Considering Market-Based Alternatives to Improve the Management of CAFOs[1]

Jerry R. Skees
H.B. Price Professor of Policy and Risk
Department of Agricultural Economics, University of Kentucky
and President of Agricultural Risk Management Consulting, Inc.
jskees@uky.edu

J. Roy Black
Professor
Department of Agricultural Economics
Michigan State University
blackj@msu.edu

Ben M. Gramig
Graduate Research Assistant
Department of Agricultural Economics
University of Kentucky
bmgram0@uky.edu

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Defining the Issue

Concentrated animal feeding operations (CAFOs)[1] create a unique set of interrelated risk and environmental concerns. The concentration of animals in one location creates the challenge of managing large amounts of manure and has frequently created externalities. In the absence of regulations or the threat of litigation, firms will manage manure collection, storage, transport, and incorporation into the soil to maximize their expected profit or utility. Regulations have been designed in an attempt to internalize the costs to livestock farms of the social problems created by manure via two mechanisms: fines and management guidelines (waste system structure, nutrient management guidelines, etc.). Manure is sometimes described as a co-product which is both technically correct and recognizes manure has value as a purchased nutrient replacement and sometimes has additional value based upon it's organic matter content. An old rule of thumb used to be that the cost of transport and incorporation was equal to the nutrient value. In short, there was not much incentive to manage manure in a way that doesn't create external effects.

It can be argued that regulations and litigation are costly ways for society to address environmental externality problems (Gray, Hylton, Polinsky and Shavell, Trubek, et al., Viscusi). This paper investigates insurance as a potentially more efficient and effective alternative for modifying CAFO manager behavior in ways that will reduce environmental and health risk, recognizing the insurance solution will be most effective only when regulatory and litigation threats are present. When coupled, effective regulatory oversight and insurance choices can improve system performance. The core of much of the argument is that farm managers are more

[1] Operations larger than a certain threshold based on species [1000 beef cows, 700 dairy cows, 2500 swine, or 125,000 broilers] are classified as Concentrated Animal Feeding Operations. For smaller operations, the EPA refers to these operations more simply as Animal Feeding Operations (AFOs). These distinctions are a result of regulatory requirements.

likely to respond positively to a risk-sharing partner (the insurance underwriter) than a government regulator.[2] In effect, the insurance underwriter has the potential to replace much of the oversight function of a government regulator.

Risk Assessment

CAFO hog facilities have been a particular source of concern; extreme weather events, such as the 1996 and 1999 hurricane-induced flooding in North Carolina, caused significant financial losses for producers, impacted environmental resources, and threatened public health (Easterling, et al. and Kilborn). While weather events clearly contribute to system risk and have been a source of great public attention, management plays a larger day-to-day role in reducing risk. This is demonstrated by Sheffield's work and the America's Clean Water Foundation (ACWF) report to the USDA-Risk Management Agency (RMA). Public scrutiny of confinement facilities extends beyond swine operations into the entire livestock sector. The use of swine as an example throughout this paper is intended only as a case to illustrate points and apply them to a particular setting.

Both federal and state regulations have been modified in attempts to address potential problems associated with CAFOs (USDA and USEPA, Metcalfe). In 2001, the EPA began a public dialogue asking for further input on CAFO regulations.[3] In December of 2002, these revised regulations were released and subsequently published in the Federal Register in February 2003.[4] Comprehensive Nutrient Management Plans (CNMPs)[5] were made mandatory by the

[2] The usage of "government regulator" should be interpreted as inclusive of any and all state or federal regulatory entities that are applicable for a given location.
[3] 66 Federal Register 9:2959-3145 (January 12, 2001) relating to 40 CFR Parts 122 and 412
[4] 68 Federal Register 29: 7175-7274 (February 12, 2003) relating to 40 CFR Parts 9, 122, 123 and 412
[5] A CNMP is the overall conservation system that addresses all aspects of an animal feeding operation. The elements a CNMP needs to address are described in the USDA Natural Resources Conservation Service's "Comprehensive Nutrient Management Planning Technical Guidance", December 2000.

Unified National Strategy for Animal Feeding Operations (1999) and under the EPA's Final CAFO Rule (2002) must be phased in by 2006. The 2002 Farm Bill put in place an incentive to have CNMPs in place before the 2006 deadline by requiring a plan before Environmental Quality Incentives Program (EQIP) cost-share assistance can be rewarded[6].

Advising CAFO operators is rather comprehensive for some areas and has grown to include every phase of the production; feeding, housing, manure lagoons, dewatering[7] equipment and systems, and careful attention to agronomic aspects of the manure use. Our focus is predominantly on those aspects that deal directly with animal waste. In most states, USDA's Natural Resources Conservation Service (NRCS) is directly involved with providing this type of advice and, to a growing extent, the oversight regarding how well the farmers are implementing CNMPs designed to mitigate nutrient overloading. NRCS provides these services free of charge, but private consultants and certified nutrient management planners are also actively providing technical assistance. Small fines are imposed in some states when certain problems occur (e.g., if the lagoon level exceeds what is referred to as "red line" level in North Carolina or other generally accepted management practices under state right-to-farm legislation).

Manure handling systems have become increasingly complex, requiring sophisticated managers to make certain that they are working properly. In the context of this paper we define a 'failure' as:

> any breakdown in the waste handling system that results in documented damages to water resources, land resources, aquatic species or wildlife habitat.

In simple terms, a failure can occur in the form of a breach over the dam of a lagoon or as a result of over application of manure to a crop or cropland. Assessing the risk can be complex.

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[6] Farm Security and Rural Reinvestment Act of 2002. May 13, 2002.
[7] Dewatering is the process of applying manure lagoon contents onto crops or cropland.

There are two important dimensions to risk: 1) frequency; and 2) severity. Having a frequent minor episode of manure spilling out on land that is far removed from a water resource is unlikely to attract public scrutiny and does not represent a failure by our definition. By contrast, an infrequent but major spill directly into a river is highly visible and will very likely result in a public response. The issue of which risks are important for society is open to debate, but location must surely be considered. For example, any system that is nearby a water resource is likely to pose greater risks for society.

Beyond location, at least three other variables are important in assessing risk: 1) design or physical aspects of the system; 2) management of the system; and 3) weather. Clearly these three variables are not independent and their interaction is critical. When aspects of all three are marginal, the chances of a serious problem increase. The modeling work[8] referenced in this study makes a significant contribution toward assessing risk for individual systems. The data collected from various sources also is useful in providing some assessment about the cause of many manure system failures. As will become clear, weather becomes a compounding variable under many conditions, but even more so when management is poor.

Regulations, Incentives, and Behavior

Animal agriculture has been largely immune from the laws allowing those concerned about the environment to sue parties releasing hazardous materials into the environment. The Clean Water Act (1972) and The Comprehensive Environmental Response, Compensation, and Liability Act, or Superfund Act (1980), largely do not apply to animal agriculture. The one exception is National Pollutant Discharge Elimination System (NPDES) permits required for

[8] The AFO management system model developed by Considine and Burns to assess system risk is described in greater detail later in this paper, on p. 20

operations above a certain size or smaller ones determined to pose an elevated risk of discharge. The NPDES requirement for operations to obtain permits based on size is not uniformly enforced across all states.[9] Large manure spills that exceed agronomic application rates are viewed by some states as "discharges" and result in fines even if pollutants never reach a body of water or hurt wildlife or aquatic species; while other states have not issued permits to govern discharges by such operations. Anticipated rules that would regulate Total Maximum Daily Loads (TMDLs) for certain pollutants (nutrients, sediment, etc.) and new CAFO regulations will result in more controls for animal agriculture. Such controls could be cumbersome and expensive. EPA has estimated the total annual monetized cost of the Final CAFO Rule to be about $335 million, inclusive of CAFO compliance expenditures and administrative costs to federal and state governments.[10] Such trends increase the importance of considering potentially more efficient and effective market-based incentives to complement regulation.

Initially, our concern is not so much with approval of the management systems and farm plans that are required of a farm operator. Approval of new systems involves a different set of issues than our major concern; the management of existing systems. The burden to demonstrate that the CAFO will not cause a problem is significantly greater for those attempting to gain approval of new systems because of increased public scrutiny of the livestock sector[11]. On the other hand, once systems are in place, this burden shifts more toward the larger community (or the public) to assure that proper management is addressing environmental and health risks. The

[9] Previously, only CAFOs were required to have permits, but under the EPA's Final CAFO Rule, state permitting authorities can require NPDES permits of smaller AFOs based on site location and other factors than have the potential to contribute to event severity if a failure occurs. The 25 year-24 hour rainfall permitting exemption has been eliminated, increasing the total number of permits to be issued.

[10] 68 Federal Register 29: 7242-7250 (February 12, 2003)

[11] While we do not address the issue of new CAFOs specifically, the ideas presented here can be applied to new CAFOs and may in fact ease the community concerns and increase the likelihood that such operations will be permitted.

burden of proof in a particular case is determined by whoever holds the property rights; for new facilities the onus is on the farmer but for existing facilities this burden falls on the public. As such, the property rights to pollute favor existing CAFO operators.

This study is most concerned with improving management of existing systems, but is just as applicable to system design. Furthermore our focus is about preventing problems rather than addressing problems ex post. Developing ex ante solutions is challenging as this requires an understanding of behavioral responses to incentives that society attempts to impose on CAFO managers. Developing a solution that combines institutions and incentives in ways that achieve reduced externalities at the lowest cost to society is our objective.

Property rights for livestock producers have changed dramatically since the passage of the CWA, but the regulatory mechanisms have remained largely the same. So called command-and-control regulation has been the predominant approach to controlling externalities and has utilized a "polluter pays" principle. Costs have been imposed on livestock operations and these expenses have been significant already. The polluter pays approach has been the standard for addressing all environmental externalities, not just from agriculture. This has resulted in a highly litigious and very confrontational scenario, whereby regulators and operators rarely see eye to eye and suspicion is more common than cooperation.

The latest round of regulatory changes has altered the property rights once again and an opportunity exists for a market-based form of regulation with the CNMP/NMP serving as an informational link between the operator, regulator and risk-sharing partner. As pointed out by Kunreuther, McNulty, and Kang underwriters and third party auditors can serve a regulation function that is accompanied by risk management technical assistance. While the property rights have changed considerably in the last 30 years, the goals of regulation still have not been achieved; society continues to bear the cost of firm generated environmental externalities. The calculus of the regulated firm is driven by profit considerations. Probabilities of detection and fine amounts are important considerations (discussed below) in deciding to self-insure or take on a risk sharing partner. Contingent claims contracts can provide a market-based risk management solution, but will not be effective unless regulatory fines and litigation remain as threats (Kunreuther, McNulty, and Kang).

Given the externality problems posed by animal waste management and that farmers are participating in a highly competitive market, CAFO operators continue to act rationally when they attempt to cut costs in ways that increase environmental risk; the cost of pollution is not internalized by the farm. USDA provides both technical advice and cost share for improvements that will reduce the environmental risk posed by livestock waste. Some states provide further cost-share assistance to this same end.[12] While not a regulatory body per se, NRCS must certainly have influence on the behavior of the farmer. When farmers receive recommendations from the entity that will play a role in approving or denying applications for cost share funds to put down filter fabric pads in feeding areas, a livestock watering system that keeps cattle out of streams, or an open air structure to shelter animal waste from rain to prevent runoff, there is an element of suasion at work to get the farmer to adopt and use the suggested practices. While the presence of a CNMP currently has no bearing on whether or not a farm qualifies for commodity payments[13], there can be no positive gains from negative interactions with NRCS employees based at local USDA Farm Service Agency offices where farmers go annually to certify acreage

[12] Kentucky, for example, has committed $9 million annually since 2000 for environmental cost-share assistance to ease the financial burden of compliance with state and federal regulation of AFOs.
[13] Cross-compliance provisions do not exist; CNMPs are not required for producers to receive commodity payments or other federal subsidies, i.e. sodbuster provisions in previous farm bills

for commodity program crops, file CNMPs, and apply for environmental cost-share assistance[14]. Thus, to the extent that many livestock farmers also receive commodity payments from the government and depend on cost-share assistance to make on-farm environmental improvements, there is an incentive to avoid friction or tension between the farmer and the local USDA office over waste handling facility design or nutrient management.

This paper challenges the current rules regarding use of the 25 year-24 hour storm discharge exemption. This metric was developed by the National Weather Bureau over 40 years ago (Hershfield) and there are a number of limitations associated with this work. First, measuring rainfall at the 96th percentile (4 events in 100 years, or 1 event in 25 years) will result in very different results depending on location (e.g., rainfall levels above the 96th percentile in a hurricane prone area like North Carolina will be very different than those in central Iowa). Second, a 24 hour storm says little about intensity. The intensity of a heavy rainfall in a few hours can have considerably more impact than the 25 year-24 hour storm. The most serious problem seems to be that this metric totally ignores the cumulative effects of rainfall from day to day. A sustained rainy period will both influence the system storage level and restrict the ability to remove that water by limiting access to fields and saturating soil.

The extent to which regulations change the behavior of CAFO managers is a function of the manager's assessment of the expected cost of not complying with the regulation versus the cost of compliance. The farmer would assess the odds of a regulatory agency imposing restrictions or fines on the farmer multiplied by the expected fine. Economists have compared regulations to our driving behavior. While it is against the law to break the speed limit, there are many drivers who exceed the limits. Ruling out the safety factor, this is rational behavior given

[14] Note: folks doing technical assistance are different from the folks doing acreage certification, etc

the expected cost of receiving a speeding ticket. In economic terms, this expected cost can be interpreted as a lower bound estimate of the driver's willingness to pay to exceed the speed limit. To illustrate the point, consider that the fine for driving between 70 and 80 miles per hour is $100. Even if the odds of getting caught were as great as 1 percent, the expected cost of speeding is:

$$\$100 \times 0.01 = \$1$$

The odds of getting caught are generally much less than 1%, making the expected cost significantly less than one dollar. Thus, we speed at some level. In most states, one can exceed the speed limit by 5 to 8 miles per hour on major highways with no chance of being stopped. On the other hand, the fines and penalties associated with speeding increase if we exceed the speed limit above a certain threshold. Most drivers are aware of stiffer penalties and the safety risk, making excessive speeding rare. The effect of speeding tickets on insurance premiums and penalties resulting from repeat offenses (loss of license, etc.) remain as deterrents and apply similarly to CAFO operators. CAFO managers respond to regulations in a similar fashion as speeders. Relatively light fines and low probability of getting caught mean managers behave rationally when they take risk in the way they operate their manure systems. In most states, even relatively serious events are unlikely to incur serious fines from regulators; unless persistent violations occur. Thus, the regulation costs of taking on more risk are generally not a deterrent for most CAFO operators at the present time.

One can build a case that threat of litigation provides stronger incentives to be careful in managing manure than the threat of fines from regulators. Here again the economics of assessing litigation are similar to that of regulation (the probability of litigation multiplied by the expected cost). While some lawsuits may be legitimate, there is a growing threat of lawsuits that are unfounded. In other words, even though the threat of litigation may create the desired change in behavior (better management and lower risk of creating environmental problems) there is still a threat of a lawsuit simply because CAFOs have become a target for certain groups. Recognizing that some lawsuits are unwarranted is important in considering solutions that will assure sound management. Should CAFO operators be allowed to purchase liability insurance for unwarranted lawsuits?

One of the more challenging aspects of regulations is to anticipate the complete cycle of incentives that are provided. Well intended regulations can create the wrong incentives. To make this point, consider the following. In some states, fines are imposed if manure levels exceed a certain threshold; what is referred to as the "red zone" in North Carolina. Thus, the incentives to pump manure from the lagoons are very strong regardless of the timing considerations and the nutrient overload problems that may be created. The probability that the regulator will discover and fine the farmer for pumping out the lagoon at the wrong time are much less than the odds that they can discover a lagoon level that is above the thresholds. It is quite easy to drive up to the lagoon and check the water level. It is not so easy to catch someone who is dewatering the lagoon during or prior to a major rainfall, or who is putting far too much manure onto a particular parcel of land.

Under state regulations, CAFO operators are generally allowed to pump effluent from lagoons and spray it onto growing crops or pasture only when soils are not saturated and only during a specified period when plant growth is adequate to remove nutrients.[15] This is a clear example of potential for unintended consequences of management regulations, given that a

[15] The exception is the 25 year-24 hour storm where dewatering is allowed even during the heavy rainfall to prevent overtopping.

farmer is acting rationally if they dewater under these conditions to bring lagoon levels into compliance.

Regulatory agencies are not the only institutions creating incentives that lead rational economic decision makers to generate negative externalities under certain conditions. For example, to protect against the economic and political liability associated with lagoon overflows, many integrators in the hog industry also require that lagoons contain some minimum amount of slack capacity or "freeboard". If lagoon levels are too high, integrators may not supply feeder pigs to producers for the winter production cycle. This loss of income can be devastating for highly leveraged CAFO operators. Lagoon levels might exceed stipulated maximum levels due to excessive rainfall during the no-spray period. They may also exceed maximums if excessive rainfall occurs during the latter part of the specified spray period keeping soils saturated and preventing dewatering of effluent from lagoons. It is not only the regulatory incentives that encourage dewatering at the wrong time, the integrators impose similar pressures in the way they oversee individual operation management and the threat that they may not allow the operator to have winter pigs if the water level is not at the desired mark. The operator faces a set of incentives from multiple principals (regulatory agency and integrator) that contributes to economic decisions with externality effects. CAFO operators, faced with the potential loss of winter production, might be tempted to risk environmental damage by spraying beyond the specified season, when the soil is already saturated, or when rain is forecast. If Sheffield's work is any indication of the larger population, it suggests that discharges related to land application account for 42% of permit violations in his sample of 285 discharges in North Carolina (39% originated with the manure handling system). In short, there are a number of incentives to over apply as a means of getting lagoon levels to the proper level.

Market-Based Alternatives

Rather than use increased government command-and-control regulation of CAFOs, placing more emphasis on market-based solutions could be less costly to society. Market mechanisms for environmental improvement have been thoroughly investigated in the academic literature and for the purposes of this paper we will consider such market-based alternatives as falling into two classes: 1) non-contingent claim solutions; and 2) contingent claims solutions. Of chief concern in designing or selecting a particular mechanism for addressing environmental risk posed by AFOs, is the improvement of individual behavior and the reduction in risk from individual systems. We will evaluate different alternatives with this key consideration in mind. The major obstacle to overcome is the hidden information that the operator has, and mechanisms that overcome or reduce this barrier to market-based solutions are viewed as having the greatest promise. The requirement of CNMPs is a key policy intervention that reduces informational barriers and creates opportunities for market-based risk sharing to occur, but the informational asymmetry is still significant. Stavins reviews the entire spectrum of market-based environmental policies that have been considered and implemented to varying degrees of success, but we will only address two non-contingent claims approaches here.[16] Several different contingent claims arrangements for AFOs will be considered.

Effluent / Pollution Charge Systems

Pollution charge systems or effluent fees have been proposed for application to a variety of environmental externality problems. This approach is targeted mainly at reducing effluent levels and does not address risk. Under NPDES regulations AFOs operate under zero-discharge conditions (except during 25 year – 24 hour storms) and thus do not lend themselves well to this

[16] For a more extensive discussion of the applicability of different market-based policies reviewed by Stavins, please refer to the ACWF report to RMA. pp. 196-203.

mechanism. The monitoring necessary to support this type of system is extensive and comes at considerable transaction costs. The infrastructure necessary to support such monitoring is not currently in place. A related approach would charge or tax firms based on nutrient content of manure. This also fails to address individual behavior and the risk of system failures that are our main objectives.

Marketable / Tradable Permit Systems

Tradable or marketable permit approaches to pollution control are the dominant market-mechanism in the academic literature and applications to water quality trading have been attempted on a limited basis already. The zero-discharge provision for AFOs under the CWA is again the major obstacle to implementing this in the current regulatory environment because there is nothing to trade without discharge. Another key obstacle is having the monitoring mechanisms in place that would be required to administer a tradable permit system. This type of mechanism may work for very large operations that utilize waste disposal plants to treat effluent. Despite the current obstacles, water quality trading is one prospective market-based alternative that could become a reality for AFOs under a recent proposal to introduce NPDES permits that allow for discharges if operations treat waste water to certain specifications before discharge. This approach would address the overall effluent on a watershed level, which is an important spatial consideration when evaluating environmental risk from AFOs, but still would not reduce the risk of failure that is one of our key objectives here.

Contingent Claims Solutions

We turn now to contingent claims markets. Freeman and Kunreuther (1996, 1997) review the relative transaction costs associated with an insurance solution versus litigation and tort. They compare the amount of the claims settlement that went to remediation of an environmental problem (about 40%) versus the percent of premium going to indemnity payments to fix an environmental problem (about 75%) and conclude that properly designed environmental insurance products should be more socially optimal than more litigation and regulation.

Command-and-control regulation creates an adversarial relationship between the regulator and those being regulated. This adversarial relationship often results in mutual suspicion and distrust. Typically, the individual or firm being regulated will provide the regulator with no information beyond the absolute minimum required to satisfy the law. CAFO operators may respond more favorably to a risk-sharing partner than to a government regulator. As a result, a diligent insurance underwriter may be more effective than a government regulator in improving manure management systems and reducing the likelihood of system failures. The cost of environmental litigation for society is very high (Vuscusi, 1998). If insurance solutions prevent litigation, then society could be made better off by lower cost with such solutions. Before developing this theme further, it is important to provide a primer on insurance so that the principles of insurance are understood.

Nonetheless, insurance solutions are not easy. Effective underwriting must be used to rectify information asymmetries that cause adverse selection and moral hazard. There are at least four keys to effective underwriting:

1) Proper risk assessment procedures (the model developed for this study is intended to serve as one mechanism to accomplish this task);
2) Effective use of the risk assessment procedures to properly classify the risk of potential policyholders;
3) Proper insurance policy designs that mitigate the opportunities of insureds to benefit from their superior information; and
4) Good monitoring systems that allow for discovery of problems created when the insured changes their behavior in ways that increase their risk.

Items one and two are designed to address adverse selection by classifying risk ex ante. Items three and four are designed to address moral hazard with clear rules for the insurance and monitoring of the insured after the purchase.

For insurance to be developed and sold to animal producers to mitigate the risk of animal waste system failures, it will be important to create a market for such a product. In creating that market, it will be critical that the insurance policies offered to producers are affordable. Third party audits could play an important part in this effort. If an insurance product could be created in which the premium were lowered for animal producers that voluntarily had third party audits of their facilities for environmental compliance, the policy could be more affordable.

One of the benefits of 3rd party inspection is in the ability to distinguish between high-risk and low-risk parties (Kunreuther, McNulty, and Kang). This subsequently creates information necessary for insurance to be priced accordingly; higher for those who are likely to incur more fines and lower for those who have reduced their risk.

What Insurance Products Might Improve Management of CAFOs?

A number of insurance alternatives can be considered for CAFOs. At one end of the spectrum is the complete contract that would indemnify the farmer for any environmental problem that may be created by their manure. At the other end of the spectrum, one can consider something much simpler that would pay only based on excess rainfall that may create manure management problems. There are several alternatives that fall somewhere between these two extremes. As shall be explained, the alternatives falling between the extremes are likely more practical. The example of a swine operation with a lagoon-based waste storage system will be used as a case to consider different potential risk-sharing arrangements.

Goals for CAFO Environmental Insurance:

1) Provide insurance that will improve the incentives of farmers.
2) Give strong preferences to insurance concepts that would compensate farmers to mitigate the risk rather than those that would pay after a problem has occurred.
3) Create incentives that couple the insurance with a stronger regulatory response for bad managers.
4) Make certain that the events that are being indemnified are well defined and can be measured.

The Complete Contract

By this point, it should be clear that offering insurance for *any* environmental problem that is created by a CAFO would be problematic. The asymmetric information regarding the management of the operation would unquestionably lead to adverse selection and moral hazard problems. Offering this type of insurance would be extremely difficult because of the problems associated with developing expected losses on which to base premium rates. Every policy would need to be premium rated based on the location and the proximity to natural resources that could be damaged when there is: 1) overtopping from the lagoon; 2) leakage from the lagoon; 3) spills during application; or 4) over application. The scope of things that can go wrong would be very large; and many of the potential problems can be linked directly to management. An open ended contract that would pay for damages has the potential to encourage bad management and increase the environmental risk if the policy were offered without third party inspections. Even with third party audits, there are many things that can go wrong and would not be considered insurable. For example, a bad motor causing a spill would generally be excluded from most insurance policies of this nature (any equipment failure is generally excluded).

The complexity of writing a clear traditional liability policy that would include all of the necessary exclusions makes it unlikely that such policies will emerge. No insurance provider would want to offer this insurance if the policy language cannot be written in a clear fashion.

Litigation over confusion in what is insured and what is not can be quite expensive in both time and direct financial resources. Nonetheless, certain 'acts of God' may be insured at some level under certain conditions. This is more likely true if these events can be well defined and if they do not carry the burden of being highly correlated. More will be said about this below.

A Simple Rainfall Index Insurance Product

Given that certain problems with manure management are caused or compounded by extreme rainfall or chronic rainfall events, the simplest contract for managing environmental risk by CAFOs may be rainfall insurance contracts. Rainfall insurance contracts could be used to indemnify CAFOs when there is excess rain and a high likelihood that the lagoon levels will be high. These indemnity payments could be used to pay fines and or compensate for lost income from not being allowed to feed animals during the winter months. CAFO operators would be less likely to risk causing environmental damage by improper spraying if insurance indemnities compensated for lost production (Martin, Barnett, Coble). Still, the use of rainfall insurance contracts would be more in the class of a derivative product in that the direct link to the event and the damage may or may not be clearly established.

To design effective derivative products that would serve as insurance, there must be a strong correlation between the event (excess or chronic rainfall) and the damage. To provide an example of how such a product might work consider the following scenario. If it is determined that rainfall amounts in excess of 10 inches over a three day period place manure systems at added risk, one could write an insurance-like contract that would make direct payments for amounts in excess of this level. The payments could be set at specific levels for every one-tenth of an inch above 10 inches. One can also envision that an upper limit on the payments would be established by the writer of this contract. For example, once rain during the period exceeds 20 inches, there would be no more payment. The maximum payout or liability could be set at $1 million.

In the language of derivatives, the 10 inches measure is called the *strike*; the one-tenth of an inch is called a *tick*; and the $1 million is called the *limit*. Between 10 and 20 inches there are 100 ticks [(20-10) * 10]. The value of a payment for each tick is then $1,000,000/100 or $10,000. Thus, if the rainfall measure is 11.2 inches, the payment will be based on 12 ticks [(11.2 – 10) * 10]. At $10,000 per tick, the payment would be $120,000. This payment would be made regardless of whether there is a problem with the manure lagoon.

The premium rating for this rainfall insurance contract would be relatively straightforward as it is based on the history of rainfall events in excess of 10 inches over a three day period for the specific locale. The key questions for the farmer are what strike to select and what limit (liability) makes sense based on risk exposure for an individual operation? The premium payments are based on the premium rate multiplied by the liability. Thus, if the premium rate for this policy were 3%, the farmer would pay:

($1,000,000 * 0.03) = $30,000.

The advantage of this type of insurance is that there is no moral hazard and adverse selection problem. Further, it is entirely up to the farmer to determine what exposure they have and what liability they wish to purchase. One can envision providing advice to a farmer faced with this choice. The question of what do you think would be the worse case scenario if your lagoon failed and most of the manure went into a nearby stream is certainly a starting point. The worse case scenario would be the basis for selecting the liability.

These types of contracts are most attractive in their simplest form as they have very low administrative costs and no moral hazard or adverse selection. The problem with the contract is that it is difficult to match the losses and the payments. It would be best used for truly catastrophic levels of rain that everyone knows will put the system under risk. However, given that there are exemptions for the 25 year-24 hour storm, the incentives for the farmer to purchase these contracts may be relatively low.

Indexes That Would Pay on Model Results for Well-Managed CAFOs

A concept that falls in between our two extreme cases would pay based upon engineering model results. The manure system model developed by Considine and Burns provides a unique opportunity to design an index type insurance policy. The index would be calibrated to model results. The model uses an engineering approach to measure inflow and outflows for the total system given the size of the manure holding facility, number of animals, agronomic system, the management plan, and weather events. Level of water in the lagoon becomes the important output variable that affords the opportunity to offer a special insurance product that would be free of adverse selection and moral hazard.

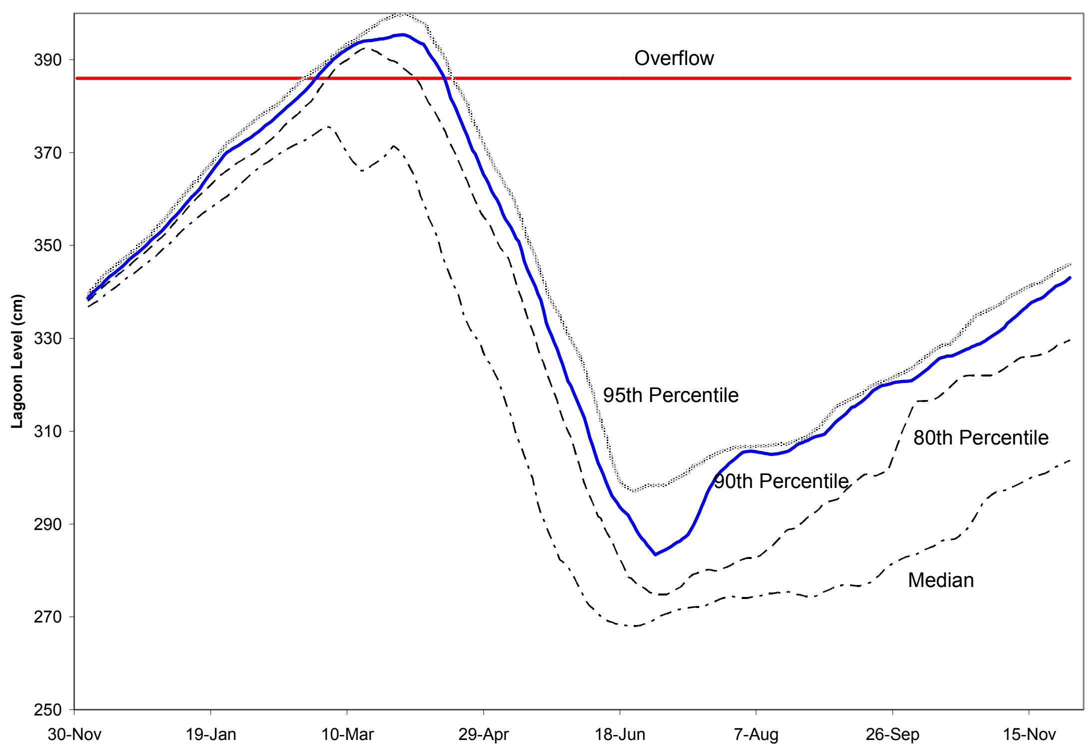
As long as the manager follows the total management plan (the CNMP discussed above), model estimates of the level of water will serve well as an index of potential challenges to the system. When the water level approaches or exceeds the capacity of the system, there are at least three possible outcomes: 1) the lagoon will overtop resulting in a manure spill; 2) the manager will over-apply manure; or 3) the manager will develop new solutions to properly remove the manure, including the possibility of trucking the manure to a new location. Obviously, the later solution is the preferred choice for society and, hopefully, for the producer. The degree to which water level estimates exceed the capacity of the system should be directly related to the problems that will result from any one of the three outcomes above. The index would pay once the estimate of the water level from the model exceeds a specified level (recall that, we call this the strike or trigger level) for a specific date. Furthermore, payments would be a direct function of water level estimates. Thus, as the water level exceeds the trigger level, the payments would increase in a similar manner as the rainfall insurance contract explained above.

An example should help clarify how this index would work. Figure 1 presents actual model results for a representative system in North Carolina. The lagoon overflow level is 386 cm. The system needs to be managed in such a fashion that the water level will have nearly a zero probability of exceeding this level. The CNMP will be used to make certain that the system is properly managed. Third party auditors would have access to the CNMP and be able to use that input to model the manure levels given the past 50 weather years. The model results presented in figure 1 allow one to see what the water levels would be, given the initial conditions, for the median, the 80th, the 90th, and the 95th percentile. As can be seen, the system is at considerable risk. There is in excess of a 20 percent chance that this system will exceed the capacity during the winter months. This is for illustrative purposes only.

The model demonstrates that the best management practice involves getting the water level to 270 cm once the planting season is complete; June 1. Under average weather conditions the system will accumulate water slowly through the summer as some dewatering is possible and sun and temperature create evaporation. Given average weather, the system would build up to about 370 cm over the winter and moving into early spring. On about March 15, dewatering can occur. The concerns are when the weather is not good and the rain and lack of sunshine create extra stress on the system. The model can be monitored as January begins by inputting the actual weather events. There should be ample warning when the system is being stressed and the likelihood of exceeding the capacity increases to unacceptable levels.

The contract would allow the farmer to obtain indemnity payments as the system approaches stress levels. For example, let's say that the farmer purchases a contract that would begin making payments anytime the model water levels exceed 370 cm during the month of January. Again, the payment structure would be similar to the rainfall insurance contract. For example, a cm could be used as the tick. The payment schedule could be set at $1,000 for

Figure 1: Model results for a representative system in North Carolina



each centimeter above 370 in the model results during the month of January. The third party auditor would be required to visit the farm when these thresholds are crossed in the model. At that point, the auditor would work closely with the farmer to determine how to mitigate the risk and prevent the overtopping or over application of manure. Funds from the insurance could be used to mitigate the risk. This could involve trucking the manure away; cutting back on the number of animals; gaining access to neighbors fields to put the manure there; etc. The third party auditor would work with the farmer to determine the best mitigation plan given the indemnity payments. Should the mitigation plan not be sufficient and a problem still emerges, it is likely that regulators will be much more forgiving of these farmers than those who have problems but have not attempted to mitigate the emerging problem.

Clearly for such a system to work, the farmer has to trust the model. The model will only be useful if the farmer supplies good information regarding the CNMP. When the actual water levels deviate from the model results, the third party auditor will attempt to determine what caused these differences. There are several possible explanations: 1) the weather measures at the nearby station do not match precisely what happened at the lagoon[17]; 2) the farmer over applied on the farm; 3) the model needs to be calibrated; etc.

There are several advantages associated with this insurance contract:

1. No moral hazard and adverse selection.
2. Relatively low administrative cost.
3. When coupled with the CNMP and the 3rd party auditor there is significantly more information available.
4. The opportunity is present to give an early warning signal of an emerging problem and make payments that can be used to mitigate the risk.
5. The adaptive learning of the entire system with model results and fully priced insurance contracts should improve the management of the system and lower the risk of failure significantly.
6. The initial levels of water in the lagoon will influence the pricing of the insurance in such a fashion that the farmer may have incentives to mitigate the risk early (e.g., if the differences in premium will *at least* pay for trucking the manure away, then there is an incentive to do this when the initial levels are high).

With this system, the focus is on preventing a problem rather than providing compensation after the problem occurs, thus the need to understand that the potential local environmental losses are reduced. Nonetheless, the policy could be designed in such a fashion

[17] This is referred to as basis risk. Back up low-cost instruments could be placed at the lagoon if there is a discrepancy. This already happens for frost insurance in California, but more as a monitoring function.

that beyond certain levels, there is another policy altogether that would fully recognize that overtopping and environmental damage has occurred.

Modifications on the Theme

Given the model results index insurance, any number of companion products could be sold jointly with the base product. This product removes much of the correlated risk problem and opens the door for some tailored products. For example, an insurance company could consider writing specific perils that might involve random events that are not tied to the model results. The third party audit gives much more information. This might then allow for an equipment failure rider to accompany the base model results index insurance. Furthermore, the extreme rainfall events could also be added as additional riders onto the base product.

Mixing Index Insurance with Hauling Options to Achieve Ex Ante Solutions

The search for good insurance contracts has focused on contracts that potentially mitigate the frequency and severity of manure system failure and transfer a portion of the financial risk if a failure occurs. Regulators are particularly interested in contracts that potentially mitigate failures and ensure that resources are used to limit or pay for damage when a failure occurs.

Among the more creative ideas to emerge from a recent study completed for the USDA Risk Management Agency (ACWF) is the concept of contracts that would result in hauling waste in such a way as to prevent or at least significantly reduce the chances of overtopping or over-applying manure. To illustrate this concept, the modeling examples developed earlier for the 10,000 head capacity North Carolina lagoon system are used. For the purpose of illustration, we specify the threshold volume as being the total holding capacity of the system, but we could just as easily specify in the contract the removal of any volume that encroaches into the emergency storm storage (previously referred to as slack capacity or freeboard).

Table 1 depicts the percentiles of volume exceeding storage capacity if the system starts on October 1 with 12 inches in storage above the treatment volume[18]. Excess waste is not observed until the 95th percentile; or, to put it another way, there is a five percent chance of a potential failure. The challenge is to define a contract to reduce the chances of failure.

One approach would be to begin hauling waste if a signal appears that there is a good chance of system failure. That is, to push the percentiles at which failures occur to higher levels and the volume of excess waste to much lower volumes-- preferably, zero. To implement such a program, an insurance provider could engage in a wide array of services for the CAFO manager. The provider could also have contracts with a trucking firm that would guarantee access to trucks when the model results signal a problem. The multiple service provider could do the following:

1) Offer a guarantee to prevent overflow by hauling excess or predicted excess manure/wastewater to a publicly owned treatment works (POTW) for treating human sanitary waste or other disposal site (land application site, commercial composting, etc.)
2) Choose to reduce the risk of overflow by slowly removing liquid given a model signal, calibrated to the site. Those signals would suggest that a significant risk of waste system failure is emerging.
3) *Or* in lieu of hauling manure away quickly, wait for more evidence of potential system failure.
4) *Or* in lieu of hauling manure, negotiate a compensation or business interruption payment that would require the CAFO manager to cease production or reduce the number of animals until the manure levels return to acceptable risk levels.

Adaptive management that accurately gauges the need for removal and the subsequent effective deployment of trucking services to implement timely removal would influence profit for the service provider.

The advantage of pairing the concept of an insurance policy based on the model results with the hauling option contract is that this combination truly does address the risk problem

[18] Treatment volume refers to the portion of the lagoon below a certain depth where a great deal of biological activity goes on to break down waste and to store heavy metals and other materials that remain within the manure storage unit. This volume represents a level below which the system is never drained for application purposes.

using mitigation. Equally important, under some conditions the cost of hauling may exceed the indemnity payments that would be required to get the CAFO operator to cease production and quit generating manure. This would be equivalent to offering business interruption insurance.

How might this approach be accomplished? A trucking firm would sell options to an AFO to haul manure away during a time of excess stress. The model results would be used to forecast periods when manure storage systems will be placed under undue stress. Given the CNMPs and third-party audits, one can envision a trucking firm offering insurance that would give the AFO manager an option to employ trucking services to haul. The firm would be legally required to haul away certain amounts of effluent as the model results demonstrate that the systems are under stress. The trucking firm could determine when to haul away the effluent. A rational decision process would use the model results early on to signal that some hauling is needed. Staging the hauling would be more economical and less alarming to the community (i.e., having a large number of trucks moving on country roads at the same time would likely attract the attention of the community).

What might such a contract cost? There are two steps in this calculation. First, what is the cost of the trucking and tipping fee[19]? Second, what is the probability weighted average cost? That is, what is the cost per gallon (cubic foot) multiplied by the probability of alternative excess waste volumes hauled? The probabilities for our case example are given in Table 1.

[19] POTWs generally charge for dumping effluent into their treatment systems. These charges are referred to as tipping fees.

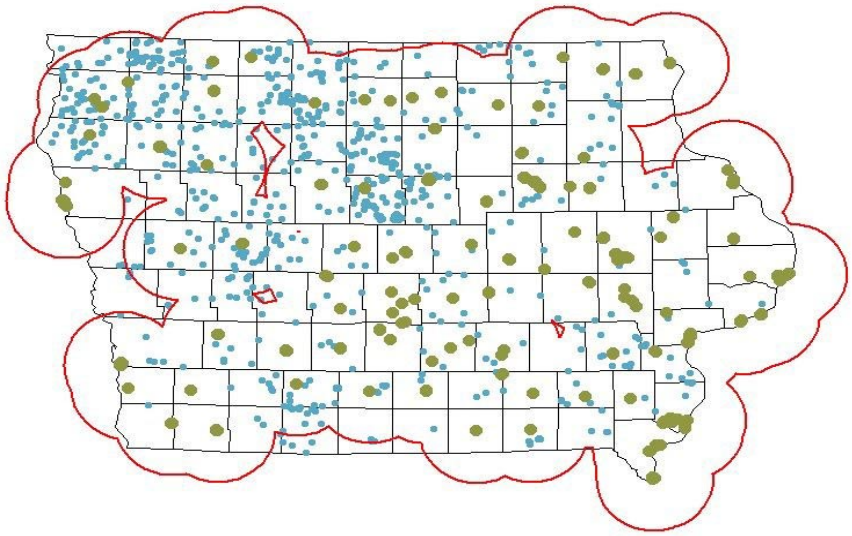
Table 1: Probability of Overflow, Quantity and Cost of Disposal estimates over 12 months starting with 12 inches of working volume on Oct. 1

Percentile	Excess Waste Volume (CuFt)	1,000 Gal	Trucking Cost
95%	31,816	238	$9,915
96%	50,906	381	$15,872
97%	65,259	488	$20,330
98%	70,141	525	$21,872
Average	4,630	35	$1,458
Max Since 1970	79,905	598	$24,913
Trucking costs are assumed to be $5.25 / 6000 gal per loaded mile. The average haul is assumed to be 25 miles, based on GIS analysis in Figure 2.			
A one time tipping fee is set at $21 / 1000 gal. Total cost per trip for a 6000 gal truck is $250			

Estimated tipping fees at a POTW are $21/1000 gallons (7.48 gal / cubic foot). Trucking fees ranging from $2.50 to $3.50 per loaded mile for 6000 gallon capacity trucks that would meet system requirements were observed with the lower end of the range for contracts that resulted in running at near capacity. In the case here, these would be option contracts that would be infrequently called into play; thus a price of $5.25 per loaded mile was used. In many areas, trucks are routinely used to haul similar materials so this fleet would not bear the full load; hence, $5.25 per loaded mile is a plausible provisional estimate.

Figure 2 shows the location of POTWs in Iowa and the concentration of swine numbers superimposed over a set of interconnected circles with a 25-mile radius. This mapping strongly suggests that over 95 percent of the AFOs in Iowa are located within a 25-mile drive of a POTW. Thus the cost for a 6,000 gallon load is approximately $250 or 4.2 cents per gallon. The average

Figure 2: Location of Iowa POTWs (larger, green circles) and CAFOs (smaller, blue circles) superimposed with 25-mile radius (red) circles to indicate hauling proximities.



excess waste reported in Table 1 is 4,630 cubic feet (34,600 gallons) which gives a pure insurance premium before loading of $1,453 or $0.15 / pig capacity. The premiums go up significantly if the system starts with a larger working volume or if the number of pigs per 1000 cubic feet of storage capacity is higher. Keep in mind that the pure premium would be risk-loaded to compensate for a number of uncertainties for the insurance provider. Thus, the loaded premium, the price that the insured actually pays, may be as much as twice the pure premium (the expected cost of the policy to the insurer). However, even at 30 cents per pig, these costs are quite reasonable and should offer an excellent opportunity for protection.

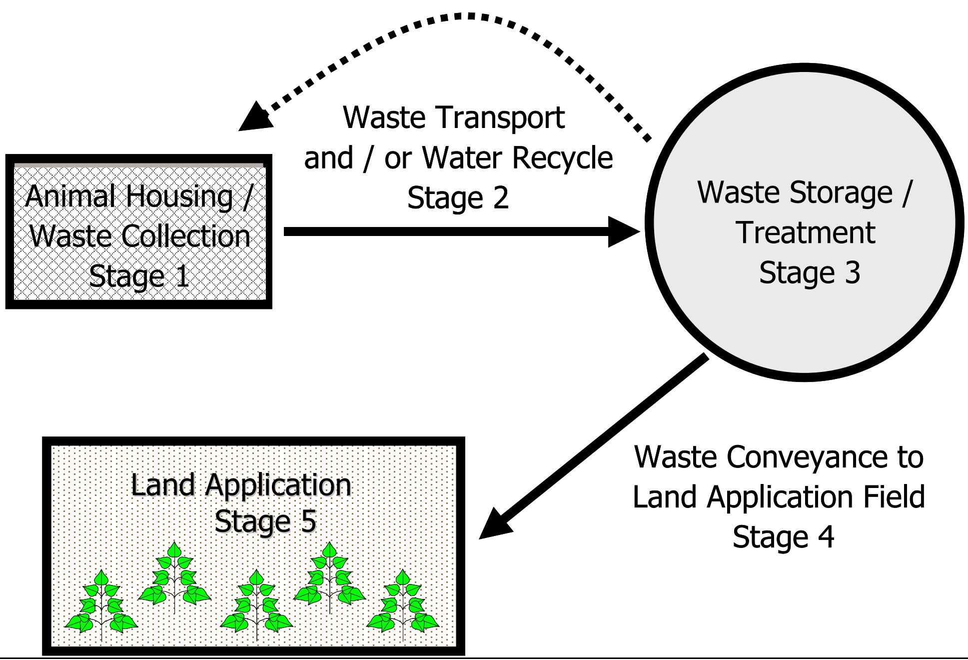
Moving Towards Complete Contracts: The HACCP Model

One can envision imposing a HACCP[20] type program that would involve inspections of the critical control points where something could go wrong as waste moves through the entire

[20] Hazard Analysis and Critical Control Point systems are customized systems for different types of industrial processes that involve extensive, regular inspection of all of the links in the production process where failures may occur. Coupling HACCP with insurance was previously proposed by Skees, Botts and Zeuli for recall insurance as a food safety measure.

management system. As depicted below in figure 3, there are five discrete stages in the entire production process that take place at any AFO that combine to create risks for society. All of the contingent claims arrangements discussed thus far in this paper address risks in only two of these five stages. Even the hybrid model results index with hauling option described above only addresses system failures at stages three and five, related to lagoon management and land application. If the goal of utilizing market mechanisms to manage risk and shift a share of regulatory functions to third party auditors is to be fully realized, a more complete or total management system is required to address failures that can occur at any stage in the system.

Figure 3: 5-point Hazard Analysis and Critical Control Point (HACCP) conceptual model



Implementing more complete contracts based on a HACCP-like model poses many questions related to firm profitability considerations and added transaction costs for the firm. If policy makers consider public support for the implementation of this type of system, a cost-benefit analysis framework needs to be utilized to evaluate the efficiency considerations from both a regulated firm and societal perspective. The movement to a HACCP system with private third party auditors will require significant changes in the current regulatory structure, but should provide for more effective targeting of efforts by regulatory agencies while simultaneously mitigating risks posed by CAFOs, ex ante; thus achieving the goals of more traditional command and control approaches by utilizing more flexible market instruments to address externality problems.

Linking the Base Insurance Product to Public Policy

Incentives may be needed to get farmers to purchase the base product that would pay for emerging problems that are revealed from model results. Since this policy is free of perverse incentives, it may be appropriate to provide some base government support. Justification for government support is based on the recognition that the government has limited resources and expertise to address the environmental and health risks posed by animal agriculture. To the extent that contingent claims can satisfy policy goals that seek to curtail negative externalities from AFOs in a more cost efficient and flexible manner than traditional command-and-control regulatory approaches, insurance may provide a preferred solution. For example, the government could consider the following: 1) continuing to pay for a portion of the implementation costs of the CNMP with EQUIP funding; 2) paying for the 3rd party auditor; 3) supporting, running, and improving the engineering/weather model; and 4) providing enough subsidy for the insurance product that the farmer would not pay more than the expected value of the indemnities. All of these considerations need more evaluation regarding the cost and benefits. In return for this type of support in a base insurance product, the farmers are giving full access to their records and their farms for auditors. This is a significant concession from the farmer that should improve the overall management of CAFOs. Once again, farmers who decide not to participate in this system would be subject to increased scrutiny from the regulators just as Kunreuther, McNulty, and Kang explained. In the longer term, there would be few farmers who were not purchasing insurance products that would help them manage and mitigate risk before an environmental problem emerged.

Conclusions

Given that a major goal is to modify behavior of the individual AFO manager in such a fashion that the risk of failure is reduced, many of the market-oriented solutions that address aggregate behavior are considered less desirable than those that focus on the individual risk. Contingent claims contracts that provide incentives for individual underwriting and monitoring are deemed most appropriate for focusing on individual behavior. However, as was clearly discussed above, such contracts must be carefully designed so that one does not create moral hazard or attract only the most risky (adverse selection). If these problems are not controlled, the risk can actually increase for the individual operation. The most attractive solutions involve using index-based contracts that will be free of adverse selection and moral hazard. To the extent that a broader range of coverage is offered – using insurance-like products – there is a clear role for third-party auditors. Finally, solutions that combine many of the principles from market-based solutions are most desirable, particularly if the combination of a contingent claims contract and a risk mitigation strategy such as hauling can be achieved.

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