

Sharing Costs of Changes in Food Animal Production: Producers, Consumers, Society and the Environment

One in a Series of Educational Programs Presented by the

Future Trends in Animal Agriculture

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PREFACE

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The Future Trends in Animal Agriculture (FTAA) offers a series of educational meetings dealing with various animal well-being issues and related areas of concern. For example well-being is often tied to ethical considerations, environmental issues, food safety concerns, consumer demand, and rural infrastructure considerations. These examples are perceived by some to be directly and negatively related to commercial agricultural interests, while others recognize a greater complexity of these issues. This greater complexity demands more than a simplistic approach to dealing effectively with these intertwined issues.

The program is provided as Appendix A. The primary audience is comprised of agency decision makers and other personnel, animal advocacy organization personnel, professional and agricultural industry representatives, and congressional staffers. All FTAA events are open to the public.

The purpose of this symposium is to briefly present perspectives of personnel from non-government, industry and professional organizations, and farmer representatives on various types of costs and corresponding issues related to food animal production. Government personnel will provide background information related to trade issues. Presentations are expected to create opportunities for in-depth discussion of the many issues surrounding costs and return-on-investment of farmers, and related consumer demands.

The FTAA organization is an informal committee, Co-Coordinated by David Brubaker, Agri-Business Consultant, Michael Appleby, Humane Society of the United States, Ken Klippen, United Egg Producers, and Richard Reynnells, USDA Cooperative State Research, Education and Extension Service. The FTAA organizing committee is composed of representatives from several animal welfare and industry organizations, universities, and USDA/CSREES. These individuals represent moderate views on animal production and the desire to work together to bring about positive benefits to animal agriculture and society.

The Mission of the FTAA is to foster and enhance balanced and enlightened public dialogue on topics related to the nature and future of animal agriculture. The Vision is: to develop programs that are inclusive and national in scope, with the committee consisting of individuals from organizations representing academia, agribusiness, animal welfare, environment, university, government and others. The FTAA seeks to present timely issues in a balanced, innovative and thoughtful manner. The Committee also seeks to enhance public dialogue and understanding about the nature and future direction of animal agriculture, and the impact of their personal decisions on this process.

FTAA Goals are: 1. To facilitate genuine collaboration and the ability of farmers to produce food for society, while improving animal well-being. 2. To provide opportunities for dialogue and

understanding of animal well-being, environmental and other issues in an atmosphere of mutual respect of consumers, farmers, advocates, commodity organizations, and others. 3. To provide information to identify critical animal production issues and enhance greater understanding of societal desires and trends that impact production agriculture.

We hope that you find the proceedings enjoyable and educational. Feel free to contact any committee member for more details of future programs.

Opening Remarks

Opening Remarks: A Vision for the Future of Agriculture

Michael Appleby, Vice President
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Farming is not like other businesses. It is fundamentally important in providing food. It is an extremely complex process of managing inputs, animals, workers, the environment and markets. It has diverse effects on all those, and on all of us, the members of society who eat the food produced. On behalf of society, farmers are stewards of the animals that feed us and of our environment. They have succeeded beyond all expectations in meeting the challenge that they were given before, during and after World War II, to produce more abundant, cheaper food. However, increasingly they are subject to a bewildering array of pressures, most obviously financial. In considering the costs of changes in food animal production (including those of crops fed to animals) that are happening now and that are needed in the future, a primary consideration must be that its producers deserve a reasonable living. The question of how we can achieve that is a major theme of this meeting. The other, overlapping theme is how resources can be managed to address other issues of concern to society, such as food safety and security, and appropriate care for farm animals, farm workers, rural communities, and the environment.

The costs of food animal production include not just the direct costs of farming and marketing, reflected in the selling prices in the shops, but the external costs. These include effects of livestock production on the environment – including water and air – and the costs of disease outbreaks, in terms of both money and food supply. We do not as a society need food that is cheaper in the supermarket. We do need food security – and self-sufficiency must be part of that, within the country and within regions. These issues offer new challenges to agricultural economists, in consultation with others such as farmers, animal scientists, consumer groups and environmentalists. They raise questions such as the following.

Should we look to a future in which movement of animal feed, animals, and food from animals is reduced rather than increased, both internationally and within countries?

What economic mechanisms would help the US agricultural industry obtain a reliable income from the home market of US consumers?

What husbandry methods are most appropriate to safeguard animal health and welfare, reducing the chance of disease and ensuring food quality and safety?

One thing is clear: that decisions about the structure of agriculture will in the future have to take greater account of public opinion than hitherto. This should not be a burden on farmers. On the

contrary, it should ensure farmers a more valued place in society and a more reliable income. The importance of public opinion is emphasized in numerous discussions of agriculture. One of the main recommendations of the UK's Policy Commission on the Future of Farming and Food (2002) is greater integration and communication between all stages of the 'food chain', from producer to consumer. And in the USA the National Research Council (2002), reviewing the research program of the US Department of Agriculture, recommends increased public accountability, for example by holding a public discussion forum every two years. It also recommends that government-funded research should in the future be less on productivity and more on public goods such as environmental stewardship.

We need a vision for agriculture in the future that will be sustainable for our animals, for our environment and for ourselves.

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Opening Remarks: A Balanced Decision Making Process

Ken Klippen, Vice President
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United Egg Producers
Washington, DC

Everyday we must make choices, including what we are to wear, and what we will eat. And, we must balance those decisions with knowledge and available information. Modern livestock production continually makes informed decisions based on knowledge and the available information. New technologies provide improved efficiencies and help balance market needs with production capabilities.

This forum is designed to help us all make informed decisions. What has modern livestock production provided so that we can make an informed, balanced decision? Lets take a look.

Modern livestock production has helped improve nutrition. Animal products in our diets provide key micronutrients such as calcium, iron, zinc, and vitamin B-12. How important are these nutrients? The U.S. Centers for Disease Control concluded recently that two infants raised and breast fed by vegan mothers suffered retarded development due to serious deficiencies of Vitamin B-12. It is possible to supplement with vitamins, but this is never an issue with mothers who eat meat, drink milk, or eat eggs.

Modern livestock production is contributing to Third World Children being able to consume more meat, and hence derive more of these nutrients. In the past 20 years, the Hudson Institute estimates the meat consumption by children in China has increased 7 times. In Mexico and Brazil 5 times. And more than 3 times in the Philippines.

One factor contributing to this increase is that modern farms can raise chickens on only 75% as much feed and 10% as much farmland as is needed by backyard farms. Backyard farming is really backwards. Not only is more feed lost by these backyard farmers who are using more land, but they expose their birds to predators, parasites, inclement weather, and diseases. This was readily apparent during the development of the U.S. National Organic Standards where the final rule mandates that chickens producing eggs must have access to the outdoors.

United Egg Producers argued these points of what outdoor access will do to the health of the chicken. The picture of a backyard farm raising a few free range chickens and a few outdoor hogs under sunny skies fails to recognize that those animals produce manure at the same rates as those kept in confinement. From the backyard farms animal waste wash into the streams with every storm event. The fact that a million chickens are distributed on 10,000 small farms doesn't make the wastes disappear. Modern farms collect the manure for nourishing the crops in the fields.

The Hudson Institute noted that if the Third World put all of its 500 million hogs outdoors, at four hogs per acre, the hogs would need another 125 million acres. 125 million acres....the land area equal to all the crop land in China. China has over 573 million laying chickens, 430 million

hogs, 26% of the world's people, and only 7% of its arable land. This is why chickens and hogs are kept in confinement. No nation in the world puts all of its hogs out in the pastures because hogs root and wallow and cause enormous soil erosion and stream bank destruction.

The Hudson Institute calculates that the world feeds about 150 million tons of grain to meat-type chickens. If those birds were raised outdoors, we would need another 50 million tons of feed per year along with another 30 million acres to raise the extra feed. And if all those birds were all in backyard farms, the cost of meat would become so high that many Third World children would not be able to consume meat, drink milk or eat eggs.

It's no accident that the criticism of modern farming comes from the best-fed people in history. They are spoiled by the good fortune that allows them to take their good diets for granted.

Producer Issues

The Economic System of U.S. Animal Agriculture and the Incidence of Cost Increases

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U.S. livestock and livestock products are sold by farmers in markets generally characterized as competitive but with elements of imperfect competition as the number of buyers available for any producer's output is typically small. The recent expansion of vertical integration and contracting has generated new concerns about how producers fare economically. But for present purposes it is sufficient to note that whether perfectly or imperfectly competitive, producers have been and will continue to be under a severe cost-price squeeze. When profits appear, they are soon squeezed out by expansion of farm output leading to lower prices sufficient to eliminate the profit.

Examples are the history of productivity growth and resulting market effects in poultry, hogs, and milk. As Figure 1 shows, the reduction in labor needed per unit output has been phenomenal for all farm products, and is even more impressive for livestock than for crops. In broilers, where productivity growth has been fastest of any major product, the labor needed for 1000 pounds of live broilers decreased from 24 hours in 1952 to 1 hour in 1984.

Who benefitted from these productivity increases? Broiler growers are doing reasonably well as compared to other farmers, but their returns have not increased anything like the rate of productivity growth. The same is true of other farm products. Who has gained big time are the buyers of those products, including principally consumers. Figure 2 shows the history of real broiler, egg, and milk prices. "Real" means these prices are deflated by the overall price index. Therefore the price declines show real gains accruing to purchasers of these products. Between 1950 and the mid 1980s real broiler prices fell from \$1.50 per pound to \$0.35 per pound. This is less than the labor productivity growth in percentage terms, primarily because other inputs into broilers, notably feed, did not decrease as rapidly as labor did in terms of use per pound of broilers produced. The gains to product buyers are nonetheless impressive and the same is true for eggs and, to a lesser but still significant extent, milk.

An issue however on the buyers' side is whether it is final consumers who gain or processors and retailers? Figure 3 shows some recent history for eggs, from 1960 to 2000. The lower plotted prices are farm level, the middle line is prices paid by retailers (formerly called wholesale prices) and the top line is the retail price of grade A large eggs. The series move closely together, and the retail price appears to have fallen by an even larger amount than the farm-level price. However, the scaling can be misleading in that because the retail price starts at a higher 1960 level, \$2.50 (1992 dollars) compared to \$1.50 per dozen, a larger fall in dollars can be smaller in percentage terms. To show the declines in equal percentages, Figure 3a shows the same data plotted on a logarithmic scale. Here a slope measures a percentage change,

and we see that all three prices decline at about the same rate, although the retail price still declines slightly more rapidly.

What is the relevance of this history to cost-sharing from more livestock-friendly production practices? The issue that arises with respect to costly changes in livestock production practices is just the converse of cost decreases due to productivity gains. Kindness to animals may well cause productivity losses and cost increases. Who then would bear these costs? The suggestion from the time series data of Figures 2 and 3 is that consumers would pay the bulk of cost increases roughly in the same proportion as they reaped the benefits of earlier cost decreases.

It may be objected that farmers are unable to pass on such cost increases because of the competitive markets they deal in, or their weak bargaining position with respect to processors. The economic argument for a pass-through nonetheless occurring is that when costs increase, production at the margin decreases, and the resulting output reduction increases market prices, or the prices contractors must pay to get the product they want. One way to get evidence on the issue is to look at what has happened when livestock production costs have risen in the past. Perhaps the best example of a cost-shock was the huge increases in feed costs that occurred in the commodity boom of the 1970s. Figures 4 and 5 give some indications of how this worked out by plotting corn prices against hog and cattle prices. Hog prices appear to have increased quite quickly along with corn prices in the 1970s, but the situation with cattle is more complicated. There were early losses as cattle were placed on the market to avoid having to feed them. But after several years, fed cattle prices averaged at permanently higher prices roughly in proportion to the feed price increases.

The preceding is in general accord with supply-demand principles, and the implication is that cost increases that might result from changed livestock production practices would also result in roughly comparable price increases in livestock prices. Analytically, the incidence of losses from cost increases depend on the relative elasticities of supply and demand. If the elasticities are equal, then sellers and buyers will share the costs in equal proportion (Figure 6). If buyers bear the majority of the costs, then it must be the case that production is more price-responsive than demand (see Figure 7); and the data I have been reviewing suggest that, at least in the longer run, that is the case.

One important aspect of cost-sharing cannot be analyzed using simple supply-demand analysis, namely the situation in which some producers but not all adopt more costly production practices. This could happen either through the voluntary choice of producers or through regulation. If McDonalds chooses to buy only certified organic or free-range chicken, that will increase their costs but not the costs of their competitors. They have to hope that there is a corresponding increase in demand for their products as a result of their changed buying practices. Otherwise their net returns will decline relative to those of their competitors. Likewise with respect to regulation: if large- but not small-scale producers are required to adopt a more costly practice, that will generate lower returns for the large-scale producers but it might even be beneficial for small-scale producers. Most importantly, costs cannot be readily passed on to consumers because aggregate production is less affected. Indeed, the exempt producers may expand production sufficiently to offset any production cutbacks by those whose costs have increased. In general, producers whose costs increase will be better off if the costs of all producers increase than they will if a substantial group of growers is exempt from cost increases.

Figure 1. Labor Hours per Unit Output

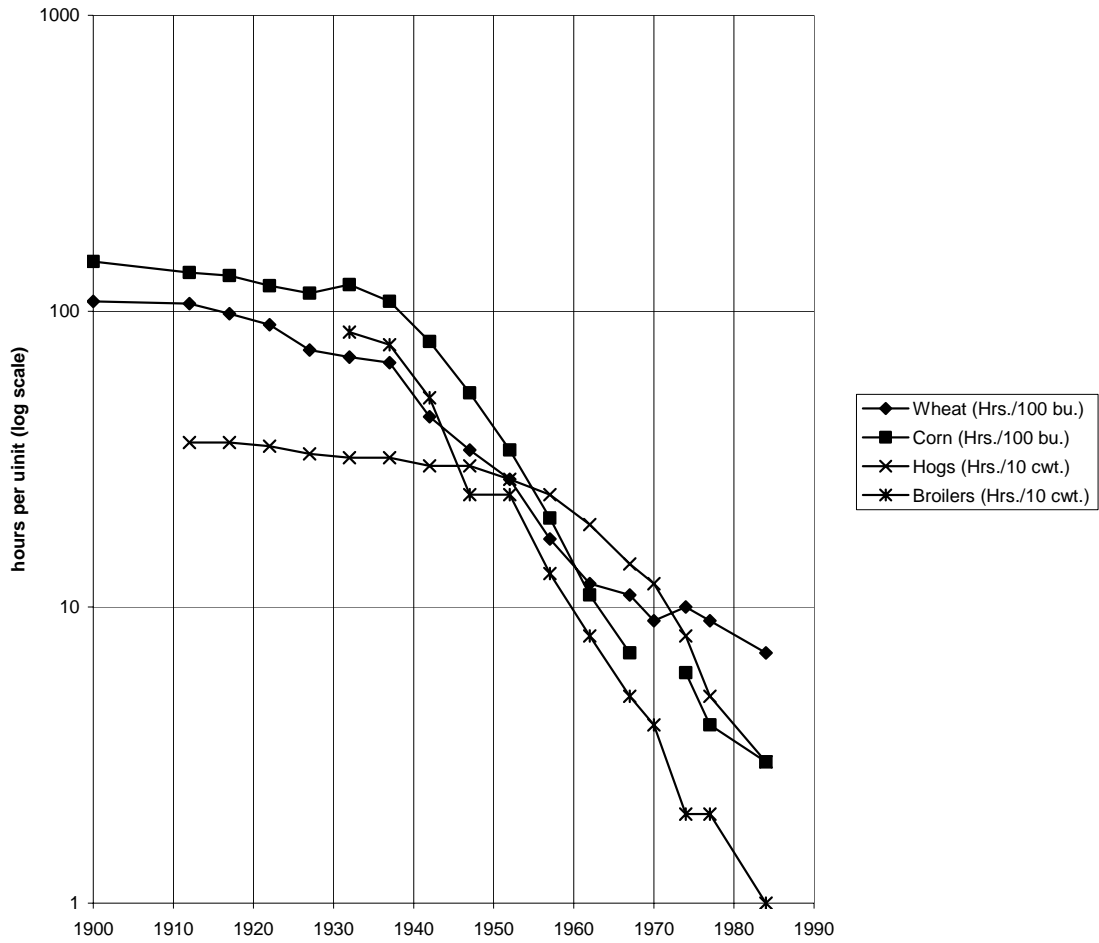


Figure 2. Real Farm Prices of Broilers, Eggs, and Milk

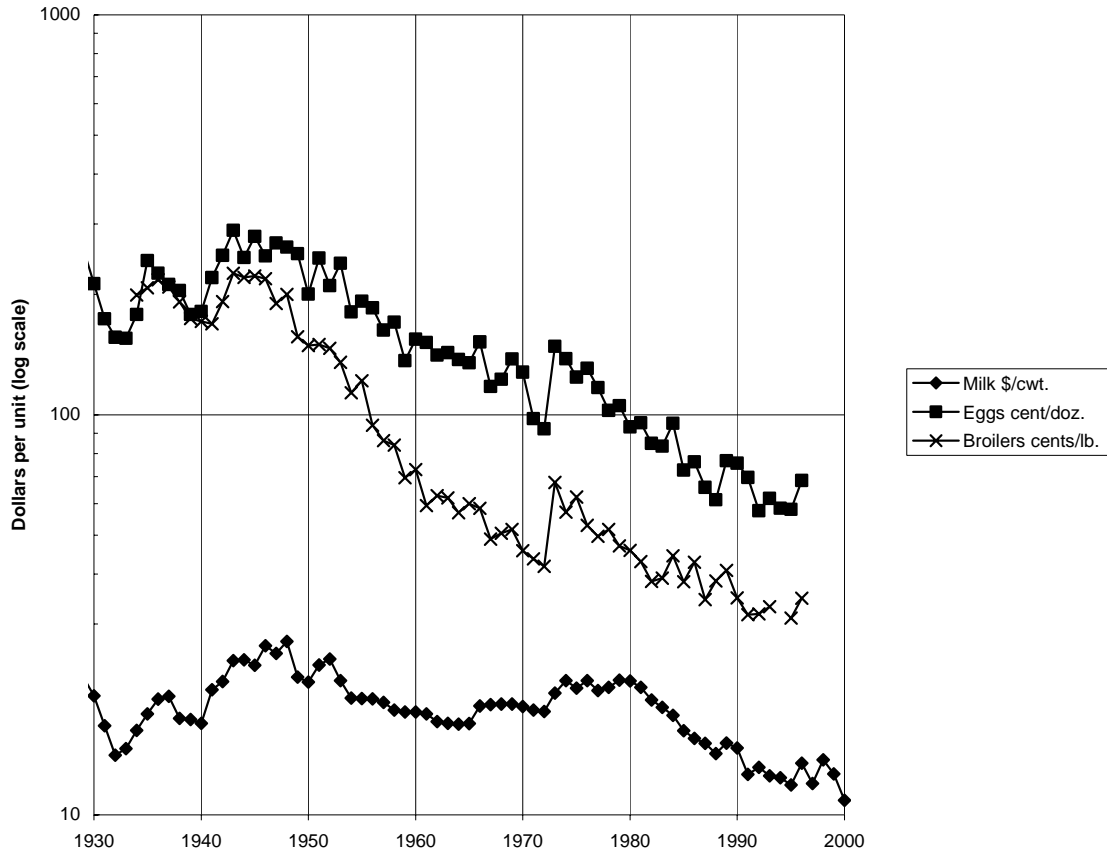


Figure 3. Real Egg Prices

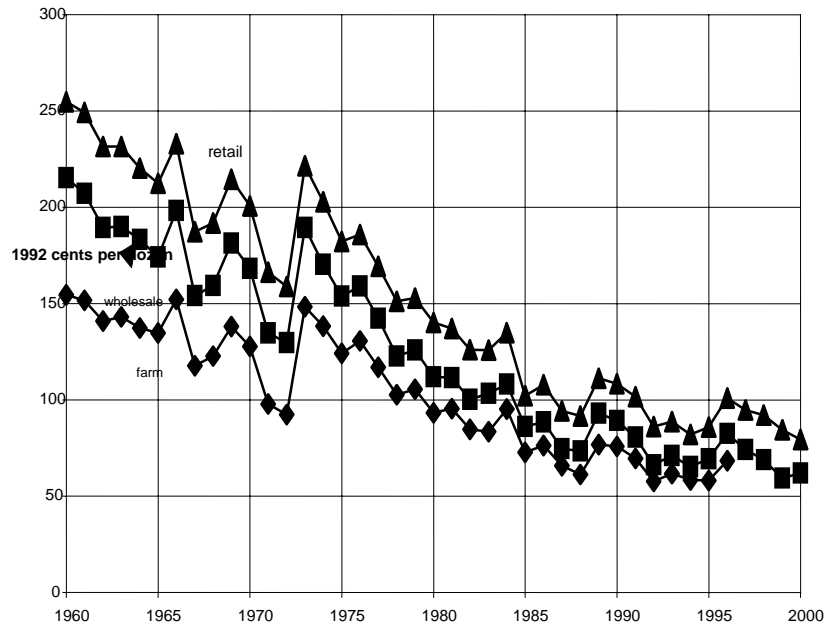


Figure 3a. Real Egg Prices

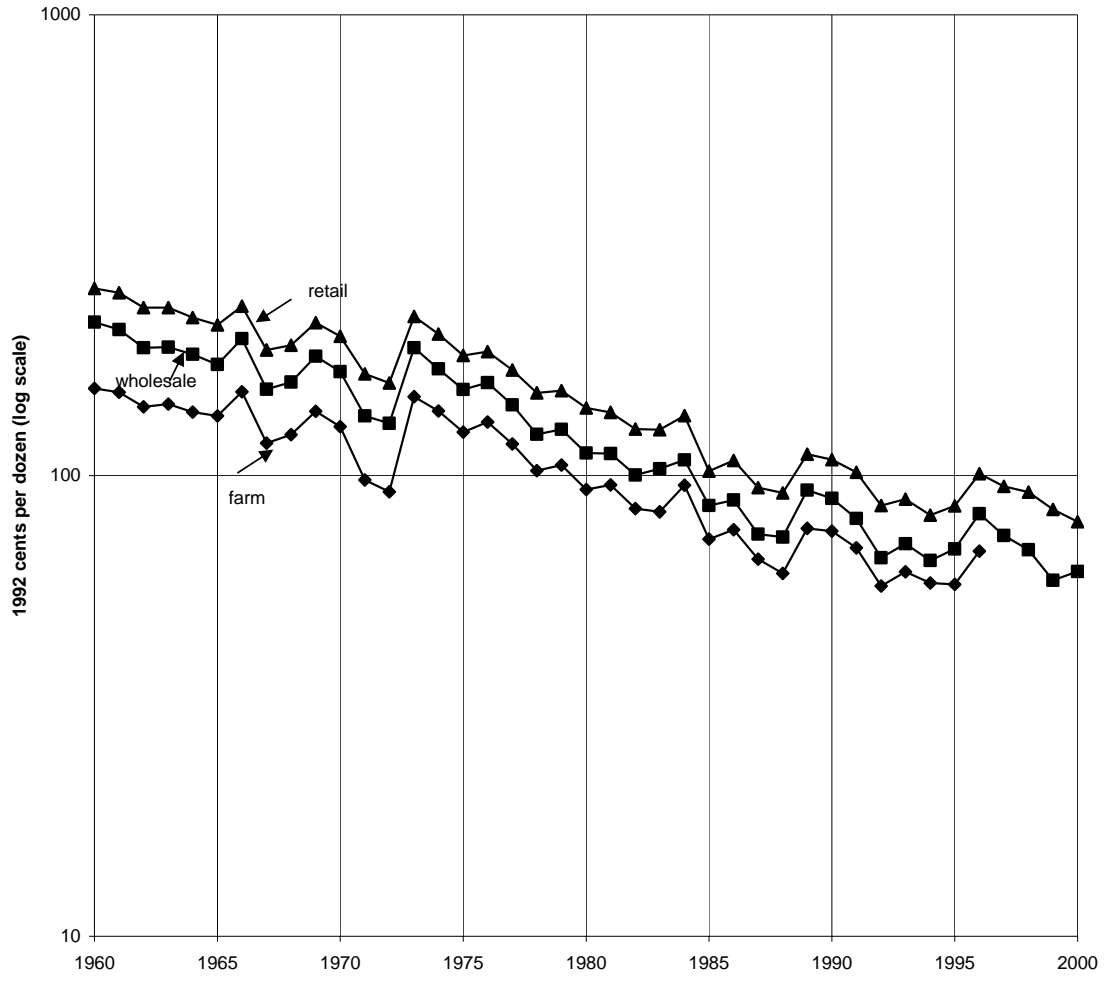


Figure 4. Corn and Hog Prices

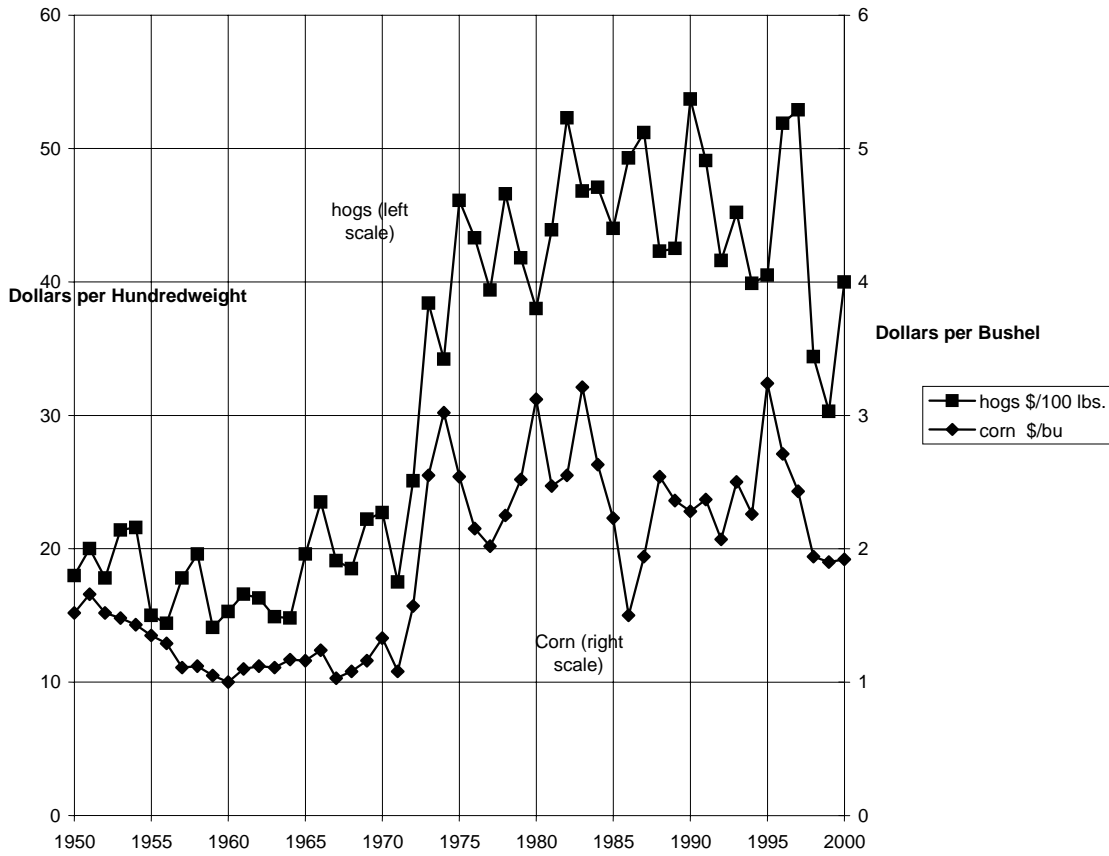


Figure 5. Corn and Steer Prices

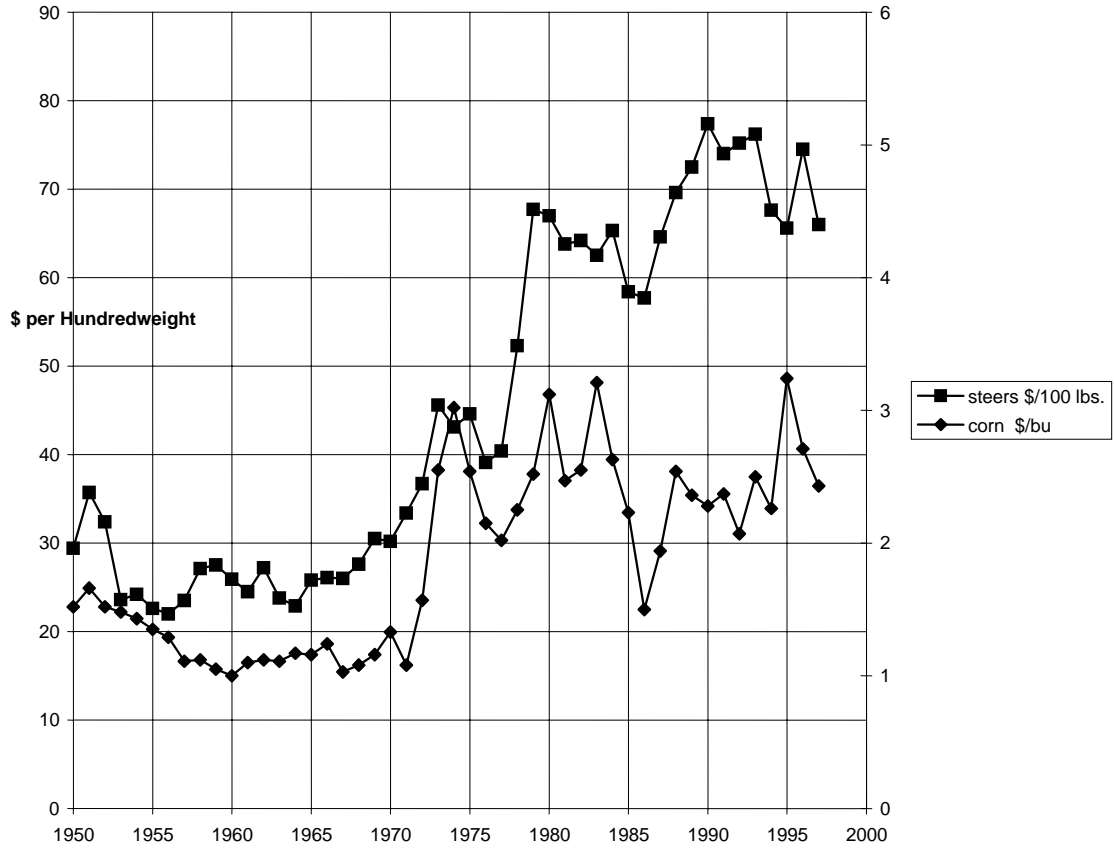


Figure 6. Supply and Demand with Equal Price Responsiveness

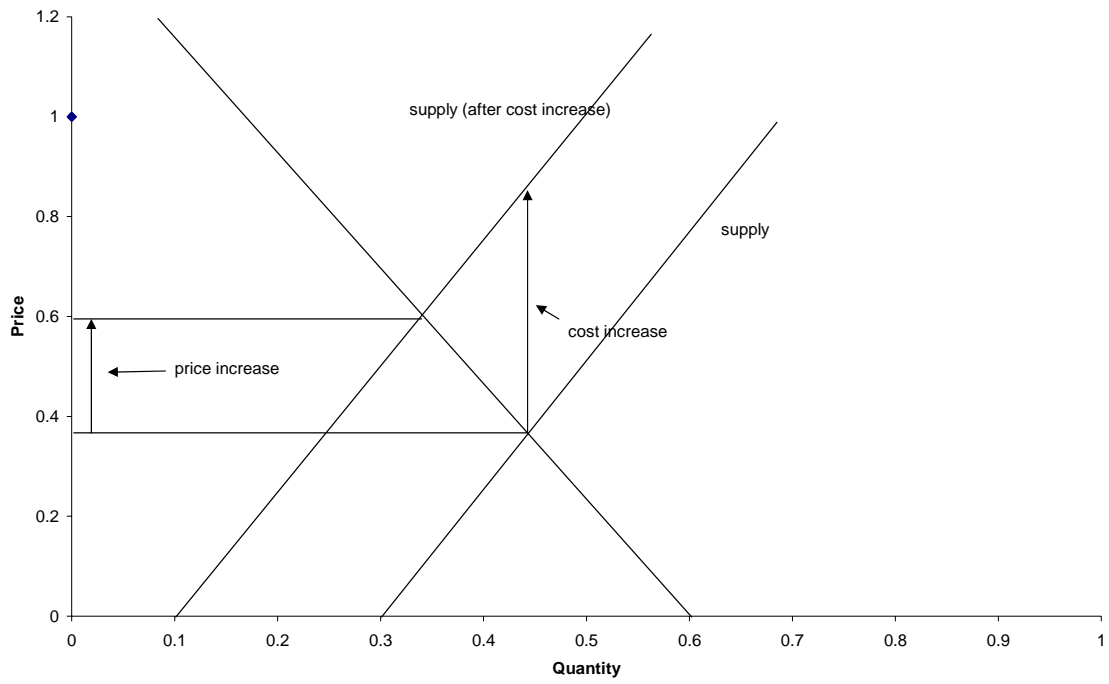
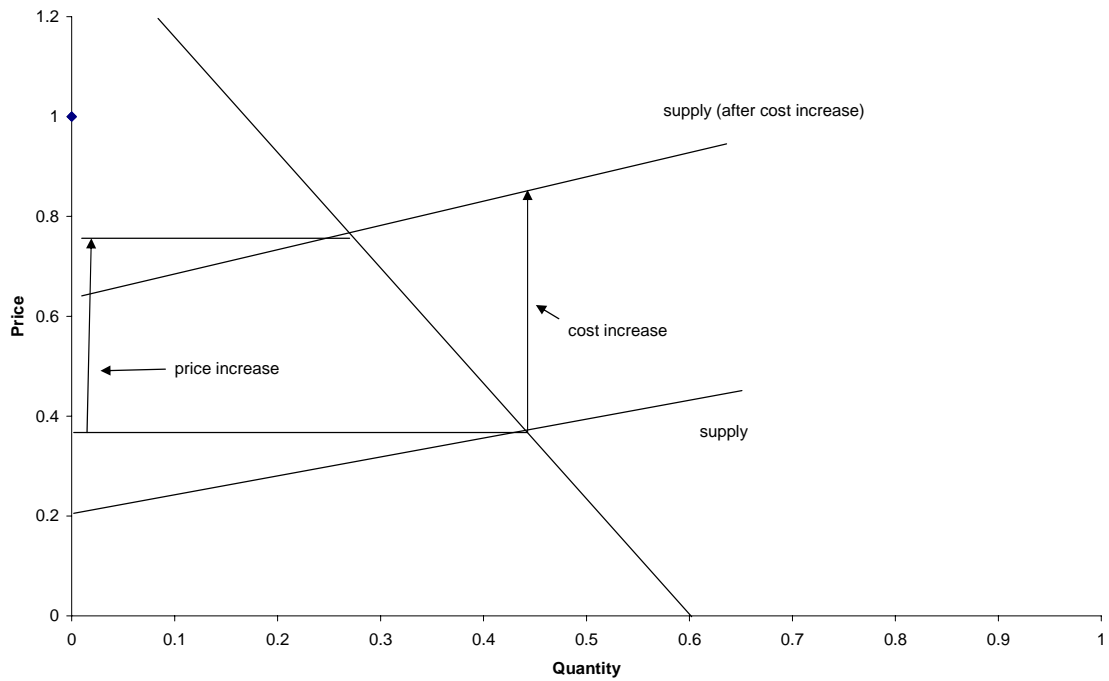


Figure 7. Supply and Demand with Supply Having Greater Price Responsiveness



Food Animal Welfare: Producer Issues Regarding Costs

Richard R. Wood, Executive Director
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Chicago, IL

Food Animal Concerns Trust (FACT) advocates for humane and sustainable farming practices that improve the safety of meat, milk and eggs. We have just completed the Nest Eggs Project, which for 18 years was a for-profit company that contracted with up to 14 egg farms in Pennsylvania. These farms produced eggs from uncaged hens for major grocery chains stretching from New York to Washington, DC, and earlier in the Midwest. Kathy Seus, FACT's Farm Program Manager, led that project. When not at FACT's offices in Chicago, I live and work on a farm in western Illinois. Prior to my coming to FACT, I helped staff farmer-directed organizations in Illinois. And so we at FACT approach the question of producer costs with some understanding of the basic issues, although today I primarily present observations and questions, letting producers themselves provide the answers to the issue of costs that are before us.

We at FACT approach the issue of cost with the same presuppositions that we approach any issue we address. First, most all farmers and producers, regardless of the size of their operations, are good people who care about their animals, and they are cautious economic realists for the most part. Their margin of profit is narrow, sometimes non-existent, making them feel highly vulnerable to any proposed change in production. That was certainly our experience at Nest Eggs as well. Producers cannot be clumped into one homogeneous group any more than we could do that with people in any other group – although we often talk in the generalized terms.

A key presupposition to our discussion today is that farm animal husbandry systems will change as we move through the next 10 years, just as there has been change in farming practices in the past. As we look to the next decade, social, ethical, public health and food safety forces are compelling the industry to address the issue of animal welfare. You probably all read the newspaper article in USA Today (8/12/03) that summarized the movement toward animal welfare, a push that was identified as coming in large part from supermarkets and fast food chains. The last statement in the article summed it up. "In agriculture, we've always said, 'We will grow it and you will eat it.' What we're doing now is saying, 'What do you want to eat and we'll grow it.' I think that's the future." (Dr. Jeffrey Armstrong, Michigan State, as quoted in USA Today).

Understanding these realities, what are the costs of change for producers? If I am a producer and change is inevitable, what are its costs? From our experience with Nest Eggs, I would like to offer five observations that basically apply to every producer of any size.

First, when discussing cost we must begin by identifying which reform will be considered. There is a continuum of humane management options for each food animal production system, whether it is producing eggs, broilers, beef cattle, hogs or milk from dairy cattle. Using layers as an example, the options include eliminating battery cages altogether, using enriched or

expanded cages, eliminating force molting, using a non-nutrient feed to induce molting, ending beak-trimming, reducing flock density in cages or on the floor, improving feed quality, providing access to outdoors, raising hens entirely outside on a rotational grazing type system, etc.

Producers have the challenge of positioning themselves on a continuum at a point where they can economically survive, while meeting customer expectations and their own concerns about animal welfare. At the same time we need to recognize that many producers are under contract to companies that set the production practices for the farms. These contracts may limit an individual producer's ability to change production practices. The market and lack of infrastructure may also put limits on the range of humane choices.

Before we can begin to talk about cost, we must first identify which specific humane husbandry steps are going to be taken.

At Nest Eggs we selected several, but not all, humane husbandry practices by which to produce eggs. That decision was based on our own perception of the critical welfare issues for laying hens some 18 years ago, coupled with what we perceived to be the most economically achievable. We decided to do three things. We chose to not use cages. We did not force molt. And we set the flock density at 2.0 square feet per bird in each house. Issues we did not address immediately included going to a free-range system. We also continued to beak-trim the birds, although we attempted to address this practice at a later date with tragic results. We did not address the practice of disposing of male chicks. In other words, we were successful in making just about everybody mad, including industry and activist groups alike. The exception was the large and ever-growing customer base looking for a more humane option than what was previously available. What we learned as producers is that there will almost always be groups pushing us to go in one direction or another, regardless of which practices we decide to adopt.

I believe the most important thing we do as producers is to take the next step toward a fully humane agricultural system. A discussion of costs begins with the humane steps we decide to take. Choices have to be made. Production costs will vary based on those choices.

Second, while there is often the assumption among producers that any shift to humane husbandry practices means phenomenal costs, this is not necessarily the case. Humane husbandry changes do not in themselves have to be cost prohibitive and those of greatest priority are not necessarily the most expensive steps to take. Nest Eggs was fortunate to have a ready-made infrastructure in the Pennsylvania farms that could easily convert to a floor based system with nest boxes. Our priority decision to produce eggs from uncaged hens was not a costly one for us. On the other hand, if we already had a large cage system in place, this choice would have been very costly to achieve and would have probably required years to accomplish. On the other hand, some large hog confinement producers have decided to switch to a more humane farming system. In some cases they have moved to group housing, using the same buildings as before with minor structural changes and minimal costs. Others have opted to use hoop houses. Construction costs for a hoop housing system are relatively small, especially in comparison to building a completely new facility. Viable and priority humane options do not mean that a producer will "lose the farm."

Of course there are some costly options for producers. If the humane husbandry priority is to move hogs from confinement to the pasture, or laying hens from cages to the floor or even

outside, these changes can result in major costs for producers. Many producers are now heavily invested in buildings and other assets. If humane housing is the priority, we must find ways to assist producers financially in making this transition. However, it is also important to remember that technological advances continue to mitigate the costs of humane animal production. Hoop houses for raising hogs in groups or outdoors is one example. These alternative systems, when compared to more traditional confinement systems, do not result in higher production costs, and in some cases, may even lower production costs.

We have observed at Nest Eggs that increased costs related to changes in production are often mitigated when all producers are required to play by the same rules, creating a level playing field of agreed minimum standards. The basic costs then become equally distributed among all producers. The history behind the Egg Safety Action Plan illustrates this point, even though this is not necessarily a humane husbandry policy. One of the motivating factors supporting this plan was that every egg producer in the U.S. had to participate in the plan, once enacted. Every egg producer regardless of size or location had to test eggs for *Salmonella enteritidis* the same number of times in the same way. This would eliminate the situation that now exists where costs are unevenly distributed among producers, often depending solely on geographic location. For example, producers in Pennsylvania participate in a rather stringent *Salmonella* control program, while Virginia producers have to meet fewer requirements. There is an unequal distribution of costs involved in meeting *Salmonella* standards from one state to the next. The creation of a level playing field, with the same nation-wide minimum requirements requires that all producers face similar risks, similar basic costs, and have the opportunity to reap similar benefits.

While creating a level playing field is important for a set of minimal standards, the continuum of potential welfare steps means that there is plenty of room for diversification and for niche producers. Also, it is important to note that there are different tools available to level the playing field. Proscriptive regulations are one tool. Credible certification programs and monitored labeling are others.

In the final analysis, when discussing the costs involved in making the transition to a more humane production system, economists and our own experience tell us that these costs will be borne by producers only for a limited period of time, as the increases eventually get passed on to consumers. This means that where there are increased production costs, the final issue of the day is not what costs producers are willing to bear, but how much consumers are willing to pay.

Third, producers must consider the reality that as one humane issue is addressed, other issues may also need to be addressed. At Nest Eggs, we chose to not beak-trim the layers in one of our houses, as we were hoping to eliminate this practice altogether. The result was a dramatic increase in cannibalism. Despite our efforts to create diversions within the henhouse, we found that the only effective response was to increase the floor space per bird, well beyond the 2 square feet normally provided. Although this step addressed the cannibalism issue, the production costs per bird skyrocketed. We also experienced a sizable production loss. If we choose not to beak-trim, we will either need the gentler, kinder bird that Dr. Cheng discussed at the May 28th ARS conference (Future Trends in Animal Agriculture; proceedings are available), or we may need to move to a free-range system. Either alternative has cost implications for producers.

Regardless of the species, husbandry practices are interconnected. Whether it is layers, broilers, beef cattle or hogs, one husbandry change may require others to follow.

An analysis of interconnected costs also needs to recognize that steps taken to address animal welfare may have impacts on other factors of production. One favorable example is that if we decide to take the welfare step of improving feed or increasing the number of animal caretakers, a consequence may be improved animal health, an issue beyond what would be considered a welfare concern.

A fourth observation is that in order to minimize the cost impacts of changing to a more humane production system, full support from the research and academic community is required. Scientific research will have to ask a new set of questions for producers to succeed in humane production. Most research in the past has focused on how to increase production. Or, when it came to layer welfare, the research questions asked often had to do with how many birds could you put into a cage. Today we need to ask questions that will help producers address humane issues, such as, what is the best next step to take in humane animal management? How can producers anticipate the other welfare consequences stemming from those initial changes? Or, how can producers maximize profits while at the same time maximizing the welfare of the animal? Research must focus on the redevelopment of breeds with a different set of social characteristics that can thrive and grow in less confined settings. It was heartening to learn from the May ARS Symposium on food animal welfare research, that researchers are beginning to ask and address this new set of questions – a critical step if producers are going to successfully meet the cost challenges of humane production.

A fifth and final observation is that producers may resist change, not simply because of the perceived costs, but because they will be asked to bear the costs for decisions over which they will have little or no control. In talking and working with producers over the years I find that when change is anticipated, producers often see themselves as being “acted upon” rather than being one of the “actors.” They feel removed from the decision-making process, seeing themselves as subjects to uncaring government regulation, consumer activists, and even their own industry groups. Change in husbandry practices will only succeed when producers themselves are involved in helping to determine that change.

Denmark has been in the agricultural news lately with the WHO report on antibiotic use in food production, but there is another story from Denmark. A couple of years ago I met with Scandinavian hog and poultry farmers and visited their farms. They were very proud of the changes they had made in improving their animal husbandry. They were equally proud of how that change took place. It did not come from the government, the politicians or even the activists “acting on” producers and farm groups. Several years ago Denmark producers understood along with others, that changes in the marketplace were underway, and they decided to “get out in front” of those changes. And so the producer groups sat down with the government and consumer groups to develop together a set of welfare standards that all could support. In this case, the producers were not acted upon or victimized by change. They were part of making that change happen.

Here in the U.S., producers of all sizes of operations understand the dynamics of the market place. They know that change is inevitable. May producers be the ones to help lead the way to a new era of humane animal husbandry. Thank you.

Decision Making in the Food Chain

Retail and Consumer Influences

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A copy of the power point presentation may be obtained by contacting the author.

How are Democratic Decisions to be made that Promote Sustainable, Adaptive Food Production Systems?

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INTRODUCTION

How does one implement a democratic process for global food production and distribution? I am not at all certain that I can provide an answer, or even make a modest contribution, to this question. In fact I can state unequivocally, that I do not know the answer. But I can also state that developing and/or maintaining a democratically based food system, both nationally and globally, should be of the highest priority.

When I first saw the proposed title of my presentation and paper, my thoughts were to immediately insist that the title be changed. However, after giving some consideration to the topic question, I decided that even though I could add little or nothing to ultimately answering the question, simply starting a discussion about the topic of democracy in the production of food was a worthwhile goal in itself. Therefore, my purpose today is to present the question, discuss briefly why I contend that democracy is an essential foundation to sustainable food systems, and then propose some preliminary ideas about how a democratic process can become a part of the system.

BACKGROUND AND STATEMENT OF THE PROBLEM

By profession I am an animal scientist, and therefore, my comments are focused primarily toward the production of food from animals. Animal scientists, like essentially all biologists today, have a strongly reductionist view of how science is and should be conducted. By reductionist, I mean that scientists look toward lower levels of biological systems as the explanation or causation for higher-level phenomena. For many aspects of biology, this has had tremendous benefits. For example, having gained an understanding of DNA has led to considerable control over the growth, reproduction, lactation, egg production, immunity, etc. of animals. There is reason to contend that this technology has potential benefit to improve the lives of both animals and humans. However, I suggest that there is also reason to be concerned that misuse, or even overuse, of this technology has the potential to cause tremendous harm. And in fact, I believe there is already reason to be concerned about the negative impact on animal welfare, some aspects of the environment, the livelihood of animal producers, and the self-sufficiency of some developing world countries. Additionally, I believe that many biologists tend to look toward the great strides that have been accomplished in understanding life processes and extrapolate to a belief that this scientific methodology can be applied to solving all problems. I will contend that this view, if taken literally, is wrong. Rather, I believe that many of the problems associated with food production today are not ones that have to do with increasing the understanding and manipulation of life processes. Instead, many of the problems today are ones that require solutions that take a systems approach that optimizes

relationships of all parties in the system, not a reductionist approach that maximizes the exploitation of one contributor to the system.

By a systems approach, I am proposing that instead of having scientists focusing almost exclusively on attempting to produce even more milk, more eggs, more growth, etc. from individual animals that scientists should be employing a scientific methodology that attempts to optimize end points. In other words, the goal should be to develop food production in such a way that the interests of the animals, citizens, and the environment are all taken into account. Currently, I would contend that only token consideration is given to endpoints other than maximizing the amount of productivity from each individual animal – with little or no consideration to the impact on the animal and in some cases little consideration for the environment. Giving consideration to the animals, or weaker individuals in general, is not a new idea. In fact one could argue that much of what I am suggesting traces back at least to Plato. The following dialogue comes from Plato's Republic. The interlocutors are Socrates (in first person) and Thrasymachus (in third person):

Then medicine does not consider the interest of medicine, but the interest of the body?

True, he said.

Nor does the art of horsemanship consider the interests of the art of horsemanship, but the interests of the horse; neither do any other arts care for themselves, for they have no needs; they care only for that which is the subject of their art?

True, he said.

But surely, Thrasymachus, the arts are the superiors and rulers of their own subjects?

To this he assented with a good deal of reluctance.

Then, I said, no science or art considers or enjoins the interest of the stronger or superior, but only the interest of the subject and weaker?

He made an attempt to contest this proposition also, but finally acquiesced.

As this dialog continues, Thrasymachus tires of his role as mentor and becomes trapped in his own argument when Socrates wishes him to continue, but Thrasymachus contends it is not his job to force his ideas into the minds of others. Possibly, we all become similarly trapped. Most all persons agree that something should be done, maybe even agree that a democratic process is best, but when addressing the task of implementing such a system, individually we find it hard to live by the rules we advocate. And maybe, it too often is easier to look toward someone else or some other group as being either the blame or else having the responsibility to bring about change. I will contend that acting responsibly as individuals is the first step toward bringing about a democratic system in food production.

SUSTAINABLE FOOD PRODUCTION SYSTEMS

Previously, I have argued that sustainable agriculture can be viewed as a balanced ecosystem involving both plants and animals wherein the benefits to animals, the environment, and humans are optimized, and the costs to each of the three parties are minimized. However, when sustainable is defined as those practices “that will last,” I will now contend that this utilitarian view alone may ultimately be insufficient for certain on-going agricultural practices to attain sustainability. Rather, I propose that ultimately the only lasting practices will be those that the citizens accept as bioethically sound. Therefore, I will contend that bioethics should be used as a basis for establishing minimal “rights” for 1) human needs, 2) animal care and welfare, and 3) the environment. Establishment of these minimal “rights” of course represents a daunting task. A major question arises, by whom should such an endeavor be attempted? I would contend that it would have to be addressed by an international body, possibly the UN. With this foundation defining the “rights” of each party that cannot be exceeded, then the maximum benefits and minimum costs should be sought for each of the three parties. In short, what I am suggesting is that a globally developed position be adopted that uses a rights-based argument for the essential considerations that must be extended to all humans, animals, and the environment. Once these minimal considerations are established, then a utilitarian based system of costs and benefits is allowed to develop to distribute the products of the food system to the citizenry.

COMPLEX, ADAPTIVE FOOD SYSTEMS THROUGH DEMOCRACY

To attain sustainability, the system as a whole must be an open one allowing it to be adaptive. By adaptive, I mean that each part of the system (biological, social, political, economic, etc.) must permit self-correcting feedback to occur. Thus, through the inclusion of a wide range of viewpoints, output from the system can modulate input allowing the various components of the total system to be self-correcting. This view is one that is complementary with the modern philosopher Rawls’ reflective equilibrium model for establishing societal ethics. Finally, I present an argument that democracy is a critical component of a sustainable agricultural system, which I believe must ultimately also be bioethically grounded. It is through a democratic process that allows input into the system that advocates the “interests” of animals, the environment, etc. If the system is designed to serve solely the interests of humans, then ultimately the system will obviously expend all resources or corrupt the environment to the extent that the system will collapse. It is through a democratic process that persons can advocate for their own as well as for disadvantaged groups and individuals within the citizenry, for animals, and for the environment. Only by having a democratic form of input from all components of the system, can the system as a whole be adaptable and self-correcting. Thus, it is argued that democracy is not only a just system for a society; it is also a pragmatic system, for democracy is a necessary component if there is to be a globally sustainable food production system.

Societal Issues

Changes in Agriculture and Community Controversy

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INTRODUCTION

Local-level disputes over livestock production practices have received increased attention in the social sciences since the mid-1990s. While increasing our understanding of community controversy is important for scholars in the social sciences, examining local level dispute is also important from a practical standpoint. As rural communities are increasingly impacted by global change they become sites of conflict related to these transformations. This is certainly the case in animal agriculture where there has been vertical integration, increased dependence on technology, and increases in size and concentration of production.

One local impact of these changes has been community controversy. In traditional societies problems were similar from year to year and village to village, making diffusion of problem-solving techniques easier with neighboring villages benefitting from each other's experiences. In a rapidly changing society, diffusion from community to community and generation to generation cannot keep pace with changes in events. Understanding controversy and identifying and clarifying different frames in dispute enhances the ability of community leaders to benefit from the experiences of other rural communities. Case studies increase the rate of diffusion and provide communities with these examples (Coleman 1957).

COMMUNITY AND CONTROVERSY

Over the past decade there has been a resurgence of interest in studying community, along with growing recognition that any contemporary phenomenon must be considered within this context. Devolution of programs by federal government agencies has placed greater emphasis on decision-making at the most local level - often the neighborhood or community (Swanson 2001). It is at this local level where residents feel they have the greatest influence in terms of participation and change (Marston and Towers 1993).

We generally recognize that communities engage in both episodes of consensual and conflictual action (Luloff 1990) and episodes of conflict have a multitude of impacts on the community. Community is a process of interaction between individuals within a place-based community. This definition suggests both a social and geographic meaning for community, but does not foreordain mutual support or meeting the needs of individual community members. Communities maintain boundaries through conflict (Cosser 1956). Threats from an outside

source increase internal cohesion, and when internal cohesion is high there is an increased likelihood of community action. In this way external conflict can strengthen the group. Internal conflict also has the ability to strengthen the group and clarify group identity. However, when there is not interdependence, internal conflict has the potential to be divisive. "Interdependence checks basic cleavages (Coser 1956:76)", reducing the likelihood of polarized issues within a group. In his notable research on community controversy, Coleman (1957) pointed out the impact of conflict on communities is significant, and "no amount of social engineering can return these communities to a former state (1957:2)." Sanders (1961) clarifies the negative side of disagreement at the community level, suggesting the group that 'loses' may not consider the issue resolved and community division may transfer itself to other activities and interaction.

FRAMING AND AGRICULTURE

Frames denote "schemata of interpretation" that allow individuals "to locate, perceive, identify, and label" things that occur in their lives and the larger world (Goffman 1974:21). Frames organize individual experiences and subsequently guide actions, both individual and collective. There are also times when there is dispute between frames as parties with opposing versions openly disagree over the definition of what is taking place. Eventually one position will either convince or dominate the other (Goffman 1974), but in the interim there is a period of frame dispute.

Framing is a useful tool for examining social change and collective action, providing a schemata for interpreting situations, experiences, and events (Snow and Benford 1992). A specific frame is not static, but rather, is an ongoing interactive ideology. Frames within collective action perform three functions - identification of problems and cause, identification of tactics and strategies, and identification of the reasons for action. The first performs the diagnostic function, the second serves a prognostic function, and the final function is that of motivation (Snow and Benford 1988). Social movements frame events and situations to mobilize potential constituents and develop support.

Community controversies over animal production are periods of frame dispute - frames are incongruent in terms of the direction local producers should take. Agrarian collective action throughout the history of the United reflects three master frames - agrarian fundamentalism, competitive capitalism, and the producer frame (Mooney and Hunt 1996). Within the agrarian fundamentalist frame, agriculture organized around an individual owner is central to the family, equality, freedom, democracy, and preserving equality. Agriculture is primary, although how it is organized is a lesser concern. Large-scale production may be seen as beneficial to local business and the community. This frame has also been successful in organizing non-farm people. The competitive capitalism frame is based on a free market ideology that relies on state intervention to maintain competition. Within the producer frame it is the direct producers who should benefit from the rewards of production, and not those providing off-farm mental labor (who, it may be suspected, attempt to take control from the producers). While there are bridges between these frames, these three perspectives have been consistent in agriculture since colonial times.

Two dominant paradigms have emerged within contemporary agriculture - conventional agriculture and alternative agriculture (Beus and Dunlap 1990). Conventional agriculture refers to mainstream "capital-intensive, large-scale, highly mechanized agriculture with monocultures

of crops and extensive use of artificial fertilizers, herbicides and pesticides, with intensive animal husbandry (Knorr and Watkins, 1984:x)". Alternative agriculture is more difficult to define due to the diversity of this group, yet there is commonality in the underlying philosophy that is held. There is a preference for reduced use of farm chemicals, small farms, reduced technology and energy, self-sufficiency, and conservation of resources. This group includes organic, sustainable, regenerative, low input agriculture; and natural farming (Buttel et al. 1986).

Change specific to ownership and structure of animal agriculture also brings to the fore questions of how we define agriculture. From one perspective there are citizens who view rurality, and the future of what they define as rural areas as one of multiple-uses, based in historical concepts of 'traditional' agricultural production. In contrast is the position that agricultural development with a high-tech approach is the foundation of present and future successful rural development (Burmeister 2000). While differences in perceived rural realities manifest themselves in local struggles over animal agriculture, this may reflect a broader political struggle over the future of rural areas. Intensive animal production, more closely related to an industrial approach, may be better defined as agribusiness and distinguished from agriculture which we historically associate with small-scale, family-based processes (Friedland 2000). This is consistent with the dominant social perception of agriculture – family versus corporate farming (Rathge and Wachenheim 2000).

Recent research focused on complaint and controversy regarding changes in animal agriculture provides a basis for the examination discussed in this paper. McMillan and Schulman (2001) found that for those on all sides of complaint and controversy there appears to be a master frame of rights and entitlements. Middle-class white activists have a civic rights frame - they believe the government should protect their rights. For African-American anti-hog activists this is an environmental justice and civil rights frame - they want the same rights as whites. Producers frame their position in terms of property rights and a right to earn a living from their land. Citizens who are neither producers nor activists frame their position in terms of the right to enjoy their own property. And community leaders are concerned with the right to make a living in terms of both agriculture and industry, as long as this doesn't violate someone else's right to make a living. These different frames, or collective identities, are drawn upon to define one's position relative to the controversy.

Observing actions of anti-CAFO (concentrated animal feeding operations) groups in the Texas Panhandle, Constance (2000) focused on episodes of resistance carried out by local residents and environmental groups. He demonstrated the difficulties associated with reconciling the goal of socioeconomic development in rural areas with protection of the environment and enhancement of quality of life. Residents were primarily motivated by human health and property value concerns. The analysis also documents the corporate response to community resistance, which primarily constituted a reconstruction of the corporate image as environmentally sound.

Although in the early stages, research in Nebraska (Blankenau and Snowden 2000) is examining how community activism develops against industrialized agriculture in rural areas. They examine a case where local farmers successfully blocked a corporate owned large-scale livestock facility. They were interested in knowing if these local activists made the connections between what was perceived as an immediate threat and the larger social, political, and economic forces behind changes taking place at the local level. What they found was an understanding of these processes in terms of local impacts, but little recognition of how they operate at the national and international level. Additionally, the ideologies of groups from

outside the local area who also opposed the development did not resonate with rural residents, with one exception. Both the positions of oppositional groups and historically held rural values were in conflict with the value of 'bigger is better'.

Research in North Carolina also considers ideologies of different groups who oppose large-scale animal facilities. Ladd and Edwards (2001) point to a convergence over time of local citizen groups with state and national sustainable agriculture and environmental justice movements in their opposition to confinement hog production facilities. Parallels have been identified between social and environmental justice concerns, the situation of small farmers, food security, sustainable agriculture, and rural community empowerment suggesting the controversy has the ability to integrate these diverse stakeholders into a single movement. North Carolina environmental justice organizations have already utilized local and state conflicts regarding hog production facilities to mobilize minority, poor, and marginalized rural communities. Also pointed to is development of new constituencies on both sides of the swine controversy in North Carolina and an expanding division between these two sets of stakeholders.

In this research community controversies in rural Minnesota are examined using a combination of qualitative research methods. A portion of the research was completed in conjunction with a study of social and community impacts of animal agriculture, part of the Generic Environmental Impact Statement (GEIS) on Animal Agriculture for the Minnesota Environmental Quality Board completed in part by the North Central Regional Center for Rural Development at Iowa State University. The scope of the GEIS research was much broader than that of this research, and only elements central to community controversy are included here. Research began by examining frames in one local controversy over change in animal agriculture. Elements of community behavior identified in the case study were then explored in a larger group of six counties.

FRAMES IN DISPUTE - THE CASE OF FRANCES TOWNSHIP

In Frances Township¹ the episode of controversy was initiated by plans for development of what is legally defined as a feedlot in a rural, unincorporated area of the county. In this case it was construction of a 2,200-head hog feeder building by the Johnson Family² on their building site. The ensuing two-year community controversy resulted in replacement of all but one Township Board member; a community petition for a state environmental review; revision of township zoning ordinances; and a court case filed by the township against Mr. and Mrs. Johnson that eventually reached the state supreme court. While the Johnsons prevailed in the courts and did build the barn, several years later there are still social divisions within the community. This is a particularly interesting case as Frances Township has had little 'new to rural' migration, and is primarily home to third and fourth generation farm families who live on what have been historically small acreage dairy farms. Several years later the community remains divided along the lines of the controversy. The Johnson family has limited relationships with nearby neighbors outside of their own family, and most people opposed to the expansion who were interviewed

¹ Frances is a pseudonym.

² To protect the identity of this family, a pseudonym is used.

still do not speak with them or their supporters. A typical comment made in interviews is that "some of these people will never talk to one another again."

A qualitative examination of newspaper coverage, court documents, and Minnesota Pollution Control Agency (MPCA) records provided a chronology of the course of this controversy. Twenty-seven months of the local weekly newspaper were reviewed for articles, public notices, and letters to the editor related to the controversy. Public records from the MPCA related to the permit for this feedlot and subsequent hearings were reviewed. And court records from the civil case brought by Frances Township against the Johnson's were examined. In addition, semi-structured interviews lasting from 30 minutes to 2-1/2 hours were conducted with 22 individuals to clarify the frames in this specific community controversy. Each contact was guided by a standard set of questions and a snowball sampling process was used, beginning with community members identified through the Generic Environmental Impact Statement (GEIS) on Animal Agriculture in Minnesota. Themes were defined by identification of problems and cause, identification of tactics and strategies, and identification of the reasons for action - the diagnostic, prognostic, and motivation functions of collective action frames (Snow and Benford 1988).

Through these research methods in Frances Township two clear frames emerged in this controversy – the *agribusiness frame* and the *quality of life frame*.

The *agribusiness frame* in the Frances Township controversy is:

- Problem and Cause. The agribusiness frame viewed the source of the Frances Township controversy as unwillingness on the part of the Johnson's neighbors to understand that practices of raising livestock have changed. Advanced use of technology in livestock production was identified in all interviews as a 'natural progression' that is anticipated to continue. There was a view that technology provides a better way, and growth in agricultural production follows the industrialization of other "industries." Those within the agribusiness frame viewed those within the quality of life frame as living in the past; anti-technology; and not able to understand why animal production practices have to change. Several stated "they need to be educated" and viewed those with a quality of life frame as acting on emotion rather than on fact.
- Tactics and Strategies. The tactics and strategies of the agribusiness frame were based on legal rights. Within this frame farmers felt they had a right to raise animals on their own land using whatever practices they choose within the bounds of reasonable regulation. Their neighbors should not have the ability to stop this on a case-by-case basis. One letter to the local paper stated "the farmer's right to farm should not be unfairly burdened with regulation, especially at the township level." The Johnsons and their supporters felt the legal system supported their legal right when they prevailed at all levels of the court. The agribusiness frame viewed the tactics of the quality of life frame as personal attacks, using school and church events as venues to alienate the Johnson Family. Several examples were given of instances when the Johnsons and their children were excluded from community functions or personally attacked through offensive hand gestures and derogatory comments directed toward them.

- Reason for Action. The underlying motivation for the agribusiness frame was constructing the barn and increasing the Johnson farm income. It was often stated that this would allow Mr. Johnson to give up his off-farm job and allow his son join the farm operation in the future. The motivation was often couched in terms of preserving the family farm – although those within the quality of life frame disagreed on this definition of family farm. Jealousy of the success or potential success of farmers who built new buildings was cited by the agribusiness frame as the motivator for those with a quality of life frame. Again, an “emotional” response to a “fact-based” business decision.

The *quality of life frame* in Frances Township is:

- Problem and Cause. The quality of life frame considered the problem here as the threat to the local environment, contamination of well water, odors, and a general decrease in quality of life that would be caused by the construction of the Johnson’s hog barn. But the source of the controversy was clearly viewed as the company that contracted with the Johnsons. One letter to the local paper defined the problem as “the unwarranted placement of factory farms.” This company was viewed as forcing “corporate farming” and “industrialized factory type farming” into the community by “convincing small farmers to raise their animals for them.” As one individual stated, “we are victims” of the company contracting with area producers, and “there’s an agenda, and someone else is benefitting.”
- Tactics and strategies. Tactics used by those with the quality of life frame were networking with neighbors, meetings in homes, daily telephone contacts, gathering and reading information from other groups involved in similar controversies, and writing individual and group letters to the newspaper, MPCA, and government officials. They also put forth and elected a new set of candidates for all but one township board position. Following the township election they worked for some time on a revised zoning ordinance that would prevent Mr. Johnson from constructing his building, as well as preventing others from building similar buildings in the township. This ordinance was eventually struck down by the courts. The quality of life group viewed the agribusiness group as trying to “sneak” factory farms in to their community. They also viewed the tactics of the agribusiness frame as “underhanded”, and closely linked to the state pork producers’ association (viewed as supporting large-scale and contract production). In almost all interviews, those with the quality of life frame indicated they thought their chances of preventing construction of the Johnson’s hog barn were slim, but they were sending a broader message to large companies who had plans to build more of these buildings in their community – they were not going to let them in.
- Reason for Action. The central motivation of the quality of life group was protection – protection of water, soil, air, local roads, quality of life, and in general, what they viewed as their traditional way of life. As one individual stated, “to ensure a quality of life for the residents of our community.” Many expressed concern with cleaning up the environmental impact of large-scale livestock production in their community in the future – that the business interests would leave it up to the local community. Those with a quality of life frame clearly viewed the motivation of the agribusiness frame as greed –

making money no matter what the costs. One person stated “there’s got to be a way for people to get rewards without hurting others.”

FRAMES IN DISPUTE - ELEMENTS OF THE CASE IN THE LARGER GROUP

Elements of community behavior identified in the study of community controversy in Frances Township were sought in a larger group of six counties. These six contexts for examination were selected in conjunction with other GEIS researchers in a process that included several criteria related to animal agriculture and community controversy. Contacts began with 12 key informants from the six counties. Key informants in this group included extension educators, feedlot officers, and planning and zoning officials. The second stage of data collection was a series of four roundtable discussions organized in cooperation with other researchers working on the GEIS. Roundtable invitees included a cross section of community leaders, agricultural specialists, livestock and poultry producers, community activists, county and township officials, faith communities, and institutional representatives (e.g., Minnesota Pollution Control Agency, University of Minnesota Extension Service, etc.). And finally, semi-structured interviews were conducted with 60 individuals in the study counties, including livestock and poultry producers, neighbors of animal agriculture producers, community leaders and other residents. It is important to note the questions included in the individual interviews cast a 'wide net', and not all data collected is included in this research. Much of this was specific to the GEIS using a question set developed by the research team. Also reviewed were nine local newspapers in the six counties. A sample of 468 editions for 1990 and 468 editions for 2000 were selected.

Review of interview notes and tapes, roundtable transcripts, newspaper items and other documents point to several themes within these counties. Within these themes we find evidence of the same two frames identified in Frances Township.

Change in agriculture

The most dominant theme in the larger group was change in the structure of agriculture, and animal production specifically. This came through in all of the case counties and roundtable discussions. The refrain “get big or get out” was used to describe how current and former farmers view their options in terms of animal agriculture. Among those with an agribusiness frame, swine and poultry producers were the ones to most often express this sentiment. It was less prevalent (but not absent) in the dairy and beef cattle sectors. One hog producer indicated that expansion is "all about dollars . . . If you don't have enough dollars to live, then you go find another income producing unit. Well, that's another hog. That means you have more hogs." Another stated " . . . if you put enough animal units behind it, suddenly everything becomes feasible."

Vertical integration was often pointed to by those with a quality of life frame, as many respondents pointed out "what happened in poultry will happen in pork", referring to the vertical integration of these sectors of animal agriculture. The notion of farmers becoming the employees of corporate-owned agriculture was a recurrent theme in interviews. The ownership arrangements of contract production (specifically in poultry and swine) were viewed by some as a precursor to increasing control and even ownership of farm-site production by national and international corporations. The term "corporate farm" was used to refer to both vertically integrated and large, multi-owner farming operations (not necessarily vertically integrated

operations). While these animal agriculture facilities are within the scope of the state's anti-corporate farming laws, it is interesting to note the differentiation by those from the quality of life frame – which includes farmers - that these are not family farms, but corporate farms.

Impacts of expansion

Non-farmers within the quality of life frame focused their concerns on fear of potential hazards to the environment and a reduced quality of life caused by the growth in confined animal feeding operations for poultry, swine, and dairy production. They also indicated concern regarding destruction done to township and county roads by heavy equipment and trucks that regularly travel to and from large animal facilities. Complaints that these vehicles destroy the roads, track roads with animal manure, and drive at speeds beyond safe limits were not uncommon. Fear of reduced property values was also a common thread. Of those interviewed with this concern, two had sold their homes and one perceived the reduction from their home's appraisal price (25%) as resulting from the location next to a large scale confined dairy.

Camaraderie to individualism

Both small and large producers suggested changes in agriculture have changed the shared production practices of farmers. Those within the agribusiness frame indicated large operations are independent and don't rely on shared equipment or labor exchanges with other producers. One person explained farmers are more "self-contained": they don't interact with many people, nor have a need for broader support. Another spoke of a transition from camaraderie to individualism. But those with a quality of life perspective felt that this represents not only a change in production practices, but also a decrease in opportunities for interaction between farm operators. While this appears to reflect a general trend in agriculture rather than one specific to animal production, it was a point made in many personal contacts.

Impact of confinement operations

From the agribusiness frame, producers who had moved into intensive production viewed this as improving their lives. A common theme was that expanding their animal operations helped create the financial means to bring their children into the farm operation. Without expanding or adding livestock they would not have made it in farming. By adding numbers to their herd/flock size, or putting up one or more confined facilities, they were able to spend more time with their family and less time away from home employed off the farm. From this perspective, confined facilities allow under-employed farm operators to become more fully employed in their own operations.

For farmers and non-farmers within the quality of life frame, proximity to a large-scale animal agriculture facility was viewed as decreasing their quality of life. Those with the greatest quality of life concerns are neighbors of poultry and swine intensive confinement facilities. Odors and physical discomfort were part of this frame. Those interviewed provided examples of individuals suffering from headaches, nausea, nasal irritation, and respiratory problems. In three cases, respondents retold accounts of nausea and vomiting while being in their yard due to the overwhelming odor from a neighboring confined animal facility. One woman who lived near a dairy reported breaking out in hives when manure was being spread on neighboring fields one-quarter of a mile from her home. Dust and fumes from large-scale confinement systems were another aspect of the quality of life frame.

Institutional interactions - hostility, neglect and inattention

Institutions are seen to be responsible for much of the blame in perpetuating a hostile and inequitable community climate. This theme was prevalent in all six case counties. For example, many from the quality of life frame were highly critical of local and state agencies such as the pollution control agency, and sometimes local planning and zoning as well as county feedlot officers and extension educators. They view these officers as complicit in developing dysfunctional and arbitrary land use policies that more frequently exacerbate problems than solve them. Many of the complaints registered concerned access, particularly in the case of the state pollution control agency. Phone calls were not returned, letters were not answered, and they felt a general lack of attention and responsiveness. The comments of one roundtable participant suggest his frustration with both local and state institutions.

Those with an agribusiness frame likewise felt unattended by the state pollution control agency who they view as generally unresponsive as indicated by unreturned phone calls, unanswered letters, and reviews not completed in a timely manner. The lack of responsiveness and responsibility of the key agency with authority to mediate potential conflicts delegitimized the state as an effective authority, and encouraged citizens to attempt to solve their problems through a variety of extra-legal means, such as seeking to get opponents fired and harassing opponents in public.

While those with an agribusiness frame recognized the need for zoning ordinances around animal facilities, they found opportunities to continue in farming obstructed by burdensome regulations that come from environmental planning. In many instances they brought up the idea that a few "bad actors" have resulted in a burden for all producers. From the agribusiness frame the cultural climate is seen as increasingly hostile and 'anti-animal agriculture' rather than supporting a culture that is respectful of the business of farming. Many expressed concern that more state regulations were just another example of an increasingly unfriendly agriculture milieu.

Land-grant universities and the agribusiness frame

Those within the quality of life frame pointed to the land-grant university as complicit in changes in animal agriculture production and support of the agribusiness frame through research and programming priorities that encourage the development of confined animal feeding operations. One farmer in his 60s explained that men of his generation believed sending their sons to college for a four-year agriculture degree was the right thing to do. But he felt many of those children returned home with very different ideas about farming. They pushed for change and expansion of the livestock operations, including the construction of confined production buildings, and forced their families into considerable debt in the process. He noted many family conflicts had resulted, including within his own family.

The quality of life frame and organizing efforts

Community responses to the siting or expansion of an animal agriculture facility are quite diverse. In some cases groups are formally organized to combat what they perceive to be a threat to their way of life through the possibility of environmental hazards and social maladies. In two of the counties an organization has taken the lead in highlighting problems associated with

confined animal agriculture (dairy and swine). This organization has been successful in calling attention to local oversights and state regulation, and in these two counties local level controversy surrounding siting and expansion of animal agriculture was predominant.

Such a response to animal agriculture may not always succeed in achieving the desired future outcomes, but it can have the impact of reinvigorating community capacity to strategically act on their own behalf rather than viewing themselves as helpless victims. Many people, especially women, told us that because of the community conflict over animal agriculture, they took a leadership role in opposing the facility. Other individuals have not developed such potential for action. Some individuals have adopted a fatalist perspective, viewing themselves as condemned to live with what they term the “stench” and the undemocratic control by those with local power.

The quality of life frame includes an element of risk for those who speak against the siting or expansion of a large animal agriculture facility. They take a significant risk, which is shared by the community through increased incivility. One example provided to us was an individual being harassed in public by those from the agribusiness frame because he signed a petition to request an environmental impact study before construction could proceed. Another woman in the same neighborhood signed the petition, and as a result the owner of the dairy went to her workplace and told her employer “...that they shouldn’t have somebody employed [there] who was opposed to their enterprise.”

Change in personal interactions between farmers

Within the farming community there appears to be a widening gap developing between those who have expanded into large-scale facilities and those who are trying to maintain their small and mid-sized operations. The interviews suggest these two groups fall within the agribusiness and quality of life frames. Large producers are not as likely to belong to local commodity associations as small and middle-sized producers are. These are historically important and strong local organizations whose memberships, according to local producers, have decreased in recent years. In one county two-thirds of the current members of the Pork Producers Association are non-producers, while producers comprised two-thirds of the membership just ten years ago. A current member recited names of several large pork producers in the area who are not members. Large producers, particularly those operating confined swine operations, perceived a sense of animosity on the part of small producers who are struggling to stay in farming. This was sometimes referred to as jealousy. The commodity pricing advantages enjoyed by large producers were clearly a sore spot for the small producers who were interviewed. Both large and small producers indicated there is a lot of “talk” about different producers and the choices they make, and much of this conversation is with farmers who have taken similar paths. In other words, large producers network with other large producers, and small producers network with their size peers.

CONSISTENCY ACROSS EXAMINATIONS

This research endeavor explored the frames adopted by individuals and groups in community controversy over changes in animal agriculture. Frame dispute is apparent in community controversies over change in animal agriculture. Different groups of local citizens interpret

changes in animal production practices differently, identifying the problem and cause, tactics and strategies, and the reasons for action based on their position in either the agribusiness or quality of life frame. Findings point to consistency in the frames in dispute surrounding livestock production. The agribusiness frame and the quality of life frame prevalent in Frances Township were also present within the themes identified in the group of six counties - all sites of recent episodes of local dispute over livestock production practices.

The agribusiness frame described here views large-scale and confinement production practices as an unstoppable trend in agriculture, and those farmers who want to be successful will proceed in this direction. This is viewed as their right, and regulation should not be enacted that will interfere. This frame is consistent with the conventional agriculture frame (Beus and Dunlap 1990), and the agrarian fundamentalist frame (Mooney and Hunt 1996).

The quality of life frame views large-scale and confinement production as a threat to the local environment, family health and welfare, and a traditional way of life. This frame is clearly focused on private sphere issues, and takes action in personal and local ways to prevent or respond to livestock production facilities that are perceived as industrial or corporate, particularly confinement facilities operated through production contracts. There are some connections here both to the producer frame (Mooney and Hunt 1996) as well as the alternative agriculture frame (Beus and Dunlap 1990).

This research also points to areas for further examination. First, the role of community members not involved in the controversy (those who identified themselves as bystanders) and the involvement of individuals from outside the community as the controversy proceeds. And second, the potential for preservation of family farming to bridge the agribusiness and the quality of life frames. It is interesting that "preservation of the family farm" is part of both the agribusiness frame and the quality of life frame. How this is to be achieved is where the differences are identified.

Over the past five years I have been a guest in the homes and offices of rural residents where they shared very personal stories of their experiences. In most cases this meant taking an hour or more from busy schedules to meet; yet very few people declined the interview request. No matter what side of the issue they were on, nearly all people I spoke with had a sense that things could have been different. What they perceived as negative change in their community and lives could have been prevented. In many cases ties with neighbors and friends were broken that remain fractured even several years later. By sharing their experiences, these rural residents hoped something could be done to prevent this from occurring in other communities.

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Food Quality, Safety and Security

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FDA is responsible for ensuring the safety and security of 80% of the U.S. food supply. FDA's legislative mandate is to protect the public health by ensuring the safety of the production, processing, packaging, storage, and holding of domestic and imported food except those products (meat, poultry, and processed egg products) that are under the jurisdiction of the U.S. Department of Agriculture.

FDA's food safety programs feature a farm-to-table approach to comprehensively improve the safety of the food supply by reducing foodborne hazards, approving new technologies and assuring the safe harvest, processing, manufacturing and delivery of foods to the US consumer. Food animal production and its practices are a critical component of the FDA arsenal, in collaboration with USDA and NMFS, to ensure a safe food supply.

The events of September 11, 2001, heightened the nation's awareness and placed a renewed focus on ensuring the protection of the nation's critical infrastructures. A terrorist attack on the food supply could pose both severe public health and economic impacts, while damaging the public's confidence in the food we eat. Even before September 11, HHS was taking steps to improve food security. As part of the initial response to these heightened concerns after September 11, Congress provided FDA with new statutory authorities and some additional resources for food inspection. As a result of new threats to the food supply and new opportunities, FDA has made fundamental changes in how we implement our mission of protecting our food supply, so that all Americans can have confidence that their foods are not only safe but also secure. In these efforts, FDA will continue to work with the White House Homeland Security Council, the United States Department of Agriculture (USDA), and the Department of Homeland Security (DHS) to further enhance our ability to detect, deter, and respond to an attack on our food supply.

Although food safety and security are different aspects of food protection, they are inherently connected. FDA, at the direction of the Department of Health and Human Services (DHHS), has established a 10-Point Program for ensuring the safety and security of the food supply. Based on activities in FDA's 10-Point Program, the Agency is employing overall strategies to (1) develop increased awareness among federal, state, local, and tribal governments and the private sector by collecting, analyzing, and disseminating information and knowledge (Awareness); (2) develop capacity for identification of a specific threat or attack on the food supply (Prevention); (3) develop effective protection strategies to "shield" the food supply from terrorist threats (Protection); (4) develop capacity for a rapid, coordinated response to a foodborne terrorist attack (Response); and (5) develop capacity for a rapid, coordinated recovery from a foodborne terrorist attack (Recovery).

International and Trade Issues

Trade Agreements and Issues: Obstacles and Opportunities

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Animal Welfare and Environmental Issues

Animal Well-Being Issues

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WELFARE ISSUES: WHERE ECONOMICS OF INTENSIVE PRODUCTION AND WELFARE CONFLICT

A usual assumption about contemporary animal production is that in the processes of domestication and of efficiency improvements in agriculture, we have unequivocally improved not only the functioning but also the quality of life of farmed animals. It also is often assumed that high productive performance in animals implies that their welfare is good and that agriculture could not be profitable if animals' welfare was poor – that is, that the producer's economic interest safeguards the welfare of the animals in his or her charge.

Many counterexamples exist to these assumptions. Contemporary farm animals are frequently subjected to procedures, practices, and living situations that cause pain and/or fear, that are potentially disabling, that contribute to susceptibility to disease, that may also impair fertility, that create stress and lower immunity, and that deprive them of the opportunity to live lives that are normal for their species (for a more detailed discussion of welfare impacts of contemporary animal production, see Halverson, 2002).

High yield of desired characteristics also has frequently been achieved at the expense of animal welfare. While it is true that welfare is important for functioning, in many cases animals can continue to produce while in a state of poor welfare. Animals are genetically programmed to produce. Except under severest deprivation, they cannot help but do so. Animals have the ability to adapt to a significant degree to their environments, including painful or stressful ones, although the adaptation may be accompanied by severe stress (e.g., Vestergaard, 1981b; Van Putten, 1988). Growth rate may also correlate positively with stressors in the environment (Friend et al., 1987). Also, antibiotic and hormonal growth promoters augment performance in contemporary animal production. Reproduction often is regulated or induced by administration of hormones, further confounding the usefulness of productivity as an indicator of welfare.

Quantitative production performance can **only** signify whether quality and quantity of nutrients, the water supply, and the microclimate are adequate; whether the animal did not contract any clinically-proved illnesses which influenced production yield; and whether there are possible genetic differences between animals (Bogner, 1981). It cannot tell us whether the environmental requirements of the animals concerning locomotion, resting, comfort, social behavior, predictability, and control are met or not. Each of these affects the mental or psychological health of the individual animal.

Welfare, as a state of the individual animal (Broom, 1988; Wood-Gush, 1983), encompasses both health and well-being. Health is not only absence of disease or injury but also presence of robust characteristics, including vigor, defined as “physical energy or strength, the capacity for natural growth and survival” (American Heritage Dictionary, 1985). It means that skeletomuscular, cardiovascular, neuroendocrine, immune, etc. systems are operating at optimal capacity. The word ‘optimal’ implies balance among the animal’s regulatory systems to achieve equilibrium at a high welfare level in the animal (homeostasis—an “approximately constant state which varies only within tolerable limits”) (Broom and Johnson, 1993, p. 8). Osteoporosis in sows housed in crates and laying hens housed in cages is an example of the adverse effects confinement housing can have on vigor (Marchant and Broom, 1996b; Knowles, 1990; Knowles and Broom, 1990; Knowles et al., 1993).

Gestation stalls

Today, gestation stall sow housing predominates in the U.S. hog industry. During their approximately 114-day pregnancies, sows are immobilized and fed concentrates once a day. To prevent constipation resulting from lack of exercise and roughage in the diet, sows housed in crates are given laxatives in the feed (Fisher, 1995). The gestation stall model has prevailed despite the existence of less intensive confinement models that result in better condition and increased longevity of the sow.

Domesticated sows that were released by scientists into “semi-natural” environments for the purpose of observing their behaviors spent much of the day foraging and eating in social groups (Stolba, 1982). Nature has endowed them with short, sturdy legs for walking long distances. Keeping sows in stalls for the major part of their productive lives causes sows to lose condition and vigor. Comparing post-slaughter muscle weight and bone strength of sows housed in stalls during their pregnancies with sows housed in large communal groups during their pregnancies, Marchant and Broom (1996b) found that stall-housed sows had lower absolute and proportional muscle weights than group-housed sows and their bones had breaking strengths only two-thirds those of group-housed sows.

Premature sow mortality is a significant and growing problem in the US swine industry (sows die or are killed on the farm) (Marbery, 2001b). Estimates range from 10% (Irwin and Deen, 2000) to 20% (Grimes, 1998) death loss of sows in intensive confinement operations while they are still in production.

Lameness is recognized as one of the greatest welfare problems of the dairy cow because it results in chronic pain and the incidence of lameness is very high (Greenough, 1996). On individual farms in Washington State, close examination of the hooves of each cow showed that over 50% of cows may have some degree of hoof disease (Newberry and Bergsten, 1999). The majority of lesions occurred in the rear feet (Bergsten et al., 1998, cited in Newberry and Bergsten, 1999). Measurements of lameness occurring in dairy cows include 35 - 56 cases per 100 cows per annum in the US, 59.5 cases per 100 cows per annum in the UK, and more than 83% of examined cows in the Netherlands (Broom, 1999). Many cases likely go unreported.

Ekesbo (1966) noted that environmentally-related dairy cow injuries and lameness increased in Sweden shortly after introduction in that country of new methods not adapted to the biological needs of the cattle, (e.g., liquid dung handling that caused hydrogen sulfide intoxication, loose-housing systems on fully slatted floors to handle liquid dung, shortening the stalls for tied cows, introducing gratings over the gutter behind tied cows, and discontinuing the use of bedding in the stalls or cubicles). Studying 707 herds between 1961 and 1965, Ekesbo (1966) found that the lowest total incidence of disease and injury occurred in the loose housing systems with soft bedding in the lying area and access to outdoors. The next lowest total incidence of disease and injury occurred in the loose housing systems with soft bedding but without access to outdoors, and the most injuries and disease occurred in closed buildings with slatted or concrete floors and without bedding, regardless of whether the animals were loose or tied. The incidence of trampled teats and traumatic injuries of the udder was lowest when the animals had soft bedding and maximum freedom of getting up and lying down. The incidence of mastitis was higher in buildings with hard lying areas. Traumatic injuries of the hoofs were more common in loose housing with fully slatted floors and in buildings for tied cattle with gratings or slatted floors over the dunging channel.

Limping, reducing the length of the stride, stiffness and stilted gait, resting the affected foot and spending more time lying down are guarding behaviors against damages of the kind that are signaled by pain (Newberry and Bergsten, 1999). This has a secondary effect on their welfare. Lamé cows become less competitive, drop in social rank, become more fearful and are three times more likely to be culled than sound cows (Newberry and Bergsten, 1999). They also have more difficulty standing up and lying down, resulting in an increased risk of teat trampling and associated mastitis.

Welfare and selection for yield -- chickens raised for meat

Physiological problems of broilers resulting from artificial selection for rapid growth and feed efficiency can prevent the performance of normal behavior patterns (Vestergaard and Sanotra, 1999). Selection for bone and muscle strength has been a low priority in broilers compared to growth rate and reproductive performance. This has led to increasing incidence of skeletal problems as the demand for increased weight has outstripped the capacity of the skeleton to support the animal (Loveridge, 1999). Fast growing broilers have more breast muscle and shorter, wider legs with immature bones. They become too heavy for their legs to carry their bodies and their skeletons become distorted, placing unnatural stress on joints and resulting in abnormal gaits.

In turn, leg deformities and leg weakness have led to immobility, prolonged lying and becoming unable to rise or reach the feeders and waterers, and subsequently to dehydration and starvation (European Union, 2000). Large numbers of broilers have impaired walking abilities and show pain or discomfort.

The welfare of broiler breeders (chickens kept for producing stock) is particularly at risk (Mench, 1991 and 1993). Degenerative disorders of the joints are more prevalent in birds grown to greater ages and weights for breeding purposes. Selection for increased growth rate has resulted in increased appetites. Broiler breeders fed on a commercial ration eat only a quarter to a half as much as they would with free access to food, and they are highly motivated to eat at all times (Savory et al., 1993). The modern broiler breeder industry is caught in a welfare

dilemma: on the one hand broiler stock appear to be chronically hungry, while on the other hand less severe food restriction leads to reduced fertility and health problems (Savory et al., 1993). The dilemma created by genetic selection for fast growing broilers (broilers with large appetites) coupled with the health problems resulting from ad libitum feeding, make it impossible for broiler breeding companies to meet the basic welfare requirement of freedom from thirst, hunger, and malnutrition.

Laying hens

Unlike broiler chickens, laying hens have not been selected for growth rate or muscle mass but for high egg production. Bone fractures are a consequence of selective breeding of hens for high egg production (Thorp and Maxwell, 1993). When insufficient calcium is available from medullary bone to support eggshell formation, calcium is obtained by breakdown of structural bone tissue and this structural bone lost during lay does not appear to be replaced while hens are in lay (Thorp and Maxwell, 1993). The longer hens are in lay, the more structural bone they may lose. Each egg requires 2.0 to 2.2 grams of calcium, representing 10 to 15% of the calcium in a hen's body (Newberry et al., 1999).

There is evidence that shell quality is maintained at the cost of bone strength. Still, in the United States, nutrient requirements identified by the Subcommittee on Poultry Nutrition of the National Research Council are adequate for eggshell thickness, but not always adequate for maintaining bone strength (Newberry, 2000). This means that when the guidelines are followed, hen diets are not sufficiently calcium-rich to preserve their bone structure.

"Spent" hens are either caged layers who no longer produce a sufficient number or quality of eggs for human consumption or broiler breeder hens who no longer produce a sufficient number or quality of eggs for hatching broiler offspring. The welfare problems of spent hens are severe. Osteopenia (the thinning and weakening of bones) and muscle weakness attributable to lack of exercise in battery cages, poor nutrition, and selective breeding for egg production lead to considerable bone breakage in spent layers prior to slaughter. Bones are frequently broken during removal from battery cages and transfer to cages for transport to slaughter (Elson, 1992; Newberry, 2000).

Bones are living and constantly undergo changes in response to nutrition, hormone balance and exercise (Elson, 1992). Bone breakage is likely to cause severe and prolonged pain and suffering. Especially in transport, vibration in typical commercial poultry transporters causes movement at fracture sites and forces birds to use muscles to maintain postural stability, contributing to tissue damage around broken bones (Newberry, 2000). Injured birds are unable to avoid other birds that may step on injured tissue.

Spent laying hens may spend considerable time in transport and, once at the slaughter plant, because they have little meat, may spend more time waiting for slaughter if more valuable loads of broiler breeders are being processed (Newberry et al., 1999). Besides suffering from broken bones, spent hens are exposed to life-threatening conditions during pre-slaughter handling and transport, including exposure to temperature extremes (Newberry et al., 1999). In the US a breakdown of the causes of post-mortem condemnations of spent hens shows relatively high levels due to septicemia/toxemia, tumors, cadavers (refers to improper bleed-out, not dead-on-arrival), contamination, and bruises, implying that hens unfit for travel are being shipped. In Canada, post-

mortem condemnation rates result from emaciation first, then from “found dead”, peritonitis, tumors, contamination, bruises, and cyanosis.

Culled animals of every farm animal species are subject to welfare concerns. Culled dairy cattle are frequently sent to auctions, stockyards, or downed animal centers injured, hungry or thirsty, pregnant, or otherwise debilitated, or with full udders (see, for example, www.defendingfarmanimals.com).

As this limited list of welfare concerns shows, economic interests of the producer come into direct conflict with animal welfare when yields are achieved at the expense of the animal either through selection pressures or through intensive management and when the animal is no longer able to contribute to the profitability of the firm. How can agriculture continue to profit – or we should say how can some in agriculture continue to profit, because there are farmers whose production methods do not create these concerns – in the face of evidence that farmed animals do suffer in many ways from poor welfare and that this is occurring increasingly as agriculture becomes more “efficient” in its use of what it considers “animal resources?” Is there something about our agricultural policies and programs that allows agriculture to profit from the suffering of animals when, intuitively, and according to a model of truly sustainable agricultural production, agriculture ought only to profit from the well-being of farmed animals? What kinds of institutional arrangements, incentive mechanisms – legislation, agricultural policies, programs -- would bring animal welfare, and for that matter, environmental and other concerns into the economic calculus of production and consumption? These are questions for which it would be good to have answers, because the answers could point to solutions.

Although critics of intensive animal production tend to point first to its social and environmental costs, it seems clear that the externalized costs of contemporary intensive production methods fall first and most heavily on the animals themselves. Simply describing the presence or absence of coping responses is not enough to indicate level of welfare. It is the cost of coping incurred by the animal that counts (Sandøe et al., 1996). This cost is not always immediately apparent (Dr. B. Algers, December 2000, personal communication). However, it is becoming clear that the public is unwilling to see these costs to animals increase and is calling for substantive reform (Severson, 2003). Matthew Scully’s recent book, “Dominion: The Power of Man, the Suffering of Animals, and the Call to Mercy” (St. Martins Press) is a particularly eloquent expression of the public call for humane stewardship.

EXPLORING ECONOMIC SOLUTIONS: SOME CONSIDERATIONS

As has been noted by other speakers, internalizing previously externalized production costs associated with animal welfare and environmental stewardship will raise the costs of production from the levels many producers have faced until now and raise the price consumers pay for food. It should be noted it will not raise the costs of farmers who have been bearing these costs of production all along. However, a balanced review also must take into consideration the costs currently born by the public and by agricultural producers that could be eliminated if more sustainable and welfare-compatible forms of production were adopted.

When estimating the private and social costs of animal welfare and applying them in a cost:benefit analysis perhaps it is more fair to balance these costs against a carefully articulated summary of

the private and social costs of the prevailing model of intensive animal production, including those that are hidden from direct observation and fall into the category of externalities. With respect to humane slaughter, for instance, slowing the line speeds for animals going through the line may raise the costs of the slaughterplant operator, but there are other costs of failing to slow the line speeds to be considered as well.

Currently, the U.S. Bureau of Labor Statistics estimates that injury rates alone among workers in meatpacking plants stand at 26.7 reported incidents per 100 workers, the highest rate among all industries (BLS, 2003). When reportable illnesses are added to this count the number is much higher. In 1990, the BLS reported that occupational illnesses and injuries combined among American meatpacking workers numbered 42.4 per 100 full-time workers (BLS, 1990). Line speeds at the plants were running at the rate of 1,000 pigs per hour, resulting not only in worker injuries but also in some animals being insufficiently stunned and being processed while still conscious, a clear welfare issue. In contrast, in Sweden, where I was studying at the time and where animal welfare considerations kept the line speeds slower (between 25 and 40% slower), combined illness and injury incidence in Swedish slaughterplant workers was 17.0 in 100 full-time workers in 1990 and 11.2 in 100 full-time workers in 1991 (National Board of Occupational Safety and Health, 1993). The Swedish figures include poultry slaughter; the U.S. figures do not. Thus, slowing the line speeds in U.S. plants may also have the social and private benefits of reducing their currently high incidence of worker illnesses, injuries and turnover and the resulting high personal costs to workers as well as social costs of lost productivity, unemployment, and social services for injured workers. However, even if there were no such benefits, should we as a society continue to allow an industry to permit such a high rate of injuries and illnesses to occur among its workers? If not, why do we?

It stands to reason that production costs will be higher when previously externalized costs are internalized by the firm. How much will the absorption of previously externalized costs by the firm reduce the costs formerly born by the public, and will it be enough to compensate the public for projected food cost increases? This is an important research question that requires carefully identifying the externalities, itemizing their impacts and where they fall, carefully estimating the costs that are being publicly borne, and weighing them against the additional cost of food. Whatever remains could potentially be paid by society as the cost of providing a public good.

The resiliency and adaptability of farm animals means that animal welfare is at least in part (that part not required for achieving production) a "public good". This limits the extent to which animal welfare can be provided in a commodity oriented market. "Public good" solutions will be required in a commodity oriented market to make incorporating animal welfare into its production function a dominant strategy of the agricultural firm.

If a legislation solution is applied, farmers from whom high standards of production are required, including animal welfare and environmental protection, should not be forced to compete with farmers who are not required to meet similar standards. Farmers should compete on a level playing field and this may require protecting farmers from more cheaply produced imports from places where farmers are not held to a high welfare or environmental standard.

Is a market solution partially or wholly possible? That is, will consumers pay more for products from animals raised according to higher welfare standards? The example of Niman Ranch clearly indicates that a sizeable portion of retailers, chefs, and consumers are willing to pay more for pork from pigs raised according to the standards of an established animal welfare organization, the

Animal Welfare Institute, in this case. Currently, the demand is greater than the supply and more farmers are being sought. Demand is not limited to upscale markets. But, economic models could be used to help try to predict what kinds of advertising for these vertically differentiated products could result in a higher proportion of consumers willing to pay for them. It is unlikely that a market solution alone will be able to include all farmed animals, however. There will still be many consumers who shop for the lowest price goods first.

Farmers need an economic return on their investment. In recent years the price of commodity pork has fallen below costs of production, placing an unfair burden on individual farmers and driving some out of business. The massive supplies that created the low prices are sometimes claimed to be needed to feed impoverished nations. But, it is not good social or economic policy to impoverish American farmers to provide cheap food for other impoverished people or to mistreat animals to provide food for people who are poor. And, should the price of food from farms where intensive management and production demands result in a low level of welfare for animals be the standard by which we judge whether food produced from animals reared according to a higher standard is too expensive? No.

Early efforts by farmers to differentiate their products on the basis of animal welfare were met by criticisms from some in the agriculture industry. Such was the case, for example, for the Pastureland Farms USDA.-approved label originated by the Animal Welfare Institute in 1988. Farmers should be supported rather than discouraged from availing themselves of the free market by differentiating their products in an effort to raise their incomes over what they could receive if they continued to produce animal products as commodities.

Care needs also to be taken to ensure that solutions developed for other production externalities do not conflict with animal welfare aims. For example, the production of energy from manure methane in intensive systems as a way to deal with the pollution issues of liquefied manure will tend to entrench production systems that create welfare problems for animals. Cows standing in unbedded barns on concrete slatted floors have more hoof problems contributing to lameness than cows on pasture or housed on carefully maintained straw beds. Pasture systems and straw beds do not have the externalities associated with collection and storage of massive amounts of manure in a concentrated area, nor do they create the cow welfare problems associated with cows standing for long periods confined in barns on concrete.

There is also a need for more animal welfare science in the U.S. Land Grant University system to provide a balance for the current output-oriented scientific programs. The discipline of animal welfare science has resulted in a substantive body of knowledge about the behavioral and biological needs of farmed animals. Animal welfare science draws on the fields of anatomy, neurophysiology, immunology, neuroendocrinology, ethology, and other basic sciences. Animal welfare science is on a higher, integrative level than any of these taken singly (Dr. P. Jensen, 2001, personal communication).

With the aid of animal welfare science, research and technology development at Land Grant Universities can help to absorb some of the costs of innovation of welfare friendly systems that farmers would otherwise incur. For example, at the University of Minnesota West Central Research and Outreach Center, the Alternative Swine Systems Program is currently researching and demonstrating alternative systems for housing gestating sows and for farrowing under extensive conditions based on a Swedish pig farming model. We have lost our animal welfare

scientist, Dr. Rebecca Morrison, who returned to Australia in the spring, and there is no money to hire another at the present time. However, our model is now up and running and research projects begun by Dr. Morrison are being carried out by staff at the Center. We are able to say that the deep-bedded gestation housing system with individual feeding stalls for each sow, contained in a hoop-structure of the kind mentioned by Dr. Wood this morning, and based on a Swedish model of pregnant sow housing, is working very well, and the Center workers enjoy the work and the system. It is clean, there is no manure odor, the sows are contented, the individual feeding stalls work well to minimize competition at feeding time and a newly remodeled former intensive gestation barn has been turned into an extensive, deep-bedded farrowing barn the sows and workers are also enjoying.

Cost savings also could result from collaborating with European universities and research institutes where animal welfare studies have been underway for many more years than in the U.S. and more progress has been made. Currently the Animal Welfare Institute is consulting with a feed company on a project involving alternative housing and management of bull calves born to dairy cows. The feed company has consulted researchers at an institute in the Netherlands and the two entities plan to work together. The aim of this project is to provide an economic incentive for dairy graziers to raise male calves on their own farms, helping the dairy graziers augment their incomes while putting an end to the inhumane transport and slaughter of surplus day old male calves.

Research and technology development funds earmarked for animal welfare research need to be sought from the Congress and channeled by U.S.D.A. toward progressive efforts such as these that implement what is already known about animal needs. It would be very helpful if the various commodity boards were supportive of research into welfare oriented production systems that may not fit with their preferred model, but that a substantial number of American farmers would like to adopt.

These suggestions are not exhaustive but suggestive. To help fill them out, the appendix to this report is the list of recommendations that accompanied the Technical Working Paper on Farm Animal Health and Well-Being that I prepared with the assistance of a committee of animal welfare scientists for the State of Minnesota Generic Environmental Impact Study on Animal Agriculture.

Finally, when comparing intensive and extensive systems with respect to animal welfare, it is important not to compare the worst of one to the best of the other. A pasture system in which pigs are full of parasites is also a welfare problem and not acceptable from a welfare standpoint. Yet there are well managed extensive systems that compare favorably with intensive confinement in terms of productivity of individual animals and also allow the animal the freedom and environmental enrichment to perform welfare-promoting natural behaviors. Some examples will be given from farms in the U.S. and Sweden. Thank you.

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Appendix

Animal Well-Being Issues

Some suggested measures for legislation and research

Affirm and legislate where practicable:

1. Farm animals are sentient beings and caretakers and animal production systems shall take into account their basic biological and behavioral needs in construction, operation and management.
2. Farm animals shall be accorded:
 - a) freedom from fear;
 - b) freedom from hunger, thirst, and malnutrition;
 - c) freedom from pain, injury and disease;
 - d) freedom to express normal patterns of behavior;
 - e) freedom from discomfort; and,
from birth through slaughter.
3. Every animal shall be accorded a painless and distress-free death:
 - a) when it is clear that an injury or disease is beyond healing, each afflicted animal shall be mercifully and expeditiously euthanized;
 - b) slaughter facilities shall be designed and managed so as to permit and ensure effective stunning prior to killing, effective killing before further handling (e.g., before dismemberment and skinning);
 - c) no injured animal shall be transported from the farm of origin until it has healed and transport can be undertaken with minimal pain, distress, or discomfort to the animal;
 - d) if transport without pain, distress, or discomfort cannot be ensured, the animal shall be euthanized at the place of origin; and,
 - e) there shall be no transport to slaughter or disposal of pregnant animals, downed animals, or animals in an otherwise weakened state; if the animal will not get well, it shall be euthanized (given a gentle death) where it is located.
4. Farm animals are entitled to and shall be accorded the freedom:
 - a) to perform natural physical movement as needed for health and vigor (e.g., flap their wings, walk, turn around, lie down with ease and in full lateral recumbency);
 - b) to associate with other animals, where appropriate of their own kind and under conditions which do not encourage aggression;
 - c) hygienic, spacious, and bedded facilities for comfort activities such as rest, sleep, and body care (e.g., no animal shall have to lie on bare concrete, wet and dung covered floors; animals shall have soft lying areas, space for self-maintenance such as grooming);
 - d) provision of food suitable for its species (e.g., not feeding animal remains to ruminants or herbivores) and fresh water to maintain full health;
 - e) opportunity and materials for exploration and play; and,

- f) satisfaction of minimal spatial and territorial requirements including a visual field and personal space, to minimize aggression in group situations;
5. Base farm program payments on adoption of environmentally beneficial and animal-welfare compatible production goals and criteria and on detectable improvements in this regard in farmers' production methods and systems.
6. Require farm animal transport vehicles to be insulated and equipped with climate monitoring devices in the cabs to ensure that animals are not stressed by cold or extreme heat; establish space requirements in transport vehicles based on animal species, sex, and age; establish driver training and special licensing programs that reflect drivers' ability to handle transport vehicles with minimum discomfort to the animals being transported. Prohibit transport of injured, ill, pregnant, or crippled animals.
7. Using Codes of Practice and legislation in other countries as a model (for example, Canada, the UK, Sweden, Switzerland, and Australia), establish codes of practice for Minnesota animal agriculture that reflect scientific knowledge and public concerns regarding the health and well-being of agricultural animals.
8. Begin a herd health program based on healthy animal immune systems, including vaccination, rather than the total exclusion of pathogens from the animal, to render Minnesota agricultural animals less vulnerable to externally introduced diseases and reduce herd health vulnerability and dependence on strict biosecurity measures. This should include a phase-out of the use of antibiotics at non-therapeutic or subtherapeutic levels in all farmed animal feeds whether substitute measures are already available or not because only necessity is likely to spur invention.
9. Require farmer and farm worker certification programs to build individual professionalism and self-respect in the industry and ensure that people responsible for animal care understand basic principles of animal biology and behavior that underlie animals' responses to their environment and human handlers.
10. Create a mechanism to fund a center or department at the University of Minnesota devoted to research and technology development and testing in respect to welfare-appropriate breeding, housing, and management of farm animals according to species-specific characteristics and needs. Fund the center and its faculty from appropriate disciplines of ethology, veterinary health, biology, and ethics by a producer tax on each battery cage and gestation crate sold in the state.
11. Institute mandatory phaseouts over periods of 1-10 years, depending on level of capital investment required for phaseout, of gestation crates, individual stall housing of boars, battery cages for laying hens, with simultaneous, full-scale investigation into and development of behaviorally appropriate and economical alternative methods. For example, certification programs that do not require capital infusions could be initiated in one to two years while phase-out of crates and cages could be gradual with a requirement that immediately no new construction can include crates and cages.

12. Hire individuals to gather information regarding and compile examples of codes of practice for welfare-appropriate animal production as enacted by legislative and industry bodies in other countries with an eye to recommending adoption of similar codes of practice in Minnesota.
13. Appoint a task force to come up with recommended codes of practice based on scientific findings and on codes of practice assembled in 12.
14. Train extension livestock specialists and other personnel that meet the public or are responsible for animal care at research stations in the basics of welfare-compatible production systems for dairy, pig, poultry, and beef production; hire more livestock specialists with training in behavior of farm animals. Sensitivity training should be part of the training programs to promote respect and openness with regard to public concerns.
15. Establish a division at the MN Department of Agriculture to oversee and fund research and farmer-initiated innovations in systems that promote the welfare of farm animals.
16. Create a division within the Minnesota Board of Animal Health that provides oversight and enforces regulations regarding the health and well-being of individual animals on farms. Fund it with a sales tax on specialized animal confinement equipment such as crates and cages.
17. Require producers to have one or more people at their facilities trained and certified as animal welfare officers. A small farmer might have just one person (and that person might even be the farmer or a member of the family), while large producers might need more people in different parts of the operation.
18. Provide up-to-date scientific information to inform producers who currently favor continued genetic or artificial selection on production traits such as yield, growth rate, and prolificacy, of the long-term costs of selection limited to production traits. Encourage producers to demand traits necessary for health and well-being, e.g., fertility, bone and muscle strength, walking ability, and vigor.

Welfare, Economics and Conventional Production

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Kathy Chinn will give the producer perspective on the following paper prepared by Dr. P. B. Thompson, Distinguished Professor, Purdue University which is the preface of the Swine Care Handbook, 2003.

Animal husbandry is traditionally understood as a blend of the producer's self-interest and duties of humane treatment for the animals on which we depend. A livestock operation cannot prosper without healthy and reproductively fit animals, and thus the profitability of the farm has tended to be regarded as a good indicator of well-being for its animals. Yet while profits provide an economic incentive for husbandry, livestock producers have never evaluated animal welfare solely in terms of dollars and cents. Taking proper care of one's animals has always been understood as an ethical responsibility, as well as a necessary business practice.

The ethical responsibilities of animal husbandry have usually been thought of in terms of duties that individual people—farmers and farmhands—must perform on behalf of the animals in their care. Although it is still true that the husbandry imposes ethical duties on those who practice it, animal agriculture has changed dramatically in scope and complexity over the last few decades. New technologies pose challenges to the way that we understand how animals fare in a given production system. New methods may seem to enhance one dimension of animal health and well-being, while seemingly causing a decline in another. New scales of production can provide opportunities for improvements in overall herd health, reproductive success and profitability, while reducing the amount of care and attention that can be given to an individual animal. Emerging trends in marketing and contracting constrain producers' flexibility and introduce powerful new actors into decision-making roles that affect animal health and well-being.

Science and imagination are needed to assess the overall impact of these trends in animal production, and it is important to ensure that the ethical side of animal husbandry does not lose out. But in a technologically complex world in which a producer's choices are sharply limited, it is no longer appropriate to place the entire burden of ethical responsibility on the shoulders of individual farmers. Above all, consumers must not expect individual farmers to undertake practices that will make them uncompetitive in the marketplace. Livestock producers will do what is necessary to compete, or else they will not be livestock producers for very long. This means that the ethics of farm animal welfare will increasingly come to be seen in terms of industry standards, market structure and government regulation, in addition to individuals' responsibility to the animals in their care.

We are entering a time when the public's demand for ethical treatment of farm animals is starting to register in the form of price premiums and special contracting requirements, as well as pressure for government action. Clearly there is a danger that the emerging system will serve neither animal nor human interests well. Scientifically validated and ethically-grounded industry standards can

provide an alternative to rules and regulations imposed from without, but only if three key conditions can be met. First, it must be clear that the ethical goals and principles place appropriate weight on the welfare and interests of farm animals themselves, at the same time that they recognize the role of animal agriculture in satisfying vital human needs. Second, consumers must have confidence that standards are taken seriously and that livestock producers faithfully follow recommended practices. Third, producers themselves must believe that standards are fairly established and administered. Although some mix of market incentives, government regulation and self-administered industry standards may eventually emerge to address the new challenges of ethical husbandry, only a system that meets all three of these criteria can truly be said to be ethically justified.

Who will take the lead in formulating and implementing such a system? Producers themselves can seize the initiative, either through existing commodity groups or through some yet-to-be-formed organization that would be one step removed from the day-to-day concern with farm policy and profitability. They will need to work with scientists and government, as well as finding new partners among non-farm groups with an interest in animal care. One thing is certain. If producers undertake a new effort to provide assurance that animal interests are being taken into account in contemporary husbandry, they can be sure that people from outside will be watching carefully, even skeptically. What is more, such an undertaking will almost certainly meet opposition from people whose view of animal protection leaves no room for animal agriculture. At present, the broader public is caught between these extremists on the one hand, and on the other a farm community polarized by extreme views and reluctant to take any coordinated action at all. Producers can and should accept the challenge of ending that gridlock, for no one is truly served by it and public confidence in the food system is its greatest casualty.

As science and technology advance, we have come to expect that standards for husbandry will evolve, and that periodic updating and revision will be the norm. The complex trade-off's between animal welfare, consumer prices and producer profitability will also be affected by shifting social values and technical change. Ethics itself must come to be seen in terms of responsiveness to change and to what we have learned. The ethics of husbandry will consist as much in how the animal industries adapt to new knowledge and altered circumstances as in the individual performance of age-old duties of animal care. This most recent guide to swine care reflects what we have learned most recently about responsible husbandry, but it also represents a commitment to continue in the search for better knowledge and better practice. Producers can meet their responsibility for ethical husbandry only by practicing what we believe to be right today and by resolving to test those beliefs, to learn and to improve in the future.

Challenges and Opportunities Facing Animal Agriculture: Optimizing Nitrogen Management in the Atmosphere and Biosphere of the Earth³

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ABSTRACT

Humans need food. Humans use energy. Production of food and combustion of fossil fuels increase concentrations of reactive nitrogen (Nr⁵) in the atmosphere, soils, and surface and ground waters of the earth. These increases are caused in part by agricultural practices aimed primarily at increasing food production – use of synthetic nitrogen fertilizers, widespread planting of N-fixing legumes, increased demand for animal protein in human diets, and increased use of fossil fuels. The world's crops, forests, and fisheries respond to Nr enrichment with some positive benefits (such as increased food, feed, timber, and fish production) and some negative consequences (including acidification and eutrophication of aquatic and terrestrial ecosystems, decreased biodiversity, increased regional haze, global warming, and such human health impacts as nitrate contamination of drinking water and increased pulmonary and cardiac disease caused by exposure to toxic ozone and fine particulate matter).

So far, most pollution abatement strategies have aimed at resolving one or another air or water pollution problems in which various oxidized, reduced, and organic forms of Nr play an important part. The time has come to consider more fully integrated strategies by which Nr management practices can be optimized to increase agricultural, forest, and fish production while decreasing Nr-induced soil-, air-, and water pollution.

Contemporary challenges and opportunities facing animal agriculture in the United States today include joining with the US Environmental Protection Agency, animal industry, university, and other scientists and policy makers in: 1) making realistic assessments of actual positive and negative

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⁵ The term reactive nitrogen (Nr) as used in this paper includes all biologically active, photochemically reactive, and radiatively active (climate changing) nitrogen compounds in the atmosphere and biosphere of the Earth. Thus, Nr includes: a) inorganic reduced forms of N (such as NH₃, NH₄⁺), b) inorganic oxidized forms of N (such as NO_x, HNO₃, N₂O, NO₃⁻), and c) organic compounds (such as urea, uric acid, amino acids, amines, proteins, nucleic acids, etc.).

impacts of Nr emissions and leaching from animal agriculture, and 2) developing practical (economic) guidelines and strategies for: a) improving nitrogen conversion efficiency in poultry, swine, beef/dairy, and fish production, b) minimizing Nr losses from manures, c) conserving and reusing Nr and other valuable nutrients in animal wastes, d) developing more cost-effective horizontally and vertically integrated systems of animal production and manure management through production and marketing of value-added products, and e) minimizing use of fossil fuels in agriculture. Key words: Air and Water Pollution, Ammonia Emissions, Environmental Impacts, Nitrogen Cycle, Nitrogen Pollution, Nutrient Management.

INTRODUCTION

This review paper was prepared with the following general purposes in mind.

- 1) Explore some general features of the nitrogen cycle of the Earth and how this cycle is being altered by humans in their quest for food, energy, and other amenities of modern life.
- 2) Explain how contemporary changes in animal agriculture are increasing the circulation of biologically active and chemically or physically reactive nitrogen (Nr) among the atmosphere, soils, forests, fish, surface and ground waters, and oceans of the earth – mainly through atmospheric emissions of ammonia from animal feeding operations and oxides of nitrogen from fossil fuels used in transport of feed grains, finished animals, manures, and marketable food products.
- 3) Consider how these increases in Nr circulation are causing some positive benefits for agriculture, forestry, and fisheries while also causing some negative impacts on air and water quality, human health, ecosystem productivity, and other air- and water-quality related values.
- 4) Explore the potential for enterprising farmers and ranchers to join with other experts in animal nutrition, agricultural engineering, atmospheric chemistry and meteorology, and agricultural economics in universities, government agencies, and the private sector -- in developing alternative technologies by which value-added products can be produced from animal manures and food processing wastes to increase the profitability of animal agriculture.
- 5) Provide justification for adopting a “Total Reactive Nitrogen Approach” (“Total Nr Approach”) rather than continuing to try to decrease emissions of oxidized and reduced forms of nitrogen separately.
- 6) Propose a “Concept of Optimum Nitrogen Management for Society” in North America, Europe, and Asia.
- 7) Encourage animal scientists to continue their education about optimizing Nr management in food production, energy use, and environmental protection.

THE NITROGEN CYCLE OF THE EARTH

Nitrogen is the very stuff of life. It constitutes a major part of the nucleic acids that determine the genetic character of all living things and the enzyme proteins that drive the metabolic machinery of every living cell. Triple bonded gaseous dinitrogen (N_2) makes up nearly 80% of the total mass of the Earth's atmosphere. But none of this huge reservoir of N is biologically available. Before N can be used by most plants, animals, insects, and microorganisms, the triple bonds between gaseous N_2 molecules must be broken and the resulting single N atoms must be bonded chemically with one or more of three other essential nutrient elements – oxygen and/or hydrogen through N-fixation processes and carbon through N-assimilation processes.

Breaking the triple bonds between gaseous dinitrogen molecules is an energy-requiring reaction. In nature, fixation of N_2 is accomplished mainly by certain unique microorganisms that have developed the special metabolic machinery necessary to produce biologically active *reduced* forms of nitrogen such as ammonia, amines, and amino acids – the structural constituents of proteins and nucleic acids. These specialized organisms include a few free-living bacteria and blue-green algae, and also certain symbiotic bacteria that have developed special metabolic relationships with the roots of leguminous crop plants such as soybeans, clover, and N-fixing trees such as alder. Oxidative fixation of gaseous N_2 also occurs in nature, but only in such high-temperature natural processes as lightning strikes, volcanic eruptions, and wild fires that lead to production and atmospheric emissions of nitrogen oxides – NO, NO_2 , HNO_3 , NO_3^- , N_2O , HONO, N_2O_5 , PAN (peroxyacetyl nitrate), and PPN (peroxypropionyl nitrate).

In the pre-human world, biological nitrogen fixation (BNF) was the dominant means by which new reactive nitrogen (Nr) was made available to living organisms. The total amount of Nr that circulated naturally among various compartments of the atmosphere and the biosphere of the Earth was quite small. Thus, the awesome biodiversity and intricate webs of relationships we find in nature evolved in part as a result of intensive competition among many different life forms – most of them growing under Nr-limited conditions.

HUMAN ALTERATION OF THE NITROGEN CYCLE

Gradually during the past two centuries, and more markedly during the last few decades, various human activities have been adding larger and larger amounts of Nr to terrestrial and aquatic ecosystems and thus augmenting the natural circulation of Nr through the atmosphere and the biosphere of the earth. As described more fully by Vitousek et al (1997) and Galloway (1998), two major human imperatives have driven these recent changes in the N cycle of the Earth:

- 1) The need for food to sustain growing numbers of people all over the world. This has been achieved primarily through:
 - a) Increased use of synthetic Nr fertilizers;
 - b) Widespread planting of N-fixing legumes; and,
 - c) Increases in animal agriculture to meet growing demand for animal protein in human diets.
- 2) The seemingly insatiable human appetite for energy and materials with which to create and transport many of the goods, services, and other amenities of modern human life.

Figure 1 shows some important aspects of the history of human understanding of nitrogen – its discovery as an element in the periodic table in 1789, its significance as an essential element for life processes in 1840, the discovery of biological nitrogen fixation in 1890, the invention of the Haber-Bosch process for making synthetic nitrogen fertilizers in 1913, and the relationship among this series of scientific discoveries and the spectacular growth in the human population of the Earth during the 20th Century (Galloway and Cowling, 2002; Galloway et al, 2002).

Figure 2 shows the timelines of change in Nr added to global circulation as synthetic Nr fertilizers through the Haber-Bosch process and other forms of Nr added through widespread planting of N-fixing legumes and combustion of fossil fuels. Over the last 150 years, the rate of addition and partial accumulation of anthropogenic Nr has increased from about 10 to about 140 Terragrams N/yr. Please note that both synthetic Nr fertilizers and N-fixing legumes are adding about four times more biologically active, photochemically reactive, and radiatively active (climate altering) N (Nr) to global circulation than the total worldwide combustion of fossil fuels. An important part of this Nr enrichment is caused by contemporary changes in animal agriculture. There also have been significant changes in fluxes of Nr to the atmosphere and oceans and some human-induced changes in biological denitrification as well.

As indicated in Tables 1 and 2, many agricultural and forestry activities, and many more industrial, commercial, and military activities, have increased and are continuing to augment the N cycle of the earth. In fact, the total amount of Nr circulating through the atmosphere and the biosphere of the earth is now unprecedented in human history and increasing rapidly especially in Asia.

THE CHANGING STRUCTURE AND GLOBALIZATION OF ANIMAL AGRICULTURE

During the last several decades, three dramatic changes in the structure and organization of animal agriculture have occurred in many parts of the world. They are all resulting in an increased need for optimization of nutrient management plans for animal agriculture – especially as they pertain to handling and processing of manures and other food processing wastes and use of fossil fuels.

These three major changes include:

- 1) Intensification – development of increasingly large confined animal feeding operations in which hundreds or even thousands of live animals are reared in open feed lots or enclosed housing units;
- 2) Decoupling – physical separation of the land area where the feed grains and other forage products are produced and the site on which the food animals are fed and reared;
- 3) Regionalization and globalization of markets – huge increases in the distance of transport of both feed grains and other forages and marketable meat, eggs, dairy, and fish food products.

Powerful economic forces drive all three of these contemporary trends. They include economies of scale, efficiencies of specialization, cheap food and transportation policies, and the pressures of

global competitiveness. These forces have stimulated development of highly specialized, large-scale, vertically-integrated livestock, poultry, and fish rearing, processing, and marketing systems. These systems are designed to maximize conversion of feed grains and other forages into the specialized and uniform swine, beef/dairy, poultry, and fish food-products demanded by price-conscious consumers. Unfortunately, as discussed more fully below, economic efficiency, often made possible by increased use of energy in the form of fossil fuels, frequently leads to some nutrient-use inefficiencies and largely unforeseen detrimental environmental consequences.

The end-result of *intensification* in confined animal feeding operations is to concentrate animal rearing and manure production on a very small land area. Here the dominant tendency is to regard manure as an "unpleasant waste material that must be disposed of by the least costly methods available." The traditional alternative, of course, was to return the residual nutrients in manure to the land where the feed grain or other forages were produced. A second alternative – and a so far much less widely accepted one – is to regard manure and other animal harvesting wastes as "valuable natural resources" from which additional value added products can be produced and sold at a profit.

The end-result of *decoupling* is to separate the land area where feed grains and forages are produced from the sites where the food animals are reared. In traditional mixed farming operations this distance was a few hundred meters and the same farmer who raised the livestock or fish also raised the feed grain or other forages on the same land base. With today's modern specialized farming operations, however, many swine, beef/dairy, poultry, and fish farmers are specialists who, more often than not, produce little if any of the feed grains or other forages on their own land.

In recent decades, both specialization among food animal producers and further decoupling of animal agriculture has been facilitated by enterprising integrators. These entrepreneurs are guided by knowledgeable animal-production scientists, agricultural engineers, economists, and extension agents in the universities and private industry. As a result, contracts are developed that link farmers, integrators, and meat, egg, dairy, and fish product-processing and marketing companies. The integrators provide engineering designs for new types of housing or other animal-rearing and manure-handling equipment and facilities, genetically improved young animals, feed rations specifically designed to maximize weight gain per unit of feed or forage consumed, prescriptions for feeding and watering rates, disease management counsel and advice, and, most importantly, a guaranteed price to farmers who deliver finished food animals to a specific food processing plant on a specified time schedule. The processing and marketing companies then deliver uniform, high-quality food products attractively packaged to meet the demands of price-conscious consumers.

The end-result of regionalization and globalization of markets is to greatly enlarge the geographical scale of production and marketing operations in the food-animal industry. Often there are remarkably long distances of transport between the places where the feed grains and forages are produced, the food animals are reared, the processing plant where the animals are slaughtered and processed, and the grocery stores and restaurants where the finished food products are delivered to consumers. Fossil fuel energy is consumed and oxidized forms of N_r are produced at every step in these often far-flung transportation processes. Powerful economic forces also are at work at all stages in these production, transport, and marketing systems. Thus high-quality and very uniform animal food products often are delivered to very far-distant markets at remarkably low consumer prices.

The major problem with all three of these contemporary trends in animal agriculture is lack of economic or other incentives for recycling – returning the valuable nutrients in animal wastes back to the land that was used to produce the feed. As a result, much of the Nr and other valuable nutrients in animal manures and food processing wastes is "disposed of by least cost methods" – that is, released into the environment in the vicinity of the animal rearing and food processing facilities. The released substances most often are volatile ammonia, amines, and nitrogen oxides that also are emitted to the atmosphere where they form ammonium nitrate or ammonium sulfate aerosols or leach into ground water.

All of the volatile inorganic and organic forms of Nr are carried by wind and deposited in precipitation or as dry deposition of gases and aerosols wherever the wind blows – sometime in the vicinity of the animal rearing or processing facilities rather than returned to the sometimes far-distant land where the feed was produced. In North America, highly competitive demand for low-cost animal food products and absence of significant economic penalties or regulations prohibiting improper animal waste management have been major impediments to optimizing management of Nr and other nutrients in animal agriculture.

BENEFICIAL AND DETRIMENTAL EFFECTS OF Nr EMISSIONS FROM ANIMAL AGRICULTURE

Every increment in amount of total Nr circulating through the atmosphere, soils, sediments, standing biomass, and oceans of the earth brings with it a corresponding potential increase in the productivity of agriculture, forestry, and aquatic ecosystems (see the beneficial effects listed in Table 3). As shown in Figure 3, however, each increment of Nr, beyond a certain optimal range, also brings with it increased likelihood of at least some among a long list of Nr-induced detrimental effects on society (see also the detrimental effects listed in Table 3).

Unfortunately, many voluntary recommended management practices or mandated rules and regulations have been focused around one specific air- or water-pollution problem at a time. In some cases, decisions about abatement strategies for one problem have interfered with measures intended to resolve another pollution problem or have affected some other social or economic aspect of society. For example, regulations in the Netherlands that require farmers to inject animal manures into soil increase the likelihood of nitrate contamination of drinking water (Erisman and Monteny, 1998). Also, decreases in emissions of nitrogen oxides have sometimes led to increases in ambient concentrations of ozone in the central core of some cities in North America (USEPA, 1997). In the United States, "non-discharge" permits intended to prevent pollution of surface and ground waters by confined animal feeding operations ignored volatile emissions of ammonia and amines from animal housing units and manure handling and storage systems.

Realistic possibilities exist for developing more rational and more fully integrated strategies and tactics for enhancing the efficiency of Nr use in animal agriculture while at the same time decreasing the frequency of occurrence of many of the detrimental effects listed in Table 3.

POTENTIAL FOR DECREASING THE DETRIMENTAL IMPACTS OF ANIMAL AGRICULTURE ON THE ENVIRONMENT

Economically viable technologies are being developed for conservation and profitable reuse of nitrogen and the other valuable nutrients in animal wastes. These wastes are of three general types:

- 1) Urine and feces in animal manures;
- 2) Waste streams from processing plants that include feathers, bones, blood, offal, and other unused or underused portions of the harvested food animals; and,
- 3) Carcasses of animals that become diseased, die of known or unknown causes, or are slaughtered deliberately to avoid the spread of dread diseases such as foot and mouth disease or mad cow disease.

The valuable nutrients in all three of these waste streams can be recovered and reused both safely and economically. There are four main approaches to this goal:

- 1) Direct application of animal manures to land used for producing grain or other forages;
- 2) Conversion of nutrients in the waste streams into marketable fertilizer products for reuse in crop, forest, or fish production;
- 3) Production of energy or other value-added products (especially high-value end products) for use in industry and commerce; and/or
- 4) Denitrification back to biologically inactive atmospheric N₂.

As suggested by Sheffield (2000) and Cowling et al (2001), the value-added end products that could be produced by converting the valuable nutrients in animal wastes into saleable commodities include:

- 1) Energy in the form of methane, biogas, diesel fuel, or electricity for direct on-farm purposes;
- 2) Electricity for sale through co-generation contracts with public utilities;
- 3) Synthetic growth media for high-value ornamental plants or soil amendments for residential or commercial landscaping purposes;
- 4) Nitrogen- and phosphorus-rich fertilizer materials for direct application to crops such as corn, cotton, sweet potatoes, etc., or to fast-growing pine and/or hardwood plantations;
- 5) Fertilizer materials for green-house production of floral crops and other ornamental plants;
- 6) Feed materials and nutritional supplements to enhance feed conversion efficiency in fish,

poultry, and livestock production. These supplements could include dehydrated duckweed, high-protein fish meal, and amino acid and vitamin supplements;

- 7) Protein products for veterinary applications in aquaculture, poultry and livestock industries including nutritional enzymes, edible vaccines and anti-viral proteins such as interferon;
- 8) Protein products for industrial applications including industrial antibodies and enzymes used in detergents, recycling, and in the processing of pulp, paper, textile, and chemical products;
- 9) Production of high-value protein-based biomaterials including adhesives, fibers such as silk, optically-active films, and other biopolymers or plastics;
- 10) Food materials for companion animals; and
- 11) Higher-value foods for human consumption including wholesome fish, vegetable, fruit, and dairy products.

Another possibility is direct conversion of Nr into nonreactive nitrogen gas (N₂) that can be returned to the atmosphere. This additional option would avoid detrimental public health, ecological, or other environmental impacts, but would provide no direct income to farmers or waste processing industries to sustain the conversion processes. Nevertheless, these direct denitrification processes should be evaluated to compare their economic and other costs and benefits with production and marketing of various saleable end products and/or viable combinations of end products.

In attempting to decrease air emissions of ammonia, it is important to recognize that most of the Nr excreted by swine and beef/dairy cattle is in the urine of the animals; and that urease, the enzyme that converts urea to ammonia, is mainly in the feces (Kaspers et al, 2002). Thus, manure-handling systems for swine and cattle that separate liquid from solid wastes will have substantially lower ammonia emission rates.

It is also important to recognize that urea conversion and ammonia volatilization processes continue from the time of excretion by the animals, during manure storage and treatment, and both before and after possible land application. In the well-ventilated barn and lagoon and spray-field system widely used in swine production in North Carolina, for example, about 40% of the ammonia is lost through the ventilation system of the houses, about 30% from the surface of the lagoons, and about 30% during and after application onto the spray fields and from decomposing bales of Bermuda hay left at the sides of the spray fields because there is little market-demand for Bermuda hay (Aneja et al, 2000, 2001).

The most serious obstacles to overcoming the consequences of intensification, decoupling and regionalization and globalization of markets in the food animal industry are:

- 1) The distances over which feed grains are transported before delivery to animal rearing facilities – sometimes in another state or even a far-distant country;
- 2) Reluctance and doubt among farmers, integrators, and their extension-service and private

consultant advisors about the technical and/or economic feasibility of alternative systems for nutrient management, animal production, and waste utilization; and,

- 3) Lack of convenient and reliable processes for combining manure-based fertilizer products with synthetic chemical fertilizer in intensively managed cropping systems.

Especially as confined animal feeding operations become more common, conversion of animal manures and animal-processing waste materials into value-added products for profitable sale is a logical strategy. It will simultaneously achieve several desirable environmental, public health, and economic goals:

- 1) Recovery and reuse of the nutrient resources in the waste streams;
- 2) Decrease or elimination of detrimental effects on public health and environment;
- 3) Development of profitable private-sector business and employment opportunities;
- 4) Enhancement of the economic and environmental sustainability and the social acceptability of food animal industries and the social, economic, and environmental well-being of the rural and near-urban communities in which these facilities are located; and
- 5) Decrease in regulatory costs (education, permitting, inspection, and enforcement) associated with current waste processing systems.

JUSTIFICATION FOR A “TOTAL REACTIVE NITROGEN APPROACH” IN AIR - AND WATER -QUALITY MANAGEMENT

So far, most of the voluntary recommended management practices and the mandated rules and regulations for management of Nr have been developed and administered separately. Also, most guidance for prevention of water discharges from confined animal feeding operations have been developed and administered without regard for the associated air emissions of volatile ammonia and amines. Air emissions of NO_x were first regulated because NO_x is an important precursor of ozone and later because it also contributes to acidification of soils and surface waters. Similarly, air emissions of ammonia first became a pollutant of concern because ammonia contributes to acidification processes. All forms of Nr participate in a variety of chemical and physical transformations in the atmosphere. As indicated in Table 3, they also can have a long series of beneficial and detrimental biological effects once they are deposited in terrestrial and aquatic ecosystems.

Thus, the time has come to develop and implement a “Total Reactive Nitrogen Approach” (“Total Nr Approach”) rather than continue to consider nitrogen-oxide pollution and ammonia pollution in isolation from each other and from other aspects of air quality management. As discussed more fully by Grennfelt et al. (1994), a “Total Nr Approach” is especially important in the context of current discussions about multiple-pollutant/multiple-effects perspectives in air- and water-quality management, and should become integral parts of Nr management in both crop and animal agriculture and in forestry, fisheries, and watershed management.

A “Total Nr Approach” is firmly grounded in the following biological principles (Linder, 1995; Gundersen, 1992; Vitousek et al, 1997).

- 1) All oxidized, reduced, and carbon-bound (organic) forms of Nr are biologically active. When transferred into ecosystems in less than optimal amounts, they increase the productivity of the system – see the ascending part of the curve in Figure 3 and the beneficial effects listed in Table 3.
- 2) When applied in more than optimal amounts, however, all biologically active forms of N contribute to the wide variety of Nr-induced pollution problems listed in Table 3 – see the descending part of the curve in Figure 3.
- 3) The biologically important oxidized forms of Nr include NO, NO₂, HNO₃, NO⁻, HONO, N₂O₅, PAN (peroxyacetyl nitrate), and PPN (peroxypropionyl nitrate). Biologically important reduced forms of Nr include gaseous ammonia, dissolved and aerosol forms of ammonium ion, and a wide variety of organic Nr compounds including urea, uric acid, amines, amino acids, etc.
- 4) The total supply of Nr in terrestrial and aquatic ecosystems is a complex function of the following:
 - a) The amounts of non-reactive N₂ gas removed from the atmosphere by free-living N-fixing microorganisms in soils and by symbiotic N-fixing microorganisms in the roots of some crop plants and a few species of forest trees;
 - b) The amounts of oxidized and reduced forms of Nr in the soil solution and in decomposing organic matter in soil;
 - c) The total amounts of Nr transferred from the atmosphere into ecosystems by wet and dry deposition processes;
 - d) The amounts of Nr applied to land as synthetic fertilizers and animal wastes;
 - e) The runoff of Nr compounds from the land to surface waters; and,
 - f) Microbial processes in soils that transform oxidized, reduced, and organic forms of Nr and release them back into the atmosphere as NO, NO₂, NO₃⁻, HNO₃, N₂O, and N₂.
- 5) Although there are transitory differences in rates of uptake and assimilation of oxidized, reduced, and organic forms of Nr by different organisms, both oxidized and reduced forms of Nr ultimately have substantially similar influences on the general productivity of the terrestrial, aquatic, and livestock-dominated ecosystems systems in which they are assimilated. This is true because at least one or another (and sometimes many) of the various plants, animals, microbes, and insects in terrestrial or aquatic ecosystems take up all oxidized, reduced, and organic forms of Nr.

After initial uptake and assimilation, these various forms of Nr are readily transformed and exchanged with other organisms and compartments within a given landscape or watershed so that all Nr molecules have a series of cascading biological effects within the natural or managed ecosystems in which they are incorporated (Galloway, 1998; Vitousek et al, 1997).

These linkages and biological principles provide strong justification for adoption and

implementation of a Total Nr Approach” in air quality management. As discussed below, they also set the stage for development of a “Concept of Optimum Nitrogen Management for Society.”

DEVELOPMENT OF A "CONCEPT OF OPTIMUM Nr MANAGEMENT FOR SOCIETY"

In his most famous book, “Future Shock,” Alvin Toffler (1970) identified three different types of futures, which he believed innovative democratic societies should consider very carefully:

- 1) “Probable futures” – hopes and aspirations of society that are largely an extension of a “business as usual” sense of what the future might hold;
- 2) “Possible futures” – exploration of all possible outcomes that a given society might wish to consider as possibilities for its future; and
- 3) “Preferable futures” – optimum outcomes that probably can be achieved only as a result of focused and well-disciplined efforts to fulfill mutually agreed upon goals and dreams which are consonant with the natural and human resources available to society.

In evaluating alternative choices about management of air and water quality in the context of other important societal goals, enlightened societies will want to consider Toffler’s suggestions and thus go beyond “business as usual” perspectives, look earnestly at a wide range of “possibilities,” and work hard to define and implement “preferable” options that are both prudent and realistic for the long-term as well as for the short-term futures of society. In thinking further about how “preferable futures” might be identified in the case of Nr, we found valuable theoretical guidance in the “theory of optimum nutrition” developed by Ingestad (1987). We also found valuable practical guidance in Gundersen’s (1992) concept of “optimum ecosystem productivity.”

Ingestad (1987) first theorized, and later established experimentally, that maximum growth and production of both agricultural crops and forest trees can be obtained by optimizing, in all stages of growth and development, the availability of each of the 16 nutrient elements that are required for growth of plants (and by inference, the 27 elements that are essential for animals). Since Nr is the essential nutrient that most often limits growth of crops and forests, Ingestad reasoned and expressed his experimental findings as ratios between the amounts of each of the other essential nutrients and the amount of Nr available to the organism of interest. Thus, Ingestad confirmed the central role that Nr plays in determining the health and productivity of plants. He also established procedures for determining optimum amounts of Nr and other nutrients to ensure maximum growth. Similar principles also apply to growth and development of livestock and fish.

Gundersen (1992) extended these ideas to show that Nr also plays a central role in determining the productivity and stability of whole ecosystems. A very slightly modified version of Gundersen’s original graph is shown in Figure 3. This figure shows that:

- 1) Growth within a whole ecosystem receiving no significant input of Nr from the atmosphere or other external sources has a relatively constant “index of productivity;”
- 2) An ecosystem receiving moderate amounts of added Nr responds by increasing the productivity of the whole system;

- 3) There is a maximum (optimal) productivity for any given living system; and
- 4) Additions of more than optimal amounts of Nr eventually cause destabilization, decrease in vitality, and eventual decline in the productivity of the whole ecosystem.

Gundersen's concept of "optimum productivity" applies to many different types of land use (and surely also to livestock feeding operations). Thus, each different type of land use follows its own unique (but similarly shaped) productivity/Nr-input curve – with productivity first increasing, then going through a maximum, and eventually decreasing with increasing inputs of total Nr. This idea is illustrated in Figure 4, where ecosystem-productivity/Nr-input relationships are shown for five general types of land use in the Netherlands.

Please note that each particular type of land use showed its own particular relationship between the productivity of the system and the total Nr input to that system from all sources. As discussed earlier, these sources include wet and dry deposition from the atmosphere (in all cases), applications of Nr in synthetic fertilizers (where applied), and application of animal manures and other Nr-containing waste materials (where applied). It is possible to further extend this idea of a curvilinear relationship between the productivity of various uses of land and inputs of Nr – and to adapt and apply this general idea in making nutrient management recommendations for various crops, species of livestock, and thus for the whole of society.

In essence, a curvilinear relationship of the general form shown in Figures 3 and 4 can be defined between what might be called an "index of societal sustainability" and the total amount of Nr transferred from the atmosphere and other external sources into different geographical areas within a given society. This proposed index of societal sustainability" would be analogous for a whole community or society with Gundersen's "index of productivity" for a whole ecosystem.

Construction of such an "index of sustainability" will require the development of a series of land-use-specific and food-animal-specific productivity/Nr-input curves for each different type of natural resource use that is commonplace within society. From the Nr-input values for maximum productivity for each natural resource system, it should be possible to determine an approximate "total Nr-input ceiling" for maximum productivity of each type and locality of resource use. These values then can be used as inputs to gridded atmospheric-source/resource-use receptor models to establish area-specific and animal-agriculture-specific input ceilings for each major source of Nr. With this information as background, it then should be possible for each community, state, or country to determine (negotiate) an optimum total Nr loading for each of the various sectors within society, and then to consider various alternative measures by which to adjust nutrient input rates accordingly. Thus, each particular geographical and economic sector within a given community, state, or country could adjust its own imports and exports of Nr – and thus do its part toward achieving a "preferable total nutrient management system within a more sustainable and equitable society."

In an attempt to illustrate how this proposed concept could be used in practice, the following suggestions are advanced. First, quantitatively defensible productivity/Nr-input curves should be developed for each type of natural resource use on the basis of both experimental data and observations of real-world production systems. Within each locality or grid square within a given community, a selection should be made of the types of land use which should be considered most limiting or most significant economically, socially, aesthetically, etc. These choices should be

made very carefully, because the land-use- and area-specific Nr input ceilings and corresponding emissions ceilings will be determined using receptor modeling.

After the emissions ceilings have been determined, comparisons must be made between actual emissions and the calculated emissions ceilings for each locality or grid square. If actual emissions are lower than the calculated optimum, then some increase in Nr emissions could be considered, so long as the allowed increase in emissions does not lead to exceedances of the optimum Nr loads in other grid squares. This means, in agricultural areas, for example, that additional animal manure or synthetic Nr fertilizers could be applied to increase crop production. If actual emissions exceed the calculated optimum, however, then decreases in emissions should be undertaken. The total Nr emissions ceiling can be achieved by decreasing the amounts of reduced Nr compounds emitted or by decreasing amounts of oxidized Nr compounds, or both.

If it appears that the Nr emissions ceilings are so low that it will not be economically feasible to meet them, the target position on the optimum curve should at least be shifted in the direction of optimum Nr loading. If the optimum loading is exceeded, then hard choices will need to be made between economical interests and ecological interests. In this way, the "Concept of Optimum Nitrogen Management for Society" provides a tool for visualizing the consequences of economically determined and ecologically determined futures. The advantage of this concept is that the measures needed to achieve optimum Nr deposition can be chosen as a trade-off between policies and procedures designed to decrease or increase inputs of Nr, depending on what is economically feasible, socially acceptable, and environmentally sound in both the short and the long run.

This "Concept of Optimum Nitrogen Management for Society" has been applied in a pilot "case study" of ammonia emissions in the province of Friesland (Erisman and van Egmond, 1997) using ammonia-emissions ceilings and maximum Nr-application rates for several municipalities in the Netherlands (Erisman et al, 1996). Portions of the concept, especially those dealing with spatial planning as a tool for decreasing Nr loads in nature areas, are also discussed by Bleeker and Erisman (1998) and most recently by Erisman et al (2001).

Further development and especially implementation of this proposed "Concept of Optimum Nr Management for Society" will require both substantially increased knowledge of the growth, development, sustainability, and possibilities or realities of detrimental effects on various ecosystems and other air-quality and water-quality related values (Erisman et al, 2001). Adoption and implementation also will require substantially increased understanding and a more widely shared sense of ecological bioethics within farming, forestry, industrial, regulatory, and political communities. Various aspects and implications of some of these ideas are further discussed by Leopold (1968), Brundtland (1987), Potter (1988), and Cowling and Nilsson (1995).

SCIENCE AND POLICY IMPLICAITONS

The major scientific and policy-relevant implications of this paper are as follows.

- 1) Contemporary changes in animal agriculture are increasing the circulation of biologically active, photochemically reactive, and radiatively active nitrogen (Nr) among the

atmosphere, soils, forests, fish, surface and ground waters, and oceans of the earth – in part through water discharges but even more through atmospheric emissions of ammonia and other volatile Nr compounds from animal feeding operations, and also through oxides of Nr from the fossil fuels used in transport of feed grains, finished animals, and marketable food products.

- 2) These increases in Nr circulation are causing some positive benefits for agriculture, forestry, and fisheries while also causing some negative impacts on air and water quality, human health, ecosystem productivity, and other air- and water-quality related values.
- 3) Enterprising farmers, ranchers, integrators, public officials, and private-sector vendors, as well as animal nutritionists, atmospheric chemists, meteorologists, and agricultural economists in universities, government agencies, and the private sector, have much to gain by joining together in research aimed at conserving and recycling the valuable Nr and other nutrients in animal manures and food processing wastes. Converting these nutrients to value-added products that can be sold at a profit is much wiser than continuing to consider animal wastes as an "unpleasant waste to be disposed of by least-cost methods."
- 4) Rather than continuing to deal with oxidized and reduced forms of nitrogen separately, strong justification is provided for development of an integrated "Total Reactive Nitrogen Approach" or, "Total Nr Approach." In most terrestrial and aquatic ecosystems, the end result of continuing heavy loads of Nr will be substantially the same whether the airborne Nr emissions occur as oxidized, reduced, or organic forms of Nr.
- 5) A "Concept of Optimum Nr Management for Society" is proposed together with suggestions about practical steps for implementation. Implementation will require construction of a series of productivity/Nr-input curves for each general type of land use and then determining land-use-specific deposition ceilings and corresponding airshed-specific and watershed-specific emissions ceilings for major sources of Nr. It then should be possible to consider various alternative measures by which to adjust area-specific Nr emissions rates and land-use-specific Nr-fertilization rates accordingly. This concept will facilitate communications which can lead to decisions by which various sectors of society can adjust their own emissions of total Nr – and thus do their part (together with other sectors of society) toward achieving a "preferable total Nr emissions load within a more sustainable and equitable society."
- 6) In addition to the usual list of specific references cited in this paper, a selected bibliography of additional references is provided for those within the animal agriculture scientific and policy communities who wish to continue their education about optimizing nitrogen management in food production, energy use, and environmental protection.

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WEBSITES RELATING TO NITROGEN EMISSIONS, DEPOSITION AND MANAGEMENT

Second International Nitrogen Conference, October 14-18, 2001. Bolger Center near Washington DC, <http://n2001.esa.org/>

National Atmospheric Deposition Program, Precipitation Chemistry Data for the USA, Illinois State Water Survey, University of Illinois, Champaign-Urbana, <http://nadp.sws.unic.edu/>

Table 1. Agricultural and forestry activities that augment the nitrogen cycle of the earth

Activity
1. Harvesting of wild animals and fish
2. Burning of natural vegetation to make way for agriculture
3. Harvesting and utilization of timber
4. Production of major food crops (especially cereal grains, beans, potatoes, and various fruit, nut, and vegetable crops)
5. Husbandry of domestic meat-producing and milk-producing animals (especially poultry, swine, beef cattle, sheep, dairy cattle, and goats)
6. Land application of animal manures
7. Combustion of crop and logging residues
8. Widespread cultivation of nitrogen-fixing legumes
9. Increased production and use of synthetic N fertilizers
10. Increased fish- and shell-fish farming in ponds, lakes, streams, rivers, estuaries, and ocean waters

**Table 2. Industrial, commercial, and military activities
that augment the nitrogen cycle of the earth**

Activity
1. Combustion of fossil fuels in: <ul style="list-style-type: none"> – Domestic space and water heating devices – Firing of pottery and manufacture of glass and ceramics – Smelting of metal-containing ores and processing of metals – Production of cement – Power plants for generation of electricity – Small and large industrial and commercial boilers – Construction and earth-moving equipment – Farm tractors and implements – Industrial machines powered by internal combustion engines – Transportation vehicles (including cars, trucks, railroads, ships, aircraft, and space vehicles)
2. Production and refining of oil for liquid fuels and production of petrochemicals
3. Other chemical industries
4. Pulp and paper manufacturing
5. Disposal of urban wastes in land fills
6. Incineration of household and municipal wastes (including garbage, food-processing wastes, waste paper, plastics, medical wastes, and construction and demolition debris)
7. Operation of sanitary sewers and sewage treatment plants
8. Land applications of sewage sludges
9. Use of explosives in peace and war

Table 3. Beneficial and detrimental effects on society induced by increased circulation of reactive nitrogen (Nr) in the atmosphere and biosphere of the Earth

Direct effects of Nr on humans

1. Increased yields and nutrition quality of foods needed to meet dietary requirements and food preferences for increasing human populations all over the world
2. Respiratory and cardiac disease in people caused by exposure to high concentrations of:
 - Ozone
 - Other photochemical oxidants
 - Fine aerosol particles
 - (On rare occasions) direct toxicity of NO₂
3. Nitrate and nitrite contamination of drinking water
4. Blooms of toxic algae and decreased swimability of water bodies

Direct effects of Nr on ecosystems

1. Increased productivity of Nr-limited crops, forests, and natural ecosystems
2. Enhanced overall soil productivity through greater microbial activity and improved soil health
3. Ozone damage to crops, forests, and natural ecosystems and predisposition to attack by pathogens and insects
4. Acidification effects on forests, soils, ground waters, and aquatic ecosystems
5. Eutrophication of freshwater lakes and coastal ecosystems
6. Stimulation of algal growth and productivity in coastal waters, with possible effects on coastal food webs and fisheries including decreased concentrations of dissolved oxygen (hypoxia and anoxia); decline or elimination of submerged aquatic vegetation; promotion of certain algal species that are harmful because they produce toxins
7. Nitrogen saturation of soils in forests, grasslands, and other natural areas
8. Loss of biodiversity through loss of N-poor habitats in terrestrial and aquatic ecosystems and shifts in ecosystems to domination by nitrophilic species of plants
9. Changes in abundance of beneficial soil organisms that alter ecosystem functions
10. Carbon sequestration can be increased in ecosystems where Nr is limiting, with possible amelioration of CO₂ accumulation and resulting climate change

Indirect effects of Nr on other societal values

1. Increased wealth and well being of human populations in many parts of the world
2. Increased yield per unit of cultivated land has made it possible to preserve marginal and forested land for ecosystem maintenance
3. Significant changes in patterns of land use
4. Regional hazes that decrease visibility at scenic vistas and airports
5. Odor problems associated with animal agriculture
6. Damage to useful materials and cultural artifacts by ozone, other oxidants, and acid deposition
7. Regional hazes that decrease visibility at scenic vistas and airports
8. Depletion of stratospheric ozone by N₂O emissions
9. Global climate change induced by emissions of N₂O and formation of tropospheric ozone
10. Long-distance transport of Nr, which causes harmful effects in regions or countries distant from emission sources and/or increased background concentrations of ozone and fine particulate matter
11. Increased cost of societal regulations necessary to avoid the detrimental effects of Nr

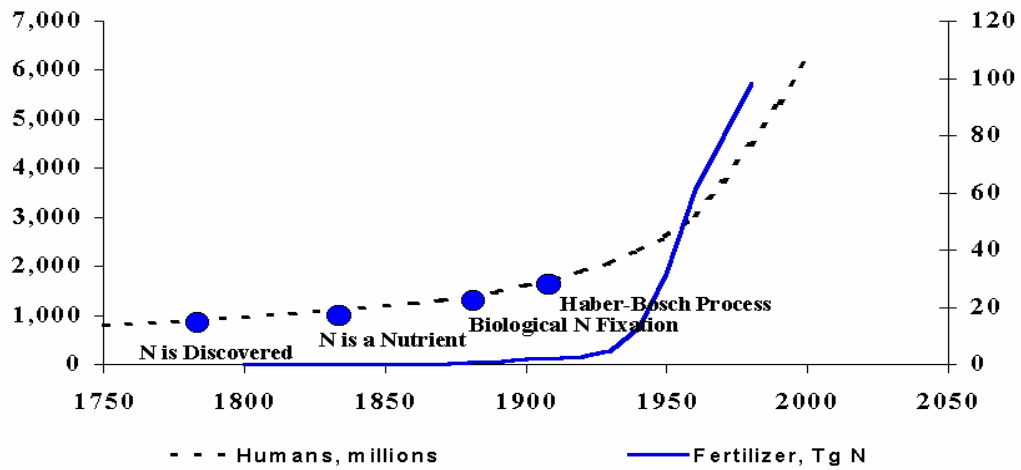


Figure 1. The history of nitrogen and the human population of the world. Please note the global human population trend from 1860-2000 (billions of people, left axis). This figures is adapted from Galloway and Cowling (2002).

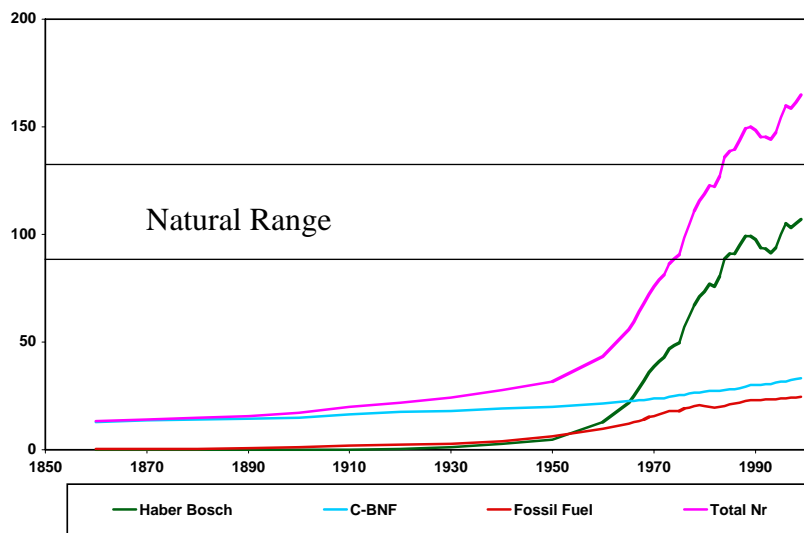


Figure 2. Human alteration of the nitrogen cycle of the Earth. Please note rates of Nr creation (Terragrams Nr per year) through various human activities: “Haber-Bosch” = synthetic NH_3 formation through the Haber-Bosch process -- mainly for production of commercial fertilizers; “C-BNF” = Nr creation through widespread cultivation of N-fixing legumes, paddy rice, and sugar cane; and “Fossil Fuel” = Nr creation through oxidative fixation of N during combustion of fossil fuels. “Total Nr” is the sum of all three major anthropogenic sources (“Haber Bosch” + “C-BNF” + “Fossil Fuel”). “Natural Range” refers the approximate global biological fixation of Nr in the pre-human terrestrial environment. This figure is adapted from Galloway and Cowling (2002).

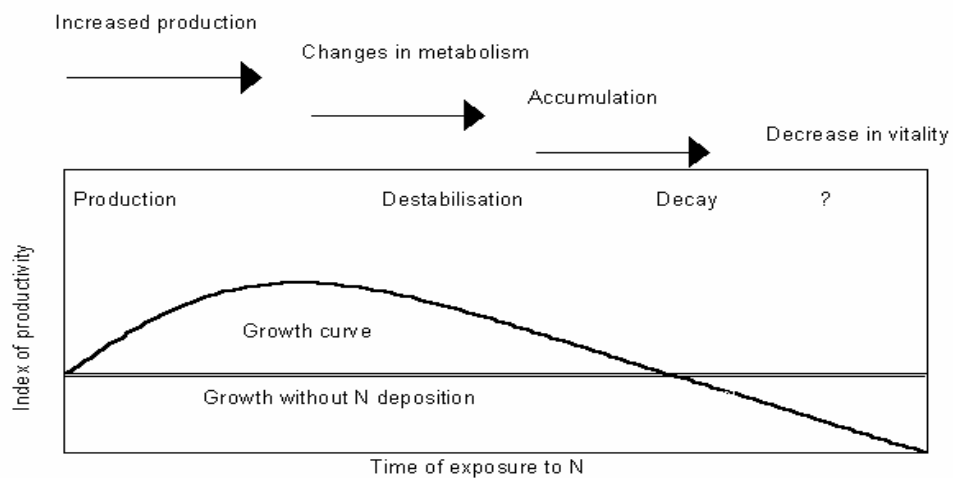


Figure 3. Hypothetical growth curve showing the productivity of terrestrial and aquatic ecosystems receiving different loadings of total reactive nitrogen. This figure is slightly modified from the original curve developed by Per Gundersen of the Laboratory of Environmental Sciences and Ecology, Technical University of Denmark, Lyngby, Denmark (Gundersen, 1992).

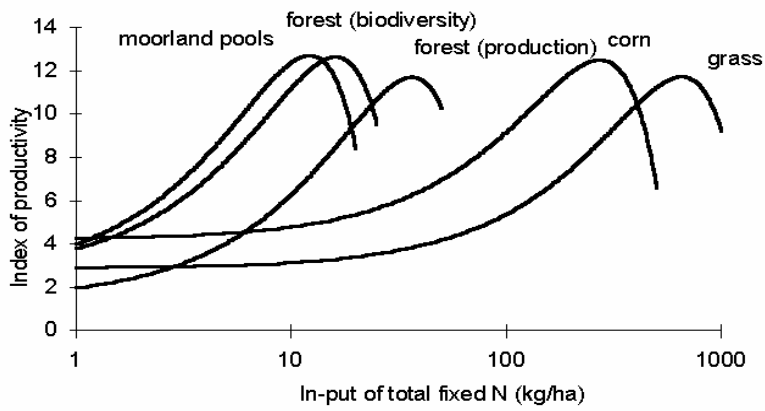


Figure 4 . Hypothetical growth curves for five different types of terrestrial ecosystems -- natural moorland pools, forest biodiversity, timber production, and production of corn and grass crops. This figure is adapted from the concept of “optimum ecosystem productivity” advanced by Per Gundersen (see Figure 3).

APPENDIX A

AGENDA

SHARING COSTS OF CHANGES IN FOOD ANIMAL PRODUCTION: PRODUCERS, CONSUMERS, SOCIETY AND THE ENVIRONMENT

MODERATOR: Richard Reynnells, USDA/CSREES

8:30 - 8:40 WELCOME:
Ann Veneman, Secretary of Agriculture

8:40 - 9:00 OPENING REMARKS

8:40 - 8:50 Opening Remarks: A Vision for the Future of Agriculture
Michael Appleby, Humane Society of the United States

8:50 - 9:00 Opening Remarks: A Balanced Decision Making Process
Ken Klippen, United Egg Producers

PRODUCER ISSUES

9:00 - 9:15 The Economic System of U.S. Animal Agriculture and the Incidence of Cost Increases
Bruce Gardner, University of Maryland

9:15 - 9:30 Food Animal Welfare: Producer Issues Regarding Costs
Richard R. Wood, Food Animal Concerns Trust

9:30 - 10:00 DISCUSSION, Led by Moderator

10:00 - 10:15 **BREAK**

DECISION MAKING IN THE FOOD CHAIN

10:15 - 10:30 RETAIL AND CONSUMER INFLUENCES,
Terri Dort, National Council of Chain Restaurants

10:30 - 10:45 HOW ARE DEMOCRATIC DECISIONS TO BE MADE THAT PROMOTE SUSTAINABLE, ADAPTIVE FOOD PRODUCTION SYSTEMS?
W. Ray Stricklin, University of Maryland

10:45 - 11:15 DISCUSSION, Led by Moderator

11:15 - 12:30 **LUNCH**

MODERATOR: David Brubaker, Agri-Business Consultant

SOCIETAL ISSUES

12:30 - 12:45 CHANGES IN AGRICULTURE AND COMMUNITY CONTROVERSY
 Kathy Kremer, Wartburg College

12:45 - 1:00 FOOD QUALITY, SAFETY AND SECURITY,
 Lou Carson, USFDA/CFSAN

1:00 - 1:30 DISCUSSION, Led by Moderator

INTERNATIONAL AND TRADE ISSUES: A PANEL DISCUSSION

1:30 - 2:30 TRADE AGREEMENTS AND ISSUES: OBSTACLES AND OPPORTUNITIES

1:30 - 1:45 **Neil Conklin**, USDA/ERS

1:45 - 2:00 **Bob Macke**, USDA/FAS

2:00 - 2:30 DISCUSSION, Led by Moderator

2:30 - 2:45 BREAK

ANIMAL WELFARE AND ENVIRONMENTAL ISSUES

2:45 - 3:00 ANIMAL WELL-BEING ISSUES
 Marlene Halverson, Animal Welfare Institute

3:00 - 3:15 WELFARE, ECONOMICS AND CONVENTIONAL PRODUCTION
 Kathy Chinn, Missouri Producer, National Pork Board Animal
 Welfare Committee

3:00 - 3:15 CHALLENGES AND OPPORTUNITIES FACING ANIMAL AGRICULTURE:
OPTIMIZING NITROGEN MANAGEMENT IN THE ATMOSPHERE AND
BIOSPHERE OF THE EARTH
 E. B. Cowling, North Carolina State University and
 J. N. Galloway, University of Virginia

3:15 - 3:45 DISCUSSION, Led by Moderator

3:45 - 4:00 OPEN DISCUSSION, Led by Moderator