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NON-RIPARIAN SHADE AS A WATER QUALITY BEST MANAGEMENT PRACTICE FOR GRAZING-LANDS: A CASE STUDY

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Cattle within riparian zones can negatively impact water-quality and riparian health which are important environmental concerns for grazing lands. Best Management Practices (BMPs) help mitigate agricultural pollution. Since BMPs are primarily voluntary, stakeholder acceptance is critical; agricultural producers need BMPs relevant to their operation that will not negatively impact production. Alternative shade has been suggested as a water-quality BMP with both environmental and agricultural benefits. After implementing the non-riparian shade structure, a 30% average reduction was observed in the time cattle spent within the riparian zone. Alternative shade can provide cattle producers with more options to achieve water-quality goals.

Key words: best management practice – water-quality – riparian zone – shade

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By Calvin R. Clary, Larry Redmon, Terry Gentry, Kevin Wagner, and Robert Lyons

Cattle loafing within riparian zones or waterways can negatively impact water quality and riparian zone health. Riparian health and stream water quality are intricately linked and important to the sustainability of in-stream contact recreation, aquatic life habitat, and fishing. Water pollution has been a prominent environmental concern since the late 1960s. According to the Environmental Protection Agency, there are 16,608 km (10,320 mi) of impaired rivers and streams known in Texas.¹ Over half of these streams are impaired from non-point sources (NPSs) such as urban runoff, wildlife (avian and non-avian), grazing, irrigated cropland, mining, and others. Agricultural operations have been cited for contributing over 20% of all in-stream pollutants in Texas.¹ To help mitigate pollution, state and federal agencies have initiated total maximum daily loads (TMDLs) or watershed protection plans (WPPs) to target needed water quality best management practices (BMPs) to reduce pollutant loading. By studying and developing additional BMPs, agricultural producers and environmental conservationists may be able to more effectively mitigate water-quality degradation.

CONTAMINANT FATE MODIFICATION

Much work has been done in examining effects of livestock on riparian health and water quality.²⁻⁵ Studies have examined links between proximity of contaminant deposition and in-stream water quality. It is generally recognized that shorter distances between contaminant deposition and the waterway, the greater negative effect on water quality.⁶ In an attempt to control contaminant deposition and fate processes, structural BMPs have been implemented to modify animal behavior. Specifically, cattle travel and grazing patterns have been modified using a variety of practices, altering fecal deposition locations. In the past, researchers were limited to visual observation to collect spatial positions of grazing livestock or fecal deposits.^{7,8} With Global Positioning Systems (GPS) technology, not only can more data be collected, but it is often more accurate, and allows cattle location to be observed in the context of a herd and at all hours of the day. GPS data points taken at evenly spaced time-intervals can be used to correlate amount of time cattle spend within a given area.⁹ Fecal deposition is acknowledged to be directly correlated to time cattle spend at any given location.¹⁰

Some common BMPs used to reduce pollution from livestock grazing operations include riparian buffer strips, exclusion fencing, prescribed grazing, off-stream water sources, and rotational stocking. Despite the variety of BMPs available, there is still need for development and testing of additional, cost-effective BMPs. This is because landscapes and operations, which BMPs are intended to facilitate, are highly diverse. Producers need BMPs relevant to their operation that will not negatively impact production. For this reason, there should be an assortment of BMPs producers could select and implement appropriate for their specific situations.

One BMP that has met much resistance from cattle producers is exclusion fencing.¹¹ Exclusion fencing is the practice of fencing-off the stream and riparian zone to prevent livestock from grazing and watering within riparian zones and waterways. While it has proven very effective at keeping livestock out of riparian zones, and has been shown to reduce bacterial and nutrient loading in some cases,^{4,12} its use has been highly unpopular among stakeholders. From a ranch management perspective, it is costly,¹³ labor intensive, overly restrictive,¹⁴ and not always effective.¹⁵ While many stakeholders agree environmental stewardship is very important, opposition exists because the BMP offers little practical benefit from a ranch productivity or management standpoint.^{16,17}

Water quality BMPs providing more practical and diversified benefits from a farm/ranch management context encourage higher adoption rates.¹⁸ Since BMPs are primarily voluntary, stakeholder acceptance is critical. It is necessary to provide stakeholders with simple, cost-effective BMPs beneficial

to the agricultural operation.¹⁶ For this reason, alternative shade has been suggested as an attractive water-quality BMP both from an environmental quality and ranch management standpoint.¹⁹ Alternative shade is thought to offer water quality benefits without the drawbacks of exclusion fencing, as well as additional ranch-related benefits such as soil conservation²⁰ and improved pasture utilization.²¹ Still, relatively little is known about the effectiveness of alternative shade as a water quality BMP.

In pastureland, natural shade is often located along the riparian zone. In summer months, cattle seek shade to cool off.²² Temperature and relative humidity have been found to be two of the main driving factors for cattle's response to seeking shade.²³ Byers observed cattle spent 80% of their time in the shade while in the riparian zone.²⁴ Providing an alternative shade source outside of the riparian zone has been suggested as a potential water quality BMP for grazing-lands.²⁴⁻²⁶ However, few studies have evaluated the effectiveness of alternative shade at modifying cattle behavior; thus, this remains a BMP that should be studied to a greater extent.²⁷ Most shade studies have been primarily focused on optimizing metabolism or milk production in cattle²⁸ rather than providing water quality benefits.

One Geographical Information Systems (GIS) study testing the effectiveness of an alternative shade structure concluded it "did not decrease the amount of time cattle spent along the streambanks."²⁵ However, Agouridis and colleagues conceded the lack of treatment effects may have been due to data constraints.²⁵ Another possible reason for this may be due to shade configurations at the study site. Presence of non-riparian shade trees⁹ may confound results because the trees act as a natural BMP. For this reason, control data from this study may not have varied significantly from treatments. This may explain why alternate shade BMP results of the study²⁵ were ineffective at reducing the time cattle spent in or near the stream. This underscores the importance of proper placement of alternative shade structures as abundant natural non-riparian shade may negate the necessity and compromise the effectiveness of an alternative shade structure.

WHAT WE DID

The alternative shade BMP was evaluated at the Texas A&M AgriLife Research Center in McGregor, Texas. As shown in Figure 1, the study site was a 28.7 ha (71 ac) grazed pasture with an intermittent headwater stream of the South Bosque River flowing through it. An estimated 6% of the pasture area was vegetated with trees large enough for shade coverage. Shade was almost exclusively limited to within the riparian zone. The pasture was provided with an off-stream water trough at the southeast corner of the pasture. The pasture had been heavily stocked, and there was evidence of stream-bank erosion at sites where cattle frequently crossed the creek. We placed six to eight Lotek ® GPS 3300LR collars (Lotek Wireless Inc., Newmarket, Ontario, Canada) on randomly-selected cows (Angus-Nelore cross) and used to record their locations over three 21 to 23 day trials. Each GPS collar was calibrated to take a single locational data-point every five minutes. The creek, pasture boundaries, and the riparian zone were delineated using remote sensing.

Before beginning trials, we placed the GPS collars on cattle and then released the cattle into the study pasture. We programmed the collars to begin collecting GPS data-points on the midnight after cattle were turned into the pasture. Data points were collected at each five minute interval for the remainder of the trial. The first 10 to 12 days of each trial served as the control period in which GPS collars were initiated to monitor cattle location prior to BMP implementation (Figure 2.). Halfway through the trial, we implemented the BMP (i.e. erected the shade cloth), while the collars continued to collect data-points for another 10 to 12 days. This 'post implementation' period served as the treatment period; allowing cattle behavior to be compared between BMP treatment and control periods. We erected a 9.1 by 9.1 m (30 by 30 ft) SunBlocker™ Economy Shade Frame²⁹ with shade cloth for the alternative shade BMP. The shade structure was placed approximately 541 m (1,775 ft) from the water trough and 140 m (459 ft) away from the creek and riparian zone where other large trees could serve as potential shade locations for cattle. We conducted trials in October of 2010, May and June of 2011, and March and April of 2012 (Table 1). We analyzed the alternative shade BMP by counting the number of data-points within different buffer zones (i.e. riparian zone and shade pavilion) before and after BMP implementation. At the end of

each trial, we removed the GPS collars and downloaded the data. We plotted the GPS data-points in ArcMap and then counted the points within each buffer zone. Data-points were normalized to account for differences between total number of data-points collected before and after BMP implementation (see equations 1 and 2 in Figure 3). We calculated the percent differences between ‘Pre’ and ‘Post’ BMP periods using equation 3 (Figure 3).

WHAT WE FOUND

Trials 1, 2, and 3, as shown in Table 1, assessed the effectiveness of a shade pavilion at reducing time cattle spent in or near the creek.

Contrary to the results of Agouridis et al.²⁵, after implementing the shade pavilion, we repeatedly observed reductions in the amount of time cattle spent within the riparian zone. On average, cattle spent 30% less time within the riparian zone following implementation of an alternative shade pavilion. Percent reductions ranged from 31% to 45% (Table 2). The average of the collective trials, as calculated from Table 3, showed cattle spent 51 min d⁻¹ within 8 m of the creek prior to implementing the shade structure. Another 61 minutes/day were spent within 8 to 16 m from the creek. Following BMP implementation, the average collective minutes per day spent in the riparian zones were reduced by 10.9 and 22.4 min for the 0 to 8 m and 8 to 16 m riparian buffers respectively.

Moreover, the amount of time cattle spent at the site of the shade pavilion increased following implementation of the shade pavilion. Cattle increased the time they spent within the 0 to 8 m and 8 to 16 m pavilion buffers by 7.6 and 2 minutes/day respectively. This accounts for almost a third of the time reductions seen at the riparian zone, and provides supporting evidence that percent reductions seen at the riparian zone are due to the alternative shade structure and not some other cause. The 2 minutes/day increase in the 8 to 16 m pavilion buffer suggested cattle will graze areas surrounding the shade pavilion more, allowing more grazing to occur on previously underutilized sections of a pasture. It is likely the other half of the time reductions seen in the riparian zone were distributed across the pasture at further distances from the shade pavilion.

It must be noted that there were several limitations to this study; severe drought being the most prominent. Drought limited water within the creek, and forage quantity and quality which affected the number of trials that could be completed and timing between trials. Trials were conducted concurrently with the McGregor Agrilife Extension’s grazing rotation plan; however, stocking rate was managed individually between trials. Herd size varied and may have contributed to differences in treatment effects between trials. The low number of repetitions and low ability to install environmental controls did not lend to more in-depth statistical analysis. For this reason, the analysis was kept as simple as possible using only a percent difference equation. While the results of these trials suggest a significant reduction in the amount of time that cattle spent near the creek following implementation of a non-riparian shade structure, further statistical analysis would be needed to confirm this assertion.

On days cattle used the shade pavilion most, it was expected the time cattle spent within the riparian zone would be significantly lower. While minutes per day increases at the shade pavilion are evident across the average of the trials, interestingly, no clear trends were observed between individual days. Similarly, as temperature, relative humidity, and solar radiation increased (Tables 5 – 7.), it was expected that time cattle spent in the riparian zone would also increase. While seasonal trends were observed between trials, no significant trends were observed on a day-to-day basis within trials. While seasonal climatic differences and changes in forage type and quality are reasonable assumptions as to why cattle used the riparian zone differently between the three trials^{6,24}, it is unclear why daily trends were not observed for temperature, relative humidity, and solar radiation parameters.

On one occasion, following implementation of the shade pavilion, a 2.5% increase was observed in the time cattle spent within the 0 to 8 m riparian buffer; however, the same trial shows a 31% reduction in the 8 to 16 m riparian buffer. This abnormality may be due to a number of possible factors; however, because no water was flowing within the creek during Trials 1 and 2, increased usage during Trial 2 is not assumed to be due to cattle accessing water. It is possible that cattle sleeping in the creek bed caused the

divergence seen in Trial 2. In fact, on several occasions during Trial 2, time data corresponding with GPS location indicated several cows had spent the night within 8 m of the creek. Also plausible, higher temperatures may have caused the divergence seen in Trial 2. Trials 1 and 3 were completed in October and April respectively while Trial 2 was completed in the hotter month of May. Prior to BMP implementation, cattle spent a higher percentage of time within 0 to 16 m of the creek during Trial 2 (11.3%) compared against Trials 1 (7.7%) and 3 (4.5%). Although Trial 2 percent reductions were smaller, minute per day reductions were larger for the 8 to 16 m riparian buffer than either Trial 1 or 3. This data suggests an alternative shade pavilion may still effectively reduce the amount of time cattle spend within the riparian zone.

We assumed cattle grazing was evenly distributed across the pasture when estimating expected percentages of cattle usage. Surprisingly, cattle used the riparian zone less when water was flowing in the creek in Trial 3 from Table 4. It is difficult to interpret exactly why this occurred. Some possible suggestions are when the creek is dry, cattle will bed-down, loaf in shade, or even travel in the creek-bed. Of the time cattle spent within the creek during Trials 1 and 2, 20% of the data points were in the creek-bed beneath one small riparian thicket. From visual observations, it was obvious cattle used the area extensively, as it was easily accessible and well shaded.

More important, in Table 4, percent usage decreased at the riparian zone and increased at the shade pavilion following BMP implementation. Comparing the observed shade pavilion values against expected value reveals how drastically an alternative shade pavilion can alter cattle pasture utilization. Following implementation of the BMP in Trial 1, cattle proceeded to use the area within the 0-8 m shade pavilion buffer, an area representing 0.05% of the total pasture area, almost 1% of the total time spent within the pasture.

Byers observed cattle rested within the riparian zone between 1.4% and 4.2% between December and March, while between April and November, cattle spent anywhere from 5.3% to 8.1% of their time within the riparian zone²⁴. In our study, prior to BMP implementation, cattle spent close to 7.7% of their time within the riparian zone during October and 4.5% from late March to early April. This falls within the range found in a study conducted by Byers in Georgia. However, during May, cattle spent 11.2% of their time within 16 m of the stream. The largest percent of riparian usage found by Byers was 8.1%²⁴. The difference is likely due to the presence of abundant non-riparian shade in the Byers pasture configurations. This suggests pastures with little non-riparian shade may see increased usage of riparian shade, potentially causing more riparian and water quality degradation. Following BMP implementation at the McGregor pasture, riparian usage was reduced to 9.45% for the month of May. Although a single shade pavilion appeared to reduce cattle dependence upon riparian shade, during hotter months, the abundance of riparian shade may draw cattle into riparian zones more frequently and for longer periods. Strategic placement of multiple shade pavilions may optimize pasture utilization and further minimize cattle dependence on riparian shade. Shade pavilions capable of being disassembled and reassembled or transported may also benefit cattle and other livestock producers using an intensive rotational grazing management method.

The scope of our case study was narrow in that it focused mainly on cattle behavior modification following implementing a non-riparian shade structure. Further study should be done to expand on the data presented here, as well as include other relevant parameters such as differences in water-quality, reduced erosion rates, and forage utilization following implementing a non-riparian shade structure. Similarly, further analysis should be done to ascertain the environmental and agricultural economic costs, benefits, and longevity of non-riparian shade relative to other water-quality BMPs. Herd size and shade area per cow should be considered when shade area may limit the total number of cattle that can use the structure.

IMPLICATIONS

Cattle repeatedly spent less time near the riparian zone following implementation of the non-riparian shade structure. During warmer months, cattle relied more heavily on riparian shade. The time cattle

spent near the shade structure greatly increased, thus providing alternative shade structures could assist producers in encouraging cattle to graze underutilized pasture, and may help reduce erosion caused by excessive loafing near riparian shade. Improved water quality may be one of the greatest benefits of providing alternative shade, as providing cattle with an alternative to riparian shade increases the buffer distance between fecal deposition and the stream. This also provides producers with an alternative to total exclusion fencing which may be overly burdensome from a range-management perspective.

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FIGURE CAPTIONS

Figure 1. Aerial photo of McGregor BMP study pasture, P-6. Fence boundaries are delineated with black lines. The creek and water trough are outlined in blue. The shade pavilion is marked in orange.

Figure 2. Shade pavilion without the shade cloth. The riparian zone and cattle can be seen in the background.

Figure 3. Equations used to calculate percent difference.

Figure 1

Figure 2

Figure 3

$$\frac{\text{No.of points prior to BMP at buffer zone}}{\text{Total points prior to BMP}} = \% Pre \quad (1)$$

$$\frac{\text{No.of points post BMP at buffer zone}}{\text{Total points post BMP}} = \% Post \quad (2)$$

$$\frac{\% Post - \% Pre}{(\% Pre)} * 100 = \% Diff \quad (3)$$

Table 1. Start and end dates of GPS trials.

	Start	BMP Implemented	End
Trial 1	7-Oct-10	15-Oct-10	27-Oct-10
Trial 2	26-May-11	6-Jun-11	18-Jun-11
Trial 3	28-Mar-12	7-Apr-12	18-Apr-12

Table 2

Table 2. Percent difference calculations per trial represent the percent reduction or increase between 'Pre' and 'Post' BMP implementation within the 0 to 8 m and 8 to 16 m stream or shade pavilion buffers respectively.

	Shade Pavilion 0-8m	Shade Pavilion 8-16m	Riparian Zone 0-8m	Riparian Zone 8-16m
Trial 1	257.2	108.7	-45.1	-39.8
Trial 2	2,801.6	616.2	2.5	-31.6
Trial 3	500.0	84.6	-39.2	-43.9
Mean	1,186.2	269.8	-27.3	-38.4

Table 3. Comparison of average min d⁻¹ calculations pre and post BMP implementation per shade trial within the 0 to 8 m and 8 to 16 m stream or shade pavilion buffers respectively.

	Shade Pavilion 0-8m		Shade Pavilion 8-16m		Riparian Zone 0-8m		Riparian Zone 8-16m	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Trial 1	3.8	13.6	2.7	5.6	46.9	25.7	64.1	38.6
Trial 2	0.4	12.2	0.3	2.4	73.2	75.0	89.3	61.1
Trial 3	0.3	1.7	1.2	2.2	34.3	20.8	30.6	17.2
Mean	1.5	9.1	1.4	3.4	51.4	40.5	61.3	39.0

Table 4. Observed and expected percent usage of shade pavilion and riparian buffers per trial. Expected values were calculated by assuming cattle-grazing was normally distributed across the pasture. Expected values simply represent the area of the buffered zone as a percentage of the total pasture.

	Riparian Zone 0-8m		Riparian Zone 8-16m		Shade Pavilion 0-8m		Shade Pavilion 8-16m	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Trial 1	3.25	1.78	4.45	2.68	0.26	0.94	0.19	0.39
Trial 2	5.08	5.21	6.20	4.24	0.03	0.85	0.02	0.17
Trial 3	2.38	1.45	2.12	1.19	0.02	0.12	0.08	0.15
Mean	3.57	2.81	2.71	2.71	0.10	0.64	0.10	0.24
Expected	3.85		3.93		0.05		0.15	

Table 5

Table 5. Temperature, Relative Humidity, and Solar Radiation daily maximum and minimum values for trial 1.

Date	Temperature (°F)		Relative Humidity (%)		Solar Radiation (W/m ²)
	Max	Min	Max	Min	
7-Oct-10	81	42	93	21	896
8-Oct-10	85	45	92	19	890
9-Oct-10	85	48	87	21	879
10-Oct-10	86	49	89	24	873
11-Oct-10	85	57	98	37	778
12-Oct-10	86	63	100	46	535
13-Oct-10	84	58	100	29	843
14-Oct-10	83	56	83	37	801
15-Oct-10	77	46	78	20	859
16-Oct-10	83	40	93	15	859
17-Oct-10	84	46	84	20	850
18-Oct-10	83	54	94	40	704
19-Oct-10	85	63	97	41	785
20-Oct-10	86	60	97	39	808
21-Oct-10	86	59	98	45	599
22-Oct-10	87	58	98	41	764
23-Oct-10	85	67	99	51	403
24-Oct-10	81	62	100	70	519
25-Oct-10	86	63	100	53	509
26-Oct-10	86	65	100	52	671
27-Oct-10	79	59	91	26	781

Table 6. Temperature, Relative Humidity, and Solar Radiation daily maximum and minimum values for trial 2.

Date	Temperature (°F)		Relative Humidity (%)		Solar Radiation (W/m ²)
	Max	Min	Max	Min	
26-May-11	99	73	91	13	1162
27-May-11	87	61	72	29	1155
28-May-11	99	66	83	28	1102
29-May-11	98	73	89	33	1088
30-May-11	97	73	89	36	1101
31-May-11	95	75	86	35	907
1-Jun-11	95	74	90	37	1013
2-Jun-11	94	71	89	24	1118
3-Jun-11	97	65	82	29	1107
4-Jun-11	98	68	81	23	1125
5-Jun-11	95	67	93	27	1131
6-Jun-11	99	68	76	28	1030
7-Jun-11	100	68	87	23	1076
8-Jun-11	98	69	80	27	1065
9-Jun-11	96	72	91	33	1103
10-Jun-11	96	72	88	27	1085
11-Jun-11	96	72	91	31	1081
12-Jun-11	97	72	87	31	1104
13-Jun-11	98	72	88	27	1104
14-Jun-11	100	73	84	25	1114
15-Jun-11	101	75	85	23	1129
16-Jun-11	101	76	83	22	1098
17-Jun-11	102	75	85	26	1108
18-Jun-11	103	79	80	23	1082

Table 7. Temperature, Relative Humidity, and Solar Radiation daily maximum and minimum values for trial 3.

Date	Temperature (°F)		Relative Humidity (%)		Solar Radiation (W/m ²)
	Max	Min	Max	Min	
28-Mar-12	77	58	91	57	965
29-Mar-12	71	61	95	68	260
30-Mar-12	79	63	98	65	926
31-Mar-12	81	65	98	67	913
1-Apr-12	84	63	98	56	1021
2-Apr-12	86	66	96	52	1031
3-Apr-12	82	68	95	51	917
4-Apr-12	80	60	96	71	614
5-Apr-12	76	51	98	58	1003
6-Apr-12	80	57	95	38	1047
7-Apr-12	79	52	96	51	998
8-Apr-12	82	63	97	49	919
9-Apr-12	81	60	96	50	978
10-Apr-12	79	58	98	55	943
11-Apr-12	81	60	95	47	680
12-Apr-12	81	59	96	46	1012
13-Apr-12	80	66	93	53	780
14-Apr-12	81	63	93	59	718
15-Apr-12	81	70	87	64	579
16-Apr-12	74	56	88	42	576
17-Apr-12	72	51	93	53	641
18-Apr-12	79	50	94	29	1108