

Analysis of GPS Position Data of Beef Cattle

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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.

Introduction

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 2.26 million beef cattle and calves in the state making Kentucky the number one beef producer east of the Mississippi River (KASS, 2001). With such a large portion of Kentucky's agricultural industry committed to the production of cattle, the environmental impacts of these grazing animals are potentially significant. Currently 75% of the surveyed river miles in Kentucky do not fully support swimming use because of high fecal coliform levels. 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. In their 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 agriculture.

Research into the effects of cattle grazing on stream water quality has been well documented in the western portion of the United States; because, the arid environments of the western United States have been viewed as more fragile than that of the humid, temperate regions of the eastern U.S (U.S. Department of Interior, 1994 as reported in Belsky et al., 1999; Clark, 1998). Thus, the water quality impacts of grazing cattle in a humid, temperate environment such as that of Kentucky may differ significantly from those witnessed in the arid West. One approach to minimizing the impacts of cattle grazing on stream quality is through the use of a program of Best Management Practices (BMPs). The purpose of BMPs is to reduce nonpoint sources of pollution. For reducing the impacts of cattle grazing on the health of the stream, both structural control BMPs and cultural control BMPs are ideal. Structural control BMPs modify the transport of the pollutants to waterways (e.g., riparian buffers and vegetated filter strips) while cultural control BMPs are designed to minimize pollutant inputs to waterways through land management practices such as managed grazing (McFarland et al., 1999). By using a program of BMPs (i.e., multiple BMPs), the achievement of water quality goals is more likely since the effectiveness of each BMP varies depending upon the pollutant(s) of concern.

Riparian Area Grazing Research at UK

Cattle grazing research conducted by the Biosystems and Agricultural Engineering Department at the University of Kentucky is primarily focused on determining whether cultural BMPs (alternate water sources, alternate shade sources, etc.) will alter cattle behavior. The research is also attempting to assess the effect of the cultural BMPs on stream water quality. The project area consists of two replications of three pasture scenarios: implemented BMPs with a fenced riparian area that limits cattle access to the stream, BMPs with free access to the stream, and free access with no BMPs (control scenario). Figure 2 is a map of the project area showing the pasture scenarios in two replications.

Data are being obtained for the project to determine the effects of the cattle on the stream and the effectiveness of the BMPs. Water samples are collected bi-monthly at multiple locations through the project area. The samples are analyzed for eleven parameters including nitrogen, phosphorus, total suspended solids, and biochemical oxygen demand. Monthly surveys are

performed of permanent cross-sections to monitor streambank erosion and monthly photographs are taken to document visual changes of the stream. An automated weather station is located near the project area and records weather data such as temperature, relative humidity, and rainfall at an hourly interval.

A survey of the project area was performed using a Real-time Kinematic Global Positioning System (RTK-GPS) to map selected features of the pastures including the fences, gates, trees, waterers, stream banks, and the stream cross-section benchmarks. The survey allowed the creation of an accurate base map to be used in the GIS analysis of the data (Fig.2).



Figure 1 - Photograph of a portion of the grazing project area.

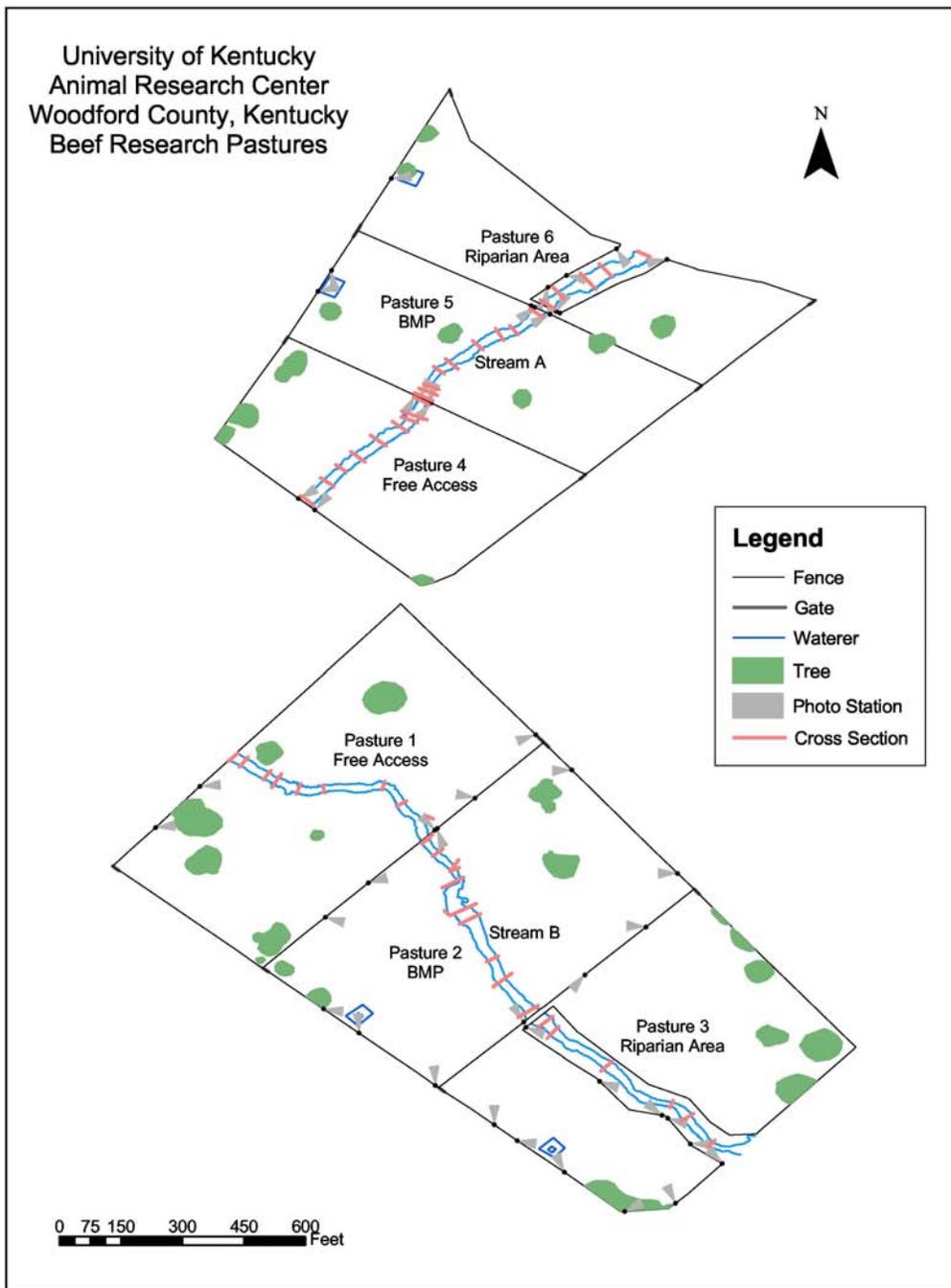


Figure 2 - Map of the project area.

Use of GPS Collars to Track Cattle Position

The University of Kentucky has been utilizing GPS collars (Fig. 3) to track cattle positions in the pastures since the early 1990s (Turner, 2002). The collars consist of an eight-channel GPS receiver, GPS antenna, radio beacon transmitter, activity sensors, data storage and a battery all attached to an adjustable leather collar. The collars can determine positions at intervals of five minutes or greater with a total on-board memory capacity of 5,208 positions. The stored information includes the collar ID, date, time, geographic position (latitude and longitude), elevation, dilution of precision, and the fix status (2D or 3D).

The data collected by the collars are downloaded onto a PC and post-processed to achieve differential correction using a software application provided by the collar manufacturer. This application outputs the corrected data files in multiple formats. One of the formats, a comma delineated text file, was selected to be imported into ArcGIS for analysis.



Figure 3 - GPS collar on a cow.

Using ArcGIS for Data Management and Analysis

ESRI's ArcGIS package was selected for our project as the software solution for data management, integration, and analysis based on the software's scalability, functionality, and ability for customization. The capability to create custom scripts and tools using Visual Basic for Applications for our specific analysis tasks allows our data to be more consistent by automating tasks while increasing efficiency.

Creating and Importing Into a Geodatabase

To store the GPS collar data, geodatabases are used to consolidate data from the individual collars into a single database for a particular data collection period. For example, 17 collars are deployed for a period of 18 days. Each of the data files collected from the collars is added to the geodatabase created for that 18 day collection period. To maintain consistency between databases, an automated script is used to create the geodatabase using predetermined attributes and data formats. For our specific analytical needs and to conserve resources, only selected data attributes from the data file created by the post-processing software are imported into the newly created geodatabase. Also, attribute names are modified based on naming preferences of the project personnel.

In ArcGIS, a custom toolbar was created to launch the scripts created to perform the tasks associated with analysis of the GPS collar data. One of the tools opens a dialogue box prompting the user to create a new geodatabase (Fig. 4). Another tool launches a script that "cleans" the data file by looking for points with null positions and imports the "cleaned" file into the user-selected geodatabase.

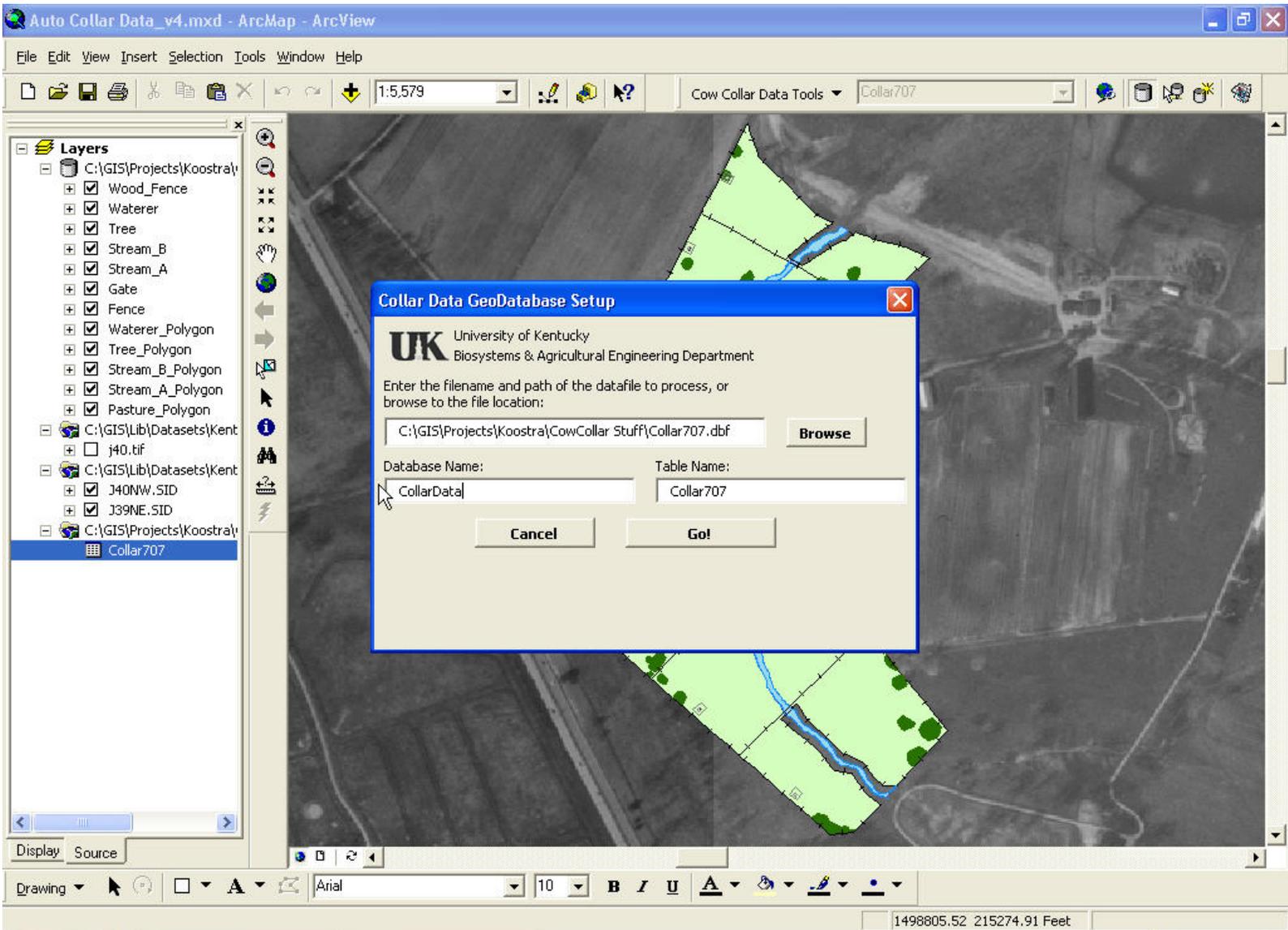


Figure 4 - Dialogue box for new geodatabase setup.

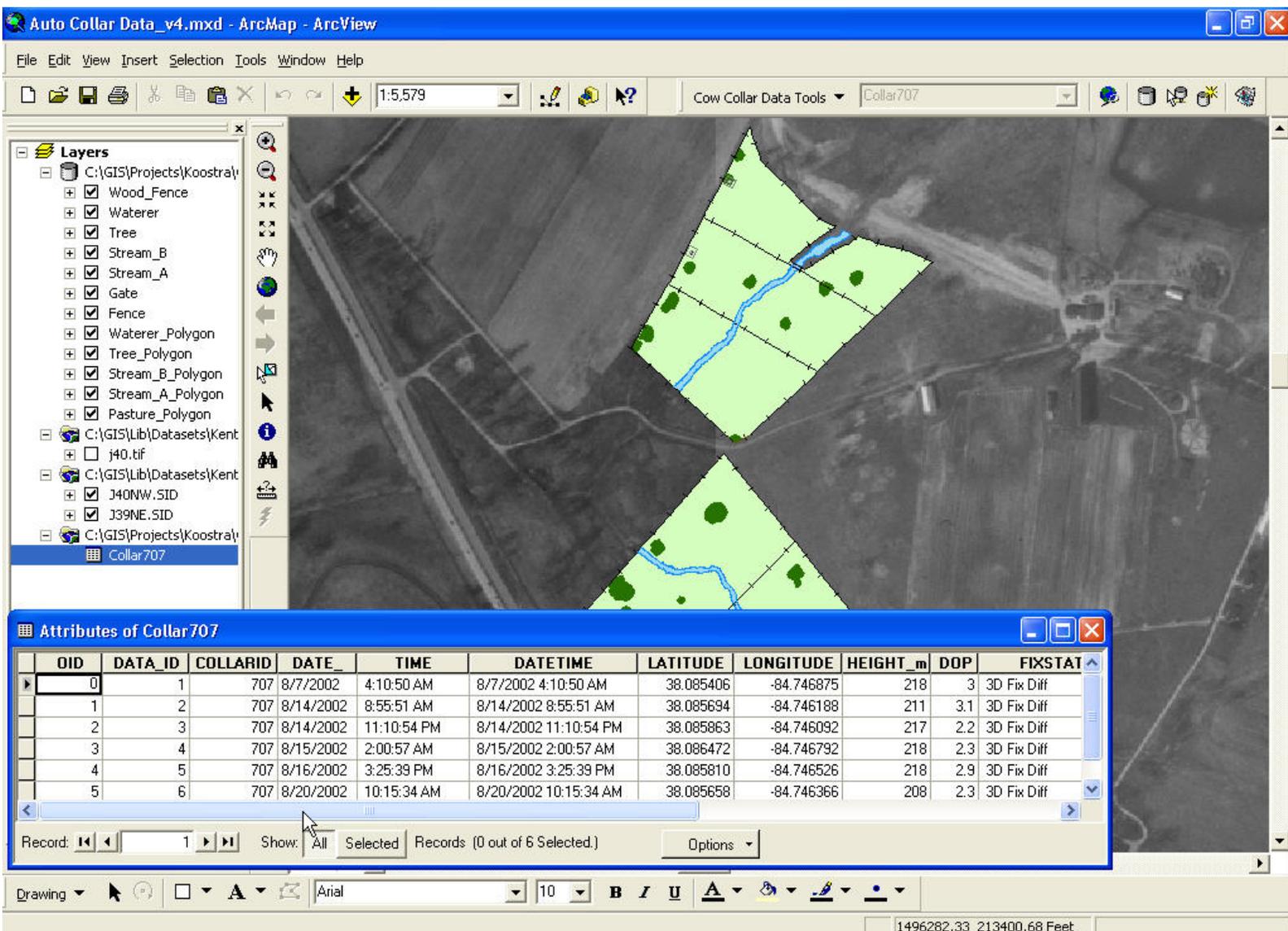


Figure 5 - Custom toolbar and example dataset.

Integrating Weather Data

Since weather information is useful in the analysis of the factors that affect cattle movement, selected weather parameters collected near the project site are integrated with the position data from the collars. Because the weather data are collected at hourly intervals and the GPS collar positions are collected at five-minute intervals, a custom script was created to integrate the data. The weather data are imported into a table and the time attribute for the collar positions are converted to an hourly format. For example, positions collected between 6:30:00 am and 7:29:59 am are assigned the hour 0700. Similarly, positions collected between 3:30:00 pm and 4:29:59 pm are assigned the hour 1600. The weather data for air temperature and relative humidity are then added as attributes to the geodatabase feature classes created for each collar.

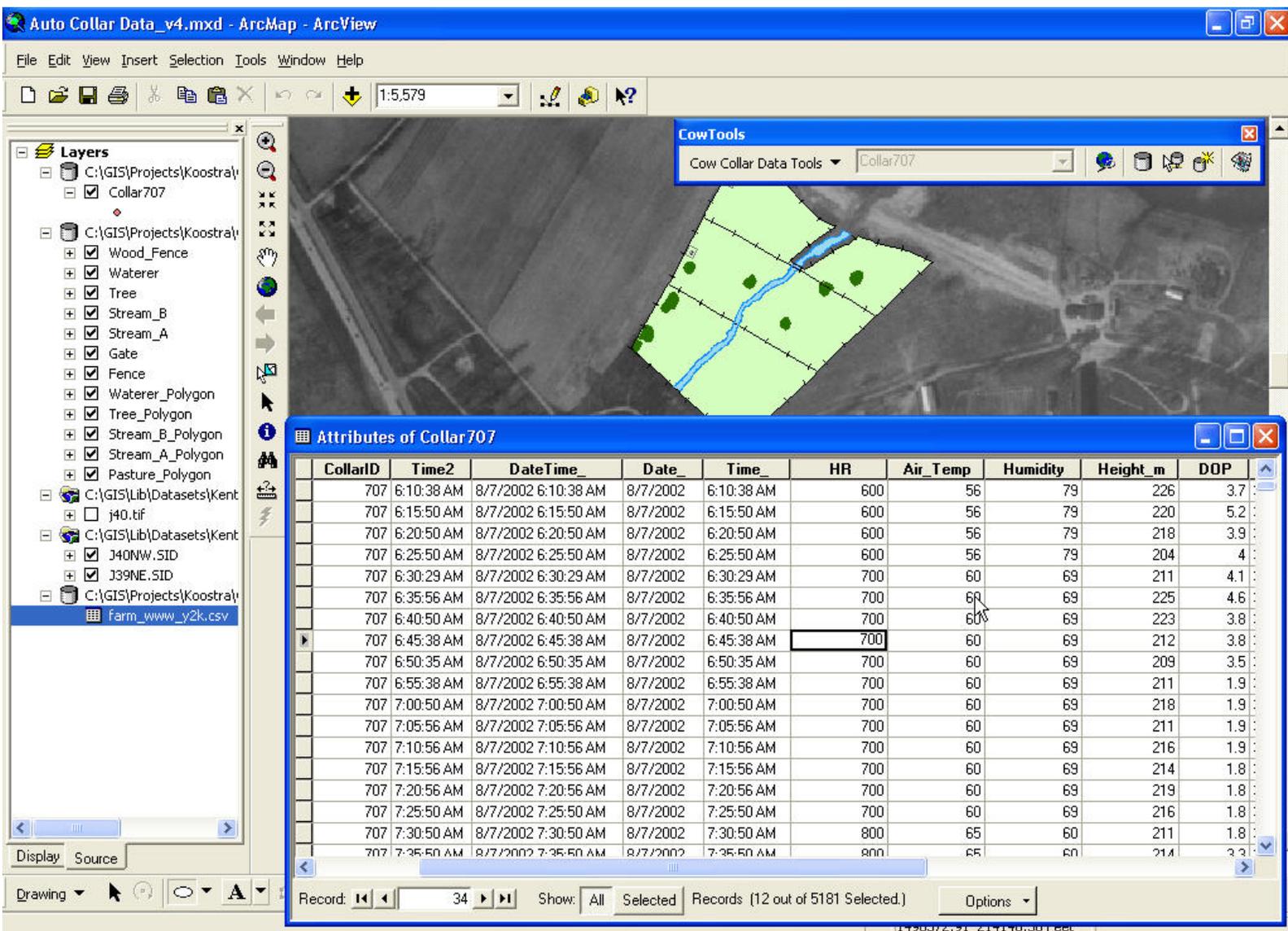


Figure 6 - Attribute table with integrated weather data.

Using GIS for Data Analysis

One of the common analysis techniques that is used for the project is determining a percentage of time that the animals are at or near a given feature (i.e. stream, stream crossing, waterer, supplemental feeding area, trees, etc.). Typically this task is performed by making a query in ArcMap using the "Select by location" feature to determine the quantity of data points (positions) located within distance buffers of the features of interest. The quantity is then compared to the total number of points resulting in percentages of time that the cattle are at or near the selected feature. For example, this information is essential in determining how much time the animals spend in or very near the stream.

A major part of the research being performed involves determining the influence of BMPs on cattle behavior specifically in relation to cattle interaction with a stream. To analyze our data, a custom script was created to determine the distance from each point to the stream. Factors that influence cattle position and movement can be investigated to determine if a statistical correlation exists between the presence, absence, or degree of the factor. For example, air temperature has the potential to affect the cattle positions by influencing the animal to seek a shaded area or to attempt to use the stream for cooling.

Additional uses of this information include determining pasture utilization by cattle. For example, the position data can be analyzed to determine poor and good grazing areas within pastures. The producer then has the information needed to delineate the poor areas as a management zone and potentially use BMPs or pasture improvements to increase the cattle utilization of these management zones.

Displaying Data

The initial methods to display the data obtained from this project for dissemination has been the creation of static maps and graphics using Adobe Acrobat .pdf format. This format allows for a relatively standard compatibility with a wide range of interested parties. Initial plans for the project included using ESRI's ArcPublisher to create more dynamic viewing experience by allowing constituents to zoom and pan within a map as well as turn on and off various data layers. Based on the size of the geodatabases, this method of viewing the data was not selected for implementation.

A future option for the project is implementing ArcIMS through the project website as an interactive method for publishing the collected data. Users would have the capability to view, query, and interact with the data on a web browser while maintaining a central, secure storage location for the data. The major limitation of this type of method is the Internet connection speed limitations of users that would potentially access the data.

Conclusion

The use of ArcGIS for data management, integration, and analysis of GPS collar data allows for consistency and efficiency by using custom scripts and tools. The results of the analysis contribute to the understanding of the influence of BMPs on cattle behavior and stream water quality.

References

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