Remote Sensing for Detecting Swine Animal Feeding Operations

Donald Garofalo & David B. Jennings
U.S. EPA, Office of Research and Development,
National Exposure Research Laboratory, Reston, Virginia

EPA Science Forum 2004
Healthy Communities and Ecosystems

ABSTRACT

Surface runoff from animal feeding operations (AFOs) and its infiltration into groundwater can pose a number of risks to water quality mainly because of the amount of animal manure and wastewater they produce. Excess nutrients generated by livestock facilities can lead to algal blooms and anoxic water conditions, shellfish bed contamination, loss of water recreation activities, and possibly fish kills and human health dangers.

Developing a cost-effective approach for locating and studying existing AFOs over a broad regional area is a first step to determining the spatial relationships between these facilities and water quality. A system, which is capable of identifying and inventorying existing facilities and determining their geographic location and distribution with regard to other landscape features such as drainage, geology, soils, slope, and vegetation, should provide important insight for assisting farmers and planners in reducing the environmental risks associated with existing and future animal feeding operations, respectively.

Our research focused on the use of a Geographic Information System (GIS) and high spatial resolution IKONOS satellite data for semi-automatically detecting animal feeding operations in an area of Duplin County, North Carolina. Our results show that single-date, high resolution satellite remote sensing data (IKONOS 4-meter, multi-spectral data) combined with GIS-based semi-automated image processing and geometric analysis of swine animal feeding operation features and geography can yield overall detection accuracies of 76% for hog barns and 79% for lagoons.

Our study area is a portion of Duplin County, North Carolina. The county has experienced problems of excessive nutrients in its waterways and of the 1,359 farms in the county (based on the 1992 Census of Agriculture survey), nearly one-quarter, 338, raise hogs or pigs. In total, more than 1 million hogs and pigs are raised in Duplin County annually.

Environmental Issues

Excess nutrient runoff and accidental lagoon spills due to poorly managed facilities or flooding can lead to:

- Drinking water contamination
- Algal blooms and anoxic water conditions
- Shell-fish bed contamination
- Fish kills
- Impairment of water recreation activities

Animal confinement occurs at specially designed facilities for feeding livestock & moving waste into storage/treatment lagoons.

Wastes are piped to lagoons

Breaches in lagoons may occur

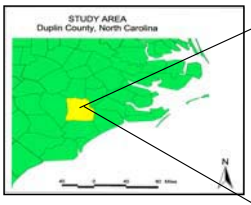
Liquid wastes may be sprayed onto fields

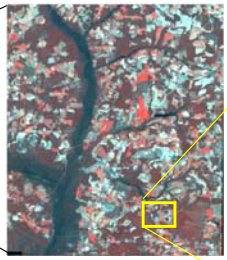
Wastes may run off to streams and rivers

Project Goal

Determine the capability of a high resolution, commercially available, satellite remote sensing system for semi-automatically detecting and mapping swine animal feeding operations over a large geographic area, and to determine both the feasibility and accuracy of our approach

Study Area





Two scene IKONOS image mosaic of USGS, Albertson, NC, Quadrangle

Swine CAFO Facilities in Study Area As Seen on IKONOS Imagery

Approach

CREATE "TRUTH" DATA SET

Mosaic two adjacent scenes of IKONOS data to create a single coverage for the Albertson, North Carolina, quadrangle.

Perform manual analysis on the image to create a "truth" data set. Use grid on the image mosaic to inventory features representing lagoons and hog barns.

MEASURE

Measure sizes of lagoons and hog barns across the study area to determine their range of sizes and distances of these features to each other. Table 1 shows the results of the inventory.

CLASSIFY

Perform un/supervised, automated classification on the IKONOS image to classify the image into land cover classes. Select and group classes that spectrally relate to known water (e.g., lagoon) and building (e.g., hog barn) features. Table 2 shows the results of the un/supervised classification as opposed to the results from the manual image analysis.

FILTER

Create shape files in ArcView representing potential lagoons and hog barns. Apply filtering to eliminate potential lagoon and hog barn features not meeting the size and distance metrics described above. Table 3 shows the results of the filtering process.

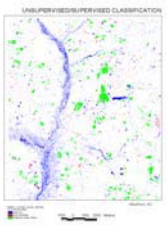
Results

	Size (square meters)	Distance
Lagoons	>1,030 and <30,000	<=105m
Hog Barns	>350 and <3,480	<=105m

Table 1. Results of measuring lagoon & hog barn features on "truth" data set.

Analysis Type	Lagoons	Hog Barns
Un/supervised Classification	161,930	15,088
Manual Image Analysis ("Truth")	123	313

Table 2. Number of Potential Lagoon and Potential Hog Barn



Filter Type Applied	Lagoons	Hog Barns
Unfiltered	161,930	15,088
Size Filter	462	558
Size + Distance Filters	127	272
"Truth" Data Set	123	313

Table 3. Data Filtering. This table shows the results of applying metrics to reduce the number of potential hog barn and lagoon polygons based on feature size and distance criteria as determined from the "truth" data set.

Accuracy

Results show semi-automated detection accuracy of 76% for hog barns and 79% for lagoons. Errors of omission and commission were also evaluated. Many errors of commission for hog barns (44%) resulted from misidentifying fallow agricultural fields with low soil moisture as hog barns. Conversely, lagoon errors of commission (47%) resulted from misidentifying fallow agricultural fields with high soil moisture content as lagoons. Errors of omission occurred when a hog barn or lagoon mapped in the "truth" set was not detected during the automated analysis. Research is continuing on ways to reduce both errors of commission and omission.