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Continuous season-long rangeland use (CSLU) by livestock has been one of the largest land uses in the western United States since the mid-1800s. Until recently, little credence has been paid to the impact of this type of land usage on riparian and aquatic habitats. Numerous grazing schemes have been implemented throughout the years in an effort to reduce the impact on these areas. One form of land management receiving attention is holistic resource management (HRM). This form of grazing is based on large numbers of animals grazing small pastures for short periods of time. This study focuses on the impact of HRM grazing on aquatic and riparian habitats in the Flint Hills of Kansas. A stream flowing from a conventionally-grazed pasture to a HRM pasture was used as the study site. A 400-meter study reach, divided into 100 1-meter transects, was established and used to evaluate the overall stream condition for both reaches. Vegetation was analyzed by placing 100 one-m^2 quadrates parallel to the stream to a distance of 1.5 meters from the water's edge and evaluating percent cover of decreasers, increasers, bare ground, and rock. The HRM study reach was divided into five blocks of 20, one-meter transects, and two endpoints of 10, one-meter transcets, to determine the ability of the stream to correct the effects of upstream management policies. The results of this study indicated that the HRM reach was in significantly better overall condition than the CSLU reach(HRM=0.536, CSLU=0.4482; P=0.0004). The vegetation study showed significantly greater cover from decreaser species of plants (HRM=12.3, CSLU=1.21; P=0.0001), and lower amounts of bare ground for the HRM site compared to the CSLU site(HRM=44.67, CSLU=37.33; P=0.0744). The results of the stream's corrective ability showed a slight difference between the two endpoints width-to-depth ratios (**a**=12, **b**=9; P=0.0899), suggesting some corrective capabilities. These results suggest HRM grazing is a better form of management of riparian zones than conventional forms.

THE IMPACT OF HOLISTIC RESOURCE MANAGEMENT AND CONTINUOUS SEASON-LONG GRAZING ON AQUATIC AND RIPARIAN HABITAT

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1: Introduction

Since the 1800s, livestock grazing has been one of the most widespread uses of land in the western two-thirds of the United States (Holechek, Pieper, and Herbel, 1995). Early grazing practices were simple and unregulated. Often large herds of livestock were left to graze an area until it was no longer grazable. Vast amounts of land were severely degraded by these practices, the impacts of which seemed to go unnoticed for years. In 1878, the effects of overgrazing were first identified as a problem in the United States (Box, 1979). Despite this, no true changes were implemented by ranchers for several years. By the 1930s, rangeland conditions had declined so drastically that government intervention was needed. Such intervention came in the form of the "Taylor Grazing Act of 1934." Congress passed this legislation as a means of regulating grazing on public lands (Platts and Nelson, 1985). This was accomplished by recognizing that unsold arid western lands were unsuited for cultivation, and the grazing on these lands must be controlled by the federal government (Holechek et al., 1995). This act alone was not enough to solve the problems of livestock overgrazing, however numerous steps have been taken since the 1930s to improve rangeland conditions, most of these actions have been directed at improving desirable and native grassland vegetation. Until recently these efforts were considered sufficient by many land managers. However, the impact of grazing on systems other than grassland systems, has begun to receive more attention.

One ecosystem that is of interest to many land users is the riparian system. A riparian ecosystem includes the stream and the surrounding vegetation. The system supplies a number of favorable resource values, including use as wildlife habitat, as a modifier of the aquatic environment and fisheries habitat, as a major factor in maintenance of the quantity and quality of water, aesthetics, and as a valuable foraging area for livestock (Kauffman, Krueger, and Vara, 1983). Because of the numerous uses for these areas, they are considered to be some of the most productive of North American habitats. However, the productivity of a riparian system is very sensitive to change. Johnson, Haight, and Simpson (1977) state riparian habitat is possibly the most sensitive of all North American habitats. This is evident because in order for a stream to achieve its values and be productive, it must be in a properlyfunctioning riparian zone. Blew, Fink, and Cornwell (1993) state such functions include stream bank stability, trapping and filtering of stream sediments, cleaning of the water, slowing of water velocities, and the recharging of groundwater aquifers. Despite the importance of these areas, until recently little research had been done on the impact of livestock grazing on them.

In the evaluation of riparian systems, the condition of the stream and the surrounding vegetation are the two areas of primary interest. Stream conditions are ustally evaluated on what is most beneficial for fish populations. It has been shown that fish populations vary significantly with the quality of a stream's morphological characteristics. Myers and Swanson (1995) state various measures of cover (Kozel and Hubert, 1989), bank stability (Binns and Eisermann, 1979), riparian vegetation (Wesche, Goertler, and Hubert, 1987), and stream channel cross sections (Kozel and Hubert, 1989) changes have all been shown to influence fish populations. Because of the impact of these parameters on fish populations, they are frequently the ones that are evaluated.

Heavy livestock use, especially by cattle, has been directly tied to many of the poor conditions found in riparian systems. Range managers recognize that grazing practices have a negative impact on the aquatic zone (Myers and Swanson 1995; Platts 1991). It is well known that cattle spend a disproportionate amount of time in the riparian zone, which can lead to overuse of these areas. Riparian areas are often some of the earliest-and most frequently-grazed areas within a pasture. It is not unusual to see cattle lingering in these areas for prolonged periods of time. This ability to attract and hold cattle is believed to be linked to the availability of water, shade, thermal cover, and the quality and variety of forage (Kauffman and Krueger, 1984). The grazing of these areas appears to have a strong impact on the quality of the surface waters within that zone. The quality of a stream is directly related to the condition of the stream bank. Grazing riparian zones can affect the morphology of a stream bank in two ways; directly through trampling damage, or indirectly through destruction of stabilizing vegetation (Williamson, Smith, and Quinn, 1992).

Trampling damage along stream banks plays a major role in the degradation of the riparian zone. This degradation is caused by constant walking and standing by large livestock along stream margins. The grazing of these stream margins can cause a decrease in bank stability, and can cause an increase in bank erosion and fine sediment inputs (Williamson et al., 1992). One of the best signs of stable, non-erosional stream banks is the presence of overhanging banks. The collapsing of such banks is often used as an indicator of actively-eroding banks and this is believed to be accelerated by animals walking along the stream banks (Williamson et al., 1992). This alteration of the stream banks can lead to a total change in the shape and form of the stream. The increase of sediment and the collapsing of the banks give a stream a wider and shallower shape.

The impact of cattle can also be evident by the condition of the vegetation within the riparian zone. Vegetation is a major factor in the stabilization of soils. However, riparian vegetation tends to be a higher quality and variety of forage for livestock (Kauffman and Krueger, 1984). Because of this, riparian vegetation appears to be used at a greater degree than surrounding vegetation. A study by Platts and Nelson (1985), found that stream-side forage received approximately 8% greater use then an adjacent range, and about 12% greater utilization than a coinciding pasture's forage. When large amounts of vegetation are lost, this can be detrimental to the quality of the stream. Loss of stabilizing vegetation can increase soil erosion and can lead to significant channel widening (Williamson et al., 1992). Therefnre, in order for stream banks to be stable, dense well-rooted vegetation is needed.

The major management scheme employed by land managers, in the Flint Hills region of Kansas, is continuous-season-long use (CSLU) or also called conventional grazing. This form of grazing has been the predominant form of management of livestock since the development of barbed wire. Season-long grazing consists of grazing a particular pasture for an entire grazing season with no organized or planned movement of the livestock. In the Flint Hills of Kansas, this annual grazing season begins on April 15 and concludes on October 15. Because of the success of this grazing scheme, it is considered the standard by which to compare other grazing regimes for forage production and livestock weight gains per animal. However, the main problem with CSLU is that this form of grazing requires the sacrifice of some areas of a pasture. Usually the hardest hit of these sacrificed areas is the riparian zone. This form of grazing is the most damaging to stream-side areas (Gunderson, 1968). Platts and Nelson (1989) found that riparian vegetation use is very high and that the potential for stream-side rehabilitation is very poor for this type of grazing. Because of the impact of conventional grazing on riparian systems, this grazing regime is considered unsatisfactory by many people.

Recent evaluations of grazed riparian zones have shown some startling conditions. In the 11 contiguous western states, the United States federal government owns approximately 316 million acres of land, representing 48% of the total acreage(Armour, Duff, and Elmore, 1991). These public lands are controlled primarily by the United States Forest Service and the Bureau of Land Management (BLM). These agencies are responsible for the management of this land. On the 316 million acres of public land, domestic livestock grazing is permitted on 150 million acres administered by the Bureau of Land Management, and an additional 138 million acres by the Forest Service (Armour et al., 1991). Therefore, approximately 41% of all of the land in the western United States is used for livestock grazing. Within the network of publicly-grazed lands, there is a large amount of riparian habitat. It is estimated the BLM administers approximately 217,254 hectares of riparian habitat, of which 181,088 hectares, or 83%, includes 19,000 miles of sport fishing streams that were in unsatisfactory condition (Platts and Nelson, 1985; Armour et al., 1991). There is also a problem with the riparian zones on much of the land run by the Forest Service. Approximately 9.3 million hectares of riparian and wetlands managed by the Forest Service are in need of attention (Platts and Nelson, 1985). In many cases, these poor conditions are a result of land management practices, including local overgrazing. However, extensive studies have shown that not all grazing regimes damage riparian zones. Platts and Rinne (1985) state a well designed regime can allow for damaged streams to recover; therefore, the act of grazing itself does not necessarily damage stream banks.

Throughout the rest of the world, numerous grazing schemes have been developed and are now being applied as an alternative to conventional season-long grazing in the United States. Most of the grazing schemes that have been implemented are designed to help reduce stress on the overall rangeland and improve livestock production. The main objective of these schemes is to raise desirable forage yields; whatever riparian benefits occur are considered a bonus. However, with increasing attention being paid to the health of riparian zones, the neglect of these areas is becoming unacceptable. Because of this, it is necessary to design a grazing technique that allows for high livestock yields without degrading the aquatic and riparian habitats. Some grazing methods that might provide rehabilitation of riparian zones are deferred-rotation grazing, rest-rotation grazing, complete livestock exclusion, and holistic resource management (Holechek et al., 1995).

Deferred-rotation grazing is a management scheme that has been employed by some land managers on cattle ranches. This system involves dividing a range into two pastures, each pasture receiving deferred grazing every other year (Holechek et al., 1995). This form of grazing has produced various vegetation responses. These responses range from no increase in vegetation of shortgrass rangelands (Hart, Samuel, Test, and Smith, 1988), to some increase in vegetative yields in tallgrass prairie ranges (Owensby, Smith, and Anderson, 1973). However, individual cattle weight gains are reduced compared to conventional forms of grazing (Owensby _et_ _al_., 1973). This scheme had a fair to good impact on riparian rehabilitation, but cattld use of these areas was still moderate to heavy (Platts, 1991). Because of the reduction of weight gains and the marginal impact on riparian zones, many consider this form of grazing an unacceptable alternative.

Another regime employed by some range managers is rest-rotation grazing. Developed by Gus Hormay in the 1950s and 1960s, this system dictates that one pasture receives 12 months of non-use while the other pasture receives all of the grazing (Holechek _et_ _al_., 1995). The vegetative benefits of this form of grazing is primarily on mountain rangeland (Ratliff and Reppert, 1974), and on cow calf operations were gains are not as important. Rest-rotation grazing weight gains are consistent with conventional schemes with low stocking rates (Holecheck, Berry, and Vavra, 1987). This form of grazing shows fair to good riparian rehabilitation potential; however, riparian use is still heavy to moderate (Platts and Nelson, 1989; Holecheck _et_ _al_., 1995). The main problem with rest-rotation grazing is the stocking rates. The moderate stocking rates required for this regime to be effective, makes economic gains more difficult for many smaller ranching operations. This system is also considered to be not as effective for rangeland other than mountain ranges; this greatly limits the amount of acreage this scheme should be used on.

Cattle exclosure by fencing is another management scheme that has been used. This form of management is very effective when it comes to improving vegetation and/or riparian health (Claire and Storch, 1983). However, fencing is not always a viable option. For many small ranchers, the total loss of use of riparian areas can drastically reduce [illegible] cattle, there

reducing possible income, or force the rancher to overstock the remaining pastureland. The cost of fencing these areas is often very expensive. Not only must the manager pay for fencing, but alternative water development is also often needed. The economics of this form of riparian management often makes it impractical for ranchers.

The one land management scheme that has received the least amount of research is holistic resource management

(HRM) or sometimes referred to as time controlled grazing. Holistic resource management is a grazing scheme developed by Allan Savory, based on the work of Vosin, in the 1960s and later introduced in the United States By Goodloe in 1969 (Holecheck et al., 1995). This grazing system consists of the practice of heavy stocking and frequent movement according to the growth cycle of certain plants. Savory's theory is to reproduce the effects of great herds of grazing animals that once roamed the open range. Savory feels that this "herd effect" churns the soil, tramples the ground litter, increases soil porosity, and encourages the establishment of seedlings (Walter, 1984). With the establishment of more seedlings, soil erosion should be diminished, leading to a healthier riparian zone. Savory focuses on the range as an entire ecosystem, and uses several tools to manage the ecosystem. Those tools, according to Savory (1988), are (1) money and labor, (2) human creativity, (3) fire, (4) rest, (5) grazing, (6) animal impact, (7) living organisms, and (8) technology. Much of the research that has been done on this system has been short-term and has focused primarily on plant growth rates, forage quality, and livestock production. Short-term research, as stated by Holecheck et al. (1995), indicated that HRM grazing accelerated plant growth (Heitschmidt, Price, Gordon, and Frasure, 1982a), improved the quality of the forage (Heitschmidt, Gordon, and Bluntzer, 1982b), and increased the production of livestock per unit area of land (HeitschmidtFrasure, Price, and Rittenhowe, 1982c). The impact of this grazing system on the riparian zone has been researched less. However, it is felt lowland areas, or areas that receive plenty of moisture, will respond favorably to this form of management (Holechek et al., 1995; Platts and Nelson, 1989). The knowledge obtained so far about this regime suggests it could be a viable form of grazing for all sizes of ranches. By using higher than usual stocking rates, 20 to 30% (Daugherty, Britton, and Turner, 1982), smaller ranchers are able to generate higher revenues with less land. This system of land management is still somewhat controversial among land managers in the United States. However, it is becoming more common since its acceptance by the Soil Conservation Service, Forest Service, United States Fish and Wildlife Service, and Bureau of Land Management.

Based on the theories of Allan Savory's HRM grazing I hypothesize that: (1) The stream characteristics of bank stability, stream shading, overhanging bank vegetation, amount of undercut banks, and the stream channel cross section will be significantly greater for a HRM managed streams than those measured on a continuous season-long grazed stream; (2) The overall condition for a stream under HRM will be significantly better than a stream under continuous season-long grazing; (3) There will be significantly more desirable vegetation and less bare ground in the riparian zone of a HRM system than a conventionally-grazed system; and (4) That the rehabilitation potential will be greater for a HRM managed stream compared to a conventionally-managed stream.

2: Study Site

In the Flint Hills of Kansas, there are few land managers that practice HRM grazing, and few grazing areas are of large enough area to encompass one or more streams that cross both HRM and CSLU grazed watersheds. One area that does meet these conditions is the DeVore ranch located near Cassody, Kansas, approximately 34 miles south of Emporia, Kansas. A stream was chosen that flows from a CSLU managed watershed, under a five-wire boundary fence, and into a HRM managed watershed. A stream flowing from a CSLU pasture to a HRM pasture allowed for determination of the rehabilitation potential of HRM grazing. The same stream was also used to ensure that similar basin conditions existed for both reaches of the stream. Similar basin conditions are important because geology, soils, water, and vegetation can influence channel shape and stream conditions (Modde, Ford, and Parsons, 1991; Blew _et_ _al_., 1993). We also assumed that similar natural starting conditions existed prior to implementing HRM management (Steve McEwen, personal correspondence). Having similar starting conditions and basin properties would allow for detection of any changes in aquatic habitat or riparian vegetation that resulted from different watershed management regimes (Myers and Swanson, 1995).

The vegetative composition in both pastures is representative of a typical tallgrass prairie. The four grass species that typify a tallgrass prairie are little bluestem (_Andropogon_ _scoparius_), big bluestem (_Andropogon_ _gerardii_), indiangrass (_Sorghastrum_ _nutans_), and switchgrass

(*Panicum virgaturm*). Some common forbs of this area are lead plants (*Amorpha* spp.), wild indigos (*Baptisia* spp.), and buckbrush (*Symphoricarpos orbiculatus*). Elms (*Ulmus*), roses (*Rosa*), cottonwoods (*Populus*), oak (*Quercus*), and willow (*Salix*) are all common among riparian areas in this area.

The HRM-managed watershed has been grazed under this scheme for five years prior to the evaluation. Before the employment of HRM grazing, this rangeland was managed under a continuous season-long use system. Under HRM grazing this paddock was allowed to be grazed by cattle usually twice annually, for periods of 3-4 days, depending upon the current growing conditions and utilization of key species within the paddock. The conventionally-grazed watershed has been grazed under this regime exclusively. Grazing on this pasture starts on April 15 and lasts until the cattle are removed by October 15. This grazing period usually coincides with the annual growing season for tallgrass prairies in this region. The variation in grazing management between the two pastures allowed for a comparison of a stream running through a CSLT managed pasture and into a pasture managed under HRM for 5 years.

3: Methods

In the evaluation process of riparian zones, numerous methods can be employed. When evaluating an entire zone, it is best to evaluate the conditions by two separate methods, one for the stream and stream banks and one for the riparian vegetation within the zone.

One of the most frequently-employed tools for evaluating the condition of a stream is a habitat suitability index (HSI). HSIs rate the suitability of a habitat by measuring several parameters and comparing them to an optimum. There are numerous HSIs for the evaluation of aquatic habitats, most based on different parameters. The evaluation of these habitats is usually done with fisheries production in mind. Most HSIs for fisheries are designed to analyze favorable conditions for salmonid populations; however, many of the conditions that indicate a healthy stream for salmonid production are favorable for multiple stream uses. The key to finding a suitable HSI for a particular study site is finding one that matches the characteristics of the area being researched. A HSI described by Blew et al. (1993) was used to evaluate the stream in this study. This HSI is a combination of two HSIs found in the "Cowfish" model (Lloyd, 1986), as stated by Blew et al. (1993) and the "Cold Water Stream Appraisal Guide for Wyoming" as discussed in Blew et al. (1993). This aquatic habitat evaluation is most effective with streams that contain the following characteristics: (1) width of 6.10 meters or less, (2) grass/forb/shrub riparian communities, and (3) streams without rocky stream banks (Blew et al., 1993). The decision to use this HSI was because it was designed for the type of stream that is being evaluated in this study. This HSI is determined by combining five parameter suitability indices (PSI) into a single HSI. The parameter suitability indices addressed by Blew et al. (1993) are percent overhanging banks, percent stream shading, percent vegetative overhang, stream bank stability, and stream width-to-depth ratio.

Blew et al. (1993) defines an overhanging bank as a stream bank overhanging at least one foot out and within one foot of the surface of the water (Figure 1). The percent overhanging banks was determined by taking the distance of stream bank that is overhanging and dividing it by the length of the stream bank being evaluated. This percent was then used to determine a correspponding PSI value for ercentage of overhanging banks using Table 1.

Figure 1: Typical cross-section of overhanging banks.

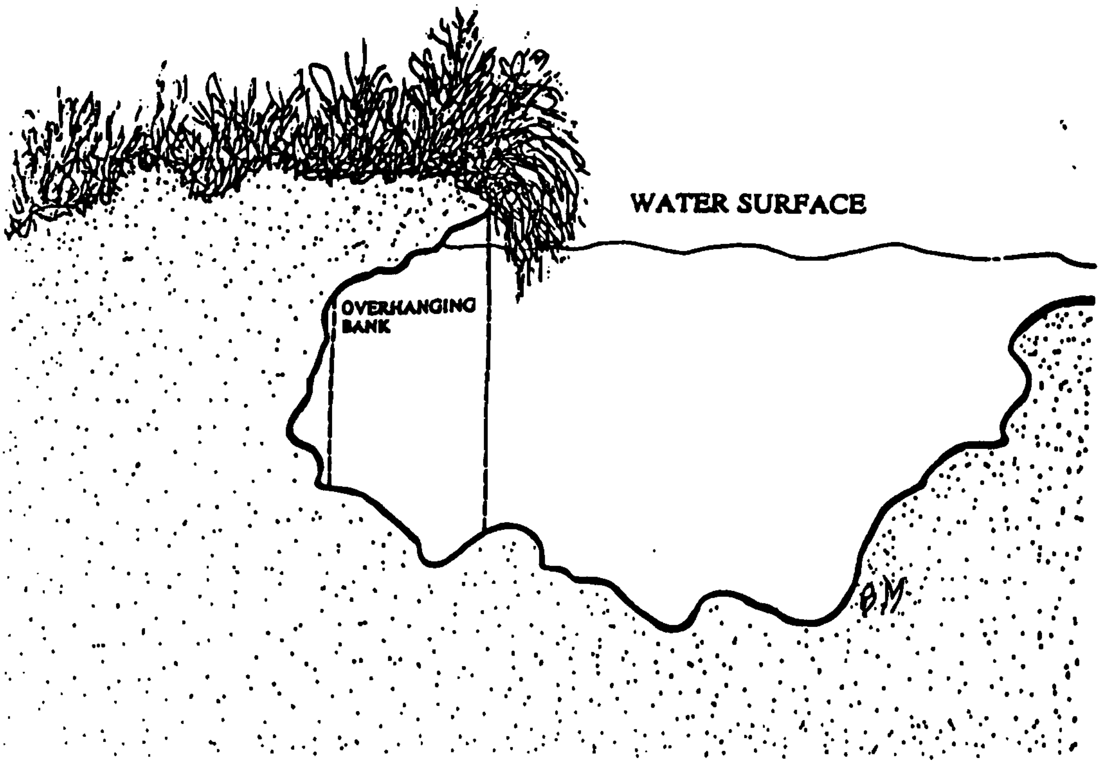

WATER SURFACE
OVERHANGING BANK
BM

Table 1: Relationship between overhanging banks and the parameter suitability index rating.

Percent Overhanging Banks	PSI
85	1.0
75	0.9
60	0.8
50	0.7
45	0.6
40	0.5
35	0.4
30	0.3
25	0.2
10	0.1
0	0.0

(Blew *et al.*, 1993)

The stream parameter, percent stream shading, is the percentage of the stream shaded at solar noon by all herbaceous and woody vegetation within the study reach (Blew et al., 1993). This percentage was determined by a visual estimation of the percentage of the study reach being shaded. This percentage was then used to determine the appropriate PSI for the percentage of the stream shaded using Table 2.

Vegetative overhang is defined as either grasses, forbs, or trees and shrubs that are within one foot of the water's surface (Blew et al., 1993). The percentage of vegetation overhang was calculated by measuring the length of the bank with overhanging vegetation, and dividing by the total length of the stream bank being evaluated. This percentage was then compared to Table 3 to obtain a PSI for the percentage of banks containing vegetation overhanging the water.

Stable stream banks are banks that show no evidence of recent erosion, deposition from the upper banks, or easily-removed soil as a result of dense, well-rooted vegetative cover or a cobble mantle (Myers and Swanson, 1995). The percentage of stable stream banks was determined

Table 2: Relationship between stream shading and the parameter suitability index rating.

Percent Shading	PSI
0	0.3
10	0.4
20	0.5
30	0.7
40	0.9
50-75	1.0
85	0.8
100	0.4

(Blew *et al.*, 1993)

Table 3: Relationship between vegetation overhang and the parameter suitability index rating.

Percent Vegetative Overhang	PSI
100	1.0
75	0.9
55	0.8
45	0.7
40	0.6
35	0.5
25	0.4
20	0.3
10	0.2
5	0.1
0	0.0

(Blew _et_ _al_., 1993)

by measuring the length of the stream bank that was stable and dividing by the total length of the stream bank being measured. Table 4 is then used to determine a PSI value for the percentage of stable stream banks.

The stream parameter, width-to-depth ratio, is defined as the bankfull width divided by the bankfull depth; this is used as an indicator of stream channel cross-sectional shape (Blew et al., 1993). This ratio is determined by dividing the width of the stream by the average depth of the stream at each transect point. This number is then compared to Table 5 to determine a corresponding PSI value for the water width-to-depth ratio.

The overall habitat suitability index for the stream is an index of relative riparian and stream health (Blew et al., 1993). The HSI was calculated by dividing the sum of all PSI and dividing by five. This Figure is then compared to Table 6 to determine at what percentage of the optimum this habitat is functioning.

There are numerous methods for analyzing vegetation within a riparian zone. The method used in this study is the percent vegetative cover as described by (Ludwig and Reynolds, 1988). Vegetation was categorized in one of two

Table 4: Relationship between the percentage of stable banks and the parameter suitability index rating.

Stability Rating	PSI
90-100	1.0
85-90	0.9
80-85	0.8
75-80	0.7
70-75	0.6
65-70	0.5
60-65	0.4
55-60	0.3
50-55	0.2
<50	0.0

(Blew et al., 1993)

Table 5: Relationship of width-to-depth ratio to the parameter suitability index rating.

Width-to-Depth Ratio	PSI
<5	1.0
12-6	0.9
13-18	0.8
19	0.7
20	0.6
21	0.5
23	0.4
25	0.3
26	0.2
<26	0.1

(Blew *et al.*, 1993)

Table 6: Mean parameter suitability index as it relates to the percent of optimum habitat suitability.

Mean PSI	Habitat Suitability (percent)	
1.0	100	Excellent
0.9	90	
0.8	80	Good
0.7	70	
0.6	60	Fair
0.5	50	
0.4	40	
0.3	30	
0.2	20	
0.1	10	
0.0	0	Poor

(Blew *et al*., 1993)

groups, either as a decreaser (Table 7), a plant that decreases with heavy grazing, or as an increaser, a plant that increases with heavy grazing (Wilk, 1984). Visual estimates of percent cover of each vegetation type, bare ground, and rock were made for 1-m^2 quadrates. These data are used to give a picture of the composition of the riparian zone for both study reaches.

The analysis of rehabilitation potential was determined by analyzing the stream condition for a series of five blocks, or group of transects, along the HRM study reach. The five blocks were labeled in succession with block **A** being closest to the CSLU pasture and block **E** being furthest downstream from the CSLU pasture. Each block consisted of 20, 1-meter transects in succession along the study reach. The water width-to-depth ratio and overall habitat suitability index were measured for each of the 20 transects in each block. Two endpoints were also evaluated by their width-to-depth ratio to determine if the stream is better the farther one goes from the CSLU grazed pasture. The two endpoints consisted of 10 transects at the beginning and the end of the HRM study reach. The endpoint closest to the

Table 7: Partial list of desirable plant species.

Scientific Name	Common Name
Andropogon gerardii	Big bluestem
Panicum virgatum	Switchgrass
Andropogon scoparius	Little bluestem
Sorghastrum nutans	Indiangrass
Tripsacum dactyloides	Eastern gamagrass
Koeleria cristata	June grass
Spartina pectinata	Prairie cordgrass
Amorpha canescens	Lead plant
Desmanthus illinoiensis	Illinois bundleflower
Petalostemum spp.	Prairie clovers
Salix spp.	Willow
Bouteloua curtipendula	Side-oats grama

(Based on Wilk, 1984)

CSLU pasture was labeled endpoint **A**, while the final ten transects were labeled endpoint **B**. These data were used to determine whether the stream is possibly correcting the problems caused by the CSLU pasture.

Data for this study were collected on two 400-meter stretches of stream. One study reach was on the holistic resource management grazed pasture; the second study reach was located on a continuous season-long-use grazed pasture. Each study reach was divided into 100, 1-meter transects spaced at 3-meter intervals, as done by Platts and Nelson (1985). Each 1-meter transect was evaluated on the five parameters used in the habitat suitability index and were given an overall condition rating as described by Blew et al. (1993). The vegetation studies were conducted along each of the transect lines by placing meter^2 quadrates to 1.5 meters out on the bank as done by Platts and Nelson (1985).

4: Statistical Analysis

Statistical analysis of the differences between HRM grazing and CSLU grazing for the individual parameters and overall stream condition were done with a simple T-test. The five blocks used to determine the treatment's rehabilitation potential were analyzed statistically using a simple one-way analysis of variance and a Duncan's multiple range test to detect differences among the five blocks. Analysis of the two endpoints was done by a simple T-test. Vegetation data were analyzed by a simple T-test between HRM and CSLU vegetative cover. All statistical evaluation was done with an alpha level of 0.05.

5: Results

The stream parameters of stream bank stability, percent overhanging banks, and percent vegetative overhang all showed no significant difference between the two treatments. However, percent stream shading and width-to-depth ratio did vary significantly between treatments (Table 8). The stream reach under HRM grazing had a mean percent stream shading of 46%, whereas the percent stream shading on the CSLU reach was only 10%. The lack of woody vegetation on the CSLU reach was the major reason the shading was so low. The width-to-depth ratio for the HRM grazed reach was 13.63, and the CSLU rating was 16.25. These data illustrate that the HRM reach is narrower and deeper than the CSLU study reach.

The overall habitat suitability index for the two streams was significantly different between treatments.

Table 8: Percentages of overhanging banks (POB), stream shading (PSS), vegetative overhang (PVO), stream bank stability (SSR), width-to-depth ratio (WDR), and the overall habitat suitability index (HSI) for the HRM and CSLU study reaches.

	POB	PSS	PVO	SSR	WDR
CSLU	2.51	9.28	44.72	61.57	16.26
HRM	5.07	46.07	50.96	57.99	13.63
P> ITI	0.2320	0.0001	0.2131	0.4598	0.0500

The mean HSI for the HRM grazed reach was 0.54, and 0.45 was the mean rating for the CSLU managed reach. These results indicate that the portion of the stream receiving HRM was operating at 54% of its optimum and the CSLU study reach was at 45% of its optimum. Therefore, the HRM reach is in better overall condition than the CSLU study reach.

No significant difference existed between the percent cover of increasers and rock for both grazing treatments; however, the difference in percent cover of decreasers was strongly significant and the percentage of bare ground was slightly different (P=0.0744)(Table 9). The mean percent cover of decreasers on the HRM site was 12.3% and the percent on the CSLU site was 1.21%. The mean percent bare ground was only slightly different with the HRM site mean of 37.33% and the mean on the CSLU site of 45.67%. These results suggest that more desirables are found in the riparian zone of the HRM site than on the CSLU site, and that more bare ground is present in the riparian zone of the CSLU reach than on the HRM site.

The stream's rehabilitation potential was not strongly supported by the data (Table 10). Analysis of the five blocks showed a slight difference between blocks **A** and **B**

Table 9: Percent cover of decreasers, increasers, bare ground, and rock on the HRM and CSLU study sites.

	Decreasers	Increasers	Rock	Bare ground
CSLU	1.21	51.13	2.89	37.33
HRM	12.3	46.69	3.78	44.67
P>|T|	0.0001	0.2947	0.6259	0.0744

Table 10: Width-to-depth (WDR) values for the five blocks on the HRM study reach. Blocks sharing the same numbers are not significantly different from each other.

	Blocks				
	A	B	C	D	E
WDR	16.18	16.72	11.14	10.16	13.95
	A	A	AB	B	AB

P=0.0633

combined from block **D**. Some slight differences were found in the width-to-depth ratios for the two endpoints. Endpoint **a** had a mean width-to-depth ratio of 12, whereas endpoint **b** a value of 9. These data suggest that the stream might get narrower and deeper the farther one goes downstream from the CSLU pasture.

6: Discussion

The study reach under holistic resource management improved substantially after five years. Four of the five measured stream parameters were better on the HRM site than on the CSLU site, although not all were significant. Although all were not significant, the percentage of overhanging banks improved slightly from 2.51% to 5.07% (P=0.2320) (Figure 2), and the percent vegetative overhang also decreased slightly from 44.7% to 50.9% (P=0.2131) (Figure 3).

Overhanging banks are important because they provide a form of shelter for fish along with some cooling of water temperatures under the overhang. Myers and Swanson (1995) and Williamson _et al_. (1992) state that cattle often cause the weakening and collapse of stream bank undercuts and have

Figure 2: Mean percentage of overhanging banks for the HRM and CSLU study sites.

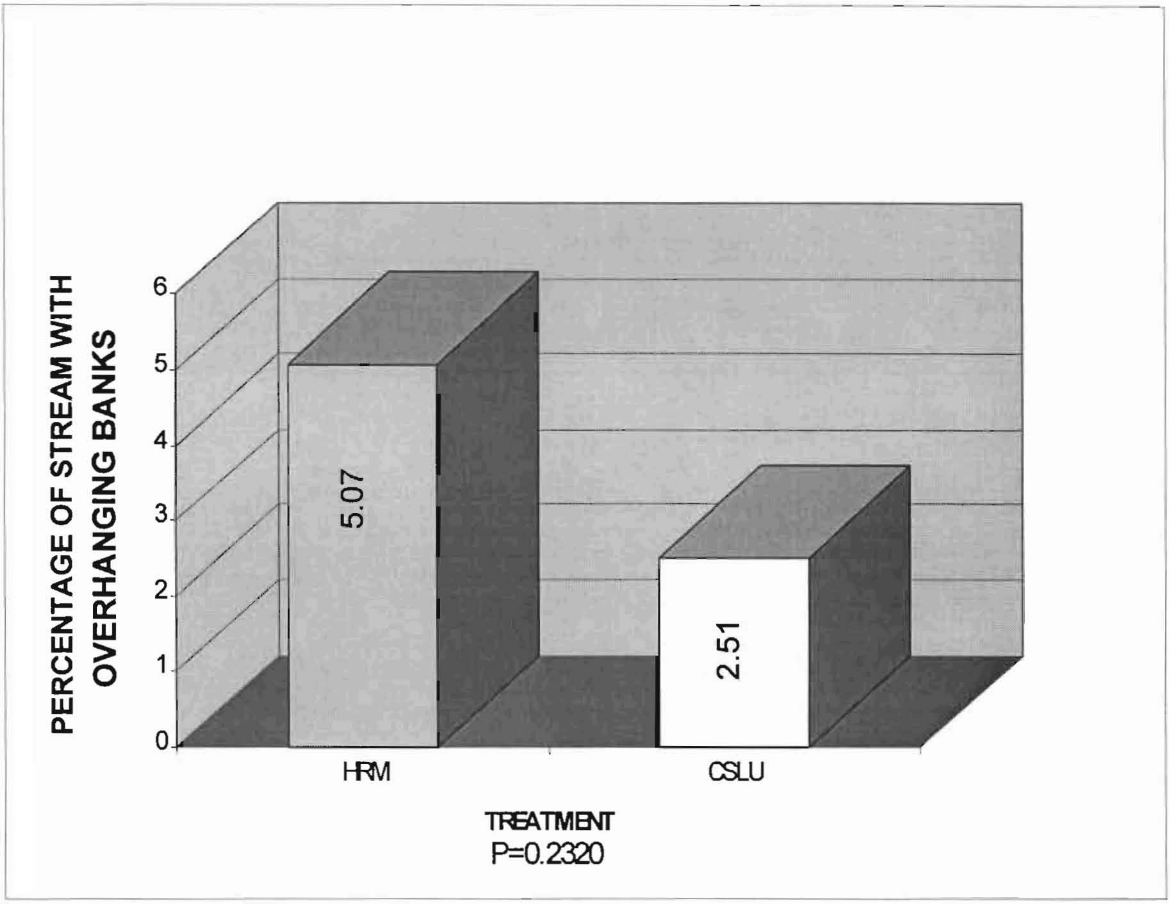
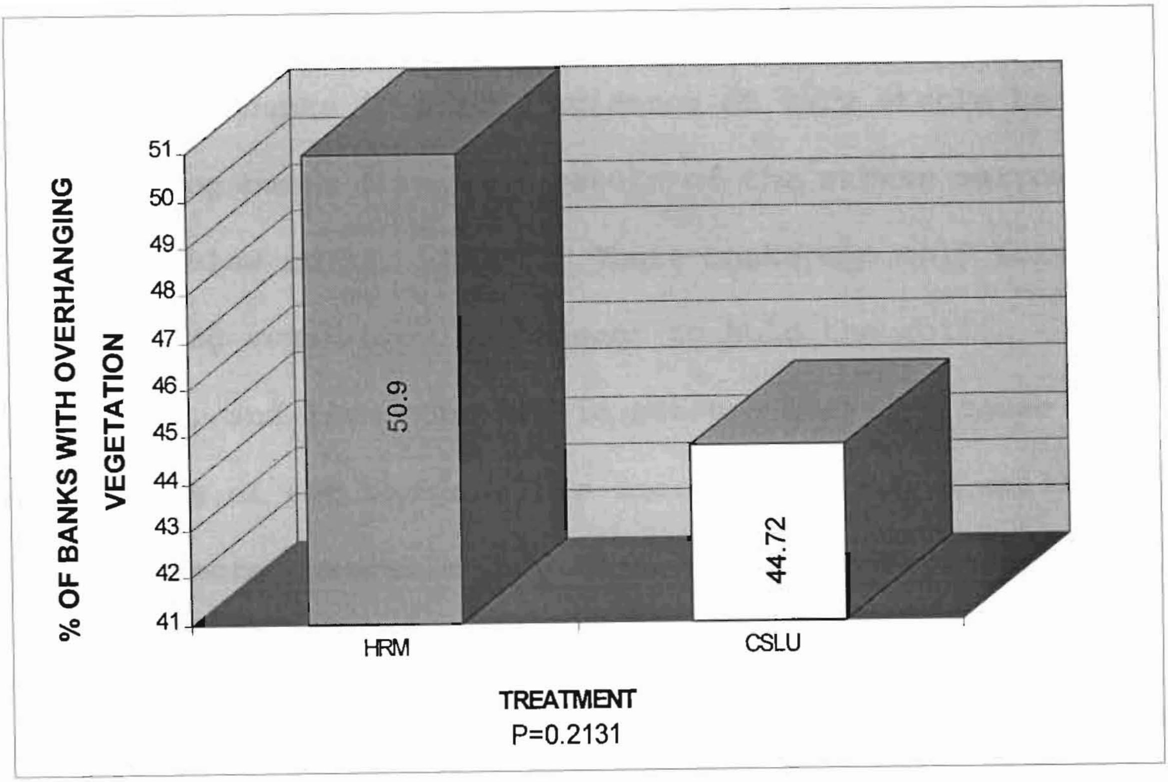

PERCENTAGE OF STREAM WITH OVERHANGING BANKS
6
5
4
3
2
1
0
5.07
2.51
HRM
CSLU
TREATMENT
P=0.2320

Figure 3: Mean percentage of banks with overhanging vegetation for the HRM and CSLU study sites.

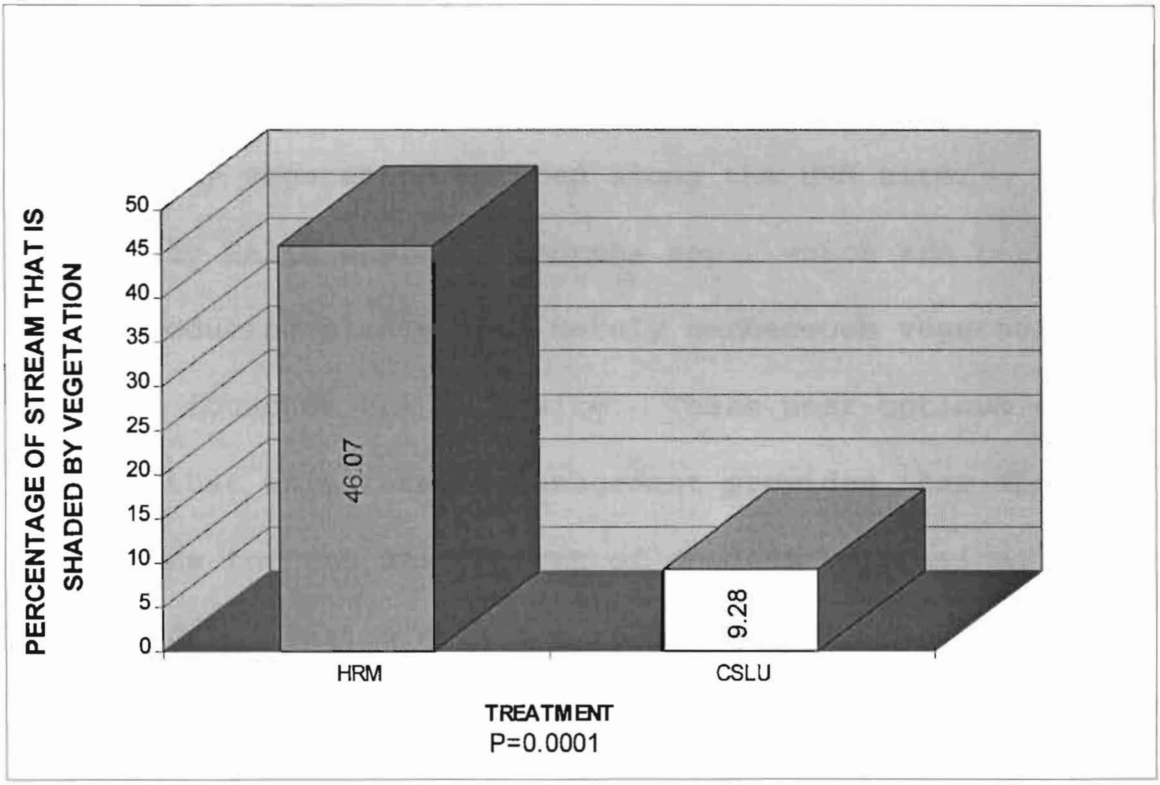

% OF BANKS WITH OVERHANGING VEGETATION
51
50
49
48
47
46
45
44
43
42
41
50.9
44.72
HRM
CSLU
TREATMENT
P=0.2131

a negative impact upon fish populations. The presence of overhanging banks is strong evidence of very stable banks. Overhanging banks form as a result of the stream narrowing process (Blew et al., 1993). These banks can only form when stabilizing vegetation is present to hold the soil particles, and livestock use is not too heavy to cause collapsing of the banks. This increase, although small, suggests more favorable conditions supplied by the HRM scheme for the development of overhanging banks.

Vegetative overhang provides cover for fish and reduces the amount of solar input into the stream (Blew et al., 1993). Stream-side vegetation also aids in the narrowing and deepening of streams. Water-loving vegetation encroaches into the stream channel, and in turn, slowly causes narrowing and deepening of the stream channel. Loss of stabilizing vegetation can increase surface soil erosion, and significant channel widening could occur; this loss can also retard the rehabilitation of previously-altered banks (Williamson et al., 1992; Platts and Nelson, 1985). The lingering habits of cattle in the riparian zone tend to strongly impact this variable. The greater percentage of overhanging vegetation found on the HRM site suggests that this form of grazing is more likely to promote stream-side vegetation growth. This increase could be caused by the smaller size of the paddocks, which places more forage within the herd's home range, and thereby encourages more balanced use of forage (Platts and Nelson, 1985).

Stream shading is important in the regulation of water temperatures. Stream shading becomes important when the temperature of the water becomes a limiting factor (Blew *et al*., 1993). When vegetation is removed, summer water temperatures can rise above 65°F, which is intolerable for many fish for prolonged periods of time (Armour *et al*., 1991). Platts and Nelson (1985), Myers and Swanson (1995) and Williamson *et al*. (1992) have all found that cattle tend to favor grazing along the riparian zone, and therefore have a strong negative impact on the shading of the stream. The percentage of the stream being shaded on the HRM reach was 46.0% while only 9.2% of the CSLU site was shaded ($P=0.0001$)(Figure 4). The optimum level of stream shading is between 50 and 75% (Blew *et al*., 1993). Using this value, the HRM reach is shaded just under the optimum level, and the CSLU is considerably less. The higher levels of shading can be explained by two characteristics of this

Figure 4: Mean percentage of the stream reach shaded by vegetation at solar noon for the HRM and CSLU study sites.

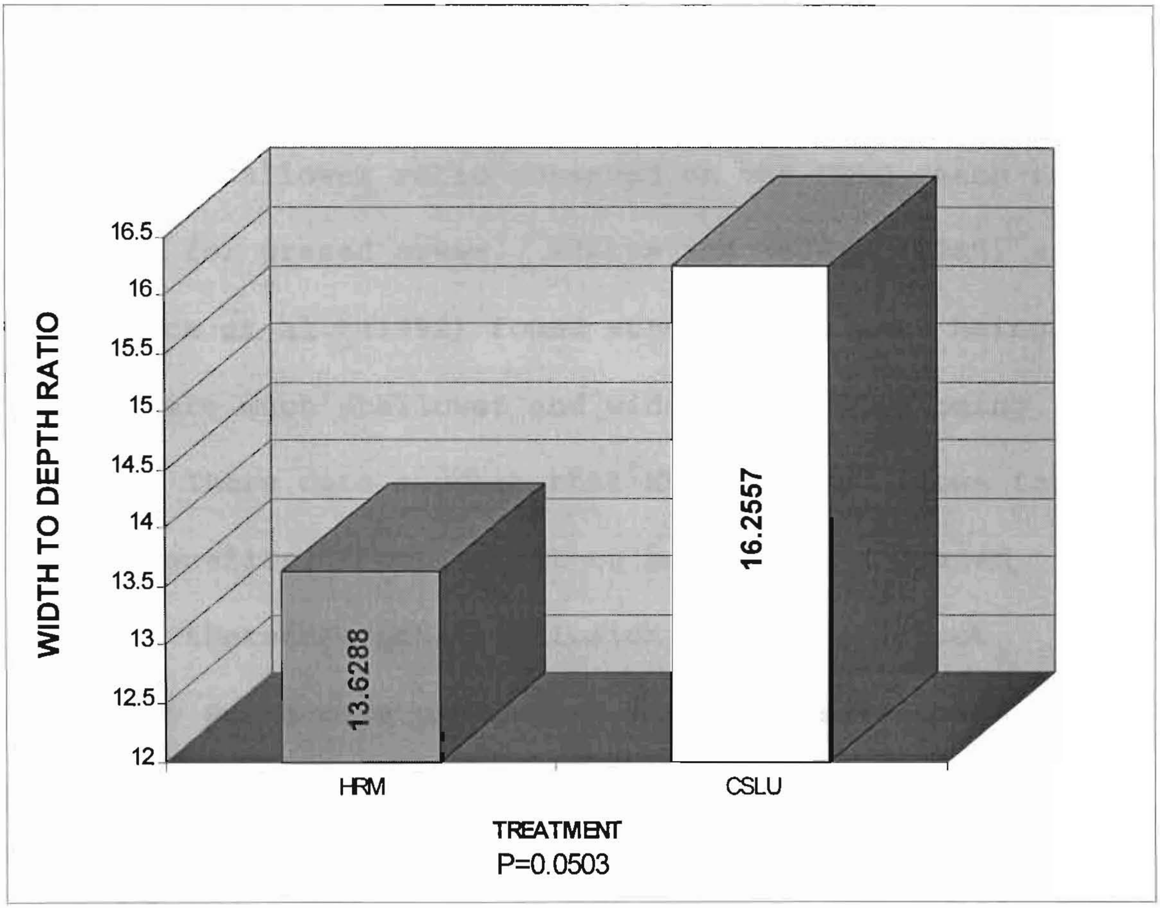


PERCENTAGE OF STREAM THAT IS SHADED BY VEGETATION
50
45
40
35
30
25
20
15
10
5
0
46.07
9.28
HRM
CSLU
TREATMENT
P=0.0001

zone: (1) the narrower width of this reach allowed for more area to be shaded by less vegetation; (2) more trees and other woody vegetation existed along the HRM site, especially Salix spp. and Amorpha spp., which are better shade-producing plants than merely herbaceous vegetation that was found on the CSLU site. These near-optimum values suggest that this form of management provides near-optimum conditions for the development of shading vegetation, whereas CSLU grazing does not as effectively facilitate vegetation growth for shading. These results show that cessation of grazing in riparian areas is not the only way to promote stream shading, but improved management can accomplish the same thing.

Stream width-to-depth ratios give us a general idea of the cross-sectional shape of the stream, along with the stream's ability to improve its banks by rebuilding (Blew et al., 1993). The stream-bank rebuilding process is important in the development of overhanging banks and the overall narrowing of the stream. The HRM reach had a ratio of 13.628 compared to 16.255 for the CSLU study reach (P=0.0503)(Figure 5). The smaller value for the HRM reach indicates a narrower and deeper stream than on the CSLU site.

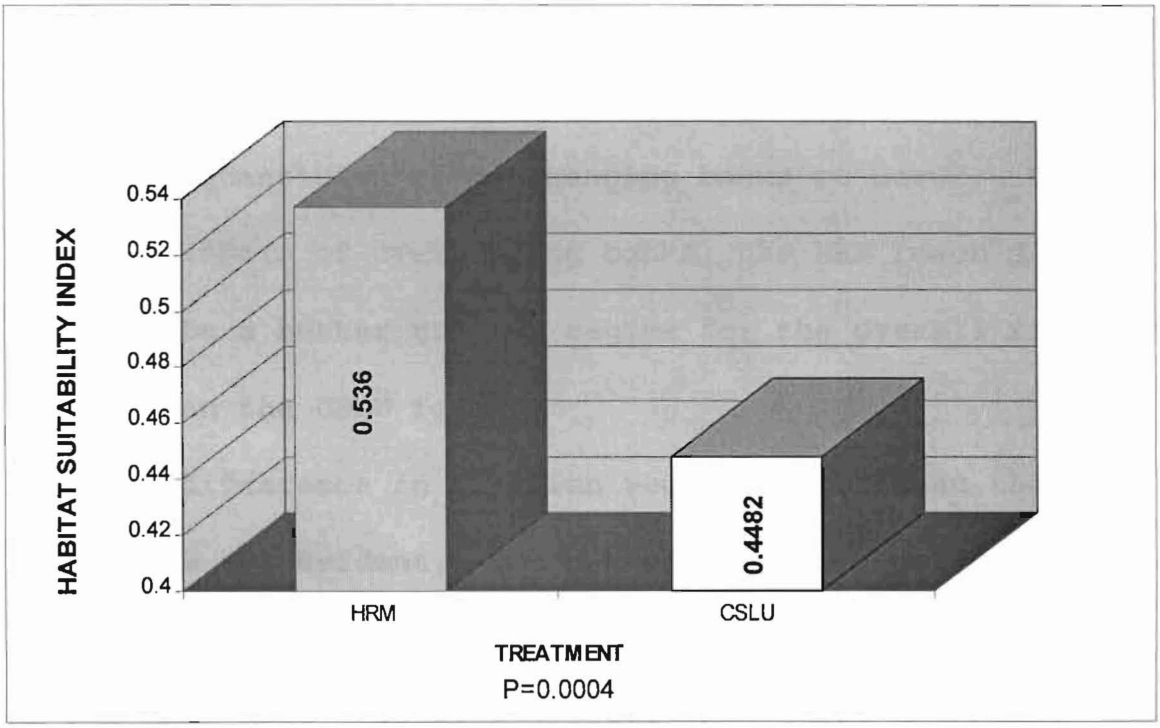
Figure 5: Mean width-to-depth ratio for the HRM and CSLU study sites.


WIDTH TO DEPTH RATIO
16.5
16
15.5
15
14.5
14
13.5
13
12.5
12
13.6288
16.2557
HRM
CSLU
TREATMENT
P=0.0503

This lower ratio can be attributed to proper management of vegetation along the water's edge (Blew et al., 1993). The wider and shallower ratio observed on the CSLU reach is not uncommon for grazed areas. Platts and Nelson (1985) and Williamson et al. (1992) found streams that were being grazed were much shallower and wider than those being rested. These data suggest that HRM grazing allows for some of the benefits of total rest to be seen in a grazed pasture; therefore total exclusion of cattle is not necessary for a more productive stream cross-sectional shape.

The improvements in four of the five stream parameters can be further quantified by the habitat suitability index of the two study reaches. The HSI gives a good indication of what level at which the stream is operating. The HSI for the HRM reach was 0.536 versus 0.448 for the CSLU reach (Figure 6). These results show that the HRM reach is significantly better than the CSLU reach (P=0.0004). The main factor that seemed to lower the overall condition of the stream was the percent overhanging banks. This characteristic is a function of all five parameters and is usually the last to appear.

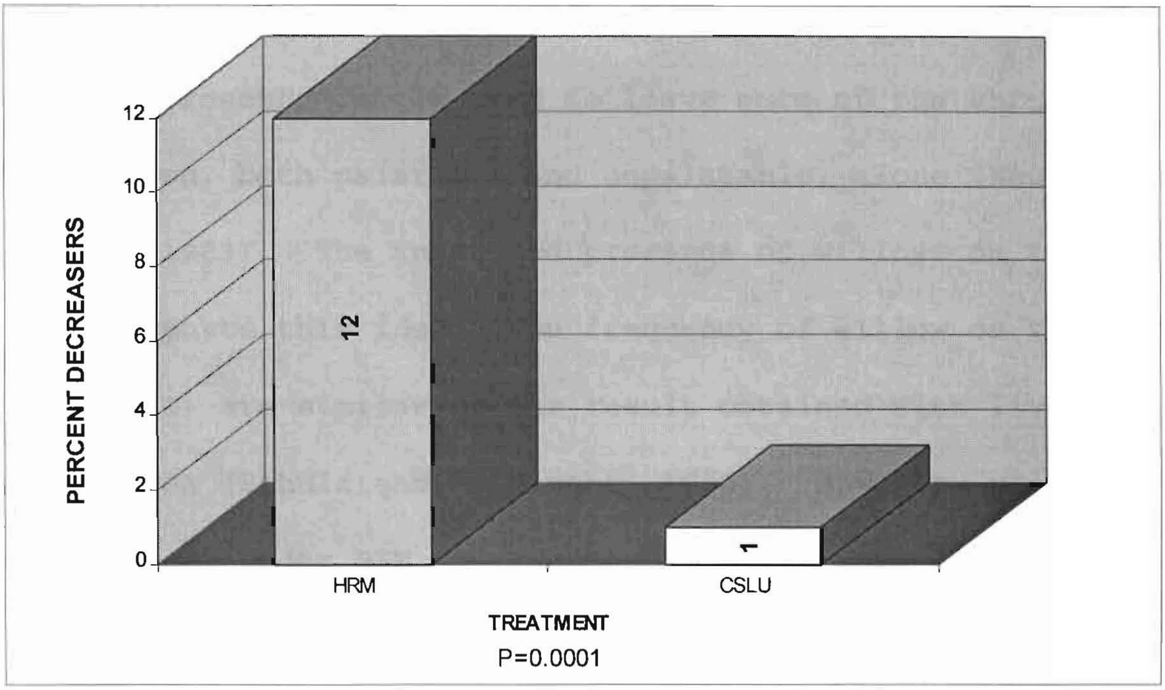
Figure 6: Overall condition of the stream expressed as a percentage of the optimum habitat suitability index.


HABITAT SUITABILITY INDEX
0.54
0.52
0.5
0.48
0.46
0.44
0.42
0.4
0.536
0.4482
HRM
CSLU
TREATMENT
P=0.0004

Considering that HRM grazing has been implemented for merely five years, this might not be a sufficient amount of time for large quantities of overhanging banks to occur. Despite the low numbers of overhanging banks, the HRM reach did prove to be a better grazing regime for the overall riparian health than the CSLU format.

The difference in riparian vegetation between the two treatments was evident. The percent cover by decreaser species varied significantly from 12% on the HRM site to 1% on the CSLU site (P=0.0001)(Figure 7). These decreaser species of plants are preferred by grazing animals. This has been recorded on the two study sites for the utilization of Tripsacum dactyloides. Utilization on the HRM site was 50%, and the CSLU use was 100% (Personal communication with J. Mayo and T. Eddy). The grazing of these preferred plants is one of the principle causes of range deterioration (Platts and Nelson, 1985). Depletion of these species is often a strong indication of overgrazing or poor land management practices. A greater the percentage of decreasers allows for the development of shrubby species along the stream banks, which provide more shade and stabilizes banks better than most herbaceous vegetation. By

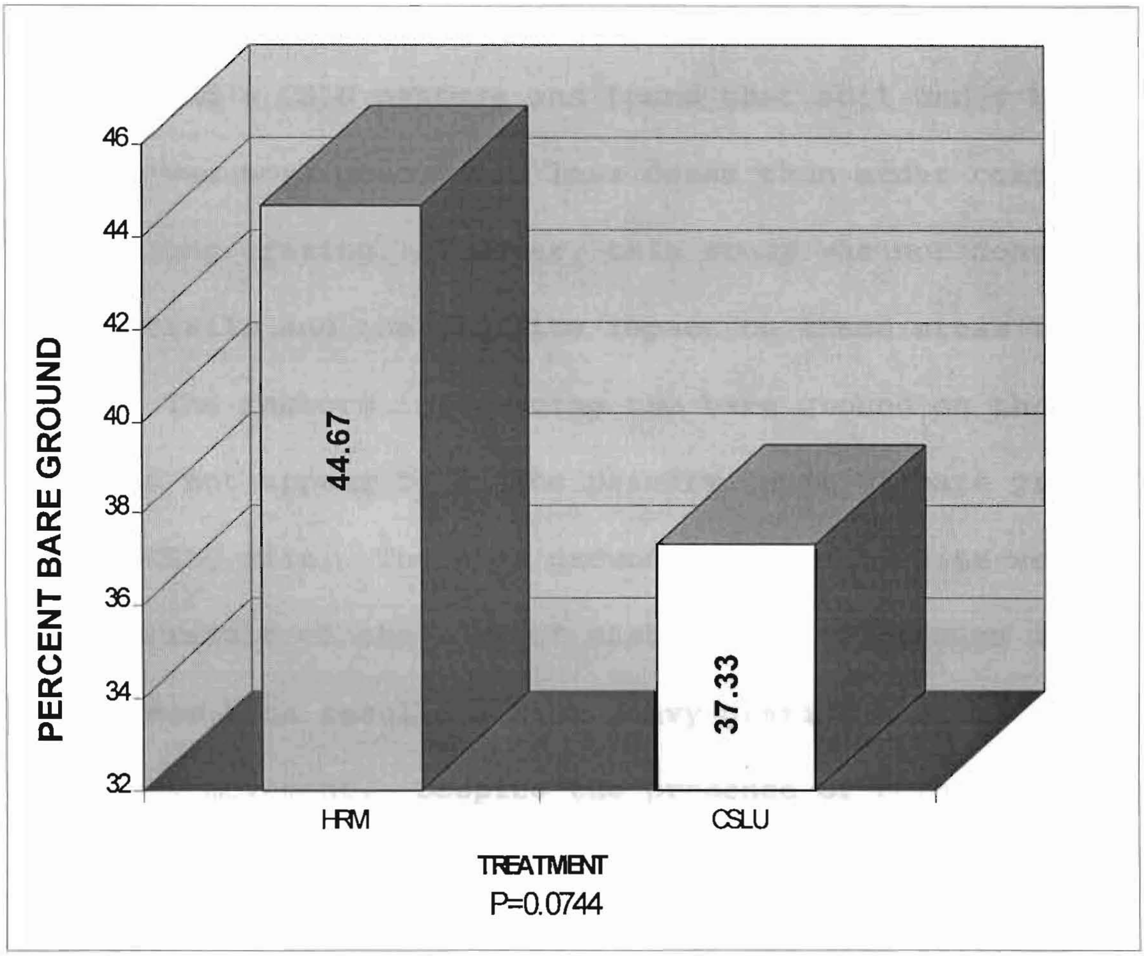
Figure 7: Percentage of decreaser cover in the riparian zones of the HRM and CSLU study sites.


PERCENT DECREASERS
0
2
4
6
8
10
12
12
1
HRM
CSLU
TREATMENT
P=0.0001

having higher numbers of the more palatable, herbaceous species present, cattle tend to leave more of the shrubby vegetation, both palatable and unpalatable, alone (Kauffman et al., 1983). The increased presence of willows on the HRM site supports this idea. The frequency of willow on the HRM site (8:1) are similar to the result obtained with livestock exclosures (Schulz and Leininger, 1990). However, unlike exclosures, under HRM the rancher is still able to graze these areas instead of completely losing them to rest.

The percentage of bare ground also showed a slight differences between the two study reaches. More bare ground was present on the CSLU site (44.67%) than on the HRM site (37.33%)(Figure 8). The majority of the bare ground on the HRM site was caused by: (1) cattle crossing a portion of the stream, or (2) by cattle trails running along the stream bank. The increased frequency of cattle trails for short-duration grazing is a common phenomenon and is to be expected with this form of grazing (Holecheck et al., 1995). It is theorized by Allan Savory (1988) that this constant churning of the ground over some bare areas might cause some increase in porosity and infiltration rates, thereby decreasing the potential for surface runoff. McDow (1995)

Figure 8: Mean percentage of bare ground within the riparian zones of the HRM and CSLU study sites.


PERCENT BARE GROUND
46
44
42
40
38
36
34
32
44.67
37.33
HRM
CSLU
TREATMENT
P=0.0744

tested core samples for bulk density and porosity on a HRM pasture and a CSLU pasture and found that soil under HRM grazing was more porous and less dense than under continuous season-long grazing. However, this study was not done on cattle trails and the definite impact on these areas is not known. The factors influencing the bare ground on the HRM site did not appear to be the primary cause of bare ground on the CSLU site. The bare ground on the CSLU site seemed to be a result of the loss of stabilizing vegetation along the stream bank resulting from heavy grazing and not from livestock movement. Despite the presence of bare ground on the HRM site, the amount was considerably less than on the CSLU site. I feel this is because of the more favorable growing conditions for the invasion of plants into the vacant areas. Although not as effective as exclosures (Schulz and Leininger, 1990), HRM grazing does seem to lower the amount of bare ground in the riparian area compared to CSLU grazing, thereby lowering the potential of soil erosion and in the riparian zone.

No significant differences were found between the percent cover of increaser species of the two sites. However, there were some interesting observations on the composition of the vegetation on both sites. One example of this is the dominant species of plants at each location. The main vegetation on the CSLU site consisted of Kentucky bluegrass (Poa pratensis). The replacement of native plant species by Kentucky bluegrass is common in moderate-heavily grazed areas (Schulz and Leininger, 1990). It has been determined that this plant can eventually establish itself as a dominant species, especially in bunchgrass meadows, as a result of site deterioration (Kauffman and Krueger, 1984). This appears to be happening on the CSLU site with the almost dominating appearance of Poa pratensis and the relatively-obscure numbers of native species of grasses. The HRM site had no dominant plant species, but was rather diverse, especially in comparison to the CSLU site. The HRM reach had more species of increasers (49) compared to the CSLU reach (29), and more species of decreasers (HRM=9; CSLU=4). It is believed that the greater the diversity of species, the better the habitat is for wildlife. Further research is necessary to quantify the impacts of HRM grazing on wildlife habitats; however, these observations suggest that HRM grazing might provide better conditions for wildlife populations to exist.

The data for the stream's rehabilitation potential were not significantly different; however some trends did exist. The analysis of the five block's width-to-depth ratios on the HRM site were not significantly different, but there was a definite trend in the data (Figure 9). The width-to-depth does show a gradual decrease the farther one goes away form the CSLU pasture. This was also supported by the width-to-depth ratio of the two endpoints (Figure 10). The width-to-depth ratio for endpoint **a** was 12 and 9 for endpoint **b** (P=0.0899). These data suggest that whatever sediment is being added to the stream is gradually being removed and added to the stream banks and not to the streambed. This process gives a smaller value for the width-to-depth ratio, representing a narrower and deeper reach. This narrowing and deepening should eventually lead to the developing of overhanging banks and a healthier aquatic habitat. These data support the idea that HRM grazing can correct some of the problems created by upstream management policies, such as roads, that can cause an increase in the sediment load of a stream (Myers and Swanson, 1995).

Figure 9: Mean width-to-depth ratio for the five blocks on the HRM study site.

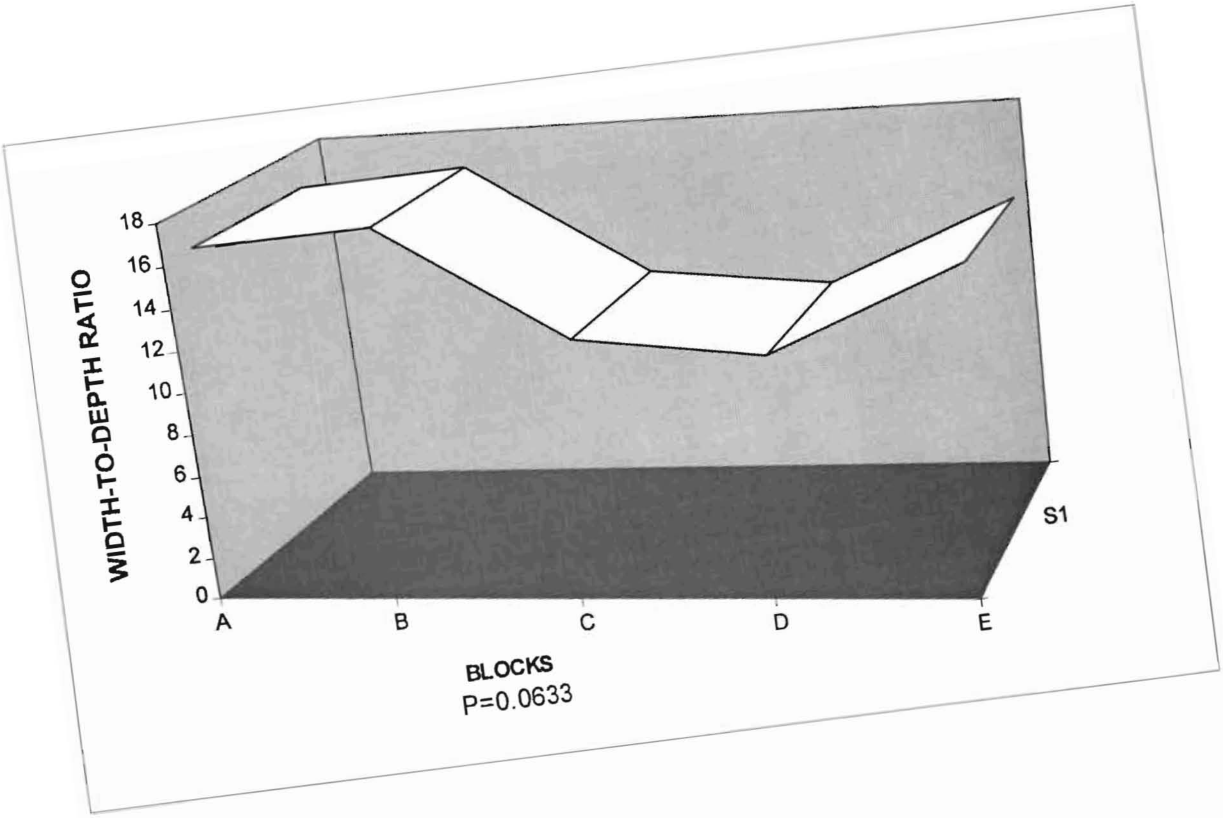
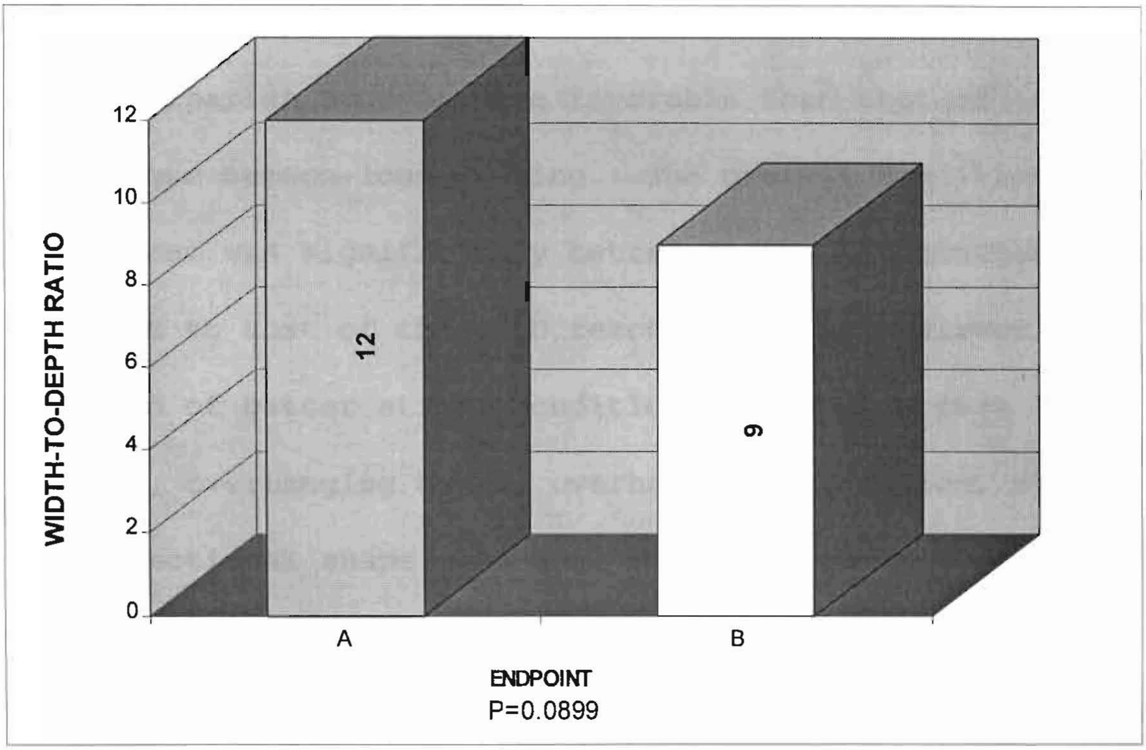

WIDTH-TO-DEPTH RATIO
18
16
14
12
10
8
6
4
2
0
A
B
C
D
E
S1
BLOCKS
P=0.0633

Figure 10: Mean width-to-depth ratio for the two endpoints on the HRM study site.


WIDTH-TO-DEPTH RATIO
12
10
8
6
4
2
0
12
9
A
B
ENDPOINT
P=0.0899

In summary, the impact of holistic resource management on the riparian zone is more favorable than that of continuous season-long grazing. The overall condition of the stream was significantly better on the HRM-managed reach compared to that of the CSLU reach. This is a direct function of better stream conditions, such as stream shading, overhanging banks, overhanging vegetation, stream cross-sectional shape, and soil stability throughout the HRM reach. I have also determined that HRM grazing is more beneficial for the production of desirable species of plants and facilitates lower percentages of bare ground in the riparian zone than the conventional form of grazing. From this research I also conclude that HRM grazing is a productive way of correcting the inputs from upstream management policies. These results show that HRM grazing is a viable and effective alternative to present forms of grazing used for riparian areas.

It is important to remember that HRM grazing has been implemented on this pasture for only five years, and that research was designed to show the present condition of the two reaches and not the trend. One can only speculate at the conditions of this riparian zone after 10 or 20 years of

HRM grazing upon it. Nevertheless, it is evident that the riparian health would be better after prolonged HRM grazing than CSLU grazing in the flint hills of Kansas.

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The impact of holistic resource management + cc
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Title of Thesis

Cooper
Signature of Graduate Office Staff

August 11, 1997
Date Received