Staff Paper

OVERVIEW OF ENVIRONMENTAL ISSUES RELATED TO THE INDUSTRIALIZATION OF ANIMAL AGRICULTURE

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INTRODUCTION

Industrialized agriculture is one of those terms that is difficult to define, yet nevertheless, is increasingly used to describe the changing structure of agriculture. To some individuals, the term is synonymous with the demise of the family farm and the rise of corporate farming. Still, to others it implies capital intensive production units which utilize specialized technologies to capture scale economies. In this paper, we use the term industrialized agriculture to refer to the concentration of production in small geographic areas with production characterized by large specialized units which employ specialized labor using routine methods (Hamilton, Rhodes).

As a result of industrialization, animal agriculture industries are becoming increasingly concentrated, both at the farm level as large-scale intensive confinement facilities arise and within a geographic region, as facilities locate in clusters near processing facilities or specialized input suppliers (Thurow). Balancing the economic advantages of industrialized agriculture with environmental sustainability is a challenge facing individuals and rural communities. To frame the relationship between industrialized agriculture and the environment, we examine two animal agriculture industries, broiler chicken and swine. The first industry has a five-decade history of industrialization, while industrialization in the swine industry is a more recent phenomenon.

Analyzing these two sectors provides a unique and informative perspective for researchers, educators and policy makers. To that end, the paper has three objectives. First, to provide a historical context in which to examine industrialized broiler chicken production and the observed changes in the swine industry. Second, to discuss the relationships between

industrialized animal agriculture and byproduct and manure nutrient management. The third objective is to address the role of public policy and environmental regulation. Here, the North Carolina pork industry is used as a backdrop for discussing industrialized animal agriculture. The paper concludes with a discussion of the opportunities and challenges facing public policy makers, researchers, and educators for balancing industrialized agriculture and environmental quality.

Industrialization in the Broiler and Hog Sectors: Historical Context

Broilers and hogs have followed similar, yet distinct paths toward industrialization. Dating back to when most farmers kept at least a few hogs on the farm as "mortgage lifters", pork production has a long history of independent, competitive production with ownership and management decisions centered at the farm-level under the control of the owner-operator. In contrast, the broiler chicken "industry" as known today was virtually nonexistent in the first half of the twentieth century. Instead, chickens were kept for home consumption of eggs and meat. Young chickens would be marketed as the "spring hatch" by-product of the laying flocks (Tobin and Arthur).

In the post-World War II period, technological improvements in housing, feeding, breeding, and disease control made possible the large-scale, specialized production of chickens raised solely for meat purposes. By 1952, commercial broiler production surpassed farm chickens as the primary source of chicken meat in the U.S. (Watts and Kennett). However, the highly variable live broiler prices of the period caused many farmers to conclude that the industry provided too many risks given the significant fixed capital investments required for production.

In an effort to both stabilize broiler prices and secure a market for their feed, feed dealers offered contracts to growers to produce broiler chickens. This practice is continued today by companies or "integrators" who contract with growers to house and care for their growing birds in exchange for a contractual fee. These companies are typically integrated firms that own feed mills, growing birds, and processing plants.

Because live broilers have limited transportability, broiler farms are typically located within close proximity to the integrator/processor. Consequently, shifts in geographic production regions have occurred to correspond with the clustering in production and processing infrastructure. Much of the shift in broiler production in the post-WWII period has been to the South (figure 1).[2] The relatively less expensive land, labor, and capital provided a major incentive for this shift. In addition, the lack of alternative economic opportunities, the eagerness of feed dealers to extend credit, and the increased social acceptance of contract production in this region due to the history of share cropping made contract broiler production an attractive alternative to traditional farm enterprises.

Today, approximately 90 percent of all broiler chickens are raised by farmers under production contracts, with the remaining broilers fed on integrator-owned farms. Open market transactions have disappeared in commercial broiler production. Over the last five decades, many of the major broiler integrators have also disappeared while others have either expanded or merged. In 1972, the four largest broiler firms accounted for 17 percent of all broilers processed. By 1994, the top four firms (Tyson Foods, Gold Kist, Perdue and ConAgra) processed more than 40 percent of broiler production, with the top 20 firms accounting for 80 percent of processing

(Watts and Kennett). The result is a highly concentrated industry, both in a geographical and firm-level context, characterized by specialized, intensive production and processing units.

Pork production may be following a similar course toward industrialization. Historically, hogs have been viewed by farmers as a means to add value to local corn production. Therefore, corn-hog farms tended to dominate in the Cornbelt states. The industry was characterized by many diversified producers with relative ease of entry and exit.

More recently, improved housing facilities and disease control measures, coupled with advances in nutrition and feeding regimes, have permitted large-scale, specialized pork production units to flourish. Fueled by technological change and economic opportunity, the historic patterns of geographic location, farm size, packing plant size and organization of pork production are changing at exceptional rates in the United States (figure 2). The number of swine farms keeps falling, with the majority of those exiting the industry keeping fewer than 1,000 head in inventory. In contrast, total inventory of farms with at least 2000 head in inventory is growing rapidly (from 16.3 million on December 1, 1992 to 28.6 million on December 1, 1996). Forty percent of the growth in this category occurred in North Carolina. Farms with more than 2000 head accounted for 28 percent of U.S. inventory on December 1, 1993 and 51 percent on December 1, 1996. Overall, the impacts of industrialization are dramatic, particularly if one looks at the changes occurring in the South

Traditionally, hog farms in the South have been smaller than those in the rest of the country and so reductions in the number of farms keeping at least one pig have been more marked in the South. In 1989, the South was home to one-third of the 306,210 farms in the country which kept at least one pig. By December 1996, the South accounted for one-quarter of

U.S. farms with at least one pig. The South's share of the national swine inventory has risen dramatically from 15.8 percent in 1989 to 26.7 percent in 1996. Between 1989 and 1996, growth in North Carolina (+6.73 million head), Oklahoma (+1.09 million), Arkansas (+115,000), and Mississippi (+60,000) offset declines in other states to add nearly 6.5 million hogs to the region's inventory (USDA, Hogs and Pigs).

Southern pork production is increasingly characterized by industrialization and contract production. Large hog firms contract with growers to house and care for their growing pigs. Relative to the 90 percent in broiler production, it is estimated that 17 percent of all hogs slaughtered in the U.S. in 1994 were finished on contract (Grimes and Rhodes). However, industry experts suggest a much higher percentage of contract production in the South. This figure would include the more than 80 percent of total production in North Carolina which is estimated to be contract finished.

Changes in the number, size, and location of packing plants are also occurring. Hayenga et al. (1985, Figure 6.1) indicated 12 packing plants in the South that each slaughtered more than half a million hogs in 1982. By December 1996, only nine such plants remained. New large plants opened in Guymon, Oklahoma and Tar Heel, North Carolina while Georgia and Tennessee each had their two plants close. Although hogs can be shipped several hundred miles to market, transportation costs sharply reduce profits. Consequently, swine production is likely to decline in areas that lack packing capacity. Unlike the broiler industry, less than 2 percent of hogs marketed in the country in 1993 were produced by packers (Hayenga et al., 1996). Most contractors in North Carolina sell market hogs to packers under term marketing agreements.

Why has pork production, and in particular large-scale intensive production, shifted to the South? Several factors help to explain this trend. For the most part, pork production in the South was not an economically important commodity prior to the 1970's. The political climate surrounding traditional cash crops (i.e., peanuts and tobacco) left many farmers uncertain as to whether there was a profitable future with these commodities. Given the small farm size and low-yielding soils, individuals recognized the need to search for and develop alternative farm enterprises. In North Carolina, beginning in 1960 (Jones), a concerted effort was made by the state government, land grant university faculty and entrepreneurs to develop a pork industry that could effectively compete on a national level. Because the region did not have significant existing capital and infrastructure, producers and processors were able to adopt the newest technologies and build associated infrastructures in order to capture economies of scale, both internal and external. Even though Southern farmers face higher feed prices than their Midwest counterparts, implementation of such technologies as all-in/all-out production, split-sex feeding and segregated early weaning, coupled with lower labor and land costs, offsets the higher feed expense. Good (1994) found that hog production costs for a large specialized farm in North Carolina were 10.6 percent less than for a traditional hog farm in the Midwest.

New technologies by themselves cannot account for the rapid growth of the South's pork industry. In fact, there are a mosaic of influences that have contributed to the clustering of pork production outside of the traditional states. The large capital requirement of modern, confined pork production units has led stakeholders to search for alternative methods to deal with risk and financing. In contrast to other regions of the U.S., the South was already familiar with and relatively accepting of production contracts due to their widespread use in broiler production.

Recognizing that price and some production risk is shifted to the integrator with production contracts, lending institutions have been more willing to provide financing for construction of new hog units. In addition, environmental regulations, zoning regulations, and anti-corporate farming regulations did not present insurmountable barriers to siting and building production units and processing plants in the region.

Although scale economies and reduced transactions cost from coordinating production-marketing activities have encouraged the movement toward industrialized broiler and pork production, gains from reduced per unit costs have not been without consequences. Focus in the industries has shifted from economies of scale in production and processing, to recognizing the environmental impacts of intensive livestock and poultry production and to searching for methods to sustain production and environmental quality.

Byproduct Management and Environmental Impacts

Increased growth in industrialized broiler and pork production and processing has multiple consequences. There are significant economic benefits to rural communities in the forms of alternative farm income, employment opportunities and increased tax revenues. There are also environmental costs, both perceived and real, involved with intensive production and processing units.

The majority of environmental concerns are associated with manure management and include pollution of air, groundwater, surface water, and soils. Air quality concerns surrounding manure include ammonia volatilization, methane emissions, dust, and most importantly, odor. From a public policy perspective, odor impacts are the most difficult to assess because odor is

measured subjectively. In contrast, much of the environmental regulation focus has been on groundwater and surface water issues. These issues predominantly involve the potential risk for large scale nitrogen leaching and runoff from animal facilities, from manure holding or storage structures, and from fields receiving manure. Soil concerns are based on the potential for nutrient buildups in the soil which may be harmful to plant productivity as well as a risk to groundwater and surface water.

Recognizing both the nutrient source and the environmental concerns associated with manure management leads to two questions. First, is manure an associated cost or potential benefit to broiler and pork production? Second, do broiler and swine units face similar environmental risks and constraints in manure nutrient management?

An economic definition of a waste is *any product that costs more to apply (use) than it is worth once applied (used)*. There is no question that all manure has intrinsic value: it contains nitrogen, phosphorus, potassium, and other nutrients essential to plant and animal growth. A problem in using manure (and many other organic byproducts) is that the nutrients are dilute, they are mixed together, they are in relative proportions that are inappropriate for most plant and animal uses, and nutrient content of manure may vary over time and from sample to sample.

The low concentration of nutrients in manure means that costs of storage, transportation and application of manure are high per pound of nutrient compared to commercial fertilizers or other feed ingredients. As an example, a ton of fresh swine manure may contain 12 pounds (0.6%) total N, 9 pounds (0.45%) P_2O_5 , and 9 pounds (0.45%) of K_2O. In some cases, the low concentration of nutrients means that the cost of application exceeds the value of the nutrients as fertilizer.

The inappropriate mix of nutrients in manure means that the value of manure in use is less than the sum of the value of the nutrients it contains. For example, a bermuda grass hay field receiving 300 pounds of N from anaerobic lagoon effluent may utilize 45 percent of plant available P_2O_5. If the manure is spread over a greater area so that the phosphorus is fully used by the crop, an additional cost of applying the manure is incurred that usually exceeds the value of the additional phosphorus utilized. In addition, a supplemental application of nitrogen is required to meet plant needs, so total application costs may be further increased.

Local conditions also affect the value of manure. Climate, soils, crop selection and yields, extent of other livestock and poultry production, and prices for land, labor, feeds and fertilizer all affect the cost effectiveness of various manure management systems. Manure management systems can have several components including removal from buildings, storage, treatment, transport, and application. Potential revenues and savings from manure management systems include byproduct sales, on-farm use of byproducts, reductions in production costs, and increases in quantity or quality of livestock or poultry produced. Basic costs of manure management systems include interest and depreciation on the initial investment in facilities, repairs, property taxes and insurance, electricity and fuel, labor, and supplies. Additional costs of manure management systems include record keeping, permitting and compliance, fines and legal fees, losses of net crop receipts, land clearing and grading.

Even though broiler and pork production units face similar environmental challenges associated with manure nutrient management (e.g., odors and an imbalance between nutrient uptake and placement), broiler units, in general, have more opportunities and choices available to them to increase the value of manure and other byproducts. A major factor for this difference is

the physical form of the manure. In contrast to the liquid product of the swine industry, broiler manure is absorbed by and mixed in with the litter placed on the broiler house floor for bedding. When removed from the house, the litter is a combination of manure, feathers, spilled feed and water, and the original bedding material (e.g., sawdust, wood or paper shavings) (Rahn). Consequently, broiler litter is more transportable than the effluent from hog units.

To capture the nutrients inherent in the litter, some broiler farmers use equipment to separate the heavy pieces of litter and apply this nutrient rich source to their fields. Still others will compost the litter and transport the composted material out of the area for field application or commercial sale. One broiler producer in Mississippi sells bags of composted manure locally for $4.95 per bag, with an estimated total cost per bag of only $0.55 (Pyenson). Even when transportation costs are significant, alternative markets still develop for dry litter removal (Burt). This transportability allows nutrient surplus areas to sustain broiler production, while recycling nutrients and transporting them to deficit areas.

A further option available to broiler producers is the feeding of deep-stacked litter to ruminant animals as a feed source. According to Ransom and Strickland, the Tennessee Valley Authority, working cooperatively with Auburn University and other interested parties, has supported activities to increase the use of broiler litter for feed and fertilizer to develop and expand the beef cattle industry in the region.

Manure and litter are not the only recyclable resources involved in broiler production. Composting of dead birds is generally permitted. This practice is in contrast to the hog industry, where not all states, particularly in the South, allow composting of dead swine. In areas of concentrated swine and poultry production, dead birds and pigs are collected daily and recycled

through rendering. Collection and rendering avoid additional nutrient loading to land surrounding hog and poultry production facilities.

An alternative strategy to managing manure nutrients at the "back-end" is to focus on the nutrients going in the "front-end". From an environmental perspective, improved feed use results in reduced surplus nutrients to be managed. While previous feeding programs mainly emphasized rapid, efficient, weight gain, increased attention is being placed on improving feeds to sharply reduce the surplus phosphorus and other minerals excreted by swine and poultry (Cromwell and Coffey). Broiler feed efficiency improved from 3.0 to 2.04 pounds of feed per pound of gain (Havenstein, et al.) between 1957 and 1992. Likewise, large, specialized farms in North Carolina use 3.0 pounds of feed to produce a pound of live hog compared to averages of 3.5 or greater on traditional Midwest farms.

An additional measure for reducing surplus phosphorus in the manure is the feeding of microbial phytase in poultry and swine rations. This supplement improves the availability of phosphorus in corn and soybean meal to the animal and therefore reduces the need for supplemental phosphorus. However, for producers to adopt such practices, they must be both economically and technically feasible. Ironically, while industrialization has facilitated the rapid adoption of many cost-effective technologies, it has not always spurred the adoption of environmentally-effective technologies such as phytase feeding. More succinctly, in an industrialized animal agriculture system, profit-driven firms and integrators are unlikely to spend more than they judge profitable over the long run on byproduct management. Likewise, when production contracts accompany industrialized animal agriculture, the separation of the central decision-maker from the farm-level environmental impacts can cause divergent interests. As

animal agriculture industries become more industrialized, what then, is the role of public policy and environmental regulation?

Environmental Regulation and Public Policy Choices

It would be an oversimplification to suggest that the geographic shifts in industrialized broiler and pork production are the result of producers searching for the path of least environmental resistance. The previous historical discussion points to a myriad of forces affecting industrialization and production locations. That is not to say, however, that environmental regulations and enforcement have not played a critical role in the rapid growth and clustering of animal production facilities in specific regions. There exists an *ad hoc* array of federal, state, and local laws and procedures facing producers and consumers who are interested in negotiating a mutually-acceptable set of environmental protection standards (Thurow). Oftentimes, however, environmental standards are either solely science-driven or socially-driven, but neglect to account for the economic implications of industrialized agriculture.

Since North Carolina accounts for 60 percent of the South's total hog inventory, 40 percent of recent growth in farms with more than 2,000 head, and because it receives the majority of attention in the public press regarding environmental impacts of intensive pork production, it seems only fitting to use this state as a background to discuss environmental regulation and public policy choices.

Prior to 1992, livestock and poultry were regulated by the state of North Carolina as nondischarging agricultural operations. Farms were "deemed permitted" unless they were found to be discharging waste to the waters of the state. It was illegal for farms to discharge waste to

the waters of the state including streams, rivers, and lakes. Farms were expected to follow Soil Conservation Service and Cooperative Extension Service guidelines to construct and operate manure management systems. The minimum setback allowed was 750 feet from the nearest residence.

In 1992, North Carolina adopted regulations referred to as ".0200". These rules required all new hog farms to have waste management plans certified by qualified engineers or by others designated by the state. All existing hog farms were required to register with the state department of Environment, Health, and Natural Resources and to develop a certified waste management plan by December 1997. Such a plan must state how many animals are on the farm, the size of the treatment lagoon, and the acres of each crop receiving effluent. Nitrogen in the effluent can be applied to cropland at no more than agronomic rates on the acres of each crop included in the plan. Such was the setting for environmental regulations prior to the summer of 1995.

In June of 1995, after 21 inches of rain had fallen over a three-week period, the dike impounding an above ground lagoon at Oceanview Farms near Jacksonville, North Carolina, broke. The entire contents of the lagoon, estimated at more than 20 million gallons, escaped and drained across neighboring fields and a highway into the New River above Jacksonville. Approximately 5,000 fish valued at $6,500 were killed. Boaters and riverside businesses downstream complained of odorous water and were warned to avoid contact with the water. Also that summer, four other hog lagoons and a poultry lagoon experienced spills. Since most hog lagoons in North Carolina are excavated rather than above ground impoundments, the other spills were of much smaller volume and only two of them reached streams directly.

In response to the lagoon spills and growing environmental awareness, the governor ordered inspections of all livestock and poultry lagoons in the state. More than 4,000 lagoons were inspected. Approximately 2.8 percent were found to have illegal discharge devices such as overflow pipes or overflowing lagoons or some other fairly serious problem. Another 400+ lagoons had lesser problems such as eroded lagoon banks or insufficient freeboard. One producer with a 14-year-old farm was found to have no sprayfield. He apparently had been discharging effluent into a swamp. This producer had his farm shut down by the state attorney general's office and was facing felony charges. Later in the summer and fall of 1995, millions of fish died in the Neuse river. Coastal residents and fisherman were alarmed and expressed concern. Environmental advocates blamed the fish kills on the hog industry and demanded action.

Responding to the incidences that occurred in 1995, the state legislature passed a law increasing the minimum setback for hog facilities to 1,500 feet from the nearest residence and 2,500 feet from the nearest school, church or other public facility. In North Carolina, counties did not have authority to zone against farming operations in rural areas. The governor, the speaker of the state house, and the president pro tem of the state senate each appointed members to a Blue Ribbon Panel on Agricultural Waste. The panel conducted hearings over several months and developed recommendations for further regulation of the livestock and poultry industries. Those recommendations, with some additions, were adopted by the state government in 1996.

The new rules (referred to as Senate Bill 1217) specified that all farms with more than 250 swine must obtain a general permit to operate. Two inspections are required each year: one

by the Soil and Water Conservation Service and one by the Division of Water Quality. Farmers must pay an annual inspection fee of $50 to $200. The rules require that a certified waste applicator be on the farm whenever waste is being land applied. In order to become certified, the operator must attend 10 hours of training, pass an examination, and attend six hours of additional training every three years. The new rules also require a setback of 500 feet from property lines for facilities and lagoons in addition to the previously established setbacks from residences, schools, and churches. Reflecting the fact that in 1993, broilers generated about 50 percent more plant available nitrogen than hogs, (Barker and Zublena, Table 3), S.B. 1217 also requires poultry producers using the litter manure handling system to have certified nutrient management plans.

In 1997, golf course developers near Pinehurst in Moore county, North Carolina sought a moratorium on new hog farm construction when a proposed new farm was sited near a golf course. Later, a group of armed residents blockaded a road to the construction site of a new hog farm in Craven county, North Carolina. A few weeks later, two hog farms in a neighboring county were vandalized and bullets were fired into the buildings. Following these events, the governor of North Carolina announced his support for a statewide moratorium to allow a "cooling off period". As this paper is being written, the North Carolina senate and house have agreed on a new bill that would give counties zoning authority over hog farms above a specified size. That bill would also impose a moratorium on new and expanded hog farm construction through March 1999 while research is completed on the measurement and control of odor. The new bill adds daycare facilities, golf courses and other public recreation areas to the list of locations from which new hog operations must be set back at least 2,500 feet.

In recognition of the fact that swine farms were found to be the source of a small part of the total nitrogen load in the Neuse River, the new bill also imposes a 5.5 parts per million limit on the nitrogen discharges of municipal treatment plants in four watersheds considered sensitive. The bill includes other measures intended to reduce nitrogen discharges from other sources such as urban stormwater and land areas greater than 50 acres that receive fertilizer.

Opportunities and Challenges for Balancing Industrialized Animal Agriculture and Environmental Quality

The shift to larger, specialized farms means greater concentration of byproducts and therefore ***potential*** for greater disaster. However, the movement toward industrialization also means a greater concentration of resources, knowledge and incentives for sustaining environmental quality. Industrialization may mean greater dependence on management and technology, thereby creating greater potential for mismanagement. On the other hand, large, specialized farms employing full time labor can spread the cost of proper manure management over more production, minimizing average cost per animal. Furthermore, because large, capital intensive farms imply large investments, owners of these farms are highly motivated to avoid liability for environmental damage.

Just as economies of scale reduce costs on larger production facilities, they present greater opportunity for treatment and alternative utilization of byproducts (see Powers for further discussion and detail). The concentration of large quantities of byproducts at one farm and in a small geographic area increases the potential for offsite marketing. Such concentration increases the potential for specialized byproduct management services such as custom poultry litter

applicators. From a policy perspective, professional applicators can be more easily trained and monitored than a large group of farmers.

Greater concentration of production imposes diseconomies of byproduct dispersion (e.g., Henry and Seagraves). Barker and Zublena note that several counties in North Carolina produce more nutrients in swine and poultry manure than can be used by crops grown in those counties. Concentration of large farms creates greater potential for centralized processing and export terminals. Centralized byproduct treatment facilities can actually improve environmental quality by removing material that was previously buried or land applied. For example, a central dead bird and pig collection site established by the Greene County (North Carolina) Livestock Association allows smaller, independent livestock producers to recycle their dead livestock.

However, not all centralized systems are economically feasible. Centralized pig manure drying facilities in the Netherlands have been abandoned because the transportation and drying costs are too high. Denmark has used centralized anaerobic digestors to treat manure and capture methane. These facilities are only feasible with a substantial subsidy from the government. Centralized composting and shipping facilities for poultry litter are profitable in some situations. In the pork industry, systems for separating, collecting, and marketing solids from treated swine manure are being evaluated.

Another issue associated with the geographic concentration accompanying industrialized animal agriculture is that livestock and poultry production may become large importers of feed such that nutrients in byproducts accumulate more rapidly than they can be applied to cropland. Nitrates are the primary concern given their mobility in groundwater and surface water. Further treatment of manure to convert the nitrogen to N_2 gas or to separate and export N, P, Zn, and Cu

are options in such situations (Barker, 1996). Producers and regional leaders weigh the costs of reducing buildups of mobile nutrients (P, Zn, Cu) in the soil against the costs of further treatment and export.

Large, specialized farms are highly visible and easily inspected compared to a similar number of livestock scattered over many smaller farms. Consequently, increased attention from the general public and from regulators seems to accompany industrialization. Such attention puts pressure on existing farms to upgrade technology. Often, older farms are already only marginally profitable and the imposition of requirements for new capital investment may cause them to close. Consequently, the process of industrialization may create interim environmental problems. Rapid increases in farm size may result in farms outgrowing popular technology: systems that worked well for 100 sows may not be as well suited to farms with 5,000 sows; setbacks that seemed adequate for 100 sows may seem inadequate for 5,000 sows.

Industrialization has a range of implications for environmental impacts of animal agriculture. Concentration of byproducts at a single site and of numerous large sites in a single area increase the potential for large scale accidents and environmental damage. This fact has caused many states to adopt more stringent permitting, inspection, certification, record-keeping, and education requirements for hog farms and other farms using liquid manure handling systems. Often, the regulation of one industry reaches out to multiple livestock and poultry sectors. Such was the case in North Carolina when the movement toward basin-wide management plans led to the imposition of certified nutrient management plans for poultry producers using dry litter systems. Regardless of whether one discusses livestock or poultry, the potential impact is the same for smaller operations: economies of scale result in a greater cost per head of regulatory

compliance for smaller operations -- consequently, the movement to regulate larger farms seems to accelerate the rate of change.

However, with change comes opportunity. Large farms and concentration of large farms create opportunities for adoption of improved recycling of nutrients and large scale treatment and marketing of byproducts. Researchers continue to develop and evaluate various alternatives for managing byproducts. Regulations are evolving to ensure environmental protection without causing unnecessary financial harm to rural communities and existing producers. In the midst of a politically charged debate, economic analysis is a critical component of current research and regulations as leaders strive for optimal resource allocation — optimal resource allocation which involves multiple objectives, including economic prosperity for individuals and rural communities, and is constrained by the local resource base, settlement patterns, production technology and byproduct management technology.

Footnotes

1. In an earlier paper (Martin and Zering), the evolutions of the broiler chicken and pork industries are discussed with emphasis on the relationships between vertical coordination (especially contract coordination), industrialized animal agriculture, and environmental sustainability.

2. Here, the South refers to the following 13 states: AL, AR, FL, GA, KY, LA, MS, NC, OK, SC, TN, TX, and VA.

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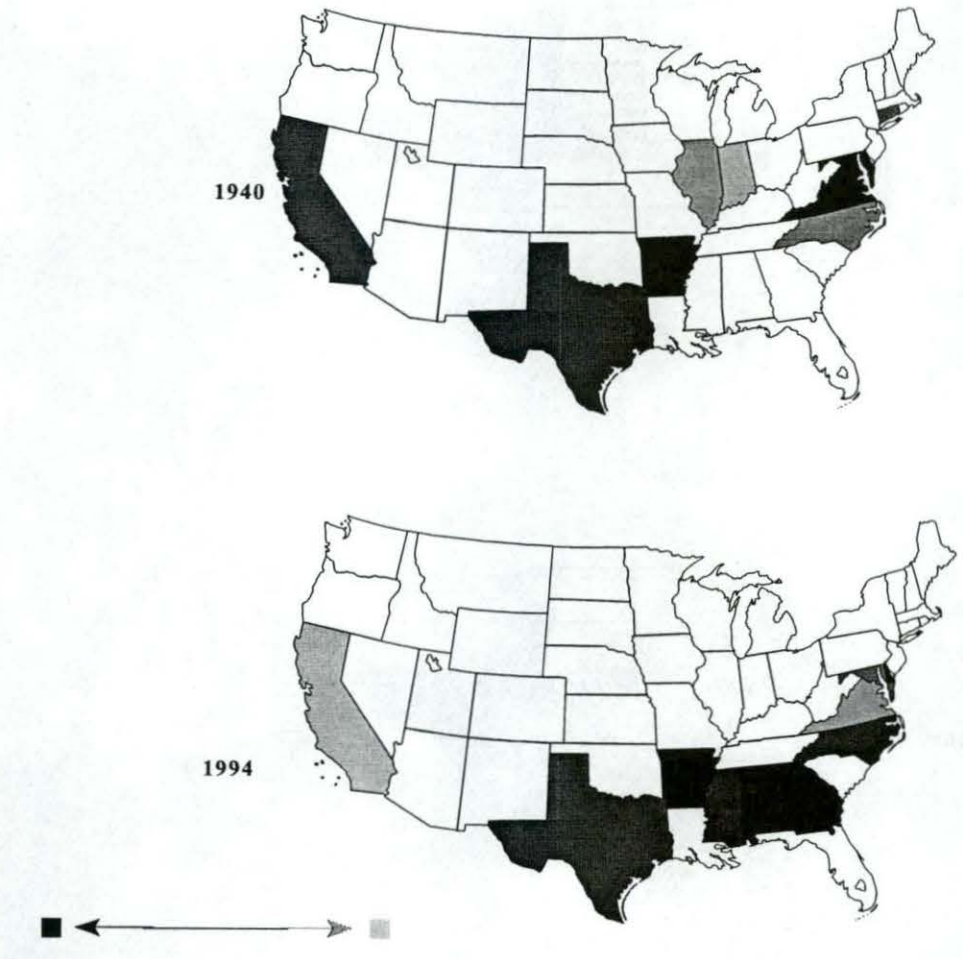
Figure 1. Top Ten Broiler Producing States



Source: *Poultry Tribune*, Centennial Edition, 1995

Figure 2. Top Ten Pork Producing States