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Kernkamp Lecture: Waiting for hurricanes: Risk, research, and the science/policy interface

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Introduction

The years I spent in North Carolina from 1994 to 1999 provided two indelible experiences. The first was to witness the arguably successful demonization of the swine industry through well-orchestrated media and political action, albeit facilitated by some regrettable events in the industry. The second was the seasonal ritual of watching tropical storms form off the distant African coast and slowly meander across the Atlantic to threaten the eastern seaboard. Most storms would fade out or change their path, becoming inconsequential and forgotten. A few would strengthen and strike, with their names achieving almost legendary status.

While visiting Minnesota in 2002, I had an opportunity to meet with a small group of leading swine practitioners. The predictable theme was the challenges facing the industry, and we discussed the role of applied research in this context. At the time, prices were toward the lower end of the recently volatile and unsatisfactory range, and the strongest viewpoint was the need for producers to have better tools for managing risk. The discussion was understandably channeled towards the financial and market conditions that dictate immediate and short-term profitability—risks whose management is more the province of the commercial and financial, rather than the technical, sectors. However, investment in applied research in swine health and production can be viewed as a risk management strategy, particularly with respect to factors that will influence product acceptability and market access in the longer term.

The key argument for directing research investment towards “societal” issues is that better knowledge can influence the perceptions of consumers and lawmakers so that the decisions they make are more informed and rational. Perhaps equally important is the need for the industry to continually re-evaluate and improve existing practices, particularly where these have evolved with a fairly narrow focus on profitability.¹ This paper discusses some issues that pose imminent or remote risks to the industry, and the need for research to enhance the collective responses to them.

The direction of applied research: A change in the weather

Applied research can deliver tangible benefits to industry when it addresses factors that are binding constraints to production efficiency and profitability under prevailing conditions or addresses issues that threaten to constrain the industry in the future. Prudent investment for the former requires understanding the nuts and bolts of the industry from both the biological and financial perspectives—getting under the bonnet and tuning the motor. Prudent investment for the latter requires reading of the broader landscape to identify, anticipate, and minimize the impact of emerging risks —i.e., preparing for the storms.

The untimely passing of Dr. Al Leman occurred during a watershed period for the US swine industry. For most of Al’s scientific career, the “climate” was fairly stable, but the industry’s motor needed tuning. Swine production in the US was relatively inefficient and it was appropriate that research and extension focused on the “techno-managerial” aspects of hog production at which Al excelled. The industry underwent dramatic restructuring and demographic change associated with gains in production efficiency. In 1992—just as the weather began to get rough—the veterinary profession and swine industry lost a great ambassador and motivator. Over the subsequent decade, it has become increasingly evident that societal reactions to complex issues surrounding food animal production will be major forces that shape the future of meat industries in developed countries. For university-based research groups, it is important to question how much of our emphasis should shift away from our traditional core business of solving “internal” problems of a primarily technical nature and move towards addressing these broader “external” or societal issues.

Globalization: Supply and demand for animal protein

Over the next two decades, the FAO predicts that meat and milk demand will increase by 80 and 190 million tons, respectively, in the developing world, where the livestock industry is expanding faster than any other agricultural sector. If realized, the projected expansion of livestock

production will attract increasing scrutiny of the environmental, social, public health, and ethical concerns that surround animal production. A detailed assessment of the global outlook for pork was presented a year ago at this meeting by Dr. Luciano Roppa, who predicted global demand for pork will rise from 91 million tons (2001) to somewhere between 106 million tons (assuming constant per capita intake) and 123 million tons (assuming constant growth in per capita pork consumption) by 2010.² However, for US producers this initially encouraging outlook is tempered by predictions that most of the growth in pork production will occur in developing countries.

The determinants of international trade developments in pork have been recently reviewed from an economic perspective.³ Without wanting to understate the crucial contribution that growth of exports is likely to make to the future viability of the US swine industry, the vast majority of US produced pork is and will continue to be consumed domestically. Therefore, it is developments in the national arena, including regulatory changes, that will primarily influence the industry in the short to mid-term. While the fundamental issues are common to all livestock industries throughout the world, over time their relative importance will differ among countries due to domestic pressures and events. Some issues have inherited their momentum from other countries (predominantly the EU), and we ignore such international developments at our peril. In 1992, John McInerney predicted the emergence of a dual structure within farming, with “quality agriculture” becoming increasingly differentiated from “commodity agriculture” as two distinct strategies for farm business survival.⁴ Although somewhat simplistic, this view does underline the point that different attributes of products will be weighted differently in different markets.

Hazard analysis: What are the issues?

If we view applied research in a risk analysis framework, the first step is to identify the hazards. For example, issues likely to impact acceptance and demand for pork include the following:

- Food safety
- Antimicrobial resistance and use
- Animal welfare
- Environmental impact
- Ethical opposition to meat consumption
- Emerging diseases
- Overnutrition and dietary trends
- Genetically modified feed/food

To paraphrase New Zealand’s Prime Minister, Helen Clark, most of these are “bleedingly obvious”—the tropi-

cal storms that have been forming, threatening, and in some cases striking, over the last decade. Others are more remote and may never have a consequential impact on US swine producers—but do seem to be edging closer. The challenges are to predict the following:

- Which of these issues, if any, might be the “big one”
- The issues’ relative impacts, which will differ between the national and international arenas, and over time
- Temporal priorities and likely effects in the short and long terms
- The extent to which better factual knowledge can influence consumer, commercial, regulatory, and producer responses to each issue

Regulatory and commercial gatekeepers and autoregulation

Before reflecting on some of these hazards, it is important to acknowledge the processes by which they may be addressed. It is always worthwhile to recall that the purpose of economic activity is consumption and not production, and that it is consumer preferences that confer value. Consumer perceptions of our products and industry are an amalgam of their perceptions of both intrinsic product attributes (e.g. price, flavor, utility, etc.) and extrinsic attributes (e.g., animal welfare, environmental impact, antibiotic use, etc). Although deliberate blurring of issues can be an effective tactic of groups that are philosophically opposed to animal production, achieving solutions that are acceptable for both producers and consumers requires that the issues be teased apart and assessed with the greatest possible objectivity. However, it is self-evident that measures introduced to address any individual issue will almost invariably have negative consequences for other concerns, and a holistic perspective must be maintained.

Simplistically, management at any level involves both setting and achieving (enforcing) standards with respect to some measurable characteristics of a system. For societal issues, if these are not readily addressed by free market forces driven by actual consumer behavior (purchasing decisions), the management functions will be entrusted to, or assumed by, regulatory authorities or commercial entities, or established by producers themselves (e.g., industry codes of practice). Historically, under the commodity industry model, either farmers have been assumed to be doing the right thing or government authorities have been the gatekeepers charged with assuring that food production was conducted in a manner that was consistent with consumers’ wishes. Over the last decade, public confidence in the production sector has been eroded and food suppliers have moved in the direction of quality assurance and product differentiation. Driven by market considerations, we have seen entities such as supermarkets

and fast-food chains assume roles as gatekeepers for consumers, particularly in relation to animal welfare standards. Recently, in line with approaches taken by McDonalds,¹ Kentucky Fried Chicken has adopted guidelines and audits for the humane raising and handling of poultry that include specifications for training of poultry supplier personnel, appropriate comfort and shelter (including space allowance), health care of the chickens, and transportation.⁵ In early July 2003, McDonalds adopted a policy to prohibit its meat suppliers from using antimicrobials as growth promotants in animals.⁶ The expansion of such “marketing driven” commercial gatekeeping is inevitable as public scrutiny of animal production increases, and particularly if there is a perceived vacuum of government regulation and industry standards and compliance. I would argue that the more remote the gatekeeping responsibility is from the production sector, the less weight will be given to animal science research and to the practical compromises that are inherent when any standards are imposed. This underlines the importance of industry initiative in developing and implementing changes that deliver standards acceptable to the wider community. The foundation for such change should be objective scientific information.

Food safety

Despite its high profile, I see food safety as the least problematic “hazard” because it is an issue where the interests of all parties are closely aligned. Nobody questions that food safety is critical to the viability of any food producing enterprise, and we are all familiar with how outbreaks of animal or human disease (e.g. BSE, *E. coli* O157:H7), contamination incidents (dioxin and medroxyprogesterone in Europe), and product recalls (e.g., Hudson Meats) have shaken consumer confidence in food safety around the world. We have now experienced over a decade of elevated public concern and debate about the safety of the food supply, and particularly of meat products. Clear messages emerging during this time are these:⁷

- Food safety is a highly political arena, nationally and internationally
- Food safety concerns can provoke radical reactions from consumers
- Food safety concerns can result in profound regulatory responses
- These responses can occur in the face of uncertainty and with a low threshold of scientific evidence (e.g., BSE; paratuberculosis and Crohn’s disease; chronic wasting disease)
- Perceptions are largely driven by disease outbreaks, which can occur at any time and affect any industry!

An estimated 76 million annual cases of foodborne illnesses in the US bear witness to the fact that systems for food safety assurance in developed countries have not met expectations of the level of protection required against such diseases.⁸ Pivotal outbreaks in 1992-93 (e.g., *E. coli* O157:H7 “Jack-in-the-Box” restaurant outbreak in the US; *Salmonella* Infantis outbreak linked to pork in Denmark) contributed respectively to the passing of the HACCP/Pathogen Reduction Act in the US in 1996 and the implementation of a national *Salmonella* control program by the Danish swine industry.⁹ These were major milestones in a paradigm shift that questioned the efficacy of traditional meat inspection systems and drew attention to the responsibilities of the animal production sector in reducing the risk of foodborne disease. The “farm-to-table” concept (acknowledging that all participants in the continuum of food production and consumption bear some responsibility for reducing the risk of foodborne disease) emerged as the fashionable paradigm for food safety. However, the high level of consensus about the appropriateness of the farm-to-table approach has not been matched by meaningful analysis of how this can be most efficiently realized. In particular, a degree of naiveté has been evident in assumptions about the feasibility and efficacy of preharvest control of enteric foodborne pathogens. Despite the popular appeal of preharvest control of foodborne hazards, the “Mega-Reg” stopped short of involvement at the preharvest level. The likely wisdom of that decision resides in the fact that, at that time, epidemiologic knowledge of most (at least bacterial) foodborne hazards in animal populations was inadequate to enable reliable and cost-effective control measures to be mandated.

There is no question that the industry must never become complacent about food safety, as single events can have monumental impact. However, in my opinion, the “food safety hurricane” has already struck and, in the wake of the storm, three developments are notable:

US pork-related outbreaks have been low

The US swine industry has remained relatively unscathed by high profile outbreaks. Data from the Center for Science in the Public Interest linked pork products to only 3% of foodborne outbreaks from 1990 to 2001.¹⁰ The total of 44 outbreaks linked to pork products was considerably less than those for other major animal food products (340 for seafood, 271 for eggs, 134 for beef, and 79 for poultry). While one may question whether this is due to good luck or good management (or is an artifact of reporting that excludes sporadic cases), changes in swine production systems have reduced the prevalence of some important foodborne pathogens in our industry.^{11,12} Other pathogens remain prevalent in the production sector, and risk reduction is primarily contingent upon interventions later along the food supply continuum.

Preharvest interventions have had limited efficacy

Considerable research into the epidemiology and control of foodborne pathogens, particularly *Salmonella*, during the production phase has reinforced that preharvest control of enteric organisms is not straightforward.¹³ For biological hazards with relatively complex ecologies, it is unrealistic to expect simple interventions (particularly far “upstream” from consumers) to provide adequate protection. Preharvest control holds most promise for hazards that have relatively simple epidemiology (i.e., limited modes of transmission), including minimal risk of cross-contamination and inability to replicate in products, and most specifically for those where potential for “downstream” contamination (i.e., after leaving the farm) is minimal. Producers and their suppliers bear the major responsibility for risk reduction for chemical or physical hazards, and the recent European disasters with dioxin and medroxyprogesterone acetate highlight the importance of adequate quality control systems in the supply of animal feeds. However, in the light of current epidemiologic knowledge, availability of effective interventions, and probability of downstream contamination, it is hard to make a strong case for preharvest control as a key strategy for enteric foodborne pathogens (*Salmonella*, *Yersinia*, *Campylobacter* or *Listeria* spp.) in swine production systems. Collectively, preharvest interventions to control enteric foodborne pathogens in pigs are characterized by uncertain efficacy and undocumented costs, coupled with a relatively high probability of post-intervention contamination. This situation obviously presents an opportunity for innovative research, but the likely prospect of low return on investment must be acknowledged.

Irradiation is becoming increasingly important

Thirdly, we are in the midst of a revolution in public acceptance of irradiation of meat products. The number of supermarkets offering irradiated meat products has increased from 84 to around 7,000 in less than three years; about 2,000 restaurants now serve irradiated meat; and irradiation of meat is approved for the school lunch program. Despite the overwhelming weight of scientific opinion in favor of irradiation as a food safety tool, and well-articulated arguments for its implementation,¹⁴ public and regulatory acceptance has been painfully slow. Osterholm and Potter (1997) pondered the reasons why public health and industry bodies were both slow to move on this issue. The acceptance of irradiation provides a quantum leap forward towards rational implementation of technology to reduce the risk of foodborne disease, with particular application to higher risk products (e.g., comminuted or ready-to-eat). Irradiation of meat also provides an excellent case study of the frustrations of integrating science into a political framework for decision-making. Similar frustrations will be encountered on any issue where strong ideological opposition exists, regardless of the strength of scientific evidence. In the area of international

trade, European bans on hormonal growth promotion and genetically modified food are good examples.

With food safety, we are now entering a more mature era in which appropriate risk management strategies that are product- and/or pathogen-specific can be developed and implemented. Part of this process will be better risk communication and acceptance of the fundamental message that our food supply can never be free of risk. Technological advances promise to deliver systems of traceability and information management to form the basis of powerful quality assurance systems.¹⁵ These will include preharvest components that for some pathogens will be a platform for food safety assurance.¹⁶

Antimicrobial resistance

There are reasons why the 35 year old debate about antimicrobial resistance and antimicrobial use in food animals rages on. Despite the furore, I do not believe that we have gained much ground in solving the central question: To what extent does the agricultural (including food animal) use of antimicrobials contribute to the problem of antimicrobial resistance in human pathogens? The issue has been endlessly reviewed and strong voices continue to be heard from both sides of the divide. As stated elsewhere, the adversarial nature of this debate has impeded the application of science-based control strategies.¹⁷ Acknowledging these ongoing uncertainties, I offer two opinions:

First, antibiotic use in food animals does contribute to antibiotic resistance in human pathogens, primarily related to enteric foodborne pathogens.

Second, with respect to the incidence of clinical treatment failures of humans due to antimicrobial resistance (i.e., the ultimate concern), cessation of antimicrobial use in animal production would result in a reduction in incidence that would be immeasurably small.

While this issue is generic across livestock production, different industries face different costs and benefits related to antimicrobial use and will respond differently to it. There will be winners and losers of market share of the global animal protein market because of this issue. A reasonable case can be made for maintaining the status quo regarding prudent use of antimicrobials in pig production. However, taking an entrenched position on antibiotic use in pig production poses a bigger risk to industry (including veterinary) image and perception than a risk to public health. Assuming that the current pressure of vocal and articulate criticism of existing patterns of antimicrobial use in animal production will only increase—and obtain considerable scientific support from Europe—this is an issue on which I believe the industry is on “a hiding to nothing.” The likely drawbacks and unintended consequences of precipitate action in withdrawing antimicrobials are increasingly evident,^{6, 18} and such an ap-

proach would have significant animal health and welfare implications in the US, particularly given the generally younger ages of pigs at weaning. Developing robust alternatives to enable reductions in antibiotic use is a major priority for applied research in this country, including identifying opportunities for reducing use that will least impact animal health, welfare, and productivity.¹⁹ Part of the overall strategy will involve differentiation and certification of production systems as part of a market-based response (probably through commercial gatekeepers). Over the next five to ten years, our energies may be better directed at constructively altering our production systems to achieve a material reduction in antibiotic use than taking an entrenched position in a battle that may not be winnable.

Animal welfare

Animal welfare is arguably the most contentious issue confronting food animal producers in developed countries. There is no question that the public profile of animal welfare, particularly in Europe, has identified the need for more applied research, and that measurement of animal welfare (a prerequisite for objective setting of standards) is much more problematic than for the other issues identified. Broad societal consensus on what constitutes acceptable standards of animal welfare in any scenario (e.g., animal production, research, or recreation) cannot be expected. The diversity of personal values coupled with widespread public ignorance of animal welfare science and of animal production in general, precludes a free market solution for managing animal welfare.

Mellor and Stafford (2001)²⁰ presented an insightful review of practical and ethical issues in implementing changes in welfare regulation, and compared “gold standard” and “incremental improvement” models for achieving welfare goals. In the gold standard model, an ideal (target or standard) is defined for a particular situation, and nothing less than that ideal is acceptable. In the incremental improvement model, the aim is to improve upon existing standards of welfare in a step-wise fashion by setting a series of achievable goals that progress towards the ideal. The authors make the case that the incremental improvement model is preferred. If the production sector displays a high level of inertia in the face of mounting criticism of current systems of animal production, it is inevitable that other gatekeepers (government or commercial) will impose ideals for animal welfare (i.e., the gold standard approach). These authors also point out that compromises between competing welfare factors (i.e., competing needs of animals) should be expected when welfare related measures are implemented.

McInerney (2002) used a generic economic framework to discuss the inevitable conflict between the human benefits from improved livestock productivity and animal benefits (or perceived welfare).²¹ While it is useful to point

out the maxim that a degree of animal welfare is in the interest of producers (and there are many features of modern systems that deliver positive welfare benefits), it is equally important to acknowledge that beyond this point there are trade-offs between productivity and animal welfare (real and perceived). Judgements of what are acceptable standards of welfare in the “economically rational” area will always be value-laden, particularly when assessment of actual animal perception is so uncertain. Another specific challenge in evaluating welfare relates to incorporating the “human factor” in addition to the “bricks and mortar” variables. We are all familiar with scenarios in which high standards of husbandry can overcome apparently inferior environmental conditions, and also of the converse. We must heed the possibility that new systems designed to deliver improved welfare outcomes may be prone to fail if they are dependent on standards of husbandry that exceed the capabilities of staff employed in current systems.

Millman (2002)²² recently identified the need for research into the following:

- Understanding the needs of swine
- Valid systems for measuring animal welfare
- Developing options to correct problems with existing systems

In my opinion there has been regrettably little epidemiologic research in the US of relationships between housing and environmental factors and specific welfare problems.^{23, 24} It is also remarkable, given our personal experiences with illness, that disease and welfare are typically addressed in separate conversations. The animal welfare benefits that have accrued from successful veterinary efforts to prevent disease in swine populations are not often acknowledged, even within the veterinary profession.

Mirroring international trends, sow housing systems (and particularly gestation stalls), are predictably under mounting scrutiny.^{25, 26, 27} This is an issue on which the gold standard and incremental approaches can be illustrated. Outright banning of gestation stalls, as implemented in the UK, constitutes a gold standard approach. However, an incremental approach that addresses both the quality (e.g., crate vs. sow dimensions),²⁴ and quantity (e.g., using a combination of stalled and pen gestation)²⁷ of sow experience in gestation stalls has the potential to deliver a considerable improvement in real and perceived sow welfare with less impact on production efficiency, and possibly a lower risk of unfavorable welfare outcomes due to husbandry failures. A significant research challenge is to validate systems for sow housing with respect to specific animal welfare outcomes,²⁸ and to develop innovative approaches that achieve tangible changes in existing systems. In the near future, other items likely to be increas-

ingly under the welfare microscope include weaning age, and all routine management procedures such as castration, tail docking, and teeth clipping.

As with the scenario for antimicrobial use, the biggest short-term risk to swine producers with respect to animal welfare is precipitate commercial or regulatory gatekeeping that adopts a gold standard approach. In the longer term, reduced end-consumer acceptance could have comparable or greater impact. Both these developments will be more likely if the industry adopts entrenched positions and displays resistance to change. Ultimately, applied research should be responsible for enabling changes in production systems to deliver real rather than perceived welfare benefits.

Ethical opposition to meat consumption

Ethical opposition to meat consumption is far from new and, based on trends in per capita meat consumption in the US and abroad, appears to be gaining little ground. Although some surveys suggest an increasing prevalence of vegetarianism and veganism in the US, the survey methodology applied in different years has not been constant.²⁸ However, it was recently estimated that 5.7 million American adults are now vegetarian, of which some 2.4 million may be vegan.²⁹ It is important to remember that vegetarianism and ethical or philosophical opposition to meat consumption are not synonymous. Decisions not to consume animal products are based on criteria more diverse than philosophical objection to eating animal products. In addition to those who shun meat purely because of dietary preferences, for others the choice of a vegetarian lifestyle may have religious or cultural foundations that are independent from the more contentious issues we confront. There is little evidence to suggest that mass adoption of vegetarian or vegan lifestyles poses any imminent or mid-term threat to the viability of food animal industries. Of far greater significance will be the more subtle shifts in the dietary preferences of the masses of omnivorous “swing voters” whose food consumption patterns will shift quantitatively and qualitatively in response to their perceptions of food animal industries. The crucial issue therefore is how these perceptions are formed.

If we accept that the Internet is becoming an important theater for exchange of opinion, it is an interesting exercise to search the web with key words such as “meat consumption.” The following items were at the top of a web search (May 25, 2003) on “meat consumption.”

- Beyond beef
- Vegan-politix
- Hoover museum—wheatless Wednesdays
- How to win an argument with a meat-eater
- The dangers of meat consumption

- Buy *Meat Consumption in the European Community* at amazon.com
- The consequences of eating meat
- Worldwatch Institute position paper opposing meat consumption
- Meat consumption may not increase breast cancer risk
- International vegetarian union—does meat consumption corrupt the eucharist?

The most neutral items that emerged were an advertisement for a book on meat consumption patterns and a report that meat consumption may not increase breast cancer. The remainder presented a range of perspectives and arguments opposing meat consumption and/or the meat industries. A key question that arises from this exercise is whether our conventional approaches for disseminating academic research are adequate for conveying scientific information to a broad public audience.

Overnutrition and dietary preferences

I believe that overnutrition (obesity) is the hazard that best fits the “hurricane” analogy. The World Health Organization (WHO) describes obesity as “one of today’s most blatantly visible yet most neglected” diseases. By 2020, an estimated two-thirds of the global burden of disease will be attributable to chronic diseases, most of which are strongly linked to diet.³⁰ The major factors implicated in this problem are increased consumption of refined foods, foods of animal origin, and increased fats, in concert with non-dietary factors (e.g., inactivity, tobacco and alcohol use). More than half of US adults are overweight or clinically obese,³¹ and US per capita energy intake is estimated to be 3800 kcal, compared with an average recommended intake of 2000 kcal. A recent Joint WHO/FAO expert consultation report proposed that nutrition should be placed at the forefront of public health policies and programs to combat obesity.³² There is considerable scientific advocacy for a shift to largely plant-based diets as an appropriate nutritional strategy for the obesity problem.³³ However we can always depend on some diversity of opinion among nutritionists, and a “hunter-gatherer” diet that is rich in lean meat, fish, fresh fruit, and vegetables has also been promoted.³⁴

This is a storm that has gathered a lot of force, and it is not the time for denial by consumers and producers alike. In the same way that it is harsh to condemn Bolivian leaf growers for US cocaine problems, US farmers have striven to deliver an abundant and affordable supply of safe food. However, criticisms of marketing in some sectors of the food industry have a familiar ring to those criticisms voiced during decades of the tobacco debate.³⁵ A successful public response to the obesity problem is contingent on research and innovation in the food industry to deliver products with low energy density and better nutritional

quality, greater responsibility in marketing by the food industry, and regulatory policies that will influence agriculture.³⁶ Substantial impact on all meat industries is an inevitable outcome of any successful strategy against overnutrition. Concern on this issue is tempered by strength of conviction that pork can be an integral component of healthy and nutritious diets.

It is often stated that the grocery cart is a powerful weapon, and there have been two recent developments that illustrate the impact of shifts in dietary patterns on meat prices. Over the last two years, strong growth in demand for bacon and increased prices for pork bellies has been attributed in part to greater use of bacon in fast food restaurants to add flavor to beef items that are now cooked longer due to concerns with *E. coli* O157:H7. Similarly, changing consumer demand towards leaner cuts of beef has had considerable impact on beef markets, particularly demand for older animals. These are examples where recent food safety and nutritional issues have, indirectly or directly, flowed through to exert strong influence on markets.

Emerging diseases

In both the human medicine and veterinary arenas, the last 20 years have provided forceful lessons in epidemiology, microbial ecology, and evolution. Previously unknown infectious agents now rank among the most topical problems in pigs (PRRS, PMWS, Nipah virus), people (AIDS, SARS), and cattle (BSE, *E. coli* O157:H7), and further examples other abound. Many of the most important foodborne pathogens of the 1990s were unknown agents in the 1970s (or were not known to be transmitted via food). In several countries, high profile outbreaks of exotic diseases have added (with scant justification) to the groundswell of criticism of modern agricultural practices, and the specter of bioterrorism looms larger than ever before. Some epidemiologic aspects related to the emergence of new diseases in pig production have been recently reviewed.³⁷ The handling of some of these emerging diseases has attracted its share of criticism. The US swine industry needs to accept the inevitability of new or different disease problems into the future. Effective management of new or emerging problems has key platforms of prevention (biosecurity), surveillance (early detection), and response. The lack of an effective initial response to PRRS virus should be a strong lesson, and it is an important responsibility for all industry stakeholders to improve systems for identifying and addressing emerging problems.

The interface of science and politics

In summary, society faces many complex issues whose solutions involve compromise. Perspectives on many of these issues are determined by values as much as by facts and opinions. Science needs to be the foundation for de-

cision making for all parties regardless of their values, opinions, and political persuasions. We have already seen the lamentable precedent of animal welfare legislation being decided by public referendum. Apart from constituting an abdication of responsibility, such a process is likely to result in science information having the least possible weight on the outcome. The enormous potential for factual misrepresentation, both deliberate and accidental, in public debate on these thornier issues places great responsibility on scientists to demonstrate leadership to ensure that the path towards compromise is science-based. Part of this responsibility centers on reviewing the choice of target audiences and modes of communication that we have used to convey information. Our conventional approaches, targeting scientific and technical audiences, may have been appropriate for techno-managerial information relevant to the business of hog production. However, the uphill battle to integrate scientific information into broader public arenas and the political decision making process obliges us to review these behaviors. In this context, and particularly for complex issues, good scholarship in synthesis and critique of existing information may be more valuable than pursuit of marginal increments of new knowledge.

For research to take its rightful place in the sociopolitical process, it needs to be timely, credible, and effectively communicated. Timeliness will always be a constraint, particularly when an issue is complex (such as animal welfare) and pressures for rapid change are strong. Research is an incremental process that rarely can deliver universal and definitive answers, and particularly in the short term. The call for further research prior to imposing new constraints is not uncommonly challenged as an industry ploy to defer regulatory or other changes. Researchers with a long involvement (and thereby knowledge and understanding) with any industry can expect their independence and objectivity to be challenged.

The number of storms looming large on the radar screens of the food animal industries indicate that significant changes to animal production are inevitable over the coming years. The ability of industries to influence the magnitude and direction of these changes towards acceptable compromises will be a function of the quality of information at hand and the manner in which it is communicated. Applied research should be a cornerstone of this process.

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