



The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

Regulatory Responses to Potential Pollutants from Animal Feeding Operations: Opting Out of Costly Permitting Regulations

Terence J. Centner and Jeffrey D. Mullen

Because of excessive water impairment, federal and state agencies have enacted regulations to reduce water pollution from animal feeding operations. Many of the regulations are based on numbers of animals rather than the potential of an operator to impair water quality. To enhance efficiency, critical production indicators and location screening factors might be used to exempt operations that are not significantly impairing water quality. In this manner, regulations could avoid imposing unnecessary costs on the regulated public and more effectively target monitoring and enforcement resources of the regulatory agency.

Key Words: concentrated animal feeding operations, pollution, production indicators, regulations, water impairment

JEL Classifications: K2, K32, Q25, Q28

Members of the public and policy makers have identified animal feeding operations (AFOs) as sources of water pollutants that need further regulation by the Environmental Protection Agency (EPA 2001a, 2001b, 2003). Nutrient contamination and pathogens from animal manure have served as a justification for more extensive regulatory controls over these operations (Centner 2003; Innes 2000; Metcalfe). Many of the legislative proscriptions have dealt specifically with large AFOs—those meeting the definition of a concentrated animal feeding operation (CAFO).

Although CAFOs have been regulated for more than 25 years (U.S. Code Annotated), many of these operations had not secured National Pollutant Discharge Elimination System

(NPDES), or analogous state permits, for a number of reasons (General Accounting Office 2003). With the adoption of revised regulations for CAFOs effective on April 14, 2003, this situation is changing. With more specific regulations, the elimination of the storm event exemption, and stipulations concerning the agricultural storm water discharge exclusion, governments can more readily identify which operations are required to have NPDES permits (Centner 2004).

Confined livestock and poultry operations generate three times as much raw waste as humans (EPA 2001b). Each year AFOs, produce an estimated 1.23 and 1.32 million tons of economically recoverable units of nitrogen and phosphorus, respectively (Taylor). Nitrates and phosphates from AFOs are leading to nutrient enrichment, causing the eutrophication of bodies of water. Nutrients and particles from this waste are thought to account for 9%

Terence J. Centner is professor and Jeffrey D. Mullen is assistant professor, Department of Agricultural and Applied Economics, The University of Georgia, Athens, GA.

of our country's impaired river and stream miles (General Accounting Office 1995). Fecal contamination of water supplies by animal waste is an especially noteworthy concern (EPA 2000).

Under the "polluter pays" principle, we might seek to impose all of the costs of this pollution on producers. However, precedents concerning the use of land, air, and water resources for the disposal of byproducts mean that we allow reasonable amounts of pollutants to enter bodies of water without requiring financial extractions (Ogishi, Metcalfe, and Zilberman). The determination of what amounts are reasonable is left for legislative bodies. A complex regulatory set of water contamination rules, including the Clean Water Act, NPDES permits, and state regulations, have been adopted by governments.

Because many point sources of pollution have been meaningfully regulated, governments are seeking ways to address additional sources of pollutants, including those from AFOs, to reduce the continued widespread impairment of bodies of water. The EPA's proposal for new federal CAFO regulations in 2001 suggested the doubling or tripling of producers required to secure NPDES permits. However, this would have been accompanied by additional annual costs of \$831–\$935 million (EPA 2001a). Under the revised regulations, producers are expected to incur an extra \$326 million in annual costs. These costs should be offset by similar annual benefits (EPA 2003).

The federal NPDES permit requirements and related state regulations have generally been based on the number of animal units at individual operations (EPA 2001a, 2003). AFOs with more than a given number of animals are declared to have a high potential to discharge pollutants and are designated as CAFOs. Each CAFO must secure an NPDES permit. This simplistic qualification fails to account for known attributes whereby certain CAFOs have little or no likelihood of having a discharge of pollutants into public bodies of water. Therefore, current legislation unnecessarily regulates some CAFOs that have limited potential to cause denigration to our waters.

Research suggests that CAFOs that do not contribute to the impairment of waters could be identified (Innes 1999; Osowski et al.). For example, we might identify production facilities with excessive quantities of phosphorus (Centner 2000). Such identification could allow us to achieve efficiency gains by designating fewer operations as CAFOs. Through new regulatory provisions, governments could implement NPDES permit requirements that are more accurately related to sources of pollutants. By using criteria other than size of operation, regulations could differentiate between operations with a high potential for discharges and those with a low potential. Permit regulations could be revised such that CAFOs with low probabilities of unacceptable discharges are exempted from some or all of the permit requirements.

State Oversight

Congress has delegated responsibilities for administering and enforcing the Clean Water Act to individual states. Consequently, state governments are responsible for implementing the NPDES permit system. Moreover, states determine the appropriate level of protection against the impairment of waters when they adopt water quality standards for the navigable waters within their jurisdiction. States have enacted provisions on the certification of operators and facilities, design and inspection of lagoons, and accountability requirements regarding the closure of operations. These regulations are important in delineating expectations and establishing standards that reduce potential contamination problems.

Certification of Persons and Facilities

One avenue to oversee environmental problems caused by animals production is to establish certification requirements that involve applicant training, examination, and the investigation of qualifications. Such requirements may regulate many AFOs that are not CAFOs and, thereby, are considerably broader in coverage than the provisions prescribed by the federal CAFO regulations. Under North Car-

olina legislation, an owner or other person in control of an AFO with more than 250 swine or 100 cattle needs to be certified (North Carolina General Statutes). Applicants must have at least 10 hours of classroom instruction before their initial certification and additional training before recertification.

Iowa requires the certification of commercial and confinement site manure applicators and charges the Department of Natural Resources with the administration of continuing instructional courses (Iowa Code). Illinois has established a certified livestock manager program to enhance management skills dealing with environmental awareness, safety, odor control techniques and technology, best management practices, and manure management plans. This program applies to AFOs with more than 300 animals (Illinois Compiled Statutes).

Rules in Georgia specify instructional items that include training in best management practices, comprehensive nutrient management planning, understanding regulations and water quality laws, standards and practices, siting, pollution prevention, monitoring, and record keeping (Georgia Compilation Rules & Regulations). Minnesota has instituted requirements whereby all animal feedlots capable of holding 50 or more animal units or 10 or more animal units located within shore land, need to register (Minnesota Rules). The state has also established limitations on the expansion of feedlots in floodplains and shore lands (Minnesota Rules).

For Maryland farmers, the Water Quality Improvement Act of 1998 mandates nutrient management plans by agricultural operations with more than \$2,500 in gross income and at least eight animal units (Maryland Agriculture Code Annotated). Only persons licensed by the Maryland Department of Agriculture can prepare such plans. Moreover, persons for hire who apply nutrients to agricultural land in Maryland must be certified or perform work under a certified nutrient management consultant. Certification is distinct from the registry of persons receiving vouchers of completion in a nutrient application educational program.

Animal Waste Lagoon Regulations

News reports on the contamination of bodies of water caused by lagoons collapsing after rain events have spurred governments to enact additional controls. Given environmental concerns about waste lagoons and other manure storage structures, many states have adopted regulations that incorporate design and inspection safeguards. The most common safeguards embody professional requirements for persons involved in designing, operating, and inspecting manure storage structures and lagoons. Generally, the regulatory provisions establish a requirement of design preparation by a professional engineer (Minnesota Rules). Alternatively, a state may limit the development of lagoons. North Carolina has reached agreement with the two largest pork producers in the state to develop a replacement for lagoons and irrigated spray fields (North Carolina Department of Justice Public Information Service). The state plans to eliminate the use of open-air lagoons entirely. A second idea, which is incorporated in a Georgia rule for new swine operations with more than 3,000 animal units, prohibits large AFOs from having an uncovered lagoon (Georgia Compilation Rules & Regulations).

Regulations often prescribe liner and free-board requirements to limit groundwater contamination and reduce the chances of an overflow caused by a rain event (Illinois Administrative Code). For larger operators and operators with spray irrigation fields, regulations may mandate the installation of groundwater monitoring wells. In Georgia, the rules on monitoring wells apply to swine AFOs with 1,001–3,000 animal units (Georgia Compilation Rules & Regulations). The Illinois regulations require at least three monitoring wells for some lagoons (Illinois Administrative Code). Other responses address the location of lagoons, including prohibitions in flood plains.

Another state regulatory response to lagoons is the delineation of provisions concerning the inspection of lagoon construction and of subsequent operations. Regulations may establish criteria for the inspection of new

lagoons during the preconstruction, construction, or postconstruction phases. For existing lagoons, inspections are needed to discern inferior design standards and maintenance lapses. Most of the animal waste lagoons that have failed and caused significant environmental damages were constructed before the design standards in use at present. AFO provisions in some states mandate annual or periodic inspection requirements (EPA 2001b). However, most states lack funds and staff to perform such a task, so officials only inspect lagoons if someone has complained (EPA 2001b).

Accountability Provisions Regarding Closure

States have also moved to adopt provisions to address environmental problems at AFOs that discontinue operations. Individualized provisions incorporated in state closure regulations adopt several avenues of accountability, including commercial or private insurance, guarantees, surety bonds, letters of credit, certificates of deposit, and designated savings accounts (Illinois Compiled Statutes). The state may require the operator to provide a detailed written estimate of closure costs and then establish a closure fund that would meet the estimated obligation (Georgia Compilation Rules & Regulations). For example, under Oklahoma's surety requirements, applicants must also submit a statement declaring their financial ability to operate (Oklahoma Administrative Code).

A different approach adopted by a few states is to establish a state fund with money that can be used in response to a problem. This involves payment by each AFO owner or operator into a fund and using the money from the fund for lagoon closure (Missouri Revised Statutes). In the alternative, a combination of individual financial responsibility obligations with a state fund can provide assurance that potential environmental problems will be remedied.

Closure requirements generally prescribe guidelines on the amount of surety. Illinois requires the level of surety to be determined on the basis of the volumetric capacity of the lagoon (Illinois Compiled Statutes). Alternative-

ly, Oklahoma lists actual monetary amounts, depending on the number of animal units and outstanding contempt citations or fines (Oklahoma Statutes). Additional rules may authorize the forfeiture of funds of licensed operations that neglect, fail, or refuse to properly close surface impoundments. Moreover, the state can order remedial work to be done on premises that fail to follow requirements.

Reliance on Numbers of Animal

Most state and federal permitting regulations use numbers of animals to identify CAFOs that need to secure NPDES permits. Different numbers of animal species are listed, and three categories of CAFOs are prescribed: large, medium, and small. Although numbers of animals may constitute a reasonable proxy for anticipated water pollutants, other conditions may also be significant. Water pollution from nitrogen and phosphorus is not always connected to the size of an individual AFO (Letson et al.). Rather, the problem involves the location of excess nutrients and their transfer to water resources. Regulations that omit any consideration of whether a CAFO is likely to have pollutants that impair bodies of water may unnecessarily be regulating firms that are not contributing to a contamination problem.

Large CAFOs (as based on the number of animals) are the most important group of permitted operations. A large CAFO is a production facility with as many or more of the following numbers of animals [EPA 2003, §122.23(b)(4)]:

- (1) 700 mature dairy cows, whether milked or dry;
- (2) 1,000 veal calves;
- (3) 1,000 cattle other than mature dairy cows or veal calves, including, but not limited to, heifers, steers, bulls, and cow/calf pairs;
- (4) 2,500 swine, each weighing 55 pounds or more;
- (5) 10,000 swine, each weighing less than 55 pounds;
- (6) 500 horses;
- (7) 10,000 sheep or lambs;

- (8) 55,000 turkeys;
- (9) 30,000 laying hens or broilers, if the AFO uses a liquid manure handling system;
- (10) 125,000 chickens (other than laying hens), if the AFO uses other than a liquid manure handling system;
- (11) 82,000 laying hens, if the AFO uses other than a liquid manure handling system;
- (12) 30,000 ducks (if the AFO uses other than a liquid manure handling system); or
- (13) 5,000 ducks (if the AFO uses a liquid manure handling system).

Medium CAFOs are facilities with fewer animals that discharge pollutants into waters in the United States (EPA 2003). Small CAFOs are those designated as a CAFO by the appropriate governmental authority. Designation is made after an on-site inspection and only if an AFO is a significant contributor of pollutants to waters (EPA 2003).

From the description of the three categories of CAFOs, it may be noted that medium and small CAFOs involve the contribution of pollutants to waters, whereas large CAFOs are specified simply by counting numbers of animals. Only the designation of small CAFOs considers the fact whether levels of pollutants from the facility are significant.

Targeting Pollution Problems

To enhance efficiency, strategies could be developed to target regulatory resources toward pollution problems rather than using size as the primary criterion for regulating CAFOs. By employing criteria other than operation size, the varying ability of systems to assimilate animal wastes could be taken into account. The objective would be to more accurately regulate pollution problems without increasing pollution streams. In other words, regulate smarter. Two suggestions for targeting CAFOs based on the probability they will generate pollutants are the use of critical on-site management and technology indicators (production indicators) and location screening.

Critical Production Indicators

Scientific knowledge pertaining to nutrients, soils, topography, rainfall, vegetation, management practices, and modeling programs has shown that diverse systems are affected quite differently when they are exposed to additional nutrients (Adams et al.; Letson et al.). Management practices have been found to be a fundamental factor in minimizing nutrient pollution (Edwards et al.). The "one size fits all" approach under CAFO regulations based on numbers of animals fails to take into account site-specific features that are important in reducing externalities associated with animal wastes.

Critical on-site production indicators could be used to identify which CAFOs are likely to cause an unacceptable degradation of water and air quality and which are unlikely to generate any externalities. Indicators might include management practices or production technologies or may involve the adoption of appropriate monitoring equipment to measure any off-site migration of nutrients (Millock, Sunding, and Zilberman). One or more mechanisms may offer a means to differentiate CAFOs, so that those without significant potential for environmental loading would not be subject to the permit regulations.

Although the use of critical on-site indicators would likely reduce the number of CAFOs subject to regulations, the administration of exemptions would need to be done with considerable care. If the regulating agency is forced to redirect old and garner new resources for new programs aimed at determining which specific CAFOs should be regulated, efficiency gains may be minimal or nonexistent. Here the onus should be on producers, not the regulating agency, to demonstrate how their production practices and technology prevent environmental loading to such a degree that their operations should not be subject to the CAFO permit regulations.

The EPA has recognized production indicators in its regulations. The provisions on effluent limitations differentiate animal species and impose more stringent requirements on swine, poultry, and veal calves (EPA 2003).

The regulations also distinguish production from land application areas. Although both areas have the potential to cause discharges of pollutants, separate provisions apply to each area. More stringent requirements apply to production areas (EPA 2003).

Additional indicators may be possible. One idea is to incorporate animal housing and manure containment technologies into the determination of which facilities should be subject to the CAFO regulations. Distinctions in housing and manure management may be more important than the number and species of animals on a particular operation. Roofed housing and feeding structures often reduce the potential for off-site nutrient migration, compared with open-air structures. Similarly, manure management practices that account for environmental and weather conditions before spreading can reduce the risk of external migration. Rather than imposing the same requirements on all operations with a given number of animals, regulatory provisions could use manure management practices and animal feeding and housing structures as indicators of the potential for an operation to generate environmental externalities.

A second example might involve the use of an animal density index to trigger permit regulations. Because the total number of animals in a given area (a watershed or stream segment) may be more important than the number of animals at a single production location, an animal density index may be a more appropriate gauge of potential pollution problems. Moreover, CAFOs situated in watersheds that are not contributing to impaired waters might be regulated by different requirements.

Another indicator could be the development and use of industry environmental management plans. Producers who implement environmental management systems or manure management plans certified by third parties might have sufficient oversight, precluding the need for additional permit requirements. For example, CAFOs with certified management plans could be exempted from state requirements for monitoring wells. The use of private-sector contractors to oversee manure management presents opportunities to avoid

governmental costs and duplicate controls. Nonetheless, governmental resources would need to be dedicated to monitoring such a system to prevent its devolution into a regulatory loophole. Moreover, indicators might not be appropriate in states that have a history of being unable to meaningfully enforce water quality regulations (Dutzik).

Location Screening for Exclusion

Apart from the critical production indicators, additional information may be useful in screening out CAFOs with very low probabilities of generating environmental externalities. Regulations could be revised for qualifying CAFOs that are unlikely to contribute to water impairment, and these operations could be exempted from the mandatory regulatory controls. One obvious distinction is location. Different rules could be established for CAFOs on the basis of the characteristics of the watershed in which they reside. Under these separate rules, less stringent requirements could exist. Alternatively, operations might qualify for an exception whereby they would not have to secure a permit.

The new CAFO provisions already recognize an exception for large CAFOs that can show they do not have a potential for a discharge (EPA 2003). An owner or operator who receives notification from the state of a determination that the CAFO has no potential to discharge manure, litter, or process wastewater does not need to seek coverage under an NPDES permit. An analogous provision for CAFOs in areas where water impairment is not a problem might reduce the numbers of permittees without adversely affecting water quality.

Drawing on the European Union's nitrate directive (European Union), we might format more stringent regulations for areas or watersheds where animal production is a contamination problem. Precision farming technology and geographical information systems enable regulators to pinpoint contamination problems and develop more individualized responses for eliminating contaminants. We might move to

nitrate vulnerable zones as occurs in guidelines for England and Wales (Smith and Frost).

Another possibility is to differentiate between CAFOs that might be expected to have nutrient problems with phosphorus. This usually occurs because of the overapplication of manure, litter, and process wastewater on fields and pastures. By using a phosphorus index, the risk of loss of phosphorus from lands could be determined. The index assesses the risk of bioavailable phosphorus loss from grasslands, cropped fields, and other agricultural land to surface waters. The loss of bioavailable phosphorus to surface waters is of concern, because it can accelerate eutrophication in lakes and streams. Through a regulation that measures the risk of phosphorus loss from fields that receive manure, litter, and process wastewater, CAFOs could be differentiated. Those that do not spread manure or litter on lands with a significant risk of phosphorus losses could qualify for special treatment.

Here, the regulating agency, not the producer, should take the lead in developing criteria used to evaluate location factors and identify locations under which regulations could be adjusted. This would help ensure regulatory consistency from a spatial and temporal perspective.

Application to CAFOs and Conclusion

Our federal and state regulations of CAFOs rely on numbers of animals at individual operations. Under this rigid criterion, firms that have little potential for impairing water quality are required to secure permits. Rather than solely using numbers of animals, regulations might incorporate further production indicators and location screening that could identify operations that have no potential to measurably impair waters. Through a more detailed regulatory system, we could exempt qualifying CAFOs from some regulatory burdens. Existing regulations would continue to apply to CAFOs with a high potential to cause an environmental problem.

Governmental CAFOs regulations have incorporated some production indicators and lo-

cation screening factors. The differentiation of animal species and special effluent limitations for different animal species show reliance on such criteria. The federal delineation of medium-sized CAFOs is based on one of two enumerated conditions governing discharges. Under federal NPDES requirements, large CAFOs can be exempted from permitting requirements if they can show that they do not have a potential to discharge (EPA 2003). The issue is whether additional criteria can be incorporated to more accurately correlate CAFOs that cause water impairment with the NPDES permitting requirements. In this manner, needless expenses would not be foisted on operations that are not significantly impairing water quality.

Production indicators and location screening might be used under a two-step process to evaluate CAFOs and disclose whether they are likely sources of pollutants. First, all AFOs over a certain size would need to seek coverage as CAFOs. The federal NPDES requirements already have this requirement (EPA 2003). In a similar manner, states have prescribed numbers of animals for their provisions. The recommended production indicators and location screening can be based on these regulatory decisions of the size of operations that should be regulated.

Second, one or more production indicators and location screening would be used to establish qualification for an exemption from unnecessary permitting requirements. Criteria might include animal housing, animal density, watershed characteristics, environmental or manure management plans, and a low risk of phosphorus loss. In this manner, CAFOs that do not meaningfully contribute pollutants to waters could be spared some or all of the expenses of securing permits.

The "polluter pays" principle is consistent with welfare maximization in economic theory; the "nonpolluter pays" is not. Because characteristics of non-point source pollution problems can preclude efficient regulatory solutions, often the response is to cast a wide regulatory net. Tailoring the net on the basis of pertinent information can improve the economic efficiency of a set of regulations. Effi-

ciency gains can be realized in two ways: by avoiding the imposition of unnecessary costs on the regulated public and by more effectively targeting the monitoring and enforcement resources of the regulatory agency. This is what we suggest for the CAFO regulations.

References

- Adams, R., S.M. Dunn, R. Lunn, R. Mackay, and J.R. O'Callaghan. "Assessing the Performance of the NELUP Hydrological Models for River Basin Planning." *Journal of Environmental Planning & Management* 38(1996):53-76.
- Centner, T.J. "Animal Feeding Operations: Encouraging Sustainable Nutrient Usage Rather Than Restraining and Proscribing Activities." *Land Use Policy* 17(2000):233-44.
- . "Regulating Concentrated Animal Feeding Operations to Enhance the Environment." *Environmental Science and Policy* 6(2003):433-40.
- . "New Regulations to Minimize Water Impairment from Animals Rely on Management Practices." *Environment International* 30(2004):539-45.
- Dutzik, T. *The State of Environmental Enforcement*. Denver: Colorado Public Interest Research Group Foundation, 2002.
- Edwards, D.R., T.C. Daniel, H.D. Scott, J.F. Murdoch, M.J. Habiger, and H.M. Burks. "Stream Quality Impacts of Best Management Practices in a Northwestern Arkansas Basin." *Water Resources Bulletin* 32(1996):499-509.
- Environmental Protection Agency. *National Water Quality Inventory: 1998 Report to Congress*. Washington: Office of Water, 2000.
- . "National Pollutant Discharge Elimination System Permit Regulation and Effluent Limitations Guidelines and Standards for Concentrated Animal Feeding Operations; Proposed Rule." *Federal Register* 66(2001a):2960-3145.
- . *State Compendium: Programs and Regulatory Activities Related to Animal Feeding Operations*. Washington: Office of Wastewater Management, 2001b.
- . "National Pollutant Discharge Elimination System Permit Regulation and Effluent Limitations Guidelines and Standards for Concentrated Animal Feeding Operations." *Federal Register* 68(2003):7176-274.
- European Union. "Council Directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources." *Official Journal* 1991(L375):1-8.
- General Accounting Office. *Animal Agriculture: Information on Waste Management and Water Quality Issues*. Washington: GAO/RCED-95-200BR, 1995.
- . *Livestock Agriculture: Increased EPA Oversight Will Improve Environmental Program for Concentrated Animal Feeding Operations*. Washington: GAO-03-285, 2003.
- Georgia Compilation Rules & Regulations*. Rules 391-3-6-.20, 391-3-6.21 (2003).
- Illinois Administrative Code*. Title 35, subtitle E. Sections 506.204, 506.205, 506.206 (2003).
- Illinois Compiled Statutes*. Chapter 510 (2003). Sections 77/17, 77/30.
- Innes, R. "Regulating Livestock Waste: An Economic Perspective." *Choices* 2nd Quarter(1999):14-19.
- . "The Economics of Livestock Waste and Its Regulation." *American Journal of Agricultural Economics* 82(2000):97-117.
- Iowa Code*. Section 459.315 (2003).
- Letson, D., N. Gollehon, V. Breneman, C. Kascak, and C. Mose. "Confined Animal Production and Groundwater Protection." *Review of Agricultural Economics* 20(1998):348-64.
- Maryland Agriculture Code Annotated*. Sections 8-802, 8-803.1, 8-803.2 (2003).
- Metcalf, M. "State Legislation Regulating Animal Manure Management." *Review of Agricultural Economics* 22(2000):519-32.
- Millock, K., D. Sunding, and D. Zilberman. "Regulating Pollution with Endogenous Monitoring." *Journal of Environmental Economics & Management* 44(2002):221-41.
- Minnesota Rules*. Rules 7020.2005, 7020.0350, 7020.2100 (2003).
- Missouri Revised Statutes*. Sections 640.745, 640.747 (2003).
- North Carolina Department of Justice Public Information Service. *Easley Announces Landmark Agreement with Largest Hog Producer to Replace Open-Air Lagoons in North Carolina—N.C. State University Takes Lead Role in Technology Development*. Raleigh: Department of Justice Public Information Service, 2000.
- North Carolina General Statutes*. Sections 90A-47.2, 90A-47.3, 143-215.10B (2003).
- Ogishi, A., M. Metcalfe, and D. Zilberman. "Animal Waste Policy: Reforms to Improve Environmental Quality." *Choices* 3rd Quarter(2002):15-18.
- Oklahoma Administrative Code*. Section 35:17-3-6(22) (2003).
- Oklahoma Statutes*. Title 2, Section 9-209.1 (2003).

- Osowski, S.L., J.D. Swick, Jr., G.R. Carney, H.B. Pena, J.E. Danielson, and D.A. Parrish. "A Watershed-Based Cumulative Risk Impact Analysis: Environmental Vulnerability and Impact Criteria." *Environmental Monitoring and Assessment* 66(2001):159-85.
- Smith, K.A., and J.P. Frost. "Nitrogen Excretion by Farm Livestock with Respect to Land Spreading Requirements and Controlling Nitrogen Losses to Ground and Surface Waters, Part 1: Cattle and Sheep." *Bioresource Technology* 71(2000): 173-81.
- Taylor, H. "Nutrients." *Agricultural Resources and Environmental Indicators, 1996-97*, at 97-114. USDA Agricultural Handbook 712, 1997.
- U.S. Code Annotated. Title 33, Section 1362(14). Washington, DC: Economic Research Service, 2003.

