Concentrated Animal Feeding Operations And The Economics of Efficiency

By Dr. William J. Weida
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Introduction

The economic model that became capitalism is based on efficiencies from standardization, specialization and concentration of productive resources. As capitalism developed and this model was applied to production activities, social and environmental problems such as child labor, unhealthy working conditions, unfair labor practices, and polluting activities often occurred. Over time, these issues were dealt with in the industrial sector through a framework of laws and regulations.

Recently, agriculture has moved toward an industrial model of production--Concentrated Animal Feeding Operations (CAFOs)--that exceeds the capacity of the land on which it is located to naturally process animal waste. In a fundamental sense, the ability of the land to naturally process animal waste defines the limits of sustainable agriculture. Agriculture can only be environmentally sustainable if it produces no more waste than the land available for waste application can absorb. Waste produced in excess of this amount must, at some point, be transferred off the land in the form of air- or water-borne pollution and when this occurs, the costs of this waste are shifted away from the land where the waste is generated.

Unfortunately, agriculture's shift to industrial CAFOs outpaced laws and regulations governing agricultural activities--laws and regulations that were meant for a non-industrial sector. This occurred partly because agriculture is viewed by the state and by society in general through a lens colored by the assumption that the enterprise of agriculture is a "closed system" where the density of animals is compatible with the land's ability to recycle animal waste.

One central rationale of laws to regulate industrial waste was the recognition that the assumption of a closed system did not apply to industries. Industrial waste often polluted the environment of those who lived around (or many miles from) the industry and laws were necessary to prevent the harm to society that might come from contact with this pollution. The laws governing industrial waste forced industry and the consumers of its products to "internalize" (pay for) the costs of dealing with this pollution.

The assumption of a closed system is usually no more applicable to CAFOs than it is to any other industrial operation, but CAFOs, masquerading as agricultural enterprises, have used the absence of laws governing agricultural pollution to avoid paying the costs of the waste generated by their operations. The reason CAFOs must shift the costs of their waste to someone else is that they are faced with significant diminishing returns in their operations. This has become the central issue in the debate about the two contracts under which CAFOs operate--the explicit contract that governs their relationships within the financial organization in which they exist, and the implicit contract between the CAFO and the region or community in which it is located.

This paper is organized in two parts to deal with these issues:

I. An explanation of some of the industrial organization issues involved in operating large, corporate hog farms, and an explanation of the two contracts that govern the behavior of corporate hog firms--the business contract and the contract with the community that hosts the firm, and the implications of these issues for the community.

II. An examination of the question of efficiency of CAFO production--whether large hog farms are more efficient than conventional hog farms.

I. THE INDUSTRIAL ORGANIZATION AND CONTRACT ISSUES INVOLVED IN OPERATING LARGE, CORPORATE HOG FARMS AND THE IMPLICATIONS OF THESE ISSUES FOR THE COMMUNITY.

Price is the mechanism by which any market conveys the basic information about supply and demand for a good. But markets in which CAFOs are employed have become very different from the old commodity-based models of agricultural production and the effects of these markets on the life and economies of local communities have changed significantly.

Initially, the issue of CAFOs seems simply to be one of price and efficiency. However, to a large extent it is really an issue of information. As Jones has noted, in agriculture

> [t] he critical emphasis is changing from resource allocation based on price to allocation based on strategic advantage...Until greater transparency of information in economic signals between industry levels occurs, there is a strong incentive for producers to develop formal partnerships through cooperatives, joint ventures, or vertical arrangements.[1]

These partnerships usually create two contracts of interest when a CAFO enters a region:

1. the contract with the CAFO's organization where information is equally shared and where the motives of all players are a consistent and singular search for profit, and
2. the contract between the community and the CAFO where asymmetrical information exists.

When a CAFO enters a rural region, it strikes a bargain with the rural community in that region. This implicit contract is usually formed around stated, not written, promises of jobs and economic growth for the region that the CAFO will provide in return for land, water, access, power and the other factors that are required for the CAFO to operate. This implicit contract also implies a certain physical relationship with the region that manifests itself in the presence (or lack) of pollution, traffic, resource consumption, etc., that arise from the operation of the CAFO.

The CAFO organization is typically well informed about the legal contract with its organization and the implied contract with the region because it signed the legal contract and it extended the verbal offers on which the regional contract is based. But the citizens of the region are privy to very little information about the CAFO's explicit contract with its organization. As a result, there is an incentive on the part of the CAFO to shift costs between the contracts based on each party's access to information about those costs. The party with the least information about costs is most likely to have those costs shifted in its direction.

Local, county, state, and national laws and policies on the environment and on zoning are important determinants of the location of CAFO facilities.[2] Further, these laws and policies affect the ability of CAFOs to control information about their operations and they are major determinants of the role the CAFO will play in the physical, social and economic environment of a region. Thus, the physical relationship between the CAFO and the region is essentially predetermined by the rules and policies that are already in place in the region--and this set of rules and policies is based on the pivotal assumptions that:

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[1] Jones, Elund, "The Role of Information in US Grain and Oilseed Markets," Review of Agricultural Economics, vol. 21, no. 1, Spring/Summer, 1999, pp. 244-247.
[2] Hennessy, David A. and Lawrence, John D., "Contractual Relations, Control, and Quality in the Hog Sector," Review of Agricultural Economics, vol. 21, no. 1, Spring/Summer, 1999, p. 53.

1. all agricultural operations are similar to the conventional, closed systems that previously dominated agriculture.
2. animal waste, as a natural product, while annoying, is essentially harmless, and not as toxic as human waste.
3. most animal-raising operations can be treated as if the waste that results is from ruminate animals.

As a result of these assumptions, when a CAFO enters a region it encounters a set of rules that have generally been structured to control a kind of agricultural production whose inputs and waste byproducts are not representative--either in quantity or chemical composition--of the Concentrated Animal Feeding Industry.

The question here is not whether the CAFO can make an implied contract with the region. Instead, the issue is that in addition to this contract being physically defined around incorrect assumptions, it will also be based on asymmetrical information that heavily favors the CAFO. Such a contract is likely to work in only one direction--it is likely to increase the profits of the CAFO by shifting the operating costs of the CAFO either to the region in which it is situated or, through some mechanism of pollution migration, to another region further removed from the CAFO. The certainty of this outcome follows directly from existence of asymmetrical information about the operation of the CAFO and from the motivation of the operators of the CAFO.

The term asymmetrical information refers to a situation where one of two individuals in an agreement or contract possesses more information than the other individual about the nature of the bargain. If one individual possesses critical additional information about the contract, this individual can use his proprietary information to gain an advantage in the bargain. Remember that capitalism is based on the concept of full and free information about all aspects of the market--something that was easy to achieve under the traditional agricultural model where no single player was big enough to affect the market or, by implication, to operate in such a manner that it could hide information on which the market price was based and thus, shift its costs.

In theory, the permitting process used to evaluate CAFO applications should insure that the citizens of a region are fully informed about all aspects of the CAFO's proposed operation. If this was indeed the case, there would be no asymmetrical information. However, the nature of the permitting process--which is usually based on incorrect assumptions that all agricultural projects are conventional in nature--allows the CAFO operator to acquire an operating permit while withholding significant amounts of information from the residents of the region. This occurs in the following ways:

1. The CAFO uses claims that its methods of handling waste are technologically advanced and thus, proprietary, to block release of information about the specifications and performance of its waste handling systems.
2. The CAFO's requirements for sterile operating facilities limit public inspection of and knowledge about the CAFO and even limit the overall organizational knowledge of many CAFO employees.
3. The usual position of the CAFO as a contract operator for a larger, out-of-area corporate interest may limit even the CAFO operator's knowledge of the source of inputs (feeds, antibiotics, etc.), the rationale behind the amounts and types of inputs selected, and the actual value of the product (the pork, chicken, etc.) to the owner.
4. Out-of-area ownership and the use of Limited Liability Partnerships (LLPs) severely limits the ability of regional residents to determine the motivation, trustworthiness, and credibility of those who own and operate the CAFO.

5. The short life span of CAFOs and the normal practice of building CAFOs as turn-key operations limits the ability of regions to establish any reliable record of CAFO performance before committing to a fully-constructed operation.
6. The legal protection extended to the CAFO by permitting authorities often insulates the CAFO from disclosures that may provide the only source of information about out-of-state operations. For example, an Idaho law specifically exempts from disclosure "records gathered by a local agency or the Idaho Department of Commerce...for the specific purpose of assisting a person [e.g. a corporation] to locate, invest in or expand business operations in the state of Idaho."[3] And manure management plans in Iowa can be changed on site without notifying the Iowa Department of Natural Resources of the changes. The working copy of the plan is held by the CAFO operator and is not available for public scrutiny.[4]
7. And finally, the CAFO permit approval process is often so rushed that residents of the region have insufficient time to learn enough about the proposal to ask intelligent questions or to do relevant research on the proposal.

A combination of all these factors creates an agreement (contract) between a CAFO and a region that is based on verbal promises of jobs and economic development (see Appendix 8 for the effects of CAFOs on regional economic development), but for which the actual information needed to validly assess the impact of the CAFO on the physical, social and economic environment is withheld from the public and is available only to the owners/operators of the CAFO. The result is that the county or other permitting agency has inadvertently created what economists call a moral hazard, a process that occurs when one party is better informed than the other about the characteristics of the transaction. By definition, a moral hazard leads to lower efficiency and to higher costs to the party that is least informed (in this case, a higher cost to the region that hosts the CAFO.)

Having created a moral hazard, the region is now faced with a second economic condition called adverse selection. This provides an incentive for additional producers who also want to shift costs to the residents of the region to migrate to the area. Thus, additional CAFOs are likely to be attracted to the region. As Milgrom and Roberts note, adverse selection is "a kind of precontractual opportunism that arises when one party to a bargain has private information about something that affects the other's net benefit from the contract and when those whose private information implies that the contract will be especially disadvantageous for the other party agree to a contract."[5]

Casson has laid out the general outlines of the relationship that develops between the region and the CAFO as a result of these factors by noting that:

> the crucial question... is whether the other party to the transaction can be trusted. There are two fundamental approaches to engineering or creating trust. The one most commonly used in much of the Western world is to monitor performance through the institutional and legal system and penalize those parties that do not fulfill their negotiated commitments. The alternative approach to engineering trust is to manipulate the incentive structure so that individuals fulfill their commitments based on rewards they receive rather than penalties they incur.[6]

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[3] Idaho Statutes s.340 (8).
[4] Letter from Veysey, Stephen W., sveysey@iastate.edu, February 28, 2000.
[5] Milgrom, P. and Roberts, J., Economics, Organization, and Management, Prentice Hall, Englewood Cliffs, NJ, 1992.
[6] Casson, M., The Economics of Business Culture: Game theory, Transaction Costs and Economic Performance, Clarendon Press, Oxford, England, 1991.

For CAFOs, the issue of trust is directly tied to out-of-area ownership and the asymmetrical information in the agreement between the CAFO and the community. Since the motivation of the CAFO is to create profit, not to control pollution or engage in any of the other social benefits the region may desire, the CAFO can only be trusted to act in its own self interest. The interests of the region could initially be protected by disclosure of full information concerning the operations of the CAFO during permitting. However, due to the factors already discussed, the CAFO usually controls the information in this part of the process. The only recourse for the region is monitoring by knowledgeable regulators.

Unfortunately, monitoring measures compliance with laws that are often crippled by the same underlying assumptions about the nature of agriculture listed earlier in this section. CAFOs are able to use laws based on loose, conventional agricultural standards to avoid pollution controls that would more fully assign the costs of waste to the CAFOs. In addition, most of the factors that make it difficult to get information on proposed CAFO operations during the permitting process also complicate attempts to monitor CAFO operation. This leads to a condition called low separability. Separability is "...the feasibility to see who has done the work. With low separability, the principal [in this case, the region] will face either high control costs or intense cheating."[7]

So far, the history of CAFO operations shows that cheating is likely. And it is made even more likely by the decision on the part of many regulating agencies to rely on citizen complaints instead of more costly professional monitoring. If monitoring fails or is not effectively implemented, the only other option for controlling the behavior of the CAFO is through economic incentives. But, as previously noted, a powerful economic incentive structure is already in place and this incentive structure has been formalized in the explicit contract between the CAFO, its own organization, and its investors. This contract directs the CAFO to operate in such a way as to maximize profit, and if it can do this by shifting the costs of its waste to its neighbors in the region, that is how it will operate.

In fact, simply accounting for these conditions and for the factors that would reward a CAFO for shifting its costs allow one to develop a simple CAFO location model. For example, a hog CAFO would look for an area where:

1. Roads for importing feed inputs and exporting pork are near and already constructed.
2. Water is readily available and cheap.
3. Local croplands require a high nitrogen input, thereby allowing more waste to be spread closer to the CAFO.
4. Waste application is not limited by phosphorus content.
5. Land is cheap, due to either soil conditions or a depressed economy.
6. And most important, environmental standards are low and enforcement is lax.

II. THE ISSUE OF ECONOMIC EFFICIENCY.

The economic issue of efficiency in production is central to the rationale for Concentrated Animal Feeding Operations. In this argument, the economic issue usually discussed is the concept of increasing returns to scale where the efficiencies are realized when more capital is brought to a production process. The resulting capital intensive process has a much higher reliance on machines and

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[7] Sauvee, Loic, "Toward an Institutional Analysis of Vertical Coordination in Agribusiness," in The Industrialization of Agriculture, Jeffrey S. Royer and Richard T. Rogers, eds., Ashgate Press, Brookfield, VT, 1998, p. 55, 56.

technology and is less reliant on labor. In the CAFO process, raw materials (feed, water, etc.) are submitted to hogs or chickens in confinement buildings and the output is pork, chicken or eggs.

In so far as the hogs and chickens and their confinement facilities can be treated as machines, the CAFO philosophy is that they can be "improved" through the addition of capital to the production process. This "improvement" comes through standardization of hog and chicken breeds and sizes, control of growth rates and animal disease, and increased specialization of workers, managers, and animal raising facilities.

If this was all there was to the CAFO process, one would expect efficiency of operations to continue to increase as more capital in the form of hogs and buildings was added to the process. In other words, the maximum efficient size of hog CAFOs would be extremely large. Further, this concentration would bring other benefits. For example, a former Agriculture Commissioner in Minnesota has stated that

> As farms and feedlot operations get larger, there will be opportunities for important land and resource restoration to occur. Greater production of crops on fewer acres will make land available for important resource restoration activities. The prairies of the state have been mostly eliminated, and some of our most important biodiversity issues must be approached by restoring grassland habitats.... The larger farming operations will also provide greater opportunities for better management of wastes and capital intensive management methods for improved air and water quality.

The Commissioner's point is valid only if the efficiency of farm and feedlot operations continually increases as they get larger and larger. In this sense, efficiency means that average costs continue to drop. However, this is not the case. Efficiency peaks as concentration rises because the cost of waste disposal for a CAFO increases sharply after one surpasses the ability of the land to absorb the waste. The fact that CAFOs try to avoid this cost by shifting the cost of their waste to the surrounding region makes no difference--the confined operation is still less efficient in an economic sense.

The Commissioner's statement also contains an unstated assumption--that the waste generated by concentrated operations stays on the site and that the land is capable of absorbing an unlimited amount of waste material. Carried to its (il)logical conclusion, the Commissioner's statement would lead one to concentrate all cattle on a single feedlot.

There is a large body of law that already regulates problems of industrial concentration that arise from a similar condition to the one the Commissioner proposes: a point source of pollution from some concentrated industrial activity damages the health of the surrounding environment. Theoretically, a concentration of industry in various locations should, in the Commissioner's words, "[make] land available for important resource restoration activities" (because it is not covered by factories.) Instead, the waste flows from those concentrated activities ruined the surrounding environment and, in the case of acid rain, the environment thousands of miles away.

A CAFO only concentrates animals in less space, it does nothing to reduce the amount of land needed to raise feed for the animals and it does nothing to reduce the amount of land that ultimately is needed to recycle the animal waste. For this reason, the switch back to conventional farming simply places the animals on the land that is also used to grow their feed and uses the animal manure responsibly to fertilize that land so that feed can continue to be grown in a more-or-less closed system. In addition, spreading the animals out in this manner reduces the need for antibiotics.

The Efficient Size of CAFO Operations

Based on studies at the University of Missouri, between 1988 and 1991 only hog producers marketing less than 1,000 head annually lost market share. Between 1991 and 1994, all producers below 3,000 head marketed annually lost market share.[8] And by 2000, a team of Purdue University economists found that pork industry concentration had increased to the point where the top four pork processing firms controlled 56 per cent of the business.[9] However, if all the economic costs of CAFO operation are considered, two economic concepts--diseconomies of scale and diminishing marginal returns--both mandate that the efficient size of most animal feeding operations should be relatively small. To understand why smaller and medium sized hog operations have lost market share to the CAFO giants it is necessary to investigate how the expected effect of these two economic concepts has been altered by the actions of the CAFO industry.

The first economic concept--diseconomy of scale—usually comes into play when problems associated with some element of a production process increase much faster than the size of the process itself increases. With hogs or chickens, such a situation occurs with attempts to control disease and the stress factors that occur during confinement, movement and transportation. The possibility of disease among hogs is so great that a heavy use of antibiotics, limitations with respect to shed populations, the requirement to maintain a sterile site, and time limits on how long hog operations can stay in one spot all act to create diseconomies of scale. In fact, large hog CAFOs are usually limited to ten to twelve years at a site before health factors become so overwhelming that they can no longer be controlled with certainty and the hog operation must abandon the site.

A second, more powerful economic concept called diminishing returns also ought to act to limit the size of efficient CAFO operations. Under this concept, when units of a variable resource (such as hogs) are added to a fixed resource (such as land) one reaches a point where the marginal product (the revenue gained from the last hog added to the operation less the cost of the last hog added to the operation) of the variable resource begins to decline. Because of the costs of handling animal waste responsibly, the point at which this decline occurs is closely related to the ability of the land on which the CAFO is located, and the land over which the CAFO will apply its waste effluent, to absorb and recycle the manure. If diminishing returns to a CAFO did not exist, all the hogs in the world could be raised on a single, small plot of land. This is clearly the philosophy of some in the hog industry who recognize no limits to hog farm growth. For example, Freese has stated that "[c]ompletely comparable costs are not publicly available to distinguish between a declining or flat average cost curve in the long run, but what is clear is that diseconomies of size are not limiting the growth of firms with 95,000 sows."[10] Such a statement, which completely disregards diminishing returns from hog waste and confinement, is nonsense.

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[8] Grimes, Glen, and Plain, Ron, "The US Swine Industry - Where to from Here?," Proceedings of Swine Strategies '95, Summer 1995.

[9] Paarlberg, Philip, "Structural Change and Market Performance in Agriculture: Critical Issues and Concerns about Concentration in the Pork Industry, Testimony before the Senate Committee on Agriculture, Nutrition, and Forestry, Washington, DC, February 1, 2000, in Anthan, George, "Hog-industry concentration assessed," Des Moines Register, Washington Bureau, February 27, 2000.

[10] Freese, B., "Pork Powerhouses," Successful Farming, October, 1995, pp. 20-22.

To overcome these costs, CAFOs have been designed to take full, economic advantage of the assumptions about agriculture listed in the previous section—assumptions that not only form the basis for CAFO permitting and regulating but also establish the tax and subsidy policies that create the economic environment in which CAFOs operate. These assumptions allow important costs of CAFO operations to be either omitted or understated in the profit and loss calculations of the CAFO. They also allow the CAFO to take advantage of important tax and investment opportunities that, in effect, subsidize its operation. These factors artificially inflate the amount of profit available from CAFO operations and generate short-term gains for developers and investors. While this would be significant in itself, artificially inflated profits also act to draw more investment into CAFO operations, contribute to the proliferation of CAFOs, and provide an economic incentive for an organizational model that gives rise to the four common attributes of every CAFO:

(1) The use of capital intensive production methods. CAFOs use less labor and more machinery to achieve production output.
(2) Employment of a production methodology that maximizes tax benefits and subsidy availability to the corporation.
(3) The use of vertically integrated operations where separate divisions of the same company produce the different stages of a product and market their output to one another.
(4) The use of cost shifting to reduce the costs of production. Cost shifting occurs when the costs of health problems, traffic, social problems and pollution (odors, chemical and particulate air pollution; chemical, pathogen, and particulate water pollution) are transferred to the residents of a region and are neither paid by the company responsible for the costs nor included in the price of the products they market.

In summary, arguments about the efficient size of CAFO operations assume that the purpose of the organization and hence, the output of its operations, are both known and clearly specified; i.e., the purpose of a CAFO may be assumed to be pork or chicken production within certain product specifications. Further, these arguments also assume that the CAFO and the more conventional operation to which the CAFO is compared both have the same fundamental production objectives. However, as the above-listed attributes demonstrate, it is not clear that pork or chicken production is the primary objective of a typical CAFO. Indeed, because a typical CAFO is designed to

1. maximize tax benefits in both industrial and agricultural categories, and
2. maximize subsidies for both industrial and agricultural operations, and
3. shift as many costs as possible to the local region while
4. producing an agricultural commodity (raising animals),

it is not clear what weight, if any, one should give to efficient sizes for pork or chicken production when discussing a CAFO operation. Any comparison of efficiency is further complicated by the fact that the price of CAFO commodities is more likely to be set by the competitive needs of the organization as a whole (in other words, the competitive price of the final, processed products produced by the vertically integrated organization--i.e., Ramsey Pricing) than by the actual need to directly compete with other producers of pork or chicken. As a result of these factors, CAFOs are also particularly ill-suited to aid in regional economic development (see Appendix 8.)

ESTIMATES OF ACTUAL CAFO EFFICIENCY AND PROFIT MARGINS

A number of scientific studies have shown that hog CAFOs are no more efficient than a significant percentage of conventional hog producers.[11] Indeed, studies have shown that "during relatively low input costs-output prices the pasture system provided the highest return above all costs per sow" and "the pasture system provided the highest income above variable costs per sow for the feeder pig production phase for all swine prices and feed cost levels studied." Since pasture costs are often sunk costs--the cost has already been incurred and further use is almost costless--this assessment is logical. Further "...total confinement...had...the highest risk [and]...the pasture system provided more stable returns, thus a lesser amount of risk." [12] In spite of this, hog CAFOs have captured a large and increasing share of the hog market over the last thirty years.[13]

At issue here is not whether large CAFOs have been able to show a profit--they obviously have or they would not be able to attract the amount of capital investment they have accumulated over the last ten years. Rather, the issue is whether this profit is an accounting profit that results from a failure to account for the full costs of operation or whether this is an economic profit that incorporates a full consideration of all costs incurred by the CAFO. If some costs have not been fully accounted for, a second, important issue is the magnitude of those costs compared to the profit margin of large CAFO activities; i.e., are the costs large enough to cause a CAFO to operate at a loss or, even if these were properly assigned, would the CAFO still show a profit.

The costs that will be considered in this comparison are the costs of responsible waste disposition only. This is done for three reasons. First, the amount of waste generated and the limited amount of land for their application are both a direct result of the concentrated operations that are the subject of this paper. Second, the costs of responsible waste management are significant enough to adequately test the case of CAFO profitability. And third, because the costs of animal waste are directly tied to animal concentration, more conventional farms do not incur most, if not all of these costs. Instead, conventional farm operations keep a population of animals that is small enough compared to the land available to spread manure that the waste is naturally recycled into the land. Thus, the costs of waste not accounted for on a well-run, conventional farm are often close to zero.

Profit margins of large and small hog producers

The accounting costs and rates of profit in the hog industry are well known. In a University of Missouri study for the period 1969 to 1993, hog producers had an average profit of $4.18/cwt ($1999), or over a $10 ($1999) profit for a marketable hog (260 lbs.) for 24 years. This equated to an average profit of nearly 10% for 1969-93. The best one-third of these producers had a profit level per cwt. was about double the average--$8.25 or almost 20%.[14] In 1988, farm records showed a range of about $14 ($1999) in average costs per cwt. between the best one-third and poorest one-third of producers in Iowa,

[11] See: "Iowa Livestock Enterprise Summaries," Iowa State University Extension, EJS 206, ASB, Ames, Iowa, 1992, 1993, 1994.
and
Lasley, Paul; Duffy, Mike; Ikerd, John; Kliebenstein, Jim; Keeney, Dennis; and Lawrence, John, "Economic Development," Understanding the Impacts of large-scale Swine Production, Proceeding from an Interdisciplinary Scientific Workshop, Des Moines, Iowa, June 29-30, 1995, p. 123.
[12] Kliebenstein, James B. and Sleper, James R., "An Economic Evaluation of Total Confinement, Partial Confinement, and Pasture Swing Production Systems," Research Bulletin 1034, University of Missouri-Columbia College of Agriculture, February 1980.
[13] The number of hog farms in the US dropped from about 900,000 in 1970 to 139,000 in 1997 while pork production remained relatively constant. Drabenstott, Mark, "This Little Piggy Went to Market: Will the New Pork Industry Call the Heartland Home?", Economic Review, Q3, Vol. 83, No. 3, Federal Reserve Bank of Kansas City, Third Quarter, 1998, p. 82.
[14] Grimes, Glen, and Plain, Ron, "The US Swine Industry - Where to from Here?," Proceedings of Swine Strategies '95, Summer 1995.

while most rapidly expanding large operations had operating at costs that were about $4.25 to $7 ($1999) per cwt. below the majority of more traditional producers.[15]

However, these figures do not accurately reflect the highly variable nature of the hog industry. Bruns et al., in a six-year study using the Swine Enterprise records, showed substantial variation in performance by individuals from year to year. Of forty producers, 73 percent were among the lowest one-third in total production cost per cwt. in at least one of the six years but only 25 percent were in the lowest one-third in total production cost for four years or more. Almost no one was in the low-cost one-third for all six years.[16]

In 1978, the average accounting cost of producing hogs in Missouri was about $100/cwt of live pork in 1999 dollars. By 1993, these accounting costs had fallen to around $51/cwt in 1999 dollars, or just slightly over 50% of the 1978 costs. Much of this reduction in cost was due to more pigs/litter and more litters/sow/year, less feed per pound of hog produced and more pounds of lean meat per live hog. [17] For example, farms with over 2,000 hogs averaged 8.8 pigs saved per litter while farms with fewer than 100 hogs saved 7.3 pigs per litter.[18] And the largest hog firms report feed conversion of 3.0 pounds of feed per pound of live hog as compared to more than 4.0 pounds of feed in other hog operations.[19]

Since well-managed, relatively small producers, acting either independently or in cooperation with neighbors, can also employ many of the all-in/all-out production by site, split-sex feeding, phase feeding, producing specialized female breeding animals, specialization of labor, marketing and buying inputs used in large-scale production, smaller producers should be able to compete with most of the large operations. And some economies of smaller, independent producers--home-produced feed, family labor and pride of ownership--should also contribute to lower costs.[20]

The small producer--who usually has a stake in the region and is often a long-time member of the community--generates less animal waste because his operation is small. In addition, the small producer usually has more land per animal on which to spread and recycle the waste. Since the

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[15] Iowa State University Swine Task Force, The Iowa Pork Industry, Competitive Situation and Prospects, Iowa State University SFTI, December, 1988, pp. 59-63 in Rhodes, V. James, "The Industrialization of Hog Production," in The Industrialization of Agriculture, Jeffrey S. Royer and Richard T. Rogers, eds., Ashgate Press, Brookfield, VT, 1998, p. 225.
and
Vansickle, J., "Expansion Dream Survives Roadblocks," National Hog Farmer, June 15, 1994, pp. 12, 14-15, 18.
and
Iowa State University Swine Task Force, The Iowa Pork Industry: Competitive Situation and Prospects, Iowa State University STF1, December 1988, pp. 59-63.

[16] Bruns, M., J. Kliebenstein, J. Lawrence, and E. Stevermer, "Iowa Swine Enterprise Return and Production Variability," Swine Research Report ASL-R971, Cooperative Extension Service, Iowa State University, December, 1992, in Ginder, Roger G., "Alternative Models for the Future of Pork Production," in The Industrialization of Agriculture, Jeffrey S. Royer and Richard T. Rogers, eds., Ashgate Press, Brookfield, VT, 1998, p. 260.

[17] Grimes, Glen, and Plain, Ron, "The US Swine Industry - Where to from Here?," Proceedings of Swine Strategies '95, Summer 1995.

[18] US Department of Agriculture, Hogs and Pigs, National Agricultural Statistical Service, Washington, DC, 1984-1996.

[19] Zering, Kelly, "The Changing US Pork Industry: An Overview," in The Industrialization of Agriculture, Jeffrey S. Royer and Richard T. Rogers, eds., Ashgate Press, Brookfield, VT, 1998, pp. 55, 56.
and
Hurt, C., "Summary and Conclusions," Positioning Your Pork Operations for the 21st Century, ID-210, Cooperative Extension Service, Purdue University, July 1995.
and
U.S. Department of Agriculture, Hogs and Pigs, National Agricultural Statistics Service, Washington, D.C., various, 1984-1996.

[20] Grimes, Glen, and Plain, Ron, "The US Swine Industry - Where to from Here?," Proceedings of Swine Strategies '95, Summer 1995.

production of hogs is only one of his activities, his property is usually good agricultural land with the costs and taxes that go along with that designation. Thus, while he shifts few costs to the local region, the small producer usually pays a full share of the costs of using his land because those costs are the price of keeping the land productive in the long run.

The large producer usually has less land per animal and thus, a smaller land cost for the property on which the animals are raised. Further, he may choose bad agricultural land because it is cheap and will lower the cost of the site. He will try to minimize the taxes and other costs by qualifying for both agricultural and industrial subsidies. The large producer usually shifts the cost of the animal waste to the host region through over-application of waste on too little land or through accumulation of waste in lagoons whose final disposition is highly problematic. These factors can give significant accounting cost advantages to the large producer--and they also transfer very real costs to residents of the region in which the producer is located.

Table 1
Percentage Reduction In Property Tax Assessments
For Farms Located Around Large CAFOs

Area	Percentage Reduction	Limitations
Grundy Co, MO	30%	
Mecosta Co, MI	35%	dwellings only
Midland Co, MI	20%	
DeWitt Co, IL	30%	now rescinded
McLean Co, IL	35%	
DeKalb Co, AL	base reassessment variable rates	
Renville Co, MN	base reassessment variable rates	dwellings only
Humbolt Co, IA.	20-40%	dwellings only--now rescinded
Frederick Co, MD	10%	now reduced to 5%
Muhlenberg Co, KY	18%	dwellings only

Source: Sierra Club, "Property Tax Reductions," scott.dye@sierraclub.org, March 13, 2000.
Radius of reduction varies up to 2 miles. All were for hogs except Muhlenberg, for chickens.

As Table 1 shows, the costs transferred by large CAFOs are significant and their impact is predictable--they lower the value of other property surrounding the site from which the costs are transferred. A study of 75 rural land transactions near Premium Standard's hog operations in Putnam County indicated an average $58 per acre loss of value within 3.2 kilometers (1.5 miles) of the facilities. The study, released in February 2000, by the departments of Agricultural Economics and Rural Sociology at the University of Missouri, primarily evaluated farmland without dwellings. Another University of Missouri study released in May, 1999 found that rural property in Saline County, MO was devalued by $2.68 million dollars, or an average of $112 per acre for 99 property owners within three miles of CAFOs, or concentrated animal feeding operations.[21]

[21] Dye, Scott, "University Research Finds Staggering Property Devaluation Near Factory Farms," scott.dye@sfsierra.sierraclub.org, March 13, 2000.

By 1995, many of the rapidly growing swine production firms who were engaged in this kind of cost shifting claimed long-run total costs of $42 to $44 ($1999) per cwt. of live hogs. The North Central benchmark cost, which included many smaller farms, has ranged from $47 to $52 ($1999) in recent years.[22] Hurt estimated that specialized 1,200-sow farms have total costs of production that are $6.89 to $14.93 ($1999) per cwt. (15 to 28 percent) lower than those of 150-sow farrow-to finish farms.[23]

These cost advantages decrease sharply with even modest increases in the number of sows. Hurt estimated a unit with 3,400 sows had a cost advantage of only about $2.15 ($1999) per cwt. of live hogs compared to one of 650 sows.[24] And Duffy has shown that average costs do not fall significantly beyond about 150 sows. Citing Swine Enterprise records from 1992, 1993, and 1994, he shows the average production cost for the top one-third of the responding producers to be approximately $42 ($1999) per cwt. in all years and the average size of the top one third operations to be approximately 120 sows."[25]

Some of the disagreement in cost figures arises from differences in accounting practices, inventory measurements, and the type of data used. Good et al., using a budgeting approach, found budgeted costs for the 3,500-sow unit were estimated to be $39.37 ($1999) per cwt., compared to $41.39 ($1999) per cwt. for a 650 sow operation and $44.04 ($1999) per cwt. for a 250-sow operation. Even so, the various figures for the cost of raising hogs show a great deal of consistency in the 1990's. As Table 2 shows, large, rapidly growing firms have only a small advantage over smaller, 250-650 hog operations. This implies that a 650-sow operation could be cost competitive with a 3,500-sow operation with some minor changes in operations. Small operations could have an accounting cost disadvantage of only $4.38-$5.48 ($1999) per cwt., or about $11 ($1999) per head produced.[26]

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[22] Zering, Kelly, "The Changing US Pork Industry: An Overview," in The Industrialization of Agriculture, Jeffrey S. Royer and Richard T. Rogers, eds., Ashgate Press, Brookfield, VT, 1998, pp. 55, 56.
and
Hurt, C., "Summary and Conclusions," Positioning Your Pork Operations for the 21st Century, ID-210, Cooperative Extension Service, Purdue University, July 1995.
and
U.S. Department of Agriculture, Hogs and Pigs, National Agricultural Statistics Service, Washington, D.C., various, 1984-1996.

[23] Hurt, C., "Summary and Conclusions," Positioning Your Pork Operation for the 21st Century, ID-210, Cooperative Extension Service, Purdue University, July 1995, p. 185.

[24] Vansickle, J., "The Midwest Can Compete," National Hog Farmer, March 15, 1995, pp. 28, 30.

[25] Duffy, M., "Profitability in Farming: Today and Tomorrow," Paper presented at 5th Annual Conference, Leopold Center for Sustainable Agriculture, Iowa State University, Ames, Iowa, March 3, 1995, in Ginder, Roger G., "Alternative Models for the Future of Pork Production," in The Industrialization of Agriculture, Jeffrey S. Royer and Richard T. Rogers, eds., Ashgate Press, Brookfield, VT, 1998, p. 260.

[26] Good, K. Hurt, C. Koster, K., Kadlec, J., and Zering, K. "Comparative costs of Hog Productin in the Medwest and North Carolina," Paper presented at Pork Global Competitiveness Seminar, St. Louis, Mo., January 9, 1995, in Ginder, Roger G., "Alternative Models for the Future of Pork Production," in The Industrialization of Agriculture, Jeffrey S. Royer and Richard T. Rogers, eds., Ashgate Press, Brookfield, VT, 1998, p. 260.

Table 2
Cost per hundred weight ($1999)

Study	Date	Approximate Cost per Hog
University of Missouri—Average	1978	$250
University of Missouri—Average	1993	$127
Duffy--Top 1/3 of Producers	1992-1994	$105
Zering--Rapidly Growing Firms	1995	$105-$110
Zering--North Central Area	1995	$118-$130
Good et al.--3,500 sow	1995	$98.50
Good et al.--650 sow	1995	$103.50
Good et al.--250 sow	1995	$110

In sum, the data on costs and profits from hog production show a fairly consistent picture. Not only have the costs incurred by both small and large hog raising operations declined consistently over the last twenty years, differences in cost between farm sizes appear to have remained relatively constant over the recent period of hog farm expansion. Table 3 shows that profits per hog for the best 1/3 of the producers--irrespective of size--can be as high as $20, but average profits per hog are more likely to be around $10.00.

Table 3
Profit per hundred weight ($1999)

Study	Date	Profit per Hog
Univ. of Missouri--Average	1969 to 1993	$10.45
Univ. of Missouri--Best 1/3	1969 to 1993	$20.65

Since the cost advantage for large producers depends heavily on the size of the smaller firms used in the comparison, the 150 sow (roughly 3000 hog throughput) operation size forms an important break point. Table 4 shows that in the worst case, where the conventional producer has only 150 sows, the advantage to the large producer may be between $17.25 and $37.33. In the more likely case, where 250 to 650 sows are employed, the advantage shrinks to $5.00 to $11.00 per hog.

Table 4
Cost Differences per hundred weight ($1999)

Study	Date	Cost Difference per Hog
Iowa State University Swine Task Force—Rapidly Expanding vs. Conventional Farms	1988	$10.62 to $17.5
Duffy--over 150 sows	1992-1994	$0
Hurt--3,400 sows vs. 650 sows	1994?	$5.38
Hurt--1,200 sows vs. 150 sows	1995	$17.25 to $37.33
Duffy--over 150 sows	1992-1994	$0
Good et al.--3,500 sows vs. 650 sows	1995	$5.05
Good et al.--3,500 sows vs.250 sows	1995	$11.68

These data on the magnitude of the cost advantages of large hog CAFOs are the central issue in the discussion of efficiency. If one accounts for the costs of responsible waste handling—waste handling that would reduce the impact on the region of large CAFOs to the same level as the historical impact of conventional hog operations—and then adds these costs to the accounting costs already recorded by large CAFOs, are large CAFOs still more efficient than smaller, more conventional operations?

Factors Inherent In Large CAFO Production That Result in Substantial Diminishing Returns to CAFO Operations

Based solely on the law of diminishing returns, one would expect that as larger amounts of animal waste are handled and as more animals are crowded into confined spaces in close proximity to one another, the potential for disease and the costs of waste handling both mandate that the maximum efficient size of a CAFO is relatively small. Thus, for a large CAFO to compete with other agricultural producers, these costs must be offset by benefits from other phases of the operation such as:

(1) using animal waste for methane generation or fertilizer application or
(2) offsetting the problems of proximity and the cost of antibiotics this requires through efficiencies that come from reduced labor requirements and/or standardization.

If these benefits cannot compensate for the increased costs of CAFO operation, the additional costs arising from diminishing returns must either be shifted away from the large CAFO producer so they are not reflected in the accounting cost of production or it is likely that the large CAFO producer will not be able to compete.

Whether or not the costs of preventing disease through crowding are recouped through efficiencies that arise from reduced labor and standardization is irrelevant to this discussion because these costs and benefits are completely overwhelmed by the costs of handling the animal waste. As a result, the economic viability of a CAFO can be evaluated solely by comparing the costs and benefits of handling animal waste. For example, take the case of swine production in a typical CAFO where:
(1) each hog produces 1.9 tons of waste annually.
(2) each hog generates .064 pounds of nitrogen per day or 23 pounds per year.
(3) each hog generates .0213 pounds of phosphorus per day or 7.8 pounds per year.[27]

The Cost of Responsibly Handling CAFO Waste

The primary goal of all waste treatment is to eliminate human pathogens. A secondary goal is to reduce the biochemical oxygen demand (BOD--the carbon and nutrient substrate for microbial decomposition) so that the waters that receive waste runoff do not become anaerobic. Finally, some heavy metals must be removed before the waste is discharged. In a sewage treatment plant for human waste, aerobic decomposition kills human pathogens and reduces the BOD while the settling process removes heavy metals to sludge (which then must be safely disposed of).

Table 5
Pollution Strength of Livestock and Municipal Waste

[27] "Hog Waste," Get the Facts: Fact Sheets, Environmental Defense Fund, 1999.

Type of Waste	BOD5 mg/l	Ammonia, NH_4N mg/l
Undiluted Livestock Waste	40,000	10,000
Manure Lagoon Effluent	14,400	-
Runoff From a Concrete Lot	1,000	-
Runoff From a Dirt Lot	500	-
Raw Municipal Sewage	250	50
Treated Municipal Sewage	30	1.5

Source: Understanding the Pollution Potential of Livestock Waste, Illinois Environmental Protection Agency, 1991.

One reason the concept of diminishing returns should be a powerful deterrent to large CAFOs is that the cost of responsibly handling and treating animal waste is so high. Anaerobic decomposition in animal waste lagoons is less effective at eliminating human pathogens and BOD, and it leaves heavy metals in the lagoon. As opposed to assumptions about its "natural and thus, harmless, nature," livestock manure creates pollution with a strength that far exceeds raw municipal sewage. As Table 5 shows, the BOD concentration in undiluted livestock waste is 160 times more powerful than raw municipal sewage and ammonia is 200 times more concentrated. Even after it has been flushed to lagoons, manure effluent is still 57 times more powerful than raw sewage.

Exposure of land-applied wastes to sunlight and microbial activity in the soil will generally finish the job of pathogen control, and the nutrients that affect BOD may be used by crop plants. In effect, application to farm land is a final step in the "treatment" of animal waste if the amount of land to which it is applied is sufficient to perform this function.[28] For this reason, the current tendency to inject hog waste directly into the ground to suppress odors is troubling. Injection nullifies efforts to expose animal waste from CAFOs to the air and to sunlight to destroy human pathogens, and the injected waste is likely to carry those pathogens into the soil and then into the water. This need for exposure also exists whether or not methane is generated from the waste to create power. And whatever method is chosen for land application, construction of lagoons to hold the effluent until it can be applied to the land is also required.

This implies that the CAFO has enough land for responsible nutrient application, and it further implies that the number of animals at the CAFO has been determined based on the amount of spreadable acreage available--and not vise-versa. It also implies a climate that is mild enough to allow year-round application, or sufficient, leak-free lagoon capacity to see the CAFO through the winter months. In sum, the requirement to spread the waste to kill pathogens creates a significant transition point in the ability of the CAFO to responsibly handle waste. Appendices 1 and 2 show that for hogs this point is relatively easy to calculate:

> Assuming average nutrient requirements for the spreadable acreage, 1 sow farrow-to-finish needs about 1 acre for the nitrogen or 3 acres for the phosphorus in the waste it and its 20 piglets excrete over the course of a year.

Thus, a 50,000 sow farrow-to-finish operation would need about 50,000 spreadable acres for the nitrogen generated by the operation and about 150,000 acres for the phosphorus. Since phosphorus contamination of water has become a major issue, the guiding number in this case should be the 150,000

[28] Lasley et.al., Op. Cit., pp. 14-15.

acre requirement. Even if this much land is available, the amount of money saved by spreading hog waste as fertilizer is open to debate.

Olson et al. reported that fertilizer expense for corn on owned land was $44.58 per acre or 17% of total expense in 1995.[29] However, the actual money saved from applying hog waste as fertilizer is considerably less than this since the phosphorus loading limits the amount of waste that can be applied--both requiring larger tracts of land for waste distribution and resulting in fertilizer applications of N that must, by definition, be supplemented by chemical application unless the land is overloaded with phosphorus.

As a rough example, since about 1 acre is needed to dispose of the nitrogen generated by 1 sow farrow-to-finish, and about 3 acres are needed to dispose of the phosphorus, only 1/3 of the nitrogen needs of the crop can be applied with hog waste--if the farmer acts responsibly to avoid overloading the land (and the subsequent runoff from the land) with phosphorus. This means that the actual savings from using hog waste as fertilizer would be about $15 per acre (in 1995$). This may explain why, even though phosphorus from agriculture is the major source of contamination of rivers like the Minnesota River, and even though "[m]anure management seems to be a potential problem area,"[30] farmers would demand yearly payments of $121 to reduce phosphorus applications on lands where the rent is only $84--or a one-time payment of $1943 which exceeded the average sale price of the land.[31]

Securing the required amount of spreadable acreage is a daunting task. In addition, when the CAFO is located in areas where the climate is unfavorable for spreading for major parts of the year or where the soil is so poor that few crops are grown and little spreading can occur, spreading the waste on the land may be impractical. Many CAFOs have realized this and their response has been to put the waste in large lagoons until it evaporates. This creates three major problems: First, lagoons leak. Second, lagoon storage does nothing to destroy the pathogens in the waste. And third, the materials in the waste--nitrogen, phosphorus, heavy metals, and salts--are now concentrated in pits for which there are usually no remediation plans even though they would qualify as hazardous waste dumps based on the chemical makeup of the materials they contain.

The following sections give the likely costs of treating hog waste to either kill the pathogens it contains or to significantly reduce the odors associated with the waste while performing these tasks in a manner that does not require spreading the waste on the land.

Baseline Estimates of Costs of Responsible Management of Animal Wastes

<u>Costs to treat the waste as sewage</u>

Humans usually inhabit places in such numbers that the land cannot absorb their wastes. Further, human waste contains pathogens that can have dire health consequences for people. Hog waste

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[29] Olsen, K.D., Talley, J. Christensen, Weness, E.J., Fales, P.A. and Nordquist, D.W., <u>1995 Annual Report of the Southwestern Minnesota Farm Business Management Association</u>, Staff Paper P96-4, Dept. of Applied Economics, University of Minnesota, March, 1996.

[30] McCann, Laura M.J.and Easter, William K., "Differences between Farmer and Agency Attitudes Regarding Policies to Reduce Phosphorus Pollution in the Minnesota River Basin," <u>Review of Agricultural Economics</u>, vol. 21, no. 1, Spring/Summer, 1999, pp. 191-192.

[31] Olsen, K.D., Talley, J. Christensen, Weness, E.J., Fales, P.A. and Nordquist, D.W., <u>1995 Annual Report of the Southwestern Minnesota Farm Business Management Association</u>, Staff Paper P96-4, Dept. of Applied Economics, University of Minnesota, March, 1996.

from CAFOs is similar on both counts--as opposed to other animal waste, hog waste is loaded with pathogens that can (and have) attacked people.

If one handles hog wastes in the manner the law forces municipalities to handle human waste, the results--for waste alone—are: (See Appendix 3 for complete calculations)

Costs to dispose of hog manure at the national average sewage disposal cost ($1997) = $57,650 to $115,335 in waste disposal costs per 1000 hogs at 1 hog = 2-4 humans.
Or a middle range cost of $86,500 per 1000 hogs--$86.50 per hog.

In addition, each hog would produce 122-244 pounds of biosolids per year that would have to be disposed of, and this waste would be contaminated with both heavy metals and salts.

Evaporation systems: (See Appendix 4 for Calculations and Specifications)

For the HYGREX$_{TM}$ Closed Loop Drying System--a typical system of this type--the capital cost for a 10 kW unit is $75,000.00. This will remove 40 liters of water per hour.[32]

A 70 kilogram (154 pound) pig releases about 65 grams of water into its surrounding area per hour. In 24 hours this amounts to about 1.5 kilograms. A barn with 1000 hogs generates 1500 kilos of moisture (about 3300 pounds or 400 gallons.)

For 1,000 hogs the capital cost of an evaporative facility would be about $100,000 or approximately 100.00 per hog. Sludge drying may take a larger capital investment and will generate larger electricity costs. This operation removes up to 96% of water from pressed filter cake sludge, thereby reducing solid waste disposal weight and cost. The moisture removed from the filtercake is recovered and ready for reuse, but the chemicals, heavy metals, and salts in the sludge cake still must be disposed of.

For a 15 kW unit that would handle 1000 hogs, the energy usage would be 23 kW per hour or 552 kWh per day. This amounts to $6.17 added to the cost of each hog. In a facility with a 12 year life span, capital cost equates to $8333 or $4.16 per hog. Thus, the total cost of an evaporative system is about $10.33 per hog--and this is based on the generous assumption that the unit would also dry and process the waste.

Bion-type systems (See Appendix 5 for Calculations)

In a Bion-type system, natural processes are used to handle environmental, water, air and waste problems and a large percentage of liquids are recycled. Flushing the barns release a slurry of waste containing approximately 5.5% solids. Waste effluent is routed to a small, designed wetland where much of the waste is biologically removed. The liquids are then returned to barns for re-use as flush water. Some treated liquid may be filtered--removing particulate matter to 0.5 microns--and then used for feed water. When this step is taken, it is estimated that less than five percent (5%) of total water needs will be drawn from wells. There is no lagoon and no irrigation system. Ozone injection may be used at various points in the system.[33]

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[32] Nikolov, Nick, HYGREX$_{TM}$ Dry Air Systems, P.O. Box 346,11 Holland Drive, Unit 5, BOLTON, Ontario, L7E 5T3-Canada, February, 2000.
[33] Communications from John Candler, 3908 E. 26th St., Tulsa, OK 74114, http://enviro-remediation.com, 6 January 2000.

Calculated costs for a bion-type system are quite low. Company figures, based on a 3-year amortization of capital costs indicate a bion-type system should cost about $1.64 per hog. [34]

Unfortunately, bion-type systems have major drawbacks. They are highly susceptible to imbalance in the biological components of the systems (the wetlands) and when bion-type systems are not working well, they are not working at all. Further, bion-type systems only function when temperatures are above freezing--and warmer temperatures work better than cooler temperatures. Thus, bion-type systems are poor choices for areas that experience any prolonged periods of cool, winter weather.

These drawbacks also make bion-type systems subject to high odor emissions. Recently, the Illinois attorney general sued Highlands LLC, a $2.5 million, 3,650-sow operation, Murphy Farms Inc., and Bion Technologies Inc. for violating Illinois state law by causing air pollution. According to the lawsuit, the waste-treatment system "does not perform in a manner consistent with the claims of (Bion), and this deficiency is contributing to the odor violations being experienced by area residents."[35] The Illinois Environmental Protection Agency received roughly 230 complaints in two years about odors from the Bion Technologies-designed waste-treatment system at the hog CAFO. EPA inspections in 1998 and 1999 confirmed the CAFO was producing a strong swine odor.

In addition to these problems, it should be noted that even if a bion-type system were to function properly, to reduce odors, and to solve the pathogen problems, there is still a requirement to spread the (dried) waste from the hog CAFO. This waste has about the same chemical makeup as other kinds of hog waste (slightly more nitrogen, slightly less phosphorus) and the same requirements for spreadable acreage exist to responsibly dispose of the waste material.

Odor Control Through Lagoon Coverage (See Appendix 6 for Calculations)

A recent Colorado law mandates that effluent lagoons be covered to decrease the odors from the facilities. Such odors are the most obvious example of cost shifting by large CAFOs to the surrounding region. An engineering analysis of the costs to comply with this law determined the following figures for two sizes of operations--roughly 6000 hogs and roughly 11,000 hogs:

Capital Costs	6000 hog Inventory	11,000 hog Inventory
Cost for Compliance	$176,700-290,700	$244,500-449,500
Cost per hog over 10 years	$2.95-$4.85	$2.22-$4.08
Annual Costs		
Cost for Compliance	$22,000	$35,600
Cost per hog	$3.67	$3.23
Total Costs per Hog:	$6.62-8.52	$5.45-$7.31

[34] Communications from John Candler, 3908 E. 26th St., Tulsa, OK 74114, http://enviro-remediation.com, 6 January 2000.
[35] Colindres , Adriana "State sues Bion Technologies/hog farm," The State Journal-Register, http://www.sj-r.com/info/copyright.htm, Knox County, Illinois, January 23, 2000.

The largest part of the operating cost is for financial assurance to protect surrounding property in the event the industrial hog operation goes out of business without properly cleaning up. This amounts to $8,000 for the 6000 hog setup and $12,000 for the 11,000 hog setup.[36]

Baseline Estimates of Costs of Water Usage in Large CAFOs (See Appendix 7 for Calculations)

Large hog CAFOs use a massive amount of water. One sow farrow-to-finish (i.e., one sow and the 20 piglets that the hog CAFO will finish during the year) would need 14,000 gallons of drinking water per year. And one sow farrow-to-finish also needs 54,650 gallons of flushing water per year. This creates a total water use of about 188 gallons of drinking and flushing water per sow farrow-to-finish per day--about the average demand of one person (roughly 200 gallons per day.[37]) Thus a 50,000 sow farrow-to-finish operation is equivalent to a complete city of 50,000 people based on water use with no recycling of flushing water.

Because of this demand for water, CAFOs tend to seek sites above major aquifers. Pumping costs at these sites can be significant, but water is essentially treated as a free good after it is removed from the ground. The vast difference between water costs for industrial uses and water evaluation from an aquifer make it difficult to accurately determine the real cost of large CAFOs that require substantial flushing. For example, one sow farrow-to-finish needs 54,650 gallons of flushing water per year. The value of this water based on business use would be .00171 X 54,650 = $93.45, or about $4.45 per hog. But based on Ogallala Aquifer use, it would be .00003069 X 54,650= $1.68, or about $.08 per hog. The true cost of water is likely to lie somewhere between these two figures. However, drilling and pumping costs should make it closer to the $4.45 figure.

Summary of Baseline Costs

The costs of treating CAFO waste in a responsible manner are substantial. And since these costs are pure additions to the current CAFO flush and dump systems, they represent one measure of the costs large CAFOs are currently shifting to the local region. In addition, each of the more responsible ways of dealing with waste from large CAFOs--with the exception of municipal sewage treatment--still leaves the CAFO operator with requirements for the same amount of spreadable acreage he had before he started. None of the methods alter the amount of heavy metals and nutrients in the waste in any significant way--and those nutrients still must be spread on an appropriate amount of acreage. Table 6 provides a summary of these alternative costs.

Table 6
Cost per Hog of Alternatives for Responsibly
Handling Waste from Large CAFOs

[36] McGregor, Dr. F. Robert, P.E., "Engineering Analysis of Costs for Compliance with Statewide Initiative 1997-1998 #113 to Regulate Housed Commercial Swine Feeding Operations," Water and Waste Engineering, Inc., 621 Seventeenth St., Suite 1020, Denver, CO, May 28, 1998, p. 5.
[37] Colorado Springs Gazette, February 13, 2000, page A10.

Alternative	Added Cost per Hog
Municipal sewage	$86.50
Evaporative technology	$10+
Lagoon Covers	$5.50 to $8.50
Bion-type system	$1.64

In addition to these costs, fairly calculating the cost of flushing water could add between $.08 and $4.45 to the cost of each hog.

Even the $1.64 cost of the bion-type system is enough to nullify almost half of the cost advantage of large CAFOs over smaller, more conventional hog farms of 650 sows or more, and the cost of an evaporative system or odor control technology nullifies almost every cost advantage recorded for large CAFOs when compared to more conventional operations of 250 sows or more. (See Table 3, above.) The cost of sewage treatment provides an excellent indication of the true costs of safely treating the output from large CAFOs if no waste spreading is undertaken.

Since these methods of waste handling are not required in smaller, more conventional operations where sufficient land is available to spread the manure, it is clear that most, if not all of the cost advantage of larger CAFOs presently comes from shifting the costs of CAFO waste to the surrounding region. It is also clear that if this cost shifting did not take place, large hog CAFOs would lose almost all of their competitive advantage when compared to smaller, more conventional operations. However, these are not the only costs that are shifted to the region. The additional costs listed in the section that follow may also result in increased profits for a large CAFO.

Additional Costs Shifted to the Region By Large CAFOs

Lagoon Seepage Costs

Waste lagoons, even with clay liners, allow waste to leach into the ground below the lagoon. In fact, lagoon specifications allow leakage through the clay liners at a rate up to 0.036 inches per day. At the maximum allowable rate, a three acre lagoon could legally leak more than a million gallons a year.[38] The cost of remediating this pollution can be significant and it should be levied against the CAFO using the lagoons and incorporated into the price of its products.[39] Instead, CAFOs shift these costs to other

[38] "Hog Waste,"Op. Cit.

[39] For example, see Ruhl, James F. "Quantity and Quality of Seepage from Two Earthen Basins Used to Store Livestock Waste in Southern Minnesota, 1997-98--Preliminary Results of Long-Term Study," US Geological Survey, Mounds View, MN, 1999, a paper presented at the conference on "Animal Feeding Operations--Effects on Hydrological Resources and the Environment," Colorado State University, Fort Collins, CO, August 30-Sept 1, 1999. A study of an earthen basin with above-grade, earth-walled embankments and compacted clay liners with a manure-water mixture from a 5000 pig gestation barn showed seepage from the basin ranged from 400-2200 gallons per day except during 1 month and three month periods when it reached 3800 to 6200 gallons per day. The seepage had concentrations of 11 to 100 mg/L of chloride, 2.58 mg/L or less of ammonium-N, 25.7 mg/L or less of nitrate-N, and organic-N concentrations of .92 mg/L or less. Nitrate-N concentrations in the seepage exceeded the US Environmental Protection Agency drinking water standard of 10 mg/L in 17 of 22 samples.

Also see Ham, J.M., "Field Evaluation of Animal Waste Lagoons: Seepage Rates and Subsurface Nitrogen Transport," Depart of Agronomy, Kansas State University, Manhattan, KS, 1999, a paper presented at the conference on "Animal Feeding Operations--Effects on Hydrological Resources and the Environment," Colorado State University, Fort Collins, CO, August 30-Sept 1, 1999. A recent study of lagoonsbuilt with compacted soil/bentonite liners and ranging in size from .5 to 2.5 ha (1.24 to 6.2 acres) with waste depths between 1.5 and 5.6 m (4.92 to 18.4 feet) found average seepage rates of 1.2 mm/day (.05 inch). Calculated nitrogen export losses from seepage were 2000-3000 kg/ha/year (1826 to 2738 pounds/acre/year).

users of the land and aquifer, and when the CAFO ceases its operations it often abandons the waste lagoons. This is a major problem in states like North Carolina, where 643 abandoned hog waste lagoons currently threaten water quality.

Health Costs

Another cost of hog CAFOs is the health costs they levy on off-site neighbors. For example, the State Health Director of North Carolina has stated that

> people living near hog farms report more adverse health effects (including respiratory and irritation symptoms and emotional disturbance) than people living away from hog farms... as a preventive public health policy, the State Health Director considers exposure to hog farm odors as a public health risk and recommends that efforts be made to minimize odor exposures.[40]

A Minnesota Pollution Control Agency study found that hydrogen sulfide levels could be expected to violate the state standard as far as five miles downwind from confinement sites. Ammonia could be expected to violate proposed standards as much as 1 1/2 miles downwind.[41] These kinds of costs should be paid for by CAFOs and counted against any benefits that might arise from the use of animal waste. Instead, these costs are currently shifted to those who reside around the CAFO.

Surveys of people living in three rural North Carolina communities suggest industrial hog farms both reduce the quality of life for people living near them and adversely affect their health. A University of North Carolina at Chapel Hill study found that"...headache, runny nose, sore throat, excessive coughing, diarrhea and burning eyes were reported more frequently in the hog community." More than half of respondents in the hog community, as compared to fewer than a fifth in the other two areas, reported not being able to open windows or go outside even in nice weather 12 or more times over the previous six months.[42]

Costs of Land Application of Hog Waste

A number of additional problems arise when hog manure is applied to the land as fertilizer. First, it increases the odor from the CAFO and decreases the quality of life in communities located around CAFOs. Second, the animal waste is so rich in nitrogen and phosphorus that the CAFO must have large tracts of land on which to spread the waste to avoid over application and contamination of aquifers. This land cannot contain ground crops (such as potatoes, beets, etc.) that will be used for human consumption. Third, due to the feeding practices of CAFOs, hog waste has a high concentration of heavy metals that can pollute the land. Fourth, there is likely to be a build up of salt contamination in the soil. Fifth, injection of the waste into the soil is likely to contaminate both the soil and the water under the land with pathogens. And sixth, the large amount of water required for land application makes such practices undesirable in arid areas or those regions with limited ground water resources. Each of these problems has costs that can easily exceed the benefits of fertilizing land with hog waste, and the combined effect of all of these problems has caused many hog CAFOs to propose operations that no longer involve application of animal waste to crop lands. These proposals call for indefinite waste

[40] "Public Health Aspects of Hog Farm Odors," Memorandum from State Health Director A. Dennis McBride, M.D., M.P.H., Distributed to the Beaufort County Commission, February 2, 1999, in Beaufort County NOW, North Carolina, February 08, 1999.

[41] "New Fear from Hog Lots: Odor May Spread Illness--Evidence Mounts That Neighbors Are At Risk," The Des Moines Register, Des Moines, Iowa, October 25, 1998.

[42] Lazaroff, Cat, "Hog Hell in North Carolina," © Environment News Service (ENS) 2000, Chapel Hill, North Carolina, February 9, 2000.

storage in lagoons and thus, they still have the costs associated with lagoon leakage. In addition, non-application plans often involve methane power generation since benefits from the fertilizer value of manure are no longer available to offset CAFO costs.

Claimed Benefits of CAFO Waste Use

CAFOs often claim that hog waste provides various benefits ranging from fertilizer use to methane generation. However, the true costs of waste application to cropland are likely to exceed the benefits unless water is plentiful and cheap, heavy metal contaminated sludge can be cheaply and safely disposed of, huge areas of non-ground crop land are available to the CAFO for waste application, and the CAFO is so isolated that its odor and potential health problems cannot adversely affect its neighbors. The probability of any, let alone all of these conditions occurring in a region is very small.

If, instead, methane generation is proposed to create economic benefits from CAFO waste the cost/benefit breakdown still does not look promising. For example, the costs and benefits of a methane powered manure system for hogs with a 10 year design lifetime would be (in $1999):

(1) Gas recovery costs for hog farm systems using 100% of the manure are $38-90/animal.
(2) Cost of gas utilization equipment depends on equipment size and energy demand. At a 5,000-head hog farm, generators cost $27/head.
(3) Annual O&M costs are $3/head.[43]
(4) At an electric price of $0.07/kWh, annual benefits from on-site electric generation at hog farms with over 1000 head are about $10/head (using 100% of manure).[44]

Thus, even if the lowest operating and construction costs for methane generation were achieved, it would still take over 8 years to simply recover the costs of building and maintaining a methane system whose life span is only 10 years. This is clearly not a sufficient benefit to offset the massive costs associated with CAFO waste.

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[43] For Dairy Cattle the costs/benefits would be ($1990)

Installation costs for gas recovery systems on dairy farms using 15% of the manure are $65-160/cow; installation costs for dairy farms using 55% of the manure are $110-210/cow. On a 1000-head dairy farm, gas-fired chillers cost $24/head; wash water heaters cost $6/head (using 15% of the manure) to $11/head (using 55% of the manure); power generators cost $24/head (using 15% of the manure) to $53/head (using 55% of the manure).

Annual O&M costs for heating and cooling on dairy farms with 500-1000 head are $2.2/head; annual O&M for power generation costs $2.3/head (using 15% of manure) to $8.5 (using 55% of manure).

At an electric price of $0.07/kWh, annual benefit from gas recovered for on-site dairy farm power generation at dairy farms is $17/head (using 15% of manure) to $43/head (using 5%). Annual benefits from recovered gas for heating dairy wash water is at least $8/head.

American Society of Agricultural Engineers. 1988. Manure Production and Characteristics, ASAE Data: ASAE D384.1. American Society of Agricultural Engineers, St. Joseph's, MI.
and
US Environmental Protection Agency. July, 1993. Options for Reducing Methane Emissions Internationally - Report to Congress, Kathleen B. Hogan (ed.), EPA 430-R-93-006.
and
US Environmental Protection Agency. October, 1993. Opportunities to Reduce Anthropogenic Methane Emissions in the United States: Report to Congress, EPA 430-R-93-012.

[44] American Society of Agricultural Engineers. 1988, Op. Cit.
and
US Environmental Protection Agency. July, 1993, Op. Cit.
and
US Environmental Protection Agency. October, 1993, Op. Cit..

CONCLUSION: WHAT A CORPORATE HOG FARM MUST DO TO COMPETE.

The fact that costs exceed benefits simply confirms what any economist would suspect must be true: diminishing returns to scale quickly lead to costs of animal confinement that overwhelm any benefits of CAFOs. Since this implies that CAFOs operate at an inefficient scale, why have CAFOs been able to capture a large and increasing share of the hog market over the last thirty years?[45] There are three reasons: First, the costs of dealing with animal waste from CAFOs have been successfully avoided by CAFO owners and shifted to the surrounding regional population. In a recent study, Hennessy and Lawrence found that "reduced environmental regulatory problems" was the main advantage of contracting out hog production listed by 22% of respondents. The only advantage listed more often was "increased financial leverage" which was the response given by 36% of the respondents.[46]

Second, CAFOs have been major beneficiaries of industrial and agricultural tax breaks and industrial and agricultural subsidies. And third, CAFOs have benefited from a degree of vertical integration of giant agribusiness firms that appears to be in violation of US antitrust law. The US packing industry is a regulated industry governed by the Packers and Stockyards Act of 1921. This Act specifically prohibits the kinds of anti-competitive practices (such as captive supplies) that come from vertical integration. However, USDA reports continually show packer's captive supplies at near 100% for the first three to four trading days of each week. And USDA data also show producers have lost over $300 per head of their share of the consumer beef dollar at the same time that four-firm beef packer concentration has increased from 36% to over 80%.[47] These three advantages have been able to compensate for declines in production efficiency due to diminishing returns.

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[45] The number of hog farms in the US dropped from about 900,000 in 1970 to 139,000 in 1997 while pork production remained relatively constant. Drabenstott, Mark, "This Little Piggy Went to Market: Will the New Pork Industry Call the Heartland Home?", Economic Review, Q3, Vol. 83, No. 3, Federal Reserve Bank of Kansas City, Third Quarter, 1998, p. 82.
[46] Hennessy, David A. and Lawrence, John D., "Contractual Relations, Control, and Quality in the Hog Sector," Review of Agricultural Economics, vol. 21, no. 1, Spring/Summer, 1999, p. 55.
[47] Callicrate, Mike, "Critics Say KS Ag Prof Flunked Marketplace Economics at Nebraska Governors Ag Forum," Cattlemens Legal Fund, November 15, 1999.

Appendix 1

Calculations Of Spreadable Acreage Requirements Based on Nitrogen

Note: Discussions with chemists confirm that the generation of methane from pig waste does not significantly alter the chemical composition of that waste.

The Circle 4 scenario in Utah[48]:

4800 brood sows, one nursery with 12,000 and 3 finishing with 12,000 each. Since total production per 6 months would be 4800 X 10 = 48000, and we have 1/4 of this amount in the nursery at any given time.

Assume 4800/6 = 800 sows give birth per month = 8000 new piglets per month = 48,000 production or the capacity of the nursery and the finishing sites.

So each month, 8000 new pigs arrive and 8000 finishers go for slaughter.

With a capacity of 12,000 pigs, the nursery could hold the pigs for a total of 1.5 months.

With a capacity of 36,000 pigs, the finishing site could hold the pigs for about 4 months (w/10% slack.)

So on a 6 month cycle, the pigs must stay with the brood sow for 14 days.

Total N/head/day[49]:

Gestating Sow: .0421 lb/head/day (169 days) (2 cycles) number of sows
=14.22 lb/sow/year.

Farrow Sow w/litter: .1318 lb/head/day (14 days)(2 cycles)(number of sows)
= 3.69 lb/sow/year.

Nursery Pig: .0162 lb/head/day (42 days)(2 cycles) (10) (number of sows)
= 13.61 lb/sow/year.

Finish Pig: .0588 lb/head/day (120 days) (2 cycles) (10) (number of sows)
= 141.12 lb/sow/year.

Total = 172.64 pounds of nitrogen per sow f-to-f per year.

Assume an average application rate of 200 lb/acre

This is conservative. Application rates for Colorado are[50]:

Corn: 162 lb/acre @ 180 bu/acre yield.

Alfalfa: 270 lb/acre @ 6 ton/acre yield.

Further, a recent study of swine effluent application in Yuma County, CO, found that the agronomic rate for corn at 180 bu/acre was 185 lb N/acre.[51] Application rates for corn elsewhere in the US are considerably lower. For example, in Pennsylvania rate of 50 to 150 pounds per acre of corn are normal.[52]

Then at a rate of 200 1b/acre:

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[48] Demographic and Economic Analysis, State of Utah Governor's Office, Planning and Budget, http://www.governor.state.ut.us/dea/publications/web...hog/h2.htm.

[49] Source for nitrogen excreted per head: Nitrogen Estimate, Agri-Waste Technology, for Midwest Farms, LLC, Disk MWF 3, May 1, 1997.

[50] D&D Farms, Inc. Waste Disposal Operations Investigation, Yuma and Phillips Counties, Letter to Dean Jarrett from the State of Colorado, Department of Public Health and Environment, December 14, 1997.

[51] Al-Kaisi, Mahdi, and Waskom, Reagan, Summary Report: Swine Effluent Study 1995-1997, Department of Soil and Crop Sciences, Colorado State University, 1998, p.1.

[52] Lanyon, L.E. and D.B. Beegel, 1993, "A nutrient management approach for Pennsylvania: Plant nutrient stocks and flows," Agronomy Facts 38-B, Department of Agronomy, The Pennsylvania State University, University Park, PA.

1 sow f-to-f needs 172.64/200 = .86 acres or roughly 1 acre at the agronomic application rate for corn.

Appendix 2

Calculations Of Spreadable Acreage Requirements Based on Phosphorus

Hog waste, especially sludge from the bottom of pits and lagoons, is typically phosphorus enriched relative to crop needs. The ratio of available nitrogen to phosphorus from hog manure can be up to 1.5:1, whereas corresponding requirements for corn grain is about 6:1.[53] Similar studies in Colorado yielded a nitrogen/phosphorus ratio of 5:1 for corn in Yuma County, Colorado.[54] Further, "... Ohio has recently changed its recommendations, so that wastes are spread according to the phosphorus, rather than the nitrogen needs of the crop. Thus, more crop land is needed for disposal."[55]

Given that ratios that can be up to 1.5 to 1, nitrogen to phosphorus, assume a more conservative ratio of 2 to 1.

Total P/head/day:

Gestating Sow: .0211 lb/head/day (169 days) (2 cycles) number of sows
=7.11 lb/sow/year.

Farrow Sow w/litter: .0659 lb/head/day (14 days)(2 cycles)(number of sows)
= 1.85 lb/sow/year.

Nursery Pig: .0081 lb/head/day (42 days)(2 cycles) (10) (number of sows)
= 6.80 lb/sow/year.

Finish Pig: .0294 lb/head/day (120 days) (2 cycles) (10) (number of sows)
= 70.56 lb/sow/year.

Total = 86.32 pounds of phosphorus per sow f-to-f per year.

Nitrogen to phosphorus requirements are from 5 to 6:1 for corn.

Thus, nitrogen requirements are about 162 lb/acre in Colorado so phosphorus requirements are about 27-33 pounds per acre (note: these estimates are also confirmed in actual crop tests by Al-Kaisi and Waskom.)[56]

This is also substantiated by a University of Pennsylvania publication that shows that even at rates of 40 lb/acre/year, phosphorus buildup in the first five inches of soil can approximate 75 ppm after 10 years. This can be compared with agronomic thresholds of 20 to 50 ppm in the states of Arkansas, Delaware, Ohio, Oklahoma, Michigan, Texas, and Wisconsin. In fact, for concentrations of more than 75 ppm, phosphorus application should be discontinued in most of these states.[57]

At the application rate of 27-33 pounds per acre:

1 sow farrow-to-finish needs: 86.32/27-33 = 2.7-3.2 acres for the phosphorus it and its 20 piglets excrete over the course of a year.

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[53] Pennsylvania State University, The Agronomy Guide 1995-1996, College of Agricultural Sciences, The Pennsylvania State University, University Park. PA, 1994.

[54] Al-Kaisi, Mahdi, and Waskom, Reagan, Summary Report: Swine Effluent Study 1995-1997, Department of Soil and Crop Sciences, Colorado State University, 1998, p.5.

[55] Understanding the Impacts of Large-Scale Swine Production, Proceedings from an Interdiciplinary Scientific Workshop, Des Moines, IA, June 29-30, 1995, p. 30.

[56] Al-Kaisi, Mahdi, and Waskom, Reagan, Summary Report: Swine Effluent Study 1995-1997, Department of Soil and Crop Sciences, Colorado State University, 1998, p.5.

[57] Managing Phosporus for Agriculture and the Environment, Penn State, College of Agricultural Sciences, Cooperative Extension, 1999, p. 4, 12.

Appendix 3

Wastewater Treatment Price Comparisons ($1997)

Sources: Colorado Springs Utilities, 1998 Fact Book, Colorado Springs, CO, June 1998. National average data from Raftelis Environmental Consulting Group 1998 Wastewater Survey based on 1977 data for 122 water systems.

1997 Wastewater Treatment Price Comparisons[58]:

Residential Average (based on 1000 cubic ft.)

COS Utilities--$12.94

National Average--$18.93

Business Average (Based on 50,000 cubic feet)

COS Utilities--311.84

National Average--$825.23

Wastewater Treatment Data[59]:

Over 47 million gallons of water per day treated.

Over 22 million pounds of dry biosolids were removed from the wastewater.

Over 65 million cubic feet of methane recycled to heat boilers.

Population served: 361, 800.

Number of residential customers: 93,297

Annual total: 17,296,711,044 gallons

Annual daily average: 47,388,249 gallons

Average wastewater disposal per person per day --136 gallons

Average annual residential disposal of wastewater--88,196 gallons

Average annual commercial disposal of wastewater--764,500 gallons

Total waste water generation for 361,800 people in 93, 297 residences: 88,196 x 93,297 = 8,228,422,212 gallons which contain 22 million pounds of dry biosolids.

Annual waste water/solid generation per 1000 people: 22,793,413 gallons containing 60,908 pounds of dry biosolids. This equates to a .00267 = .3% solids ratio.

Costs to dispose of hog manure at the national average cost ($1997) = $18.93 per 1000 cubic feet

There are 7.48 gallons per cubic foot. Thus, disposal costs are $2.53 per 1000 gallons of waste. This equates to a national average of $2.53 x 22,793.41 = $57,667 in annual costs for wastewater disposal for 1000 people --or for 500 hogs for one year = 1000 hogs each of which stays 6 months at the facility from farrow to finish.

This equates to $57,650 in waste disposal costs per 1000 hogs at 1 hog = 2 humans or

$115,335 1 hog = 4 humans

Or a middle cost of $86,500 per 1000 hogs.

Biosolids costs: annual waste water/solid generation per 1000 people: 22,730,448 gallons and 60, 908 pounds of biosolids. Thus for hogs, we would get 2 to 4 times as much biosolids per 1000 or 122,000-244,000 pounds per year.

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[58] Colorado Springs Utilities, 1998 Fact Book, Colorado Springs, CO, June 1998, p.15.
[59] Colorado Springs Utilities, 1998 Fact Book, Colorado Springs, CO, June, 1998, pp.10-14.

Appendix 4

Evaporative Waste Control Systems

The HYGREX$_{TM}$ Closed Loop Drying System is typical of systems of this type. The capital cost for a 10 kW unit that will remove 40 liters of water per hour is $75,000.00. This system removes the smell via a closed loop dehumidifier process. The smell and odors travel through moisture and the water is taken out of the air. To dry out the manure requires another stage in the process. No odors or gas emissions are generated and the condensed water is reusable.[60]

A 70 kilogram (154 pound) pig releases about 65 grams of water into its surrounding area per hour. In 24 hours this amounts to about 1.5 kilograms. A barn with 1000 hogs generates 1500 kilos of moisture (about 3300 pounds or 400 gallons)

For 1,000 hogs the capital cost of an evaporative facility would be about $100,000 or approximately 100.00 per hog.

For the 15 kW unit that would handle 1000 hogs, the energy usage would be 23 kW per hour or 552 kWh per day.

Sludge drying may take a larger capital investment and will generate larger electricity costs. This operation removes up to 96% of water from pressed filter cake sludge thereby reducing solid waste disposal weight and cost. The moisture removed from the filtercake is recovered and ready for reuse, but the chemicals, heavy metals, and salts in the sludge cake still must be disposed of.

The national average cost of 1 kWh = $.062 for commercial usage.[61] At this rate, 23 kWh would cost about 34.25 per day or $6170 over the 180 days 1000 hogs would stay in the facility.

Thus, the cost per hog for electricity would be $6.17 per animal plus a $100,000 capital cost. In a facility with a 12 year life span, this equates to $8333 in capital cost per year. Since 2000 pigs would pass through the facility per year, this amounts to $4.16 per pig.

The total cost of the evaporative system is $4.16 + $6.17 = $10.33 per hog. This is based on the generous assumption that this unit would dry and process the waste.

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[60] Nikolov, Nick, HYGREX$_{TM}$ Dry Air Systems, P.O. Box 346,11 Holland Drive, Unit 5, BOLTON, Ontario, L7E 5T3-Canada, February 2000.

[61] Colorado Springs Utilities, 1998 Fact Book, Colorado Springs, CO, June 1998, p.7.

Appendix 5

Bion-type Systems

In a Bion-type system, natural processes are used to handle environmental, water, air and waste problems and a large percentage of liquids are recycled. Flushing the barns releases a slurry of waste containing approximately 5.5% solids. Waste effluent is routed to a small, designed wetland where much of the waste is biologically removed. The liquids are then returned to barns for re-use as flush water. Some treated liquid may be filtered--removing particulate matter to 0.5 microns--and then used for feed water. When this step is taken, it is estimated that less than five percent (5%) of total water needs will be drawn from wells. There is no lagoon and no irrigation system.[62]

At a finish site with 13,600 animals and sixteen barns the costs for a Bion installation was $52,375.00. The installation is about average, on less than thirty acres, would accommodate another 5,100 animals without expanding facilities.[63]

Capital costs over a 12 year lifespan would be $4364 per year for as many as 18,700 hogs. This equates to 37,400 animals given a 180 day pass-through or about $.12 per hog.

System energy use:
One (1) Separator rated at 125 gpm.
Energy use 220 VAC, single phase, 15 Amp operating. Total Watts, 4.4 kW.
Two pumps rated @ 125 gpm.
Energy use 220 VAC, single phase, 17.5 Amp operating. Total Watts, 7.7 kW.
Two (2) Ozone generators.
Energy use 110 VAC, single phase, 2.5 Amps operating each. Total Watts .55 kW.
One injects 1.036 grams of Ozone @ 4 cfm, 40 psi. The other injects .986 grams of Ozone @ 1 cfm, 100 psi into separated liquids which are used for flushwater.
Two (2) Ozone injection pumps.
Energy use 110 VAC, single phase, 6.3 Amps operating each. Total Watts 1.4 kW.
Total wattage: 14.05 kW. kWh use in 24 hours: 337.2

Electricity Cost:
The national average cost of 1 kWh = $.062 for commercial usage.[64] At this rate, 337.2 kWh would cost about 20.91 per day or $3763 over the 180 days the hogs would stay in the facility.
This would cost $3763/13,600 = $.28 per hog.

For a 12 year system life, this system should cost about $.40 per hog.

Based on company figures, the total cost of a bion-type system is $0.00091 per gallon of wastewater processed.
A Finish Pig Uses: 15 gallons/head/day (13,600)(120 days) (2 cycles) = 48,960,000 gals of flushing water per year
This would equate to $44,553.60 per year or a cost of $1.64 per hog.

[62] Communications from John Candler, 3908 E. 26th St., Tulsa, OK 74114, http://enviro-remediation.com, 6 January 2000.
[63] Communications from John Candler, 3908 E. 26th St., Tulsa, OK 74114, http://enviro-remediation.com, 6 January 2000.
[64] Colorado Springs Utilities, 1998 Fact Book, Colorado Springs, CO, June 1998, p.7.

Appendix 6
Odor Control Costs Through Lagoon Coverage

Source: McGregor, Dr. F. Robert, P.E., "Engineering Analysis of Costs for Compliance with Statewide Initiative 1997-1998 #113 to Regulate Housed Commercial Swine Feeding Operations," Water and Waste Engineering, Inc., 621 Seventeenth St., Suite 1020, Denver, CO, May 28, 1998, p. 2.

For an 800,000 pound inventory, assuming 250# for finishers and 450# for sows:
450X + 250(10X) = 800,000#
= about 300 sows farrow-to-finish or 6000 hogs per year throughput
For an 1,500,000 pound inventory, assuming 250# for finishers and 450# for sows:
450X + 250(10X) = 1,500,000#
= about 550 sows farrow-to-finish or 11,000 hogs per year throughput
Then, costs of compliance as a percentage of overall costs would be

Capital Costs	6000 hog Inventory	11,000 hog Inventory
Cost for Compliance	$176,700-290,700	$244,500-449,500
Overall Facility Cost	$4.5mm-$5.8mm	$7mm-$9mm
Compliance Cost as % of Overall Cost	3.1%-6.5%	2.7%-6.4%
Annual Costs Amortized over a 10 year lifespan	.3%-.65%	.3%-.6%
Cost per hog over 10 years	$2.95-$4.85	$2.22-$4.08

Annual Costs	6000 hog Inventory	11,000 hog Inventory
Cost for Compliance	$22,000	$35,600
Annual Facility Revenue	$.8mm-1.2mm	$1.5mm-2.0mm
Compliance Cost as % of Overall Revenue	1.8%-2.8%	1.8%-2.4%
Cost per hog	$3.67	$3.23

Note: The largest operating cost is for financial assurance to protect surrounding property in the event the industrial hog operation goes out of business without properly cleaning up. This amounts to $8,000 for the 6000 hog setup and $12,000 for the 11,000 hog setup.[65]

"The capital costs for compliance fall in the range of 2.7% to 6.5% of the overall capital cost for the facility. The low range cost for compliance will be for new systems that include the appropriate design features from the outset. The high range cost for compliance will likely apply to existing operations that must retrofit their anaerobic lagoons for odor control. The operating costs for compliance would be in the range of 1.8% to 2.8% of the total annual revenues."[66]

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[65] McGregor, Dr. F. Robert, P.E., "Engineering Analysis of Costs for Compliance with Statewide Initiative 1997-1998 #113 to Regulate Housed Commercial Swine Feeding Operations," Water and Waste Engineering, Inc., 621 Seventeenth St., Suite 1020, Denver, CO, May 28, 1998, p. 5.
[66] McGregor, Dr. F. Robert, P.E., "Engineering Analysis of Costs for Compliance with Statewide Initiative 1997-1998 #113 to Regulate Housed Commercial Swine Feeding Operations," Water and Waste Engineering, Inc., 621 Seventeenth St., Suite 1020, Denver, CO, May 28, 1998, p. 2.

Appendix 7

The Use and Cost of Water In Large CAFO Operations

Water Costs:
National Business Average Water Cost:--$639.70/375,000 gallons = .00171 per gallon[67]
Estimate of Ogallala water cost—opportunity cost only, not pumping cost--$10 per acre-foot or $.00003069 per gallon. [68]

"Water use in a hog confinement system is related to the actual water consumption of the hogs, plus the amount of fresh water used to clean the facility and flush the gutters, plus any fresh water used to help refill the lagoons after occasional sludge removal. Finishing hogs drink three to four gallons per day. Facilities that use fresh water to flush the gutters in hog facilities may use an additional 15 gallons per finishing hog or 35 gallons per sow and litter per day." [69]

"The choice to use recycled lagoon water versus fresh water is driven partly by the ratio of rainfall to evaporation, and availability of water. Lagoons must be kept filled to a certain level to maintain their treatment and efficiency...In dry climates where evaporation exceeds rainfall, fresh water must be added to lagoons to counteract evaporation." [70]

Drinking Water
Total drinking water consumption/head/year: (Source of figures:[71] and [72])

Gestating Sow: .5 gallons/head/day (169 days) (2 cycles) number of sows
= 1690 gals/sow/year.

Farrow Sow w/litter: .7 gallons/head/day (14 days)(2 cycles)(number of sows)
= 196 gals/sow/year.

Nursery Pig: .3 gallons/head/day (42 days)(2 cycles) (10) (number of sows)
= 2520 gals/sow/year.

Finish Pig: .4 gallons/head/day (120 days) (2 cycles) (10) (number of sows)
= 9600 gals/sow/year.

Total = 14,006 gallons of drinking water per sow f-to-f per year or
38 gallons of drinking water per sow f-to-f per day.

Thus, a sow farrow-to-finish would need 14,000 gallons of drinking water per year. The value of this based on business use would be .00171 X 14,000 = $23.94. Based on Ogallala Aquifer use, it would be .00003069 X 14,000 = $.43 per year.

Flushing Water:

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[67] National Average data from Raftelis Environmental Consulting Group 1998 Water Survey based on 137 water systems (1997 data). and
1998 Fact Book, Colorado Springs Utilities, City of Colorado Springs, Colorado Springs, CO, June, 1998.

[68] Communication From Howe, Charles W., Environment and Behavior Program, Institute of Behavioral Science, University of Colorado at Boulder, Boulder, CO, March, 2000.

[69] Structures and Environment Handbook, 11th Edition, 2nd Revision, Midwest Plan Service, Iowa University, Ames, Iowa, 1987 in Donham, Kelley, and Thu, Kendall, "Introduction," Understanding the Impacts of large-scale Swine Production, Proceeding from an Interdisciplinary Scientific Workshop, Des Moines, Iowa, June 29-30, 1995, p. 14.

[70] Donham, Kelley, and Thu, Kendall, "Introduction," Understanding the Impacts of large-scale Swine Production, Proceeding from an Interdisciplinary Scientific Workshop, Des Moines, Iowa, June 29-30, 1995, p. 14.

[71] National Average data from Raftelis Environmental Consulting Group 1998 Water Survey based on 137 water systems (1997 data). and
1998 Fact Book, Colorado Springs Utilities, City of Colorado Springs, Colorado Springs, CO, June, 1998.

[72] Donham, Kelley, and Thu, Kendall, "Introduction," Understanding the Impacts of large-scale Swine Production, Proceeding from an Interdisciplinary Scientific Workshop, Des Moines, Iowa, June 29-30, 1995, p. 14.

Total waste flushing water /head/year: (Source of flushing water figures[73] above and [74])

Gestating Sow: 15 gallons/head/day (169 days) (2 cycles) number of sows
= 5070 gals/sow/year.

Farrow Sow w/litter: 35 gallons/head/day (14 days)(2 cycles)(number of sows)
= 980 gals/sow/year.

Nursery Pig: 15 gallons/head/day (42 days)(2 cycles) (10) (number of sows)
= 12,600 gals/sow/year.

Finish Pig: 15 gallons/head/day (120 days) (2 cycles) (10) (number of sows)
= 36,000 gals/sow/year.

Total = 54,650 gallons of flushing water per sow f-to-f per year or
150 gallons of flushing water per sow f-to-f per day.

Thus, a sow farrow-to-finish would need 54,650 gallons of flushing water per year. The value of this based on business use would be .00171 X 54,650 = $.93.45. Based on Ogallala Aquifer use, it would be .00003069 X 54,650= $1.68 per year.

Total water use would be 188 gallons of drinking and flushing water per sow f-to-f per day. Additional water may be required for lagoon management.

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[73] National Average data from Raftelis Environmental Consulting Group 1998 Water Survey based on 137 water systems (1997 data). and
1998 Fact Book, Colorado Springs Utilities, City of Colorado Springs, Colorado Springs, CO, June, 1998.

[74] Donham, Kelley, and Thu, Kendall, "Introduction," Understanding the Impacts of large-scale Swine Production, Proceeding from an Interdisciplinary Scientific Workshop, Des Moines, Iowa, June 29-30, 1995, p. 14.

Appendix 8
The Economic Effect of CAFO Production On Regional Economies

The four economic characteristics of a CAFO:

(1) The use of capital intensive production methods.
(2) Employment of a production methodology that maximizes the tax benefits.
(3) The use of vertically integrated operations.
(4) The use of cost shifting to reduce the costs of production.

are fundamentally incompatible with regional economic development. Regional economic development proceeds on the premise that the wages paid and purchases made by a company are transferred to other individuals or companies in the region. The multiplier effect of these payments further assumes that they are again spent within the confines of the region and that they do not "leak" into other areas of the state or nation. However CAFOs are structured so that they cannot aid regional economic development for the following reasons:

<u>(1) Constraints on Regional Economic Development Due To Employment</u>

As a capital intensive company, a CAFO is designed to minimize the number of workers and hence, minimize the economic impact on the region. A 1998 Colorado State University study found that only 3-4 direct jobs (jobs with the hog producer) are created for every 1000 sows in a CAFO sow farrowing operation.[75] Ikerd calculated that a farrow-to-finish contact hog operation would employ about 4.25 people to generate over $1.3 million in revenue. His figures showed that an independently operated hog farm would employ about 12.6 people to generate the same amount of hog sales.[76]

Depending on the state, the employment multiplier for agriculture varies from 1.8 to 2.2 for every direct employee (thus, indirect and induced impacts on related economic sectors of the economy would create 1.8 to 2.2 total jobs for each person employed in hog production.) However, if one treats CAFOs as industrial operations, the multiplier would be much lower--about 1.35.[77]

It is likely that even this figure overstates the economic impact on rural counties. For the employment multiplier to operate at the levels specified in the Department of Commerce RIMS II model, all employees must both live and work in the county. Given the ability to commute, it is likely that many workers will live well outside the region and that the actual employment multiplier will be further depressed.

The size of the employment multiplier further depends on amount of purchases a CAFO makes in the region. However, large-scale animal production facilities are more likely to purchase their inputs from a great distance away, bypassing local providers in the process.[78] A 1994 study by the University of Minnesota Extension Service found that the percentage of local farm expenditures made by livestock farms fell sharply as size increased. Farms with a gross income of $100,000 made nearly 95% of their

[75] Park, Dooho, Lee, Kyu-Hee, and Seidl, Andrew, "Rural Communities and Animal Feeding Operations," Department of Agricultural and Resource Economics, Colorado State University, Ft. Collins, CO, 1988.
[76] Ikerd, John E., "Sustainable Agriculture: An Alternative Model for Future Pork Producers," in <u>The Industrialization of Agriculture</u>, Jeffrey S. Royer and Richard T. Rogers, eds., Ashgate Press, Brookfield, VT, 1998, pp. 281-283.
[77] RIMS II, Department of Commerce, Bureau of Economic Analysis, Washington, DC, October 1997.
[78] Lawrence, John D., et al., "A Profile of the Iowa Pork Industry, Its Producers, and Implications for the Future," Staff Paper No. 253, Department Of Economics, Iowa State University, 1994.

expenditures locally while farms with gross incomes in excess of $900,000 spent less than 20% locally.[79]

Confined animal production can occasionally benefit local grain sellers, but only when it consumes all the grain produced in the county. If the county has to export even one bushel of grain, all the grain in the county will have to be priced at a lower level that will enable the grain to compete in the export market.[80]

(2) Constraints on Regional Economic Development Due To Taxes

Federal, state and local taxes are levied on taxable amounts calculated on federal returns. The numerous tax write-offs that are possible because CAFOs are sometimes treated as industries and, at other times, treated as farms, significantly decrease the amounts of taxes paid locally. At the same time the operations of the CAFO create social, health and traffic costs that the local government must finance. The local government, in turn, must rely on increased taxes to pay these CAFO-induced costs--and this can decrease other economic activity in the region.

For example, additional costs associated with hosting a CAFO include increased health costs, traffic, accidents, and repairs. One Iowa community estimated that its gravel costs alone increased by about 40% (about $20,000 per year) due to truck traffic to hog CAFOs with 45,000 finishing hogs. Annual estimated costs of a 20,000 head feedlot on local roadways were $6447 per mile due to truck traffic.[81] Colorado counties that have experienced increases in livestock operations have also reported increases in the costs of roads, but specific dollar values are not available.[82] In addition, an Iowa study found that while some agricultural land values increased due to an increased demand for "spreadable acreage," total assessed property value, including residential, fell in proximity to hog operations.[83]

(3) Constraints on Regional Economic Development Due To Vertical Integration

Vertical integration requires purchases from and sales to other members of the vertically integrated company, not from local producers and suppliers. Thus, vertically integrated companies stimulate regional economies only to the extent that all elements of the company are located in the region. Historically, this factor has severely limited the economic impact of CAFOs on the regions in which they are situated. For example, Lawrence found that in Iowa smaller hog operations (less than 700 head annually) purchased 69 percent of their feed within 10 miles of the operation. Large hog operations (2000 or more hogs per year) that are more likely to be vertically integrated only purchased 42 percent of their feed within 10 miles of the operation.[84]

(4) Constraints on Regional Economic Development Due To Cost Shifting

The previous three sections have described the reasons inherent in the structure of CAFOs that most of the money from a CAFO will either be directly spent outside the region or it will quickly migrate there. However, through cost shifting the CAFO will leave the costs of its odor, health risks, surface water pollution, ground water pollution and in the long run, its abandoned lagoons and facilities for the region to deal with. This directly effects both long and short run economic development.

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[79] Chism, John, and Levins, Richard, "Farm Spending and Local Selling: How Do They Match Up?," Minnesota Agricultural Economist, no. 676, University of Minnesota Extension Service, Spring, 1994.
[80] Hayes, Dermot, Iowa's Pork Industry--Dollars and Scents, Iowa State University, January 1998.
[81] Duncan, M.R., Taylor, R.D., Saxowsky, D.M., and Koo, W.W., "Economic Feasibility of the Cattle Feeding Industry in the Northern Plains and Western Lakes States," Agricultural Economic Report No. 370, Department of Agricultural Economics, North Dakota State University, 1997.
[82] Park et al., op. cit.
[83] Ibid.
[84] Lawrence et al., op. cit.

Put bluntly, every company has many choices of location and active recruitment is practiced by most regions. Quality of life is a major factor in decisions to locate in a region, and most companies would never consider locating in an area where a CAFO is operating. In addition, CAFOs such as large hog farms adversely impact the value of neighboring property in the region.

Palmquist et al., in a 1995 study in North Carolina, found that neighboring property values were affected by large hog operations based on two factors: the existing hog density in the area and the distance from the facility. The maximum predicted decrease in real estate value of 7.1 percent occurred for houses within one-half mile of a new facility in a low hog farm density area. A 1997 update of this study found that home values decreased by $.43 for every additional hog in a five mile radius of the house. For example, there was a decrease of 4.75% (about $3000) of the value of residential property within 1/2 mile of a 2,400 head finishing operation where the mean housing price was $60,800. [85] A 1996 study by Padgett and Johnson found much larger decreases in home value than those forecast by Palmquist. In Iowa, hog CAFOs decreased the value of homes in a half-mile radius by 40%, within 1 mile by 30%, 1.5 miles by 20% and 2 miles by 10%.[86]

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[85] Palmquist, R. B. et al., "The Effects of Environmental Impacts from Swine Operations on Surrounding Residential Property Values," Department of Economics, North Carolina State University, Raleigh, North Carolina, 1995.
[86] Park et al., op. cit.