Cattle Temporal and Spatial Distribution in Midwestern Pastures Using Global Positioning (A Progress Report)

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Summary and Implications

Pastures on five southern Iowa cow-calf farms were used to evaluate the effects of pasture characteristics and microclimatic conditions on cattle grazing cool-season grass pastures with streams and/or ponds. Pastures ranged from 33 to 309 acres and contained varying proportions of cool-season grasses, legumes, sedge, broadleaf weeds, brush, and bare ground. The percentage of pasture area that was shaded ranged from 27 to 73%. Cows were Angus and Angus-cross on four of the farms, and Mexican Corriente on the remaining farm. In spring, summer, and fall of 2007 and 2008, 2 to 3 cows per farm were fitted with Global Positioning System (GPS) collars to record position at 10 minute intervals for periods of 5 to 14 days. Ambient temperature, black globe temperature, dew point, relative humidity, and wind speed and direction were collected with HOBO data loggers at ten minute intervals over the 2007 and 2008 grazing seasons on each farm. Streams, ponds, and fence lines were referenced on a geospatial map and used to establish zones in the pastures. Designated zones were: in the stream or pond, and 50, 100, 200, or greater than 200 ft (Uplands) from the stream or pond (water source). Seventy-four data sets were obtained throughout the 2007 and 2008 grazing seasons. Mean proportions of observations when cattle were in the water source did not differ ($P<0.05$) between farms. However, mean proportions of time cattle spent within 50, 100, or 200 ft or greater than 200 ft of the water source differed ($P<0.05$) among farms. The proportion of time cattle were within the riparian area (defined as being in the water source or within 100 feet of the water source) increased with increasing ambient temperature.

Introduction

Rathbun Lake is the primary water source for 70,000 residents in 17 counties and 48 communities in southern Iowa and northern Missouri. In addition, to providing drinking water, this 11,000 acre lake provides recreation opportunities for one million visitors annually. Fifteen sub-watersheds of the Rathbun Lake watershed have been identified as carrying nearly 73% of all sediment and phosphorus delivered annually to the lake. The primary factor contributing to this pollution has been identified as livestock grazing on pastures, which comprise 38% of the watershed. This pollution could be related to grazing management practices that allow cattle to congregate in and near pasture streams.

Previous research has shown that grazing cattle tend to congregate in riparian areas of pastures to obtain water and shade for thermoregulation. However, problems associated with thermoregulation may be increased because of the presence of endophyte-infected tall fescue in pastures. Quantifying the temporal/spatial distribution of grazing cattle in riparian pastures will assess the risk of sediment, nutrient, and pathogen loading into streams and ponds from these cattle Furthermore, defining the relationships between cattle distribution and such pasture characteristics as size, shape, shade distribution, botanical composition, and climatic factors related to heat stress will provide the basis for the development and implementation of management practices which will minimize non-point source pollution possibly associated with grazing cattle.

Therefore, the objective of this project was to evaluate the effects of pasture characteristics and botanical composition, and climate on the temporal and spatial distribution of grazing cattle within and outside the riparian zones of pastures.

Materials and Methods

Pastures on five cooperating beef cow-calf farms (A, B, C, D, and E) in the Rathbun Lake watershed were identified as appropriate for the project in the fall of 2006. Pastures ranged from 33 to 309 acres. Four of the five farms had Angus or Angus-cross cattle with Mexican Corriente cattle on the remaining farm. Cows on four of the farms were spring-calving with the remaining farm having both spring- and fall-calving cows. During spring, summer, and fall of 2007 and 2008, 2 to 3 cows per farm were fitted with Global Positioning System (GPS) collars to record position at 10 minute intervals for periods of 5 to 14 days. Seventy-four data sets, all farms combined over two years, were obtained throughout the grazing seasons to determine cattle locations. Collars were not placed on cows on Farm D in spring 2007 and summer 2008.

In the summer of 2007, streams and/or ponds and fence lines were referenced in the pasture of each farm using a handheld Garmin GPS72 receiver and a geospatial map using ArcGIS 9.2 software. Upon referencing, points were used to establish zones in the pastures. Designated zones were: in the stream or pond (water source), and 50, 100, 200, or greater than 200 feet (Uplands) from the water. The water sources included streams and ponds on Farms C and E, streams on Farms A and D, and ponds on Farm B. Riparian area was expressed as the area of the water source plus the 50 and 100 feet zones. Cow distribution across zones was located using the measurements from the GPS collars.

Microclimate data, including ambient temperature, black globe temperature (solar radiation), dew point, wind speed and direction, relative humidity, and rainfall, were recorded, at 10 min intervals using HOBO data logging weather stations over the two grazing seasons on each farm. To evaluate the effects of heat stress, a temperature humidity index (THI), black globe temperature humidity index (BGTHI), and heat load index (HLI) were paired with microclimate data for each observation time. For each unit increment of each microclimate variable, the number of observations that a cow was in or within 100 feet of the water source was divided by the total number of observations at that temperature or heat index unit to determine the probability of a cow being in either of these zones at that microclimatic variable increment.

The LOGISTIC procedure of SAS was used to test the effects of microclimate variables on the probability of the cattle being in or within 100 feet of the water by calculating an odds ratio to determine the effect of each unit change in the microclimatic variable on the probability of cows being in or within 100 feet of the water source. The climatic variable that best predicted the presence of cattle in or within 100 feet of the water source was determined using Akaike's Information Criteria (AIC).

To determine the botanical composition of each pasture, two of the pastures were divided into 164 x 164 ft grid and three of the pastures were divided into 328 x 328 ft grids on aerial photos using ArcGIS 9.2 software. In late spring of each year, bare ground or forage species were visually identified and sward height measured with a falling plate meter (8.8 lb/yd^2) in the center of each square of the grid in each pasture, as located by a GPS handheld receiver, and at four equidistant locations from the center of each grid. Observations within each grid were divided by the number of vegetative species within the grid and percentages from each grid were combined for determining the total percentage of vegetative species within a pasture. Vegetation species observed included tall fescue, reed canarygrass, Kentucky bluegrass, smooth bromegrass, orchardgrass, timothy, legumes (white and red clover), sedge, weed grasses, broadleaf weeds, brush, and other brush species. The most predominant forage species observed over the five farms was tall fescue, which ranged from 7 to nearly 50 percent, with varying amounts of the remaining vegetative species.

The shade distribution of each pasture, including total pasture shade and the proportion of total shade in the riparian area, was determined from aerial photos using ArcGIS 9.2 software. Total shaded acres were divided by total pasture acres to determine the percentage of pasture shaded. Riparian shade was determined by the acres shaded divided by the total acres within the riparian area. Riparian shade, as a percentage of the total pasture shade, was determined by multiplying the percentage of riparian shade by percentage of riparian area in the pasture, divided by, percentage of riparian shade by percentage of riparian area in the pasture plus the percentage of non-riparian shade multiplied by the percentage of non-riparian area in the pasture.

The effects of farm and season on the distribution of cows in pastures was analyzed using the GLM procedure of SAS using years as the replicate. The effects of season and year on the distribution of cows were also analyzed using the GLM procedure using farm as the replicate. A P-value of 0.05 was used to determine significance.

Results and Discussion

There were differences ($P<0.04$) in seasons, spring and fall compared to summer, for the percentage of observations of cows located in the water source, but not between years ($P>0.05$), when using farms as experimental units. In spite of seasonal differences for the percentage of time cows were located in the water source (Table 1), cows across all farms spent less than an average 2% of observations in the water source. This presence in the stream is lower than percentages reported by others in the literature. However, pastures used in the previous studies were smaller than the pastures of the current study.

The proportion of observations when cows were located in the riparian areas of pastures were not different ($P>0.05$) between seasons, when using farms as experimental units, but differences existed between farms ($P<0.05$, Table 2). Because differences ($P<0.05$) were observed between farms of cows within a water source and within the riparian zone, when using year as the experimental unit, alternative factors influencing cattle temporal/spatial distribution were evaluated. Microclimatic changes and abnormal rainfall amounts that caused flooding in summer 2008, may have contributed to differences of cattle distribution within the riparian area between years.

Botanical composition of pastures in 2007 were evaluated and regressed against cattle locations within the riparian area, but no relationship existed when using farms as experimental units. The effects of botanical composition of the pastures on cow distribution in 2008 will be evaluated.

Cattle locations and microclimatic factors were paired to evaluate the temporal/spatial distributions within the riparian area of a pasture. Of the climatic variables and indices of heat stress measured, ambient temperature most accurately predicted the probability of cow presence in the riparian area, as determined by the lowest AIC and covariate value.

Using PROC LOGISTIC, each farm was modeled for the 2007 grazing year (Figure 3), for predicting the probability of cattle presence in the riparian area of a pasture. The differences in probability curves between farms imply that there may be characteristics of individual pastures affecting cow spatial/temporal distribution.

In order to determine the factors causing the differences in cow distribution in riparian areas, the distribution of pasture shade across all farms were analyzed (Table 3). Total pasture shade ranged from 27.2% on Farm E, to 72.8% of the pasture area on Farm D. Riparian shade ranged from 55.5 to 79.1% of the riparian area and accounted for 2.8 to 58.4% of the total pasture shade. In spite of this variation in pasture shade, the proportion of cow distribution was only weakly related to the proportion of total pasture shade in the riparian area (Figure 1), particularly in the summer and fall when the effects of shade should have been the greatest.

In contrast to the effects of riparian shade, the proportion of cattle observations in riparian area was related to proportion of riparian area in total pasture (Figure 2). The proportion of riparian areas in the total pasture accounted for 76, 63, and 92% of the variation in the proportion of observations of cows within the riparian areas of the pastures in the spring, summer, and fall grazing seasons.

Preliminary results imply the presence of cattle in riparian areas of pastures increased with increasing ambient temperature and increasing the proportion of pasture as riparian area. The proportion of time that cattle were in the riparian area of the pastures was only weakly related to the proportion of the total pasture shade in the riparian areas. However, these pastures contained considerable shade outside of the riparian area. Surprisingly, the presence of cattle in riparian areas was not related to proportions of tall fescue in pastures that contained 7 to 50% tall fescue.

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Table 1. Mean percentage of observations of cattle within the water source of pastures in spring, summer, and fall seasons on five farms in 2007 and 2008.

Water Source	2007 and 2008 Grazing Seasons		
Name	Spring	Summer	Fall
	% of observations		
Farm A	1.3[a]	0.7[b]	0.9
Farm B	0.2[b]	1.7[ab]	1.1
Farm C	1.4[ab]	2.2[a]	1.0
Farm D	1.9[a]	1.2[ab]	1.0
Farm E	1.2[ab]	2.8[a]	1.4

a,b superscripts differ by (P=0.05) between farms within seasons (columns).

Table 2. Mean percentage of observations of cattle within the riparian area of pastures in spring, summer, and fall seasons on five farms in 2007 and 2008.

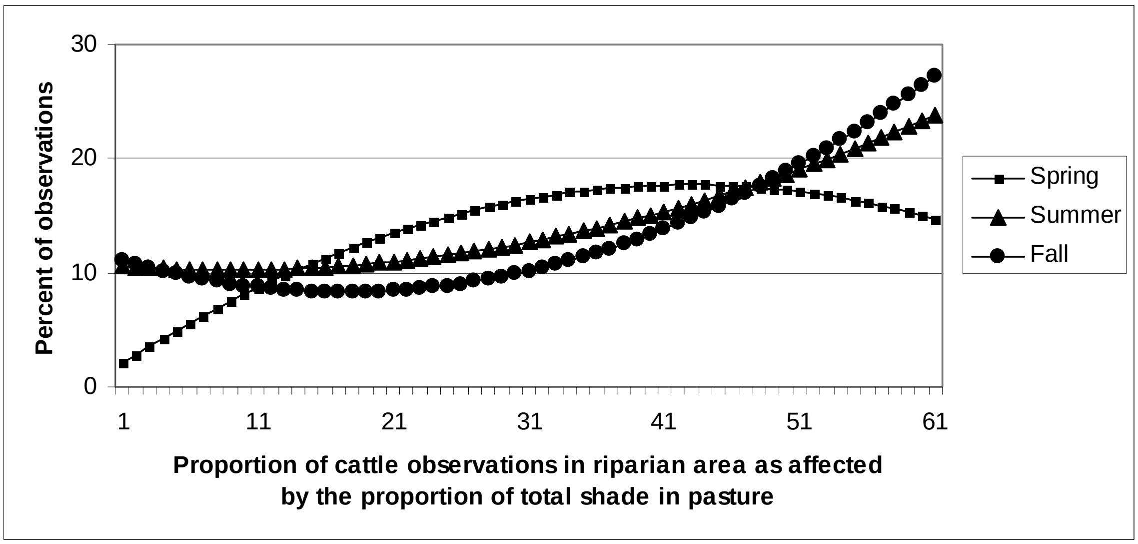
Riparian Zone	2007 and 2008 Grazing Seasons		
Name	Spring	Summer	Fall
	% of observations		
Farm A	17.5[b]	10.5[bc]	13.2[b]
Farm B	2.5[c]	5.8[c]	5.4[b]
Farm C	17.3[ab]	10.4[bc]	9.5[b]
Farm D	26.8[a]	19.6[a]	22.4[a]
Farm E	17.6[ab]	27.3[a]	27.7[a]

a,b,c superscripts differ by (P=0.05) between farms within seasons (columns).

Table 3. Shade distribution of pastures in 2007 and 2008.

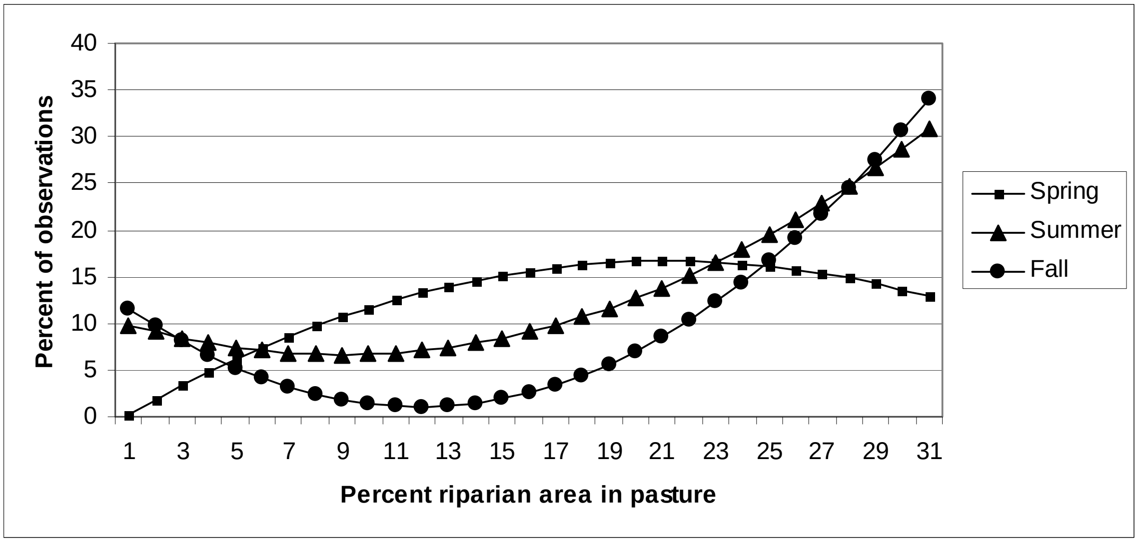
	Riparian Shade		Pasture Shade
Name	% of Riparian Area	% of Total Pasture Shade	% of Pasture Area
Farm A	75.8	31.5	57.8
Farm B	67.2	2.8	59.6
Farm C	79.1	44.8	30.5
Farm D	68.0	21.0	72.8
Farm E	55.5	58.4	27.2

Figure1. Proportion of cattle observations in riparian area in 2007 as affected by the proportion of total pasture shade in riparian area.



Spring: $Y=2.09+0.75x-0.009x^2$; ($P<0.01$); ($r^2=0.75$)
Summer: $Y=10.58-0.08x+0.005x^2$; ($P=0.14$); ($r^2=0.19$)
Fall: $Y=11.04-0.33x+0.010x^2$; ($P=0.04$); ($r^2=0.37$)

Figure 2. Proportion of cattle observations in riparian area in 2007 as affected by the proportion of riparian area in total pasture.



Spring: Y=0.29+1.62x-0.04x^2; ($P<0.01$); (r^2=0.76)
Summer: Y=9.83-0.80x+0.05x^2; ($P<0.003$); (r^2=0.63)
Fall: Y=11.60-1.95+0.09x^2; ($P<0.001$); (r^2=0.92)

Figure 3. Estimated probabilities of cows within riparian area as affected by ambient temperature by farm and percent riparian area in the pasture.