6	NS	2.8 (50.0%)	NS	2.8 (50.0%)	NS
	Channel	9.2	1.0	0.01	0.9 (98.9%)	NS	0.01 (1.1%)	0.01
	Pine	49.6	10.2	0.01	4.0 (38.8%)	0.01	6.3 (61.2%)	0.01
	Riparian shrub	10.7	5.3	0.01	4.0 (74.1%)	NS	1.4 (25.9%)	0.01
	Streambank	3.0	1.5	NS	1.1 (73.3%)	NS	0.4 (26.7%)	NS
Milk Creek	Wet Meadow	0.4	1.3	NS	0.6 (75.0%)	NS	0.2 (25.0%)	NS
	Moist Meadow	16.0	27.3	0.01	14.3 (51.1%)	0.01	13.7 (48.9%)	0.01
	Dry Meadow	31.8	46.9	0.01	22.6 (47.1%)	0.01	25.4 (52.9%)	0.01
	Hawthorne	5.8	7.1	NS	4.2 (57.5%)	NS	3.1 (42.5%)	NS
	Channel	0.8	0.7	NS	0.5 (71.4%)	NS	0.2 (28.6%)	NS
	Wet / Moist	3.0	2.2	NS	1.5 (65.2%)	NS	0.8 (34.8%)	NS
	Pine/ Wheatgrass	11.4	4.8	0.05	3.2 (65.3%)	NS	1.7 (34.7%)	0.05
	Pine / Rye	31.0	7.3	0.01	3.8 (50.7%)	0.01	3.7 (49.3%)	0.01
	Streambank	2.3	2.3	NS	1.6 (66.7%)	NS	0.8 (33.3%)	NS
North Powder	Willow	3.5	13.8	0.01	7.1 (50.7%)	0.01	6.9 (49.3%)	0.01
	Saltgrass	21.5	31.4	0.01	10.7 (33.4%)	NS	21.3 (66.6%)	0.01
	Quackgrass	1.5	1.1	NS	0.6 (54.5%)	NS	0.5 (45.5%)	NS
	Rush / Salt	46.0	45.9	NS	27.0 (57.8%)	NS	19.7 (42.2%)	NS
	Channel	2.5	0.9	NS	0.7 (77.8%)	NS	0.2 (22.2%)	NS
	Overflow	3.0	1.1	NS	0.8 (72.7%)	NS	0.3 (27.3%)	NS
	Rush	22.0	3.7	0.01	2.0 (52.6)	0.01	1.8 (47.4%)	0.01
	Streambank	2.0	2.2	NS	2.1 (65.6%)	NS	1.1 (34.4%)	NS

† Area of streambank is also contained in the tally of surface area of individual plant communities.



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