

# Cattle Production Practices in Grazed Watersheds of the Humid Region

USDA Proposal Number 2001-04909

Final Report  
December 9, 2004

S.R. Workman, J.R. Bicudo, E.S. Vanzant, and D.R. Edwards  
University of Kentucky

## FINAL REPORT

### SUMMARY

In September 2001, the University of Kentucky was awarded a USDA Section 406 Integrated Research, Education, and Extension grant for a two-year period to study cattle production practices in grazed watersheds of the humid region. A one year, no-cost grant extension was requested and approved to extend the grant to September 14, 2004. The extension allowed for the collection of two additional position data events as well as further data analysis.

During the project life, more than 600,000 cattle position points were collected over eight GPS data collection periods spanning two grazing seasons. A Ph.D. student, a M.S. student, undergraduate students, and a half-time research associate were funded from project. As described below, the project has produced refereed journal articles, conference proceeding papers, abstracts, magazine articles, and an international award winning web site. In addition to the hard copy materials, producers have learned about techniques through the UK Grazing School, extensions talks, field days, and radio programs.

### 1.0 INTRODUCTION

#### 1.1 Background

The beef cattle industry of Kentucky is prominent in the United States (8<sup>th</sup> in beef cows, \$3 billion in valuation). Kentucky is the #1 beef producing state east of the Mississippi River. As of January 1, 2000, Kentucky had 1.07 million head of beef cattle on 41,000 farms. In addition, Kentucky ranks 18<sup>th</sup> nationally in the total number of milk cows (130,000 on 3,200 farms). Therefore, the average farm size can be characterized as small to mid-sized, averaging between 25 to 40 head of cattle per farm. Kentucky is ranked 5<sup>th</sup> in the nation in the number of farms with beef cattle indicating the prominence of cattle production to the state's agricultural base. A shift towards more cattle is likely as the production of tobacco decreases. Furthermore, Kentucky's pastures are rolling-to-steep and are permeated with streams and dry runs, and it is known that uncontrolled livestock access to streams can be greatly damaging to the ecological integrity and sustainability of riparian ecosystems. This is important because Kentucky contains more than 89,000 miles of streams and rivers

The U.S. Environmental Protection Agency (EPA) Office of Water (1998) noted that the most common pollutants to Kentucky's rivers included fecal coliform bacteria and siltation. Currently, 75% of the surveyed river miles in Kentucky do not fully support swimming use because of high fecal coliform levels. In a 1998 Report to Congress, the EPA's Office of Water noted that the leading source of river and stream impairment was agricultural activity with the states reporting that 59% of the documented water quality problems were from agricultural contributions. Approximately 41% of the continental United States (365 million ha) was dedicated to agricultural production of which 43% was pasture and range land.

The large farm investment in cattle production has to be balanced against the environmental and regulatory pressures imposed by government and society. One means to reduce the environmental effects of cattle is to exclude them from streams with fencing. However, producers believe stream exclusion will dramatically reduce their profits because of the high cost of fencing and the loss of pasture area available for grazing. In a few limited studies, other methods to alter livestock distribution in a pasture such as off-stream water, moveable shade, and pasture enhancements have been very effective in reducing the environmental impact of cattle on riparian systems.

## 1.2 Goal and Objectives

The goal of this project was to provide the agricultural community with information about management practices that will enhance cattle production for small to mid-sized farm operators while addressing nutrient management, environmental/regulatory requirements, and operator training needs. The objectives of the project were to:

- determine the particular factors that influence cattle behavior in terms of movement, pasture utilization, grazing decisions, and use of riparian areas/stream systems under natural/control conditions in the humid region of the U.S..
- determine the influence of alternative management strategies such as off-stream water, fencing, shade (permanent and movable), and pasture improvements on cattle behavior and performance.
- educate livestock producers and other stakeholders on management systems that minimize adverse impacts of grazing on the environment and natural resources while maintaining or improving their production efficiency

## **2.0 METHODS**

The overall project goal was to provide the agricultural community with information about management practices and technologies available for small to mid-sized cattle producers that affect cattle behavior in the humid region. In order to effectively evaluate the various management systems, a replicated field study was utilized.

### 2.1 Study Area

The study area was located on the University of Kentucky's Animal Research Center (ARC) in Woodford County, Kentucky, approximately 15 miles northwest of Lexington, Kentucky (38°02' N, 84°36' W). The climate is humid and temperate with a mean monthly rainfall ranging from 66 mm in October to 118 mm in July with a mean annual rainfall of 1150 mm. Temperatures range from a mean monthly average low of 0.3°C to an average high of 24.3°C with a mean annual temperature of 12.6°C (University of Kentucky Agricultural Weather Center, 2004). The ARC is characterized by gently rolling hills with elevations ranging from approximately 240 to 260 meters above mean sea level. One stream drains much of the ARC through two bedrock bottom second-order tributaries, Camden Creek and Pin Oak, whose confluence is near the property boundary of the ARC. Camden Creek flows in a southwesterly direction, and Pin Oak flows in a northwesterly direction (Figure 1). Soils at the study site are derived from limestone and consist of the Hagerstown (fine, mixed, mesic Typic Hapludalf) and McAfee (fine, mixed, mesic Mollic Hapludalf) soil series along Pin Oak and the Hagerstown and Woolper (fine, mixed, mesic Typic Argiudoll) soil series along Camden Creek. The land use along the lowermost reaches of these tributaries is pasture. The pastures at the ARC are dominated by endophyte (*Neotyphlodim coenophialum*) infected tall fescue (*Festuca arundinacea*). Two replications of three pasture plots were established in the pastureland along the streams (i.e. one of each treatment per replication per stream).

## 2.2 Treatments

Data collection involved two replications (one replicate was located on Camden Creek and the other on Pin Oak) of three treatments (i.e. pasture plots), listed in downstream order as 1) BMPs and a fenced 9.1 m wide riparian area to exclude cattle from the stream (equipped with a 3.7 m wide stream crossing constructed in accordance with NRCS specifications), 2) BMPs with free stream access, and 3) free access with no off stream water or fencing (control) (Figure 1). Treatments were ordered such that the anticipated severity of the treatment increased in the downstream direction. The implemented BMPs included an alternate water source, alternate shade (started in July 2003), and pasture improvements consisting of fertilizer plots and herbicide plots, each 30.5 m × 30.5 m. Fertilizer (ammonia-nitrate) was applied annually to all pasture plots at a rate of 45 kg/ha prior to the start of the grazing season. The fertilizer plots received an additional 11 kg/ha of fertilizer and the herbicide Select® from Valent Chemical was applied per manufacturer recommendations to the herbicide plots (150 mL/ha with 300 mL/ha surfactant) in April 2003. The pasture plots used for each treatment within a replication spanned the stream with approximately equal stream frontage. One replication, along Camden Creek, contained pasture plots with an area of approximately 2 ha while the other pasture plots, located along Pin Oak, were nearly 3 ha. The difference in plot size for the replications resulted from the amount of land available for the study. Every attempt was made to ensure that plot characteristics such as topographical features, soil, existing shade, riparian characteristics (if applicable), and linear feet of stream frontage was as consistent as possible among the treatments.

High tensile electrical fence was used to separate the pasture plots and to exclude cattle from the riparian areas. Cattle stocking rates were varied throughout the year based on the amount of available forage. However, the maximum practical rate was used with stocking rates remaining the same for all treatments within a replication. Initial stocking rates were set at 1,300 kg/ha. Attempts were made to weigh cattle on a monthly basis during the grazing season (typically mid-April until late October).

High tensile electrical fence was used to separate the pasture plots and to exclude cattle from the riparian areas. Cattle stocking rates were varied throughout the year based on the amount of available forage. However, the maximum practical rate was used with stocking rates remaining the same for all treatments within a replication. Initial stocking rates were set at 1,300 kg/ha. Attempts were made to weigh cattle on a monthly basis during the grazing season (typically mid-April until late October).

## 2.3 Cattle Positions

Understanding the impact of grazing activity on streambank erosion required knowledge of animal position. Global positioning system (GPS) collars, GPS\_2200 Small Animal GPS Location Systems (Lotek Engineering, Inc., Newmarket, ON), were used to collect position



information on a sample of cattle from each pasture plot. Detailed descriptions of the GPS collars were presented in Agouridis et al. (2004). Position information was collected over eight, 18-day periods during May, August, and November 2002 as well as April, June, July, November 2003 and May 2004. A five-minute sample interval, the smallest permitted with the GPS collars, was selected. Data from the GPS collars were filtered and differentially corrected allowing use of only the highest quality position points in the analysis (Agouridis et al., 2004).

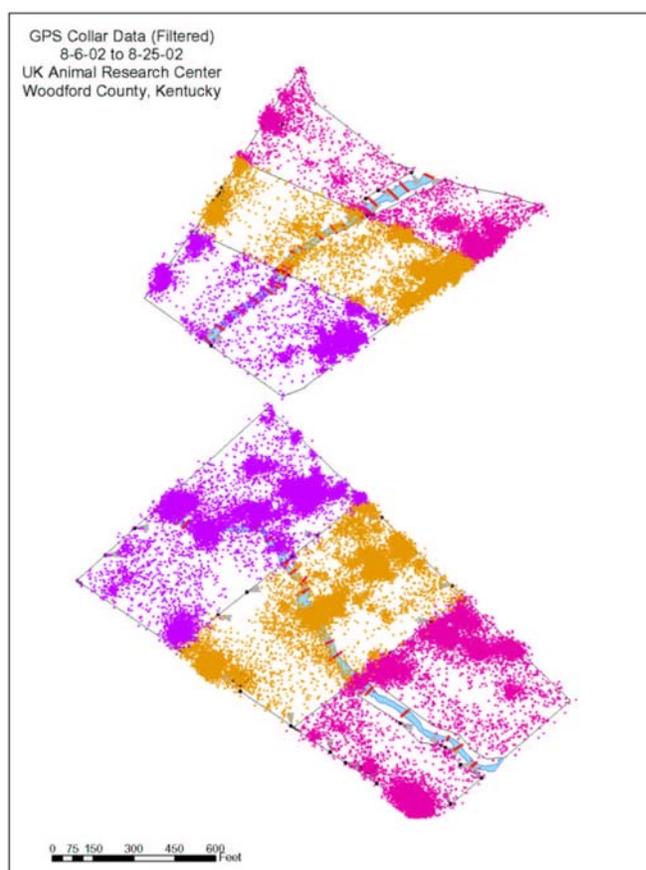
Prior to the start of the project, a base map identifying key pasture features was created using a Real Time Kinematic Global Positioning System (RTK-GPS) with a published horizontal accuracy of 2 cm. Key pasture features included the streambanks of Camden Creek and Pin Oak, fences, trees, and all BMPs (i.e. alternate water sources, alternate shade sources, stream crossings, and pasture improvements). This base map was used in conjunction with the data collected from the GPS collars during the eight cattle-monitoring periods to characterize cattle behavior and activity along the streambanks.

All cattle on each of the pasture plots were weighed at 28-day intervals during the grazing season for each year of the project. The final weights and cattle numbers for each pasture plot and for each period were used to compute stocking densities. Every attempt was made to maintain equivalent stocking densities across the pasture plots for a given period. Stocking densities varied with available forage, ranging from 1670 kg/ha at the early stages of the grazing seasons to 720 kg/ha during the latter part of the grazing seasons.

### 3.0 RESULTS

#### 3.1 Use of GPS Collars to Monitor Cattle Behavior

Our literature survey indicated that very little information was available concerning the grazing behavior of cattle in humid environments. Fundamental to the development of alternative management practices was the understanding of cattle preferences in natural systems.



Visual field observations and some limited data indicated that cattle spend part of their day in or near a stream if a stream water source was available. No information was available that related cattle movement to ambient temperatures, pasture features, and forage quality. For this reason, intensive monitoring activities were targeted at obtaining cattle behavior information in the humid region.

A key component of the project was the use of GPS collars rather than visual observations to obtain the position data. Visually tracking the quantity of animals at the number of experimental pastures with the level of accuracy needed would have been cost prohibitive. Intensive visual observations were collected during one sampling event to validate and check the data accuracy.

### *3.1.1 ASAE paper and presentation*

Sixteen GPS collars were available to our project. Although the collars have traditionally been used in wildlife studies, there was limited information to describe their abilities to precisely locate animals in the research pastures. A series of intensive tests were conducted to determine the accuracy of the collars under a variety of conditions. The conditions included open field, near fences and gates, and under trees. A paper was prepared and delivered at the 2003 International Meeting of the ASAE.

*Examination of GPS Collar Capabilities and Limitations for Tracking Animal Movement in Grazed Watershed Studies* (C.T. Agouridis, T.S. Stombaugh, S.R. Workman, B.K. Koostra, D.R. Edwards)

Abstract. The traditional means of tracking animal location in a field is by visual observation. Not only is this method labor intensive, it is also prone to error as the observer can alter cattle movement, observation periods are often too short to obtain confidence in general daily behavior patterns, and observer fatigue becomes an issue. In the 1990s, the University of Kentucky began using GPS collars on cattle to track their position with the goal of incorporating this information into cattle management practices. One of the key unanswered questions regarding the GPS collars is the accuracy of the position data recorded by the collar. Static and dynamic tests have been conducted on up to 16 GPS collars to assess the accuracies, capabilities and limitations of using GPS collars to track animal movement in grazed watersheds. Static tests were conducted in an open field, under trees, and near fence lines to ascertain the impacts of various field features on collar performance. Dynamic tests were carried out to examine the errors associated with the collars while operated under "real-world" conditions. Results from these tests will assist researchers in the development of experiments based on collar capabilities and limitations.

### *3.1.2 Refereed Journal Article – Transactions of the ASAE*

The ASAE paper described in 3.1.1 was well received. The paper was revised slightly and sent to the Transactions of ASAE for review and publication. The article was published in 2004 (TRANS of ASAE 47(4): 1321-1329).

*Suitability of a GPS Collar for Grazing Studies* (C.T. Agouridis, T.S. Stombaugh, S.R. Workman, B.K. Koostra, D.R. Edwards, and E.S. Vanzant)

Abstract. The traditional means of tracking animal location in a field is by visual observation. Not only is this method labor intensive, it is also prone to error as the observer can alter cattle movement, observation periods are often too short to obtain confidence in general daily behavior patterns, and observer fatigue becomes an issue. In the 1990s, the University of Kentucky began using GPS collars on cattle to track their position with the goal of incorporating this information into cattle management practices. One of the key unanswered questions regarding the GPS collars is the accuracy of the position data recorded by the collar. The objective of this work was to assess the capabilities and limitations of using GPS collars to track animal movement in grazed watersheds. Static tests were conducted in an open field, under trees, and near fence lines to ascertain the impacts of various field features on collar performance. Dynamic tests were carried out to examine the errors associated with the collars while operated under "real-world" conditions. Results from these tests indicate that the collars generally provide data with horizontal accuracies of 4 to 5 m. This information will assist researchers in the development of experiments based on collar capabilities and limitations.

### *3.1.3 ESRI Conference paper and presentation*

A key component of the project was the collection and analysis of GPS collar data. This is more easily said than done when considering over 600,000 data points were retrieved. In each case, collar data must be downloaded from the collar, differentially corrected, labeled with respect to collar and pasture, augmented with weather information, and inserted into the database. Custom scripts were developed by project personnel and described at the annual user conference of ESRI, a leading Geographic Information System (GIS) vendor.

*Analysis of GPS Position Data of Beef Cattle* (B. K. Koostra, C. T. Agouridis, and S. R. Workman)

Abstract. Water quality and nutrient management research at the University of Kentucky related to beef cattle interaction with streams involved the collection and analysis of GPS position data. Typical data collection periods consisted of a position data point for each of 16 collars every five minutes for 18 days. Because of the volume of data points, multiple geodatabases were designed to organize and store the spatial data. Custom scripts and analysis techniques were developed to determine distance and location relationships using ArcGIS. The data were formatted and made available for research extension purposes using ArcPublisher.

## 3.2 Cattle Behavior in the Humid Region

One of the key purposes of the research project was the determination of stream changes that occur as a result of cattle access in the humid region of the US. The inclusion of a fenced treatment allowed the project to study the effect of excluding cattle from a large portion of the stream.

### 3.2.1 ASAE Paper and Presentation

Grab samples were collected at the downstream point of each research pasture, analyzed and presented at the International meeting of the ASAE. Results of the analysis indicate that differences in stream water quality could be observed between the treatments.

*Effects of Cattle Grazing and BMPs on Stream Water Quality* (C.T. Agouridis, D.R. Edwards, S.R. Workman, J.R. Bicudo, J. L. Taraba, E. S. Vanzant, R. S. Gates)

Abstract. Cattle production is a major component of Kentucky's agricultural economy, accounting for approximately 15% of the total agricultural sales in 2000. There are over 2.2 million beef cattle and calves in the state making Kentucky the number one beef producer east of the Mississippi River. Research into the effects of cattle grazing on stream water quality has been well documented in the western portion of the United States with some estimates indicating that 80% of the damage to riparian areas was caused by grazing livestock. However, the impacts of grazing cattle in a humid environment may differ significantly from those witnessed in the arid West. Furthermore, relatively little information exists regarding the effectiveness of grazing best management practices (BMPs), such as alternate water sources, alternate shade sources, supplemental feeding, and riparian buffers, for improving the water quality of streams in grazed watersheds of the humid region. As part of a larger research endeavor into cattle production practices in the humid region, water samples were collected over a two year period at the project site located on the University of Kentucky's Animal Research Center. The project sites consisted of two replications of three treatments: control, selected BMPs with free access to the stream, and selected BMPs with limited access to the stream. Grab samples were collected at the upstream and downstream pasture edges. Samples were analyzed for nitrate-nitrogen, ammonium-nitrogen, total Kjeldahl nitrogen, dissolved orthophosphate, total phosphorus, total suspended solids, pH, chemical oxygen demand, five-day biochemical oxygen demand, fecal coliforms, and fecal streptococci. Results indicated that minimal water quality benefits were incurred by implementing the BMP systems (i.e. treatments). One of the most substantial understandings gleaned from the project was the importance of upstream land use, and to some degree soils, when attempting to identify significant treatment effects within a small reach. Additionally, the karst geology, which is characteristic of the Bluegrass Region of Kentucky, influenced the rate of transport (i.e. flashy system with quick response time to rainfall) of nutrients from upland areas (i.e. row crops), especially along Pin Oak. These external factors may have resulted in the lack of uniformity in significant constituent concentration differences between the two streams when cattle were present. Furthermore, the background constituent concentration levels may have prohibited the identification of treatment effects. Results from this project indicated that minimal water quality benefits were incurred by implementing a BMP system (with or without a partially excluded riparian zone). However, these results may differ if cattle were completely excluded from the stream or if the BMP system was implemented at a site with larger pastures, different geology (nonkarst), soils (low in phosphorus), or stream morphology (nonbedrock bottom channel).

### 3.2.2 ASAE Paper and Presentation

In addition to water quality, the project studied the effect cattle had on streambanks. Before cattle were added to the research pastures, cross sections were established across the

streams at 50 locations. These cross sections were routinely measured to determine changes with time. A paper was written and presented at the 2004 ASAE meeting.

*Streambank Erosion Associated with Grazing Practices in Central Kentucky.* (Agouridis, C.T., D.R. Edwards, S.R. Workman, J.R. Bicudo, J.L. Taraba, E.S. Vanzant and R.S. Gates)

Abstract: Research into the effects of cattle grazing on stream health has been well documented in the western portion of the United States, but is lacking in the east. Western researchers have estimated that 80% of the damage incurred by stream and riparian systems in these arid environments was from grazing livestock. Stream and riparian damage resulting from grazing includes alterations in watershed hydrology, changes to stream morphology, soil compaction and erosion, destruction of vegetation, and water quality impairments. The objective of this project was to provide the agricultural community with a better understanding of the impacts of cattle grazing on stream bank erosion so as to enhance current cattle production methods on farms in the humid region of the U.S. The project site, located on the University of Kentucky's Animal Research Center, consisted of two replications of three treatments: control, selected BMPs with free access to the stream, and selected BMPs with limited access to the stream. Fifty permanent cross sections were established throughout the project site. Over a two year period, 18 surveys were conducted using conventional surveying techniques. Changes in stream cross sectional area were used to quantify soil loss or gain associated with the different treatment levels. Preliminary results indicate that erosion losses were localized within the reach. This project will provide the agricultural community with information regarding the degree of stream change associated with cattle grazing and the influence of best management practices on these changes.

### *3.2.3 Refereed Journal Article (in review) – Transactions of the ASAE*

The paper described in 3.2.2 has been reworked and developed into a refereed journal article. The article has been submitted to the Transactions of ASAE and is currently in review.

*Streambank Erosion Associated with Grazing Practices in the Humid Region* (C.T. Agouridis, D.R. Edwards, S.R. Workman, J.R. Bicudo, B.K. Kooststra, E.S. Vanzant, J.L. Taraba)

Abstract. Research into the effects of cattle grazing on stream stability has been well documented for the western portion of the United States, but is lacking for the east. Stream and riparian damage resulting from grazing can include alterations in watershed hydrology, changes to stream morphology, soil compaction and erosion, destruction of vegetation and water quality impairments. The objective of this project was to assess the ability of a BMP system to reduce streambank erosion along a central Kentucky stream. The project site, located on the University of Kentucky's Animal Research Center, consisted of two replications of three treatments: BMPs (alternate water source, alternate shade source, and forage improvements such as fertilizer and herbicide applications) and a fenced riparian area to exclude cattle from the stream except at 3.7 m crossing, BMPs with free stream access, and no BMPs with free access (control). Fifty permanent cross sections were established throughout the project site. Each cross section was surveyed monthly from April 2002 until November 2003. A multiple linear regression analysis was performed to determine which variables influenced cross-sectional area for each cross section and for each sampling period. Treatment, cross-sectional cattle activity, and cross-sectional flow were significant variables in the multiple linear regression, whereas time and

stocking density were not. Results from the project indicate that streambank erosion can be minimized through the incorporation of a BMP system (with or without an excluded riparian zone). In the absence of a protected riparian zone, grazing managers should modify their practices to minimize cattle activity and associated erosion along streambanks during periods characterized by higher flows and/or hot, humid conditions.

### *3.2.4 Refereed Journal Article – Journal of American Water Resources Association*

With so few studies being conducted in the humid region regarding cattle and stream interactions, an extensive review of the literature was conducted to assemble the available material for researchers studying stream water quality. The review was accepted for publication by the Journal of American Water Resources Association and is in press.

*Livestock Grazing Management Impacts on Stream Water Quality: A Review* (C. T. Agouridis, S. R. Workman, R. Warner, and G. Jennings)

Abstract. Controlling agricultural nonpoint source pollution from livestock grazing is a necessary step to improving the water quality of the nation's streams. The goal of enhanced stream water quality will most likely result from the implementation of an integrated system of BMPs linked with stream hydraulic and geomorphic characteristics. However, a grazing BMP system is often developed with the concept that BMPs will function independently from interactions among controls, climatic regions and the multifaceted functions exhibited by streams. This paper examined the peer reviewed literature pertaining to grazing BMPs commonly implemented in the southern humid region of the United States to ascertain effects of BMPs on stream water quality. Results indicated that the most extensive BMP research efforts occurred in the western and midwestern U.S. While numerous studies documented the negative impacts of grazing on stream health, few actually examined the success of BMPs for mitigating these effects. Even fewer studies provided the necessary information to enable the reader to determine the efficacy of a comprehensive systems approach integrating multiple BMPs with pre- and post-BMP geomorphic conditions. Perhaps grazing BMP research should begin incorporating geomorphic information about the streams with the goal of achieving sustainable stream water quality.

## 3.3 Alternative Management Strategies

A number of alternative management strategies were implemented on the research plots including moveable shade, off-stream water, pasture fertilization, and vegetative growth control. Data regarding many of these strategies are being analyzed, but some have been completed.

### *3.3.1 ASAE paper and presentation*

Off stream waterers were provided as a BMP treatment on the research pastures. In order to track the usage of these waterers, dataloggers were used to monitor water use and temperature. This paper presented at the International meeting of the ASAE described the differences in water usage as a function of stream access. This paper will be revised and submitted for review in a refereed journal.

*Effects of Air and Water Temperature, and Stream Access on Grazing Cattle Water Intake Rates* (J. R. Bicudo, C. T. Agouridis, S. R. Workman, R. S. Gates, E. S. Vanzant)

Abstract. The objective of this study was to characterize water intake by grazing beef cattle in warm weather, with or without access to a stream. Two pairs of pasture plots each with stocking rate of about 850 kg/ha (760 lb/ac) were used as experimental units. Two different treatments were evaluated: (a) limited access to the stream through a constructed crossing with an alternative water source; (b) free access to the stream with an alternative water source. Water intake from alternative water sources, water and air temperature, and relative humidity were monitored continuously for two months (August and September of 2002). Most pastures plots were severely dry, and cattle either lost weight or gained very little during the study period. Approximately 50% of the total numbers of cattle grazing in any one plot were fitted with GPS collars for position and activity monitoring. Cattle water intake was significantly affected by water temperature (WT), temperature and humidity index (THI), and stream accessibility during warm weather. Water intake rates were higher when THI values were above 75 or WT values were below 25 °C (77 °F) for either free or limited stream access. Cattle with free access to the stream consumed water mostly from the streams, especially when WT values was above 25 °C (77 °F). Diurnal water intake patterns seemed to follow previously reported cattle behaviors in grazing situations, but it was interesting to know that cattle spent more time near the waterers in the afternoon hours, corresponding to the hottest part of the day.

### *3.3.2 Animal Science Abstract and Masters Thesis*

One of the problems in southern pastures dominated by fescue is the infestation of endophyte. An effective management strategy to influence grazing distribution (i.e. where grazing cattle spend their time), besides fence construction, is to alter the placement of supplemental feed. This abstract and masters thesis looked at the use of energy supplementation (in particular, with fiber-based energy supplements) on high-quality fescue pasture, which is the dominant pasture in KY and much of the Southeastern US.

*Effect Of Increasing Level Of Soybean Hulls On Intake And Utilization Of Tall Fescue Hay* (L. van Rensburg, E.S. Vanzant, J.A. Benson, C.L. Adkins, and K.A. Beighle)

Abstract. Twenty ruminally cannulated, crossbred beef steers (476 kg) were randomly assigned within weight blocks to receive soybean hulls (SH; 18.0% CP; 58.7% NDF) at 0, 0.32, 0.64, 0.96, or 1.28% (DM basis) of BW as a supplement to endophyte-infested tall fescue hay (14.1% CP; 68.0% NDF). Adaptation (d 1 to d 14) was followed by a total fecal collection (d 15 – d 21), Co: EDTA dosing (d 22 at 0600) and subsequent ruminal fluid sampling (d 22; 0600, 1100, 1400, 1700, 2000; d 23 at 0600) for Co, pH, NH<sub>3</sub>-N, and VFA analyses. Voluntary forage OMI decreased linearly ( $P < 0.01$ ; 1.55, 1.50, 1.33, 1.11, and 1.02 %BW) and total (1.55, 1.75, 1.94, 2.01, and 2.22 %BW) and digestible (0.98, 1.14, 1.31, 1.40, and 1.54 %BW) OMI and liquid dilution rate (9.4, 9.96, 10.6, 11.7, and 12.2 %/h) increased linearly ( $P < 0.02$ ) with increasing SH. Total tract OM digestibility increased as SH increased from 0 to 0.96% BW and plateaued with the next increment of SH ( $P < 0.001$ ); 63.8, 65.0, 67.8, 69.5, and 69.3%). All ruminal fermentation characteristics except molar proportion of acetate had sampling time x treatment interactions ( $P < 0.10$ ). Generally, ruminal pH decreased linearly ( $P < 0.07$ ) and total VFA concentrations increased linearly ( $P < 0.02$ ) with increasing SH. Peak ruminal NH<sub>3</sub>-N concentrations (at 1100) increased as SH increased from 0 to 0.96% BW and decreased with the next increment of SH (quadratic;  $P < 0.01$ ). Molar proportions of acetate decreased (linear;  $P < 0.01$ ) with increasing SH and, in general, molar proportions of propionate increased ( $P < 0.06$ ) with increasing SH. Changes in digestible OMI and modest shifts in fermentation characteristics

suggest that increasing SH supplementation from 0 to 1.28% of BW would result in linear increases in growth of stocker cattle consuming endophyte-infested tall fescue.

### **3.3.3 ASAE Paper and Presentation**

The cattle position data were used to estimate time spent near various features of the pasture. These features included the stream, off stream waterers, supplemental shade, trees, etc. The analysis procedure and results were presented at the 2004 ASAE meeting. This paper is presently being revised and will be submitted as a refereed journal article.

*Influence of BMPs on Cattle Position Preference* (Agouridis, C.T., D.R. Edwards, S.R. Workman, J.R. Bicudo, J.L. Taraba, E.S. Vanzant and R.S. Gates)

Abstract: The beef industry is an important component of Kentucky's agriculture accounting for approximately 15% of the state's agricultural sales in 2000. Dairy also plays a prominent role in Kentucky's agriculture (state rank of 18<sup>th</sup>). The state's significant cattle production occurs primarily on small to mid-sized farms averaging between 25 and 40 head of cattle per operation. As tobacco production decreases across the state, the shift is towards increased levels of cattle production. Considering this upward trend in cattle production along with Kentucky's 140,000 km of rivers and streams, rolling pastures and karst geology, the potential for damage to riparian ecosystems from uncontrolled livestock access is high. The objective of this project was to determine the influence of alternate management strategies such as off-stream water, fencing, shade (permanent and movable), and pasture improvements on cattle behavior in grazed pastures of the humid region of the U.S. The project site, located on the University of Kentucky's Animal Research Center, consisted of two replications of three treatments: control, selected BMPs with free access to the stream, and selected BMPs with limited access to the stream. Cattle placed on the research pastures were fitted with GPS collars to track their positions. The use of GPS collars for tracking animal movements and behaviors eliminates errors often introduced in human observations. GPS collar data was collected at five minute intervals for seven sampling events over a two year period. Results from this project will provide managers with information regarding the effectiveness of alternate management strategies for minimizing the time cattle graze in riparian areas allowing for maximum water quality benefits.

## **3.4 Education Efforts**

Diverse audiences have a need for accurate information on the issue of grazing systems and environmental protection. There is little or no information that is easily available to the interested groups (producers, local and state government officials, other policy makers, extension educators, engineers and consultants, and concerned citizens). A coordinated dissemination effort was used to provide the transfer of information.

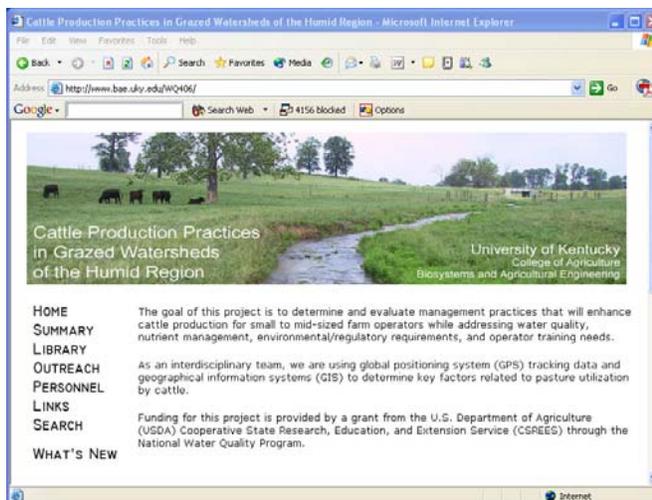
### **3.4.1 Web Site**

A project web site was developed soon after funding was awarded (<http://www.bae.uky.edu/wq406/>). The site contains links to project publications, photographs, and data. Publications include fact sheets, newsletters, and some research articles. Photographs include a series of pictures illustrating the construction of a cattle crossing through a stream.

Other photographs document monthly changes in the streambanks. The Web site won a Blue Ribbon Award for Educational Aids at the 2003 International Meeting of the ASAE.

### 3.4.2 Conference Talks

Scientific, technical, and educational information on project results, technology, and best management practices were disseminated at many conferences. These included the International meeting of the American Society of Agricultural Engineers, USDA-CSREES National Water Quality Conference, ESRI Users Conference, and the Kentucky GIS Conference. The project and technology was represented at such large events as the Central Kentucky Home and Garden Show (approximately 16,000 visitors) held in Lexington, KY and the National Farm Machinery Show (approximately 300,000 visitors) held in Louisville, KY.



### 3.4.3 Field Tours

The research location provided numerous opportunities to showcase and describe the results during field tours. These included large tours such as over 100 visitors representing the Kentucky Conservation Districts in 2004 and the Kentucky Grazing School Field Days in 2004 to smaller tours such as the Woodford County Farm Bureau. Individual tours were given to Dr. Joseph Jen, USDA-Under Secretary for Research, Education, and Economics, Colien Hefferan, Administrator, USDA-Cooperative State Research, Education, and Extension Service, and Dr. Wendy Baldwin, Vice-President for Research at the University of Kentucky.

### 3.4.4 Kentucky Grazing School Curriculum

Technical information was condensed into user-friendly extension information for producer and non-producer audiences widely accessed through the KY Cooperative Extension Service activities. One of the highlights of the extension effort was the KY Grazing School. In 2004, 617 producers from 80 counties participated in the grazing school. Seventeen multi-county (two or more counties) groups around the state were formed. Each of those groups had 10 sessions in the grazing school. Sessions included management, nutrition, forages, facilities and animal behavior, environmental stewardship, industry issues, genetics, reproduction, herd health, end product and marketing).

### 3.4.5 Popular Press, Newsletters, and Radio

Popular press articles were distributed to members of the Cattleman's Association. These included a story about the project in the Cow Country News and separate newsletters called GPS Grazing News in 2002 and 2003. Dr. Bicudo discussed stream water quality and the effects of grazing cattle on the KY Agriculture Radio News Network

([http://www.bae.uky.edu/ext/News\\_Events/BAE\\_Radio.htm](http://www.bae.uky.edu/ext/News_Events/BAE_Radio.htm))

### **3.4.6 Student Involvement**

A Ph.D. student, Carmen Agouridis, was instrumental in setting up the research pastures and overseeing much of the data collection and analysis at the Animal Research Center. Dr. Agouridis has accepted a position with the Department of Biosystems and Agricultural Engineering to oversee the development of two experimental stream restoration sites. One of the experimental sites includes riparian land used for the 406 project.

A M.S. student, Laurentia van Rensburg, was funded off of the project and evaluated the effects of supplemental feed for the fescue pastures encountered in Kentucky. Ms. Van Rensburg has accepted a position with the Department of Animal Sciences and oversees the entry of electronic herd data into a statewide database for use in tracking cattle and analyzing cattle performance.

A research associate, Benjamin Koostra, set up the database of position data and oversaw the programming and handling of the GPS collars. Mr. Koostra has accepted a position with the Department of Biosystems and Agricultural Engineering to help train users across the state on equipment to collect and analyze GPS data. Mr. Koostra is also funded to oversee the installation of Best Management Practices to reduce sediment transport off of urban horse farms in and near Lexington, KY.

A Ph.D. student, Leonardo Conti, was funded for a month to compare visual observations of cattle position to GPS recordings. Leonardo has presented preliminary results to his department in Florence Italy.

Numerous undergraduate students were employed by the project to collect and analyze the data. Two of those students are now project engineers for consulting engineering firms in Lexington, KY and Cincinnati, OH. Others are either in graduate school or still completing the requirements for their undergraduate degree.

## **4.0 Awards**

Blue Ribbon Award for Educational Aids-Web Page for “Cattle Production Practices in Grazed Watersheds of the Humid Region” by B.K. Koostra, C.T. Agouridis, J.R. Bicudo, S.R. Workman, E. Vanzant, and D.R. Edwards, 2003 International Meeting of the ASAE.

## **5.0 Publication Listing**

Agouridis, C.T. 2004. Cattle Production Practices in a Small Grazed Watershed of Central Kentucky. Ph.D. Dissertation, University of Kentucky.

Agouridis, C.T., D.R. Edwards, S.R. Workman, J.R. Bicudo, J.L. Taraba, E.S. Vanzant and R.S. Gates. 2004. Effects of Cattle Grazing and BMPs on Stream Water Quality. Paper for the 2004 ASAE International Meeting, Paper #042131, Ottawa, Canada, August 2-4, 27 p.

Agouridis, C.T., D.R. Edwards, S.R. Workman, J.R. Bicudo, J.L. Taraba, E.S. Vanzant and R.S. Gates. 2004. Influence of BMPs on Cattle Position Preference. Paper for the 2004 ASAE International Meeting, Paper #042182, Ottawa, Canada, August 2-4, 28 p.

Agouridis, C.T., D.R. Edwards, S.R. Workman, J.R. Bicudo, J.L. Taraba, E.S. Vanzant and R.S. Gates. 2004. Streambank Erosion Associated with Grazing Practices in Central Kentucky. Paper for the 2004 ASAE International Meeting, Paper #042227, Ottawa, Canada, August 2-4, 26 p.

Agouridis, C.T., D.R. Edwards, S.R. Workman, J.R. Bicudo, B.K. Koostera, E.S. Vanzant, J.L. Taraba. 200? Streambank Erosion Associated with Grazing Practices in the Humid Region TRANS of ASAE (in review)

Agouridis, C.T., D.R. Edwards, and B.K. Koostera 2003. BAE study evaluates impact of cattle grazing on stream bank erosion (<http://www.bae.uky.edu/wq406/publications/Newsletter%20-%20Spring%202003.pdf>)

Agouridis, C. T., T. S. Stombaugh, S. R. Workman, D. R. Edwards, B. K. Koostera. 2003. Examination of GPS collar capabilities and limitations for tracking animal movement in grazed watershed studies. ASAE Paper No. 032001, St. Joseph, MI:ASAE.

Agouridis, C.T., T.S. Stombaugh, S.R. Workman, B.K. Koostera, D.R. Edwards, and E.S. Vanzant. 2004. Suitability of a GPS Collar for Grazing Studies. Trans. ASAE 47(4):1321-1329.

Agouridis, C.T., S. R. Workman, R. C. Warner and G. D. Jennings. 2005 Livestock Grazing Management Impacts on Stream Water Quality. Journal of American Water Resources Association (accepted for publication)

Bicudo, J.R. 2002. Improving water quality. UK College of Agriculture Radio News, September 9-13. ([http://www.bae.uky.edu/ext/News\\_Events/BAE\\_Radio.htm](http://www.bae.uky.edu/ext/News_Events/BAE_Radio.htm)).

Bicudo, J.R. 2002. GPS Grazing News. Univ. KY, Dept. of Biosystems & Agr. Engr., Lexington, KY. (<http://www.bae.uky.edu/wq406/publications/Newsletter%20-%20Fall%202002.pdf>)

Bicudo, J.R., Agouridis, C.T., Koostera, B., and Workman, S.R. 2003. Cattle production practices in grazed watersheds. Fall Newsletter of the Environmental and Natural Resources Issues (ENRI) Task Force, University of KY Cooperative Extension Service, Lexington, KY

Bicudo, J.R., C.T. Agouridis, S.R. Workman, R.S. Gates, and E. Vanzant. 2003. Effects of air and water temperature and stream access on grazing cattle water intake rates. Paper No. 34034 presented at the 2003 Annual International Meeting of the ASAE, Las Vegas, NV. July 27-31, 2003.

Bicudo, J.R. and Akers, J. 2002. Master cattleman environmental stewardship and industry awareness. University of Kentucky Cooperative Extension Service CDAS-004, Lexington, KY (on CD-ROM).

Bicudo, J.R., Burris, R., and Laurent, K. 2002. Master cattleman facilities and animal behavior. University of Kentucky Cooperative Extension Service CDAS-005, Lexington, KY (on CD-ROM).

Bicudo, J. R. and R. S. Gates. 2002. Water consumption, air and water temperature issues related to portable water systems for grazing cattle. ASAE Paper No. 02-4052, presented at 2002 ASAE Annual International Meeting/CIGR XV World Congress, July 28-31, Chicago, IL

Kooststra, B.K., C.T. Agouridis, and S.R. Workman. 2003. Analysis of GPS position data for beef cattle. ESRI User Conference, San Diego, CA. July 9.

van Rensburg, L., E.S. Vanzant, J.A. Benson, C.L. Adkins, and K.A. Beighle. 2003. Effect of increasing level of soybean hulls on intake and utilization of endophyte-infested tall fescue hay by beef steers. *J. Anim. Sci* 81(Suppl. 2):105-106.

van Rensburg, L. J., and E. S. Vanzant. 2004. Effect of increasing level of soybean hulls on intake and utilization of endophyte-infected fescue hay by beef steers. *Kentucky Ag. Exp. Sta. SR-2004-2*. pp 14-17.

Vanzant, E. S. 2004. Increasing level of soybean hulls for stocker steers grazing endophyte-infected fescue. *Kentucky Ag. Exp. Sta. SR-2004-2*. pp 19-21.

Vanzant, E. and S. Workman. 2002. GPS for tracking cattle. *Cow Country News*, November, 2002. Kentucky Cattlemen's Assn., Lexington, KY.

Workman, S.R., Bicudo, J.R., Vanzant, E.S., Edwards, D.R. and Agouridis, C.T. 2003. Cattle Production Practices in Grazed Watersheds of the Humid Region. Presentation for the USDA-CSREES National Water Quality Conference in Tuscon, AZ., January 12-15.

Workman, S.R., Bicudo, J.R., Vanzant, E.S., Edwards, D.R. and Agouridis, C.T. 2004. Cattle Production Practices in Grazed Watersheds of the Humid Region. Presentation for the USDA-CSREES National Water Quality Conference in Clearwater, Florida, January 11-14.

### **In Preparation**

Agouridis, C.T., D.R. Edwards, S.R. Workman, J.R. Bicudo, J.L. Taraba, and E.S. Vanzant. Influence of BMPs on Cattle Grazing Preferences. *Transactions of the ASAE*.

Agouridis, C.T., D.R. Edwards, S.R. Workman, J.R. Bicudo, B.K. Kooststra, E.S. Vanzant, J.L. Taraba. Cattle Behavior as tracked by GPS Collars. *Journal of Applied Animal Science Behavior*.

Agouridis, C.T., D.R. Edwards, S.R. Workman, J.R. Bicudo, J.L. Taraba, and E.S. Vanzant. Effects of Cattle Grazing and BMPs on Stream Water Quality. *Transactions of the ASAE*.

Agouridis, C.T., D.R. Edwards, S.R. Workman, J.R. Bicudo, J.L. Taraba, and E.S. Vanzant. Field Accuracy of GPS Collars. *Transactions of the ASAE*.

Agouridis, C.T., D.R. Edwards, S.R. Workman, and E.S. Vanzant. Activity Sensors and Animal Behavior. *Transactions of the ASAE*.