Topical Session A: Integration of Environmental Policy and Science

The Effect of Environmental Regulation on the U.S. Livestock Industry

Park Dooho[1], Andrew Seidl[2], and W. Marshall Fraiser[3]

Since enactment of the 1972 Clean Water Act (CWA), industries potentially creating point sources of water pollution are required to obtain National Pollutant Discharge Elimination System (NPDES) operating permits. With revision of the CWA in the mid-1980s, livestock operations of greater than 1,000 Animal Units, or those found in environmentally sensitive locations, also were subject to regulation. Currently, 43 States have enforcement authority of NPDES permits by the U.S. Environmental Protection Agency. In addition, State and local concerns surrounding environmental management of livestock operations created a mosaic of State-level environmental policy conditions. In 1998, at least a half-dozen States and the Federal Government considered legislation to more closely monitor emissions from livestock operations. Environmental policies applied to livestock generally discriminate against larger, incorporated, or vertically integrated operations. These policies tend to address ground- and surface-water concerns and, increasingly, air-quality issues.

Concurrently, the livestock industry has been in a state of change. Due to technological innovation and lower transportation costs, the livestock industry has become less tied to feed supplies. The choice of where to locate is determined largely by access to input and output markets, technology employed, and the environmental attributes of the land. Lower transportation costs free location decisions and result in the specialization and concentration of several livestock species industries. It has been hypothesized that the stringency of environmental regulation is either (a) driven by or (b) becomes the catalyst for change in the livestock industry. Alternatively, the willingness and ability to enforce regulations may affect location and stocking decisions. Currently, little empirical evidence testing these hypothesized relationships is found in the literature.

This paper examines the state level (50 States) effects of environmental policy across livestock species (for example, hogs, beef cattle, dairy, and chickens) over the almost three decades since the passage of the CWA. We differentiate between the letter of the law and indicators of the willingness to enforce it on a State-by-State basis. State level differences between environmental policies and growth rates are developed by livestock species over time. We expect changes in stocking rates and operation profiles to lag the imposition of new environmental policies for existing operations and anticipate them for new operations. We expect the combination of the stringency of environmental regulation, coupled with the willingness to enforce them (for example, highest average compliance costs), will most strongly guide the evolution of the livestock industry when location factors are most open. Potential information emanating from this study includes the efficacy of uniform Federal standards for reaching national water-quality objectives and evidence about the effectiveness of competition among States for livestock-based economic development using weak environmental policy as an attractor for the industry.

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[1]Colorado State University, Fort Collins, CO 80523 (dhpark@lamar.colostate.edu)
[2]Colorado State University, Fort Collins, CO 80523 (aseidl@agsci.colostate.edu)
[3]Colorado State University, Fort Collins, CO 80523 (mfraiser@lamar.colostate.edu)

Integrating Physical and Human-Induced Characteristics in the Decision-Making Process

Carol Mladinich[1] *and Richard Zirbes*[2]

Decisions regarding land and resources are complex and emotionally charged. Features on or below the land surface often are not taken into account nor clearly portrayed. By combining the physical characteristics of the land with the human settlement patterns, we can achieve a more accurate and comprehensive depiction of the landscape, which can help communities make decisions regarding growth and its impacts. The U.S. Geological Survey Front Range Infrastructure Resources project is developing a Group Spatial Decision Support System for integrating the scientific data characterizing an area; such integrated information will help people make decisions that can mitigate many of the consequences of growth.

[1]U.S. Geological Survey, Box 25046, MS 516, Denver, CO 80225-0046 (csmladinich@usgs.gov)
[2]U.S. Geological Survey, Box 25046, MS 516, Denver, CO 80225-0046 (rjzirbes@usgs.gov)

Delaware's Animal Feeding Operations Strategy: A Critical Analysis of the Goals and Measures of Success

J. Thomas Sims[1]

More than 25 years of research has shown that agricultural nutrients are impacting Delaware's ground and surface waters. Nitrate contamination of ground waters used as drinking-water supplies and eutrophication of fresh and estuarine waters by agricultural nitrogen (N) and phosphorus (P) are the major water-quality problems in Delaware historically, and today. Human-health concerns related to eutrophic waters (for example, *Pfiesteria*) have emerged in recent years and created an additional impetus for improving agricultural nutrient management.

Delaware agriculture is dominated by a large and geographically intense poultry industry. Approximately 260,000,000 broiler chickens are produced each year in a State with about 225,000 hectares (ha) of cropland. Research has shown that the nutrient surpluses and nutrient-management problems associated with concentrated poultry production play a major role in nonpoint-source pollution of Delaware waters by agriculture. Fertilizer N use is another significant factor. In 1997, Delaware entered into a Total Maximum Daily Load (TMDL) agreement with the U.S. Environmental Protection Agency (USEPA) as a result of a lawsuit filed against USEPA by a consortium of environmental groups. In the TMDL agreement, the State of Delaware agreed to reduce N and P loads to surface waters by as much as 60-85%. Close upon the TMDL settlement have come State efforts to develop a coordinated response to the newly developed U.S. Department of Agriculture (USDA)-USEPA Unified Strategy for Animal Feeding Operations. A Governor's Agricultural Industry Advisory Committee on Nutrient Management prepared a series of recommendations in late 1998 and proposed legislation in the spring of 1999 that would establish a Delaware Nutrient Management Commission to "*..regulate those activities involving the generation and application of nutrients in order to help improve and maintain the quality of Delaware's ground and surface waters to meet or exceed federally mandated water quality standards, in the interest of overall public welfare"*. Similar legislation has been passed in Maryland, Pennsylvania, and Virginia.

One of the major needs in the ongoing effort to improve nutrient management for water-quality protection is a systematic process to clearly establish goals and document success. This presentation critically analyzes the establishment of nutrient-management goals that will achieve water-quality improvement and outlines a series of measures that can be used to determine if we are progressing toward these goals. The emphasis will be on the changes needed in nutrient management by animal agriculture, and specific recommendations will be made on the most effective means to implement change, as well as areas where future research should be focused.

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[1]Delaware Water Resources Center, University of Delaware, Newark, DE 19717-1303 (jtsims@udel.edu)

A Research Overview of the Effects of Confined Animal Feeding Operations on Aquatic Ecosystems

Thomas A. Muir[1], Franceska D. Wilde[2], James W. Preacher[3], and Lawrence R. DeWeese[4]

Confined animal feeding operations are a rapidly growing sector of the United States agricultural economy. The U.S. Geological Survey (USGS) is actively involved in research efforts to assess the effects of Animal Feeding Operations (AFOs) on aquatic ecosystems and on the chemical quality of ground-water and surface-water resources. The purpose of this presentation is to provide an overview of USGS research and monitoring activities related to AFOs. In addition, some USGS capabilities for studying the effects of AFOs on aquatic biota and the effects of aquaculture on the environment will be examined.

USGS scientists are applying diverse and interdisciplinary approaches to ecosystem research, in particular with respect to understanding contaminant transport and assimilation processes. Questions being addressed through research and on-site monitoring involve the occurrence and magnitude of nutrients, pharmaceuticals, and pathogens that could be entering streams and ground-water systems and that originate from concentrated sources of animal feed and waste products. The results of these studies are germane to public concerns that industrial-scale livestock, dairy, swine, poultry, and aquaculture operations could have acute, long-term, and cumulative effects on riparian, surface-water and ground-water resources.

A summary of some of the major categories of USGS research and investigations related to concentrated animal feeding operations follows:

PHARMACEUTICALS (antibiotics and endocrine disruptors): Reconnaissance sampling of 100 streams across the United States is underway to provide baseline data on the occurrence of antibiotics in streams. Occurrences of antibiotics will be compared with predominant animal types for respective watersheds.

PATHOGENS (viruses, bacteria, and protozoa): Streams and ground water adjacent to high-density animal production facilities are being sampled for pathogens in five States.

NUTRIENTS (nitrates, ammonia, phosphorus): Monitoring the water quality of springs in a region of northern Arkansas populated with poultry AFOs is ongoing to determine the nonpoint source of nutrient contamination.

METALS, TRACE ELEMENTS, AND PESTICIDES: The fate and transport of these contaminants in runoff from dairy operations in California is being investigated.

TECHNOLOGY AND METHODS DEVELOPMENT: Analytical methods to detect low concentrations of some of the most prevalent classes of pharmaceutical compounds are being developed and validated. DNA testing is being conducted to determine the source (poultry or cattle) of fecal-coliform contamination in Missouri streams. RNA ribotyping techniques are being developed and applied to track the source of microorganisms in Virginia streams and ground water near AFOs. Age dating and nitrogen isotope ratio analyses are being applied to ground-water samples in Colorado to determine the origin of elevated nitrate and ammonia. Computer models, such as SPARROW, are being developed and adapted to assist water-resource managers in their decision making

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[1]U.S. Geological Survey, MS 300, 12201 Sunrise Valley Drive, Reston, VA 20192 (tom_muir@usgs.gov)
[2]U.S. Geological Survey, MS 412, 12201 Sunrise Valley Drive, Reston, VA 20192 (fwilde@usgs.gov)
[3]U.S. Geological Survey, MS 300, 12201 Sunrise Valley Drive, Reston, VA 20192 (jim_preacher@usgs.gov)
[4]U.S. Geological Survey, P.O. Box 25046, MS 406, DFC, Denver, CO 80225-0046 (rdeweese@usgs.gov)

Hydrologic Monitoring to Characterize Dominant Controls of Ground-Water Flow and Transport in an Area of Confined Animal Operations on a Mantled Karst Terrane, Northwestern Arkansas

John V. Brahana[1], Thomas J. Sauer[2], Phil Hays[3], Timothy M. Kresse[4], Paul Little[5], and Jaysson Funkhouser[6]

The Savoy Experimental Watershed (SEW) is a University of Arkansas property of approximately 1,250 hectares (ha) in northwestern Arkansas. The SEW occurs on a mantled (regolith-covered) karst and is the site of an integrated research effort between the University of Arkansas, Arkansas Department of Environmental Quality, Agricultural Research Service of the U.S. Department of Agriculture, and the U.S. Geological Survey. As part of the integrated research effort, a long-term, interdisciplinary field laboratory will be developed for the in-situ quantitative determination of processes, controls, and hydrologic and nutrient-flux budgets in surface-water, soil-water, and shallow ground-water environments in response to specific, near-surface confined animal operation (CAFO) activities and land uses. Comprehensive research at SEW encompasses the detailed aspects of flow and solute budgets (1) from precipitation, (2) from near-surface anthropogenic activities, (3) in runoff, (4) from within the soil zone, (5) at the epikarst, (6) from within identifiable components of the shallow karst aquifer, and (7) at spring resurgences. This presentation is limited to selected elements of budget terms (5), (6), and (7), with the objective of relating areal, stratigraphic, and temporal variations in water quality to identifiable CAFO activities and to ground-water processes and controls. Current CAFO activities in basin 1 at SEW have focused on cattle and poultry.

Continuous hydrologic monitoring at SEW includes measuring precipitation in 0.01-inch increments, and measuring interflow, epikarst flow, streamflow, water levels in selected wells, spring discharge, and appropriate water-quality parameters, all at 15-minute increments with automated probes and samplers. Discrete samples of groundwater from the previously mentioned sources are also collected throughout selected storm hydrographs (at about 1-hour increments) for analyses of water-quality constituents not easily measured by existing sensors. These data provide a wealth of information that allows mass-balance calculations, boundary-flux determinations, and water-quality evolution, all within a well-constrained areal and temporal framework amenable to numerical simulation at a site-specific scale.

Understanding gained at SEW has been applied to studies of CAFO sites elsewhere in the mantled-karst areas of the southern Ozarks, and has been used to guide data-collection rationale. Preliminary conclusions of interest are:

1) Temporally random sampling not keyed to specific hydrologic flow conditions is of little value, and does not characterize important transport features of the system;
2) Sampling from springs in karst terranes integrates the most important components of the flow system, as contrasted to sampling from wells, which typically are indicative of only a single flow component;
3) Dissolved nitrate concentrations in ground water from CAFO areas of northwest Arkansas range from 0.5 to greater than 50 milligrams per liter (mg/L). Most nitrate concentrations in ground water are less than 5 mg/L, and most of the concentrations greater than 20 mg/L have been traced to failed septic systems, and not CAFO sources;
4) Dissolved phosphorous species in ground water typically are less than 0.5 mg/L. Ground-water flow paths do not appear to be major pathways of dissolved phosphorus transport in this hydrogeologic setting;
5) Pathogen densities in ground water are dependent on flow conditions, and have been observed to range from less than 10 to greater than 500,00 colony forming units per 100 milliliters (cfu/100 mL) from the same spring. Pathogen transport in karst aquifers appears to involve resuspension of microbes from the sediment, with highest concentrations occurring at the leading edge of flood pulses; and
6) Pharmaceuticals from CAFO areas are transported in ground water, but the concentrations measured thus far in Northwest Arkansas are below the microgram per liter level.

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[1] University of Arkansas, 118 Ozark Hall, Fayetteville, AR 72701 (jbrahana@jungle.uark.edu)
[2]U.S. Department of Agriculture, Agricultural Research Service, National Soil Tilth Research Laboratory, 2150 Pammel Drive, Ames, IA 50011
[3]U.S. Geological Survey, 401 Hardin Road, Little Rock AR 72211-3528 (pdhays@usgs.gov)
[4]Arkansas Department of Environmental Quality, 8001 National Drive, Little Rock, AR 72209
[5]University of Arkansas, Fayetteville, AR 72701 (pr101@comp.uark.edu)
[6]U.S. Geological Survey and University of Arkansas, Fayetteville, Arkansas (jefunkho@usgs.gov)