CHOICES
The magazine of food, farm, and resource issues
3rd Quarter 2006 • 21(3)
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Table of Contents

3rd Quarter 2006 — Volume 21, Number 3

A Statement from the Editors 125
Washington Scene 127
Coordinated by Tamara Wagester and Sarah Thomas, C-FARE

Articles

Theme: Resources and the Environment

Invasive Species
(*Rachael E. Goodhue and Gregory McKee, Guest Editors*)

Overview: Designing and Implementing Invasive Species Prevention, Eradication, and Control Policies: Economics, Biology, and Uncertainty 129
Rachael E. Goodhue and Gregory McKee, Guest Editors

Bioeconomic Modeling of Greenhouse Whiteflies in California Strawberries 133
Gregory McKee, Colin A. Carter, James A. Chalfant, and Rachael E. Goodhue

On the Garden Path: An Economic Perspective on Prevention and Control Policies for an Invasive Species 139
Brooks A. Kaiser

Institutional Uncertainty at Home and Away: The Case of Lemons from Argentina 143
Eduardo Romano and Suzanne Thornsbury

Invasive Species and the Depth of Bioeconomic Integration 147
David Finnoff, Chad Settle, Jason F. Shogren, and John Tschirhart

Theme: Agriculture and Trade

The Future of Animal Agriculture in North America
(*Walter J. Armbruster, Steve A. Halbrook, and Mary M. Thompson, Guest Editors*)

Overview: The Future of Animal Agriculture in North America. 153
Walter J. Armbruster, Steve A. Halbrook, Mary M. Thompson, Guest Editors

The Future of Animal Agriculture in North America 155
Steve A. Halbrook, Walter J. Armbruster, and Mary M. Thompson

Economics of Animal Agriculture Production, Processing and Marketing 159
Michael D. Boehlje

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Consumer Issues and Demand 165
Helen H. Jensen

The Global Competitiveness of the North American Livestock Industry 171
Flynn J. Adcock, Darren Hudson, Parr Rosson, Harold M. Harris, and Cary W. Herndon

Environmental Issues in Animal Agriculture 177
Charles W. Abdalla and Jennifer L. Lawton

Community and Labor Issues in Animal Agriculture. 183
Peter Goldsmith and Philip L. Martin

Policies to Protect Food Safety and Animal Health 189
H.L. Goodwin, Jr., F. Dustan Clark, Dawn Thilmany, and Sandra J. Hamm

Animal Welfare 195
David Blandford

Grab Bag

Comparison of a Fixed and Variable Corn Ethanol Subsidy 199
Wallace E. Tyner and Justin Quear

Coming Attractions 203

Setting the Stage for the Next Farm Bill: No Easy Choices / *James Richardson, Guest Editor*

Animal Identification / *David P. Anderson and Larry Falconer, Guest Editors*

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The magazine of food, farm, and resource issues
3rd Quarter 2006 • 21(3)
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A Statement from the Editors

Welcome to our ninth issue of *Choices* (Q3 2006).

In this issue of *Choices,* we offer two collections of papers. One covers economic issues associated with the invasion of foreign pest species. The other addresses the future of the livestock industry, including possible changes, key unknowns, and policy/business strategy alternatives. This issue also contains an article on ethanol subsidies.

Look for future issues where we plan coverage on the Farm Program, Animal ID, Illegal Immigration, Water Quality, Returns to Research and Extension, Produce Marketing, and Food Quality Assurance. See our thematic coverage page at www.choicesmagazine.org for a complete list and planned schedule.

In light of the AAEA Board's decision regarding *Choices*' funding and the uncertainty as to whether another funding source will allow continuation, the editors will no longer accept new thematic proposals. Our schedule is full through June 2007 when our editorship ends. Proposals currently in process will be moved through to publication. This policy will continue unless funding conditions change. Grab bag submissions will continue to be processed until all issues through June 2007 are full. We encourage you to submit single articles for the "Grab Bag" section of *Choices*. For submission requirements, see www.choicesmagazine.org

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Choices is the outreach vehicle of the American Agricultural Economics Association (AAEA) and is designed to provide current coverage regarding economic implications of food, farm, resource, or rural community issues directed toward a broad audience. *Choices* publishes thematic-oriented groupings of papers and individual papers. The broad themes we will repeatedly visit in *Choices* are agriculture and trade, resources and the environment, consumers and markets, and agribusiness and finance. Submitted manuscripts are subject to peer review for publication consideration.

Choices is published at the end of each quarter of the year by the American Agricultural Economics Association. Visit our web site at http://www.choicesmagazine.org.

Editorial Communications

Potential manuscripts, thematic proposals, and comments can be submitted through http://www.choicesmagazine.org/submissions.htm or directly emailed to the editors at Choices@ag.tamu.edu. Editorial communications can be sent to Choices@ag.tamu.edu.

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Washington Scene

Coordinated by Tamara Wagester and Sarah Thomas, C-FARE

As Congress prepared for the August District Work Period, Washington, DC was busy with activity throughout the summer.

Research

Research issues remain in the sights of members as Congressman Gil Gutknecht (R-MN) introduced HR 5832 on July 19 to establish a National Institute of Food and Agriculture. This legislation is a complement bill to S 2782 introduced on May 10 by Senator Jim Talent (R-MO) and Senator Tom Harkin (D-IA). The major difference between the two bills is that H.R. 5832 would provide mandatory funding by using Commodity Credit Corporation (CCC) authorities, while S 2782 authorizes appropriations.

The Federal Funding Accountability and Transparency Act of 2006, or S 2590, was introduced by Senator Tom Coburn (R-OK) on April 6. The legislation was approved by the Senate Homeland Security and Governmental Affairs Committee on July 27 and authorized the creation of a comprehensive Internet database that requires full disclosure of all individuals and organizations receiving federal funds. On June 21, The US House of Representatives passed a similar bill with HR 5060. The House bill does not require the database to include information on federal contracts, which has attracted criticism from watchdog groups.

Farm Bill

The Farm Bill is also of continuing interest to both policy makers and stakeholders. On July 27, 2006 the House Agriculture Committee Subcommittee on Conservation, Credit, Rural Development, and Research Subcommittee held a hearing on current conservation programs in preparation for the 2007 Farm Bill. The Senate had their first hearing addressing conservation issues on June 7, 2006.

The Administration is also preparing for the Farm Bill debate. On August 8, Agriculture Secretary Mike Johanns released an analysis prepared by USDA economists of the department's renewable energy and energy efficiency programs. This is the fourth in a series of subject areas that warranted a comprehensive examination based on comments received during last year's nationwide Farm Bill Forum listening tour.

Trade

Trade discussions continue to be an important focus in Washington, DC. On July 20, House Agriculture Committee Chairman Bob Goodlatte (R-VA) held a hearing to review H.R. 3849, which was introduced in September 2005 by Congressman Frank Lucas (R-OK). The bill will "amend the Federal Insecticide, Fungicide, and Rodenticide Act to implement pesticide-related obligations of the United States under the international conventions or protocols known as the PIC Convention, the POPs Convention, and the LRTAP POPs Protocol." This legislation is necessary to ratify three international treaties regulating the use of chemicals to protect human and environmental health. According to a Committee Press Release, until the U.S. ratifies the treaty, which is dependent on passage of H.R. 3849, U.S. negotiators cannot participate in the discussions to modify the current agreements. On July 27, 2006, the House Agriculture Committee passed HR 3849 and sent it to the House floor with a favorable recommendation.

Lawmakers were very pleased with the July 27 announcement from Japan that they will resume imports of U.S. beef from cattle 20 months of age and younger.

Many of the recent Trade and Farm Policy discussions were led by Dr. J.B. Penn, Under Secretary of Agriculture for Farm and Foreign Agricultural Services. On August 8, 2006, the Secretary of Agriculture announced Dr. Penn's resignation effective at the end of August.

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Conservation

Senate Energy Committee Chairman Pete Domenici (R-NM) introduced S.3711, The Gulf of Mexico Energy Security Act of 2006, on July 20. This legislation is designed to open up between 2.9 million and 8 million acres in the Gulf of Mexico to offshore oil and gas drilling. S.3711 passed the Senate on August 1 by a vote of 71 – 25.

Meanwhile, on July 19 the House Resources Committee considered 23 bills, focused on wildlife, land, and water legislation. The Committee voted support for HR 4857, the "Endangered Species Compliance and Transparency Act." This bipartisan legislation, sponsored by Rep. Cathy McMorris (R-WA), requires Power Marketing Administrations to list direct and indirect cost estimates associated with Endangered Species Act (ESA) compliance.

The Secretaries of Agriculture, Interior, Commerce, the Administrator of the Environmental Protection Agency, and the Chairman of the White House Council on Environmental Quality announced the dates and locations of the second set of listening sessions on cooperative conservation and environmental partnerships.

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Overview: Designing and Implementing Invasive Species Prevention, Eradication, and Control Policies: Economics, Biology, and Uncertainty

Rachael E. Goodhue and Gregory McKee, Guest Editors

JEL Classification: Q18

As discussed in the other contributions to this themed set of articles, invasive species may disrupt trade flows, management of natural resources, and agricultural production. An invader may be used as the justification for erecting a barrier to trade. Fishery stocks can be decimated by an invader, requiring the recalibration of quotas, seasons, and other policy instruments. Agricultural yields or output quality may be reduced by an invader. Because of the potential for deliberate introduction, invasive species policy is even a relevant issue for policymakers addressing terrorism.

Invasive species represent a unique challenge for policymakers and for economists analyzing optimal pest control policies because of the uncertainty regarding the effects of an invasive species on pre-existing biological and economic relationships. By definition, an invasive species problem involves the invader's biological and economic interactions with the invaded ecosystem and economic agents involved in that ecosystem. The primary theme unifying these articles is that critical mistakes regarding policy choices can be made if relevant economic and biological relationships are not incorporated into analyses of policy options. Each article identifies a key lesson for invasive species policy analysis.

Modeling the Depth of Bioeconomic Integration

Finnoff et al. explore the importance of choosing the correct degree of integration within a bioeconomic model. As in McKee et al., in order to address a bioeconomic policy question, feedback between the two systems must be incorporated into the model. Finnoff et al. introduce a bioeconomic model with multiple feedback loops. They examine the effect of imposing quotas on pollock harvests in the Bering Sea in order to increase populations of the endangered Steller sea lion. Fishing quotas affect the market for pollock; in order to estimate the net welfare impacts in this market, the demand for pollock must be included in the bioeconomic model.

Limiting the analysis to this set of bioeconomic relationships would distort the overall welfare analysis in an important way; it does not place any value on the sea lion population, but simply takes it as the source of an exogenous biological constraint on the system, which requires the imposition of fishing quotas. The authors incorporate a second set of bioeconomic relationships that address this problem: the market for wildlife tourism in the Bering Sea,

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which benefits from increased populations of the Steller sea lion and other marine mammals. Ignoring these relationships would have two effects: first, the sea lion population would either be exogenously specified or chosen as a function of biological relationships alone, and second, the benefits of quotas would be underestimated since the value to marine tourism would be ignored.

The primary lesson from this analysis is that all relevant markets must be included in the bioeconomic model. A further implication is that all relevant biological relationships must be included in the model.

Integrating Prevention and Control Policies for an Invasive Species

Kaiser discusses problems stemming in part from the structure of U.S. invasive species policy. First, responsibility for invasive species policy is divided among a large number of agencies, which discourages the development of an integrated approach to prevention and control. Conceptually, this problem is driven in part by the tendency for prevention efforts to be targeted at preventing the anticipated economic and ecological losses that a given potentially invasive species may cause, while management and eradication efforts tend to be driven by the irreversible changes to ecological systems that are realized after the successful establishment of an invader. One result of this fragmentation is that resources are not allocated efficiently across species, or across prevention and control efforts for a given species. Coordinating policy across agencies, or consolidating mandates within fewer agencies, could increase the benefit of funds currently allocated to prevention and control efforts.

The economic and ecological costliness of the fragmentation of policy responsibility can be represented fully only in a bioeconomic framework. Kaiser illustrates this using the case of an invader to a closed ecosystem: the brown tree snake in the Hawaiian Islands. Limiting attention to biological factors might result in research and policy efforts directed only at preventing an invasion, in part because an earlier brown tree snake invasion on Guam has proven to be ecologically catastrophic. In the case of the brown tree snake, such efforts focus on preventing the introduction of additional specimens through materials transported from Guam. Given that prevention is by nature imperfect, however, some brown tree snakes will escape detection and enter the Hawaiian ecosystem.

Once introduced, the species requires control efforts. Because the marginal cost of control increases as the population declines, optimal policy requires the net benefit of preventing an additional snake from entering the population equals the net benefit of removing an additional snake from the existing population. Hawaiian expenditures on prevention and control are significantly distorted, relative to the point where this relationship would hold.

Hawaiian efforts regarding the brown tree snake approximate the case where only biological parameters are considered. Current annual expenditures on prevention are about $2.6 million, while expenditures on control are about $76,000. These limited control expenditures have proved insufficient to identify and reduce the existing population to optimal levels; instead, snakes that have escaped prevention efforts are able to reproduce and increase the population. (Of course, the alternative possibility is that prevention efforts have proven perfectly effective and there is no existing population. However, this seems statistically and scientifically unlikely.) The distortion in prevention and control expenditures will ultimately result in a larger Hawaiian brown tree snake population than would be the case if the same total expenditure was optimally allocated.

Value of Information and Methodological Choices in Bioeconomic Modeling

McKee et al. address one manifestation of the heightened uncertainty facing policymakers regarding an invasive species problem, relative to an established pest problem. Often, policy decisions must be made when relatively little information is available, be it in the form of experimental data regarding the specific invasive species problem or otherwise. In this event, methodological choices become critical because the role of method-driven assumptions cannot be limited by data. Often, due to data limitation, analysts construct simple reduced-form population models where current population levels are estimated based on past population levels. The authors illustrate the cost of this specific methodological choice in the context of a specific invasion: the greenhouse whitefly in California strawberries.

The authors construct two bioeconomic models of the greenhouse whitefly-strawberry relationship. The economic components of the models are identical, as is the relationship governing the effect of the whitefly population on strawberry yield. Only the models of the whitefly population differ. One is a reduced-form

autoregressive model that relies only on experimental data to predict the development of the whitefly population as a function of its previously observed levels. The second is a structural simulation model that incorporates information regarding determinants of the whitefly's life cycle from the scientific literature, as well as the experimental data regarding observed population levels.

The two models are compared to the observed data. While both describe the overall pattern of population peaks and troughs reasonably well, the structural simulation model does a more accurate job of representing the magnitudes of the peaks and troughs. This suggests that incorporating data from other sources and constructing a structural simulation model can improve the descriptive power of bioeconomic models, at least in some circumstances. More critically, the authors demonstrate that this difference in the models causes growers to respond differently to regulations regarding pesticide use for whitefly control in strawberries. Using the reduced-form model, the cost per acre to a grower of the regulation limiting the number of applications of a specific pesticide to two per season is $2,500, while under the structural simulation model it is $2,100, a difference of $400 dollars per acre. This difference in the estimate of the cost is substantial, equaling about 10% of profits under the grower's unregulated profit-maximizing choice. When balancing the costs of the regulation against its benefits in terms of reducing the development of resistance, the cost will be overstated.

Institutional Uncertainty and Bioeconomic Systems

One motivation for the erection of agricultural trade barriers is the possibility of an invasion of a pest or disease that may negatively affect production in the importing country. Romano and Thornsbury examine a specific case: a U.S. ban on the importation of Argentine lemons due to diseases not present in the United States. In efforts to get the ban removed, Argentina's citrus producers developed a set of institutions to develop and implement a systems approach to phytosanitary regulation.

A systems approach to invasive species policy involves multiple control steps at different stages of production and marketing. The use of multiple, sometimes independent, control steps is intended to reduce the risk of an invasion. Successful implementation of a systems approach can be technically and politically difficult. Technically, a systems approach requires an understanding of the production and marketing chain, as well as the biology of the crop and pest in question. Institutions must be capable of mastering these technical elements and be able to undertake multiple control steps. Politically, the feasibility of implementing a systems approach in order to enable the removal of a trade barrier depends on the credibility of the institutions regarding their ability to master these technical requirements, as well as on the political influence of competing interest groups and the parameters set by international trade rules.

Such political considerations are made more powerful by uncertainty. When information regarding a bioeconomic system is incomplete, then a systems approach to regulation must be implemented based on the information available. Different stakeholders may assess the costs of the resulting risks, or even the risks themselves, very differently. Romano and Thornsbury identify U.S. growers' reluctance to allow imports based on information provided by U.S. and Argentinian institutions as "institutional uncertainty." Concerns regarding the quality and quantity of the provided information have played an important role in the still ongoing trade dispute. Clearly, when deciding how much information to obtain prior to choosing a policy, the information collection decision should be guided by the economic consequences of making a mistake, and the cost and likelihood of doing so as a function of the amount of information collected.

Lessons for Policy Analysis

Bioeconomic modeling provides a means of incorporating known information into a single decisionmaking framework. There is a great deal of uncertainty regarding the bioeconomic relationships determining the optimal policy response. The analyses in this set of articles derive four specific lessons regarding the use of bioeconomic models in invasive species policy analysis: First, all relevant economic and biological relationships must be included in the model in order to get a full picture of the benefits and costs of potential policies. Second, a complete analysis of policy choices regarding potential invasions should include not only the optimal management, eradication, or prevention policy, but a comparison of these optimal solutions that balances the marginal benefits of funds allocated to each activity. Third, methodological choices will affect estimates of these marginal benefits; alternatives

to statistical methods that can incorporate additional information should be considered. Simulation models provide a means of identifying the unknown parameters that are most likely to affect the choice of the optimal policy solution. Finally, information collection efforts should be guided in part by the projected costs and probability of making policy mistakes in the absence of this information.

In sum, invasive species policymaking is a process, rather than a single decision. Bioeconomic modeling can play a role at every stage of the process, from representing the context for choosing the initial policy, identifying missing information that's important for assessing the impacts of that policy, assessing post-implementation impacts, and providing information for revising existing policies. This set of themed articles has identified guidelines for using bioeconomic models effectively in the policymaking process.

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Bioeconomic Modeling of Greenhouse Whiteflies in California Strawberries

Gregory McKee, Colin A. Carter, James A. Chalfant, and Rachael E. Goodhue

JEL Classification: Q18

When a species invades an agricultural system, policymakers and producers need ways to compare the cost and benefits of control alternatives. In this paper, we examine the greenhouse whitefly invasion of California strawberries and a set of control alternatives, along with the effects of the information included in the analytical framework.

The greenhouse whitefly invasion into California strawberries has three economic and biological characteristics that make it a particularly interesting case. First, restrictions associated with pesticides registered for use against the greenhouse whitefly (hereafter called the whitefly) create a complex management problem. Only one chemical was registered for use against whiteflies on strawberries during the harvest period, pyriproxyfen (Esteem). Furthermore, regulations limiting the number of Esteem applications to strawberries complicate management. Namely, the Environmental Protection Agency has imposed a limit that only two applications of Esteem may occur per year.

Second, the whitefly's life cycle can be modeled plausibly based on data from a single season. The resultant model can be used to study management alternatives and to guide data collection efforts for other invasive species by revealing key parameters associated with population development and interactions with economic activities. Third, the whitefly is a significant economic problem in two geographically separate California regions. The climate and other differences across these regions create different host cycles and whitefly population dynamics, which then lead to differences in decisions concerning whitefly management.

The biological, economic, and regulatory features of the invasion cause grower incentives for whitefly control to vary by region and by week. Therefore, in order to create economically and environmentally efficient whitefly management policies, an understanding is needed of a grower's profit-maximizing response to pest damages. Empirical "bioeconomic" models, which unify information on biological relationships, economic relationships, and interactions between them, are useful in developing such policies (McKee, 2006; McKee, Goodhue, Chalfant, & Carter, 2006; Eiswerth & Johnson, 2002; Knowler & Barbier, 2000).

Also, when doing invasive species modeling it is often the case that limited information is available. In this study, we examine the value of adding information first using only data arising soon after the establishment of the whitefly population and then adding other information about the whitefly's life cycle from the scientific literature.

Models of Whitefly Population Development in California Strawberries

The whitefly invasion started in the mid-1990s in Ventura County and was later observed in the Watsonville/Salinas strawberry-growing region (Monterey and Santa Cruz Counties). Though whiteflies were common in coastal California prior to that time, strawberries had not been recorded as a host.

Strawberries are grown along the California coast almost year-round. A plant is typically in the ground for approximately nine months, usually starting in the fall. Weekly yields are relatively small in the early spring, increase very rapidly in mid- to late-spring, and then taper off during the summer. The population growth rate of the greenhouse whitefly on strawberries changes throughout the season since temperature regulates maturity rate. Whitefly reproduction and population development are slowest during the coolest parts of the growing season and

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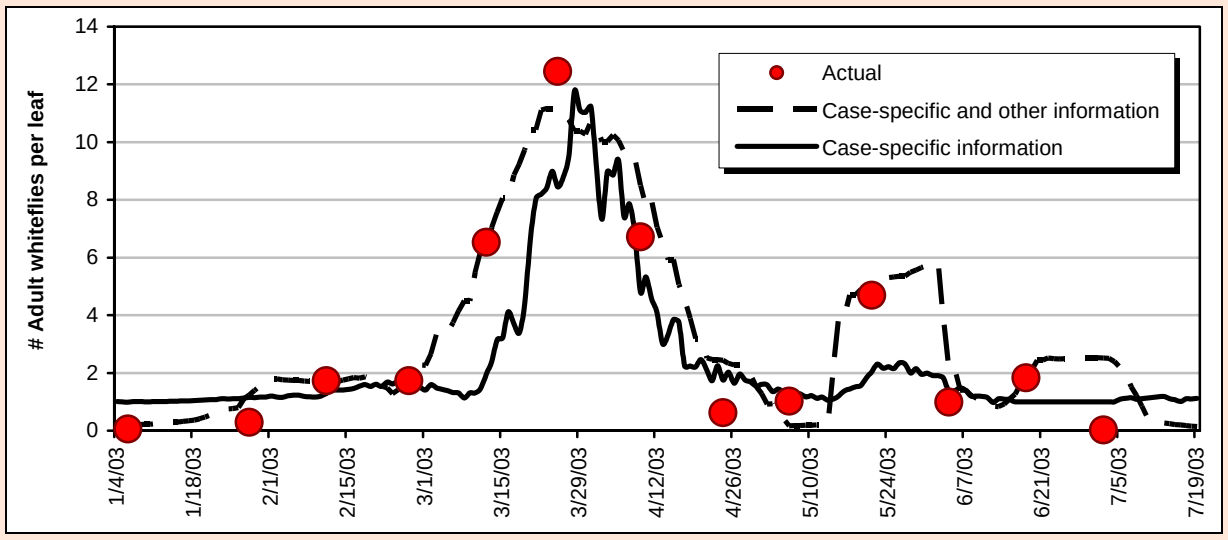

Figure 1. Modeled and observed adult whitefly populations in strawberry plants for a commercial strawberry field, Watsonville, CA (2003).

more rapid during the hotter, spring and summer months.

Alternative Approaches to Modeling

We use statistical techniques to predict the future whitefly population. Initially, we only use data from the invasion during the 2002-2003 growing season. This requires limited relatively immediate data and permits rapid model and policy development. However, it may omit important biological factors, such as variations in the population growth rate over time, if no such data are available. Later, we augment the approach with information from whitefly studies in similar environments utilizing results on various life stages. This may also be an attractive option since the costs for data collection have already been incurred, and only an analysis of emerging information is needed. However, the main question is whether data obtained from outside sources are relevant.

Thus, two models are used. The first estimates a daily adult population series using egg count data from the invasion. The second uses invasion egg, nymph (juvenile whitefly), and adult whitefly data, along with observations from other whitefly studies (Hulspas-Jordaan & van Lenteren, 1989) to inform the model about how variations in environmental conditions affect whitefly population development. The additional population data were acquired at little additional cost.

Results

In order to assess control alternatives we compare estimated net revenues, after spraying costs and population predictions, under various strategies using the two models.

Model Replication of Population

We first evaluate the model results to see which model replicates the observed data better. If the two models both adequately reflect the whitefly population dynamics, then the estimated population series should be comparable. If they are not, this indicates that information is lost when the augmenting experimental information is not used. If a significant difference is observed, then the additional information allows more accurate and effective evaluation of prospective whitefly management policies.

The solid line in Figure 1 represents the estimated adult whitefly population series from the first model; the dashed line represents the second. The 13 large dots represent the observed sample. As the figure shows, both models reasonably predict the timing of peaks and troughs in the whitefly population.

One way to more precisely compare the results of these two models is to measure the area under each curve. This area measures the size of the population and the length of time it persists, stated in units we call "whitefly-days." There were 505 cumulative whitefly-days observed in the sample. The first model (case-specific data only) predicts 430 whitefly-days (15% error), while the second predicts 564 cumulative whitefly-days (10% error). Based on this criterion, the second model generates a superior prediction.

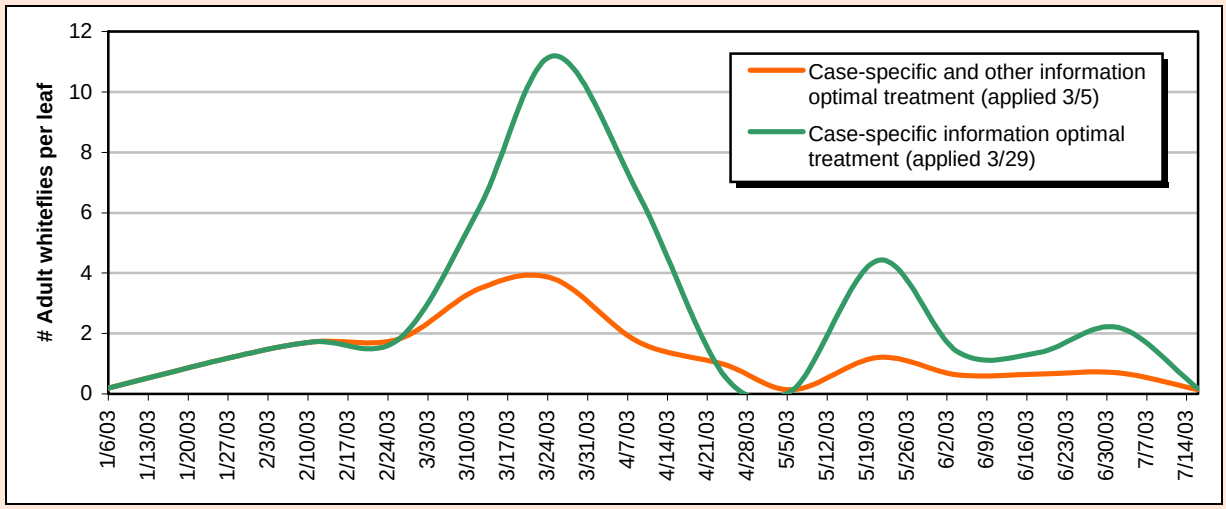

Figure 2. Whitefly population development under low/high information models.

Information and Costs of Esteem Limits

Fundamentally, what matters is not the existence of a difference in predictive power, but whether or not there is a substantive economic consequence when evaluating a policy option. To address this question, we examine net revenue and population changes caused by Esteem application restrictions. The optimal application program in each model is the one with the largest net revenues.

We first examine the difference in the model results regarding the development of the whitefly population for the case of a single Esteem treatment, illustrated in Figure 2. When using the first model, the optimal date for a single Esteem application is March 29, just after the largest observed adult whitefly population peak. In contrast, the additional information used in the second model changes the optimal pesticide application date to March 5th, just before the adult whitefly population begins to build. Prior to March 5, the populations are identical. The population generated by the March 5 application generates smaller population peaks than the March 29 application, and higher net revenues. Collectively, the more accurate model results in a difference of approximately 3% of net revenue per untreated acre.

To provide further perspective, we examine the cost of the Esteem regulation limiting growers to two or fewer applications per season. Using the second model, under two applications we get about $7,800 per acre, as opposed to about $9,500 per acre for three, a regulation cost of about $1,700 per acre. In contrast, under the simpler model the net revenues from the restricted case are about $4,700 per acre, compared to about $7,000 per acre for the relaxed case, which is a difference of about $2,300 per acre.

The added information suggests the cost of the regulations is smaller under more informed pest management, amounting to 18% versus 33% of net revenue. The benefit is partially due to the difference in the optimal spraying time, and partially due to the more accurate representation of post-treatment population development. Based on about 1,000 infested acres in 2003, the value of relaxing the application limit would have been $1.7 million, in net revenue, per year. However, additional applications would have increased the likelihood of resistance, and if complete resistance arose we estimate losses relative to the two-application case would be about $7.8 million per year. While this is obviously a very simplistic view of the implications of resistance, it illustrates how large the benefits from preventing or delaying the development of resistance can be in this specific case.

The weaknesses of the first model suggest that for decisionmaking support it would be valuable to merge experimental data on pest life cycle stages with other known information. Of course, if unlimited data were available, the performance of the first model would be augmented including other relevant variables. However, our model comparison was motivated by the often limited data available for policymakers examining invasive species policy options, as existed in the case study we examined.

What Types of Models should Policymakers and Growers use for Decisionmaking?

When a species invades an agricultural system, policymakers and growers require integrated bioeconomic

models in order to evaluate control options. When constructing these models, there is an inevitable tradeoff between implementing a control approach early in the invasion and waiting to collect data specific to the invasion in order to make a more informed decision. We have examined addressing this tradeoff by combining scientific information from other sources regarding the whitefly with available data from its invasion of California strawberries. Using readily available data and physiological models to estimate the economic harm the greenhouse whitefly causes—decreased strawberry yields—generates a more accurate whitefly population prediction than one that only uses case-specific data.

We found that the difference in the population models substantially affected the estimates of the per-acre cost of the Esteem application limit for growers. Using only data from the invasion, the cost was $2,300 per acre, or $2.3 million in the infested area. Using the augmented model, the cost was $1,700 per acre, or $1.7 million in the infested area.

Our analysis of this specific case illustrates that information on the life cycle of the pest, when available, can improve decision making. Namely, the model with more information is better able to describe the feedback between grower management decisions and the invader/host plant environment. Policymakers need to determine whether or not they need to intervene in the system. In our case, regulators were concerned about the possibility of the whitefly developing resistance to the only effective control treatment prior to the development of alternative treatments. Using the augmented model resulted in a 26% lower estimated per-acre cost of complying with the requirement of two or fewer Esteem applications in order to obtain the benefit of a decreased likelihood of resistance development. Of course, the off-setting caveat is that the modeler must make careful decisions regarding which outside information is sufficiently relevant.

For Further Information

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On the Garden Path: An Economic Perspective on Prevention and Control Policies for an Invasive Species

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JEL Classification: Q20, Q57

Economists currently use the term invasive species to denote species that arrive in a new ecological setting and spread, creating ecological and economic damages. The problem facing invasive policy managers is to select strategies that minimize the overall invasive species-related costs over time, including prevention and control expenditures and damages. This article aims to highlight the connection between prevention and control in decisions to best utilize scarce resources to fight invasive species and arises from a more extensive literature involving this author and others (Burnett et al., 2006; Olson & Roy, 2005).

Definitions and the Policy Environment

An invasive species generally causes more harm than good through its aggressive spread. Prevention efforts, however, cannot always identify distinctions between harmful, beneficial, or benign introductions, nor intercept all introductions, and are thus more risky policies compared to controlling a known invader. Thus, risk-averse managers often prevent too little (Finnoff et al., 2006, in press).

Opportunities for efficient management of invasive species from arrival to adaptation are missed in a web of overlapping mandates and complex biological and economic pathways for the introduction and spread of species. Historically, the many different avenues for invasive species propagation and intervention have led to piecemeal policy approaches to invasive species. Twenty federal agencies, from the Department of Homeland Security to NASA, administer over a dozen major congressional acts pertaining to invasive species. Executive Order 13112 (Feb. 3, 1999) acknowledged the difficulties presented by this piecemeal policy and established a coordinating interdepartmental National Invasive Species Council (NISC), but the agency has no authoritative powers, and policy conflicts and gaps remain.

Consider the differences in legislative policy:

- There are acts targeting individual species (Sudden Oak Death, Pub. L. 108-488, Dec. 23, 2004; Brown tree snake, Pub. L. 108-384, Oct. 30, 2004; Nutria, Pub. L. 108-016, Apr. 30, 2003). These exist despite the fact that there is no definitive reason to believe that these invaders are worse threats than all others; however, the targeted legislation may limit attention toward other equally damaging prospects.
- There are direct, broad mandates to reduce harm from non-native species (Plant Protection Act, Pub. L. 106-224, Jun. 20, 2000; National Invasive Species Act, Pub. L. 104-332, Oct. 26, 1996; Lacey Act, 18 USC §42). Most of these focus on preventing the introduction of new invasive species that are likely to harm agriculture or other markets or quantifiable resources.
- There are statutes that indirectly target invasive species prevention and control for the preservation of specific assets (Public Lands Corp Healthy Forest Restoration Act, Pub. L. 109-154, Dec 30, 2005; Endangered Species Act, 16 USC §1531-1539). These statutes generally apply control measures after invasion as indirect intervention for the protection of non-market amenities such as biodiversity.

As such, the biological and economic consequences of individual species *and our awareness of these species and their consequences* may generate poor allocation of resources among species. The net benefits or damages of an introduced species may vary significantly depending on

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the state of the existing ecosystem. For example, using exotic plant species for quick stabilization of denuded hillsides might bring significant benefits by mitigating massive flooding in one location, whereas introduction of the same species in another location may reduce biodiversity or water supply. Intertemporal considerations abound; today's quick fix may be tomorrow's bane.

Economic and Biological Considerations in Invasive Species Control

The problem facing invasive policy management is to minimize the expected net damages and prevention and control costs of new and existing invasions over time. This problem is also subject to the biological constraints of the species. Figure 1 illustrates how a species whose minimum viable population (E_i) is low and that grows rapidly to a large carrying capacity population (K_i) is most likely to invade successfully. One whose initial population threshold (E_n) is higher, requiring a higher initial volume of arrivals, whose growth rate is slower, allowing for more time to eradicate, control, or contain a spreading population, and whose carrying capacity population is lower(K_n), does not present the same biological threat. Furthermore, a lower initial population threshold, such as (E_i), makes eradication considerably more costly as a smaller population must be located and removed. Research and prevention policies might therefore focus on identifying and stopping species from entering based solely on their biological parameters.

However, biologically driven policies may not always target the correct species with the most efficient efforts. The biological potential of a species must be combined with economic theory and the expected damages and costs of control for the species. We discuss how the characteristics of damages and costs impact prevention and control decisions.

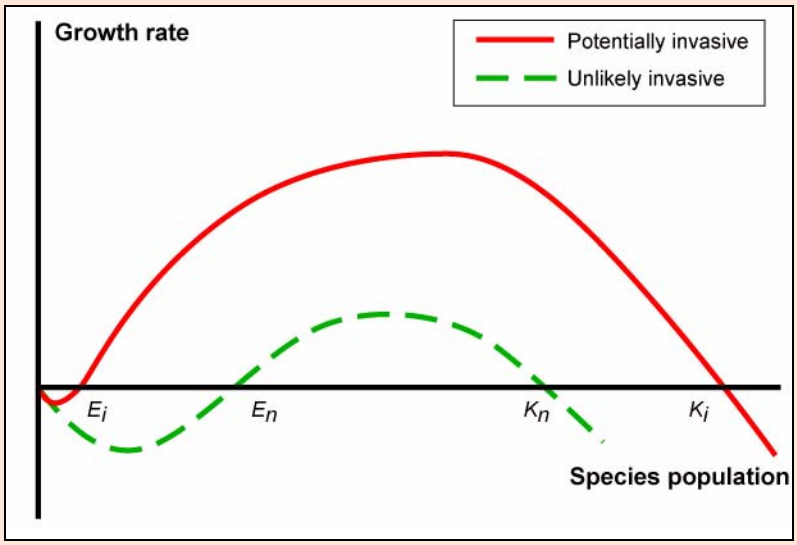

Figure 1. Role of biological growth.

Damages may be economic or ecological. Economic damages are generally in the forms of direct damages to facilities, human health, natural resources, and indirect damages from ecological change. Ecological change may commonly include losses in water or soil quality or quantity, biodiversity and resiliency losses, and productive resource losses. The expected damages are a function of the invasion size. In many cases, ecological damages may outweigh economic ones. This is likely when the value of the threatened assets is generated from biodiversity, tourism, aesthetics, and the like. Non-market valuation techniques may be necessary to establish these damages (See Loomis, 2005). We can use information on these characteristics to determine the expected damages from taking no action, or accommodating the invasion, and the benefits from control across a spectrum of invasion sizes corresponding to policy choices and expenditures.

Economic Conclusions Related to Invasive Species

Though similar to the harvest problem of any renewable natural resource (Clark, 2005), in which management weighs the net benefits of harvest (removals) today against the net benefits of future harvests, invasive species problems are more likely to involve cases where extinction is optimal policy or where accommodation of the damages, without control efforts, is the best choice. Determining the appropriate policy is particularly complicated when there are significant biological uncertainties surrounding the invasive species' capabilities in a new ecosystem and when there are difficulties in measuring resource values, such as with many non-market amenities. It is useful, therefore, to determine some rules of thumb regarding these parameters.

- Control policy must consider the overall cost of controlling an invasion.

If the net benefits from the invasive species removal (harvest) outweigh current control costs, conserving the species for tomorrow does not generate a net economic benefit, and biological extinction, or eradication, may well be the optimal policy. If the costs of harvest outweigh the damages of the population, it may be optimal to allow the species to invade unchecked. All other factors equal, lower levels of damages or high costs relative to the damages will decrease control activities, as will time-delayed damages.

- Control policy must consider the cost of controlling an invasion as a function of the size of the invasion so that the benefits of controlling or preventing the invasion may be weighed against the costs of doing so.

Once a species is established, we expect that the per pest cost of control will generally increase as the size of the population decreases. This is due to increased difficulty in detecting and removing fewer and fewer specimens from any given area. All other factors equal, the higher the costs of removal, the larger the population that will be accommodated, once present.

- The degree of rise in cost as control efforts increase also plays an important part in control policy.

A relatively flat cost structure is more likely to result in accommodation than a cost relation that drops off to lower levels at higher populations. On the other hand, fast increasing costs may favor eradication followed up by prevention of reintroduction.

- Policy should also weigh the intertemporal advantages, in terms of present discounted value, of preventing or removing an additional invasive specimen today against those of leaving the problem for tomorrow.

The role of prevention, either before an initial arrival or after a successful eradication, should also be integrated into policy formation. Prevention efforts should be based on the expected outcome if prevention fails. Since prevention is imperfect, over time the cumulative probability that a new species will evade detection and establish itself is nearly one. Prevention expenditures delay this establishment, but cannot eliminate it altogether. When prevention fails, the species will establish and begin to grow and cause damages. Thus, prevention expenditures for a given species should continue until the point where the cost of preventing the next specimen from entering is equal to the cost of controlling another specimen on the ground.

- A species' ability to spread will significantly impact the costs of control.

For example, if the species needs a relatively large population to maintain itself, as visualized by E_n in Figure 1, reducing the population to this extinction level, rather than to zero, negates further control costs, though the population is not eradicated. Optimal policy determining effort allocations between prevention and control at small population levels may involve only prevention, only control, or a combination of prevention and control, and are quite sensitive to the biological and economic parameters of the system.

- Across species, the marginal benefits of prevention and the costs of control activities should also be equal.

The relationship between prevention and control, therefore, may be quite complicated. For example, it is not clear whether prevention should be high or low for a species whose optimal control policy after establishment is accommodation; if this is the case due to control costs that are always higher than damages, in spite of high damages, then prevention should be high, in order to delay the damages. If, however, accommodation is the policy because the present value of damages is quite low, then optimal prevention might also be low.

A Case Study: Brown Tree Snake Prevention in Hawaii

The economic reasoning described here has been applied to the cases of the Brown tree snake in Hawaii with interesting results (Burnett et al., 2006). The Brown tree snake is a significant concern to the Hawaiian Islands because of its behavior on Guam over the past 50 years. Both Guam and Hawaii were snake-free islands until the Brown tree snake arrived in Guam sometime in the 1950s. Since that time, its unchecked predation has led to some of the highest snake densities known in the world, caused extirpation of 10 of 13 native bird species and caused significant economic damage to power supply and human health. Eight specimens have been intercepted in Hawaii in transported materials from Guam. A small but uncertain number may have escaped detection in Hawaii already. The carrying capacity for Hawaii is estimated at almost 39 million snakes and the damages are conservatively estimated at an average of $122 per snake per year from losses in biodiversity, power supply, and medical expenditures (Burnett et al., 2006).

It might seem that almost no amount of prevention expenditures could be too high to avoid these damages. The old adage that "an ounce of prevention is worth a

pound of cure" comes to mind, but unfortunately, it may not be true. In cases like this where prevention is focused on a small number of expected pathways, while control of a small population might require searching over a large area at high cost, lavish prevention expenditures will not successfully minimize the threat from invasion. If one is not actively searching the broader habitat for the specimens that avoid detection through prevention mechanisms, these may rapidly reproduce and grow beyond a stage where they are eradicable or easily contained.

In the case of the Brown tree snake, such oversight could be extremely expensive. If, for instance, the current mix of prevention and control is pursued without change, $2.6 million per year will be spent on preventing the species from reaching Hawaii, but about $76,000 will be spent on searching for snakes that evade prevention efforts. Since these have proved to be insufficient funds to catch a snake from a very small population, under status quo efforts, the existing population will continue to grow until there are enough snakes that this limited annual expenditure results in catching a snake, imposing perhaps billions of dollars of silent damages in the meantime. Instead, if there indeed is an existing population in Hawaii, it would be preferable to spend much more of the prevention money on ferreting out that population and limiting damages directly. An additional avenue for reallocating the prevention money might be toward joint production of snake removals with other conservation activities, should such a possibility exist.

Concluding Comments

In sum, prevention and control decisions must be integrated thoroughly to best utilize scarce resources to fight invasive species. Policy must consider that invasive species are a function of human trade and discourse, which is increasing in even the most remote corners of the globe. Optimal strategies will vary by anticipated biological growth, economic cost of prevention and control activities, and economic valuation of potential damages as a function of invasion level. Assessment of these parameters may require creative and iterative interdisciplinary processes. Closed ecosystems like Hawaii provide excellent natural labs for study and are important purveyors of irreversible assets, particularly biodiversity, that deserve particular attention in the battle against invasive species.

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Institutional Uncertainty at Home and Away: The Case of Lemons from Argentina

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JEL Classification: F13, Q17, Q18

Ultimately, the success of any trade relationship depends on achieving satisfactory levels of trust and confidence among trade partners. Uncertainty in such relationships has increased with the adoption of World Trade Organization [WTO] regionalization criteria. An important, and often overlooked, aspect of these criteria governing invasive species regulation is the degree of confidence and trust among regulatory agencies to conduct pest risk assessments, monitor changing conditions, and enforce standards (Thornsbury & Romano, 2002).

One policy response has been increased use of a systems approach; multi-step sanitary and phytosanitary regulations designed to reduce pest risks (USDA APHIS, 2002).[1] We rely on an ongoing case to illustrate attempts to alleviate uncertainty and the complexity of negotiations over policies to manage invasive species risk.[2] Specifically, we examine efforts by Argentina to gain access to U.S. lemon markets illustrating

- how private/public partnerships can build institutions in developing countries to increase the likelihood of access to new markets;
- linkages between institution building and increased trust between trade partners; and
- pressures from industries at home.

Pests of Concern

Argentina is currently the largest lemon producer in the world with approximately 30% of global production (more than 1 million metric tons a year) and a large exporter (more than 330,000 metric tons annually), mainly to European countries (Figure 1). Despite gaining entry to Europe and Japan, Argentine lemons are banned from U.S. markets. In the 1960s, Argentina was only a modest lemon producer with most orchards concentrated in the humid Northeastern states, where the plant disease citrus canker is prevalent. Concern over inadvertent transfer of citrus canker was a primary reason for the original U.S. ban on Argentine citrus (USDA APHIS, 1998b).[3]

Citrus canker is a highly contagious bacterial disease that causes leaf loss, premature fruit drop, and lesions on leaves, stems, and fruit. It is endemic in some major citrus-producing regions of the world (i.e., Brazil), but is generally considered manageable for fruit that will be further processed. The canker alters exterior appearance with a major impact on fresh fruit sales.

1. *An example includes a requirement to test for pathogen presence (step 1) and mandatory pesticide application (step 2), regardless of the outcome of step 1. These measures are independent and risk reduction is additive: if there is a failure in step 1 (the test is negative when in fact a pathogen is present), then there is not an automatic failure in step 2 (USDA APHIS, 2002). Such practices are applied to fresh avocado imports from Mexico into the United States (e.g., Orden & Romano, 1996).*
2. *There are many other examples of disputes over such policies. For example, in 2005, USDA identified 41 trade issues involving potential impediments to U.S. horticultural exports (USDA FAS, 2005). In addition, 33 complaints were raised in the WTO Sanitary and Phytosanitary Committee between 1995 and 2002 regarding policies governing trade in horticultural products (Roberts & Krissoff, 2004).*
3. *Other pests of concern were later identified by APHIS (fruit flies, sweet orange scab, and citrus black spot).*

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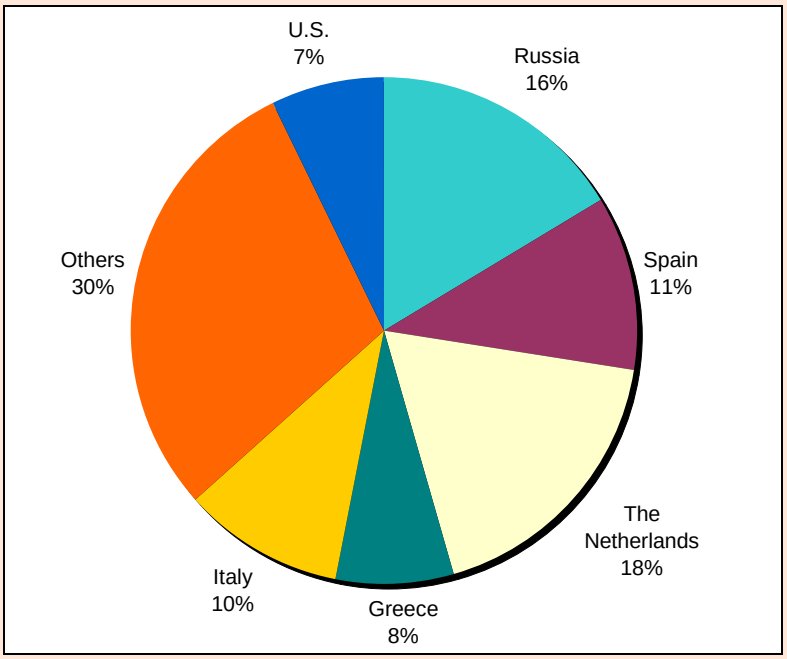

Figure 1. Destination of Argentine lemon exports, 2001. Year 2001 was chosen to show U.S. participation. For years other than 2001, exports to the U.S. equal zero.

In the early 1990s, a group of Argentine businessmen hoping to expand exports planted substantial citrus acreage in four Northwest Argentina states free of citrus canker. In 1991, citrus producers, processors, and exporters in this area established the Phytosanitary Association of Northwest Argentina (called AFINOA), a grower-sponsored institution with a goal of fostering cooperation to implement sanitary and phytosanitary [SPS] practices that would help promote citrus exports. The investors' plan was to apply modern technologies to produce fruit targeted towards European and American markets.

A Challenge to Argentine Institutions

In 1993 Argentina requested entry for fresh grapefruit, lemons, and oranges from the Northwest area to the United States. In 1994, a group of U.S. Animal and Plant Health Inspection Service [APHIS] pathologists visited to assess conditions. Preliminary results indicated that, although the region appeared to be canker-free, it did contain citrus black spot and sweet orange scab, two citrus fungal diseases not present in the United States. In 1995, APHIS denied the request for entry unless canker-free status could be documented and treatments for the other two diseases approved (Harlan Land Co. v. USDA, 2001).[4]

4. The United States was not canker-free at this time since the plant disease had been detected in the Miami-Dade County, Florida area during 1995. An aggressive eradication program was underway, and avoidance of additional pest entry was considered critical to success. The U.S. eradication program included quarantine restrictions on movement of domestic product as well.

The Argentine regulatory agency was neither willing nor able to satisfy U.S. concerns and the process stalled in a political dispute. The U.S. position requested scientific evidence of pest-free status. The Argentine position stated that, since European Union-approved policy allowed citrus imports from Northeastern pest-free orchards located in nonpest-free states, the risk of transferring disease from regions deemed pest-free had to be negligible. The Argentine position failed to acknowledge the myriad of different elements and conditions that influence species invasion across geographic areas, as well as different risk preferences and thresholds among potential importers. This illustrates how difficult it is for regulators in a developing country to understand the importance of following established sanitary protocols and to demonstrate scientifically proven phytosanitary health.

To some extent, this controversy underscores the differences in American and European approaches to invasive species management. While APHIS followed the WTO's regionalization principle to allow imports from certified pest-free regions, Europe followed protocols based only on identification of pest-free orchards (FVO, 2002). Momentum to break the impasse came from the Argentine grower organization AFINOA. This group enlisted the academic community to provide scientific expertise to satisfy the requests from APHIS. In addition, the grower organization gathered political support from the Governors of Northwest Argentina to improve and document phytosanitary measures insuring separation of products from pest-free regions. To address U.S. concerns over institutional uncertainty, the Government of Argentina began to elevate the status of its regulatory and enforcement

agencies, developing a new institutional umbrella (National Agrifood Health and Quality Service, or SENASA in Spanish).

Subsequently APHIS, given the scientific surveys and research results in 1996, in turn issued a supplemental pest risk assessment, which estimated that the median chance for establishment of pests of concern in the United States was negligible (1 in 3.2 million). In August 1998, APHIS published a proposed rule that allowed citrus imports using a systems approach to guard against black spot and sweet orange scab (USDA APHIS, 1998a). Included were safeguards at the grove and post-harvest levels, a phytosanitary certificate, cold treatment, disease detection protocols, and limitations on distribution and repackaging. Responding to the need to understand and accommodate APHIS' requirements, Argentina was able to move the process forward despite initial mistrust. As a result, the dispute evolved into a less-trade-restrictive protocol based on multiple safeguards built into the systems approach.

Still, increased trust among regulatory agencies had not been transferred to U.S. growers and public comments to the proposed rule revealed continued opposition. Concerns were raised about the scientific basis and execution of the systems approach. Meanwhile, regulatory officials were confident in the scientific merits of the proposal and APHIS moved forward with other aspects of the process. In late 1998, an economic analysis determined that the rule "[would] not have a significant economic impact on a substantial number of small entities" (USDA APHIS, 2000). An environmental assessment was published, which concluded there was negligible environmental risk but if the systems approach failed, the subsequent environmental impact would be "considerable" (USDA APHIS, 1998b).

Despite institutional confidence, domestic industry concerns led U.S. officials to be cautious in rule-making. Argentine officials eventually complained about unnecessary delays and APHIS published a final ruling on June 15, 2000, which allowed immediate entry (Magalhães, 2001; USDA APHIS, 2000). Regardless, opposition in the United States continued as growers questioned the ability of trade partner institutions to adequately monitor and carry-out the steps of the systems approach. Legislative representatives from California threatened APHIS with a withholding of fiscal year 2001 funding until after a review of the Argentine citrus rule and associated risk assessment were commissioned (NAWG, 2000; Costa, 2000).

To address grower concerns, APHIS personnel conducted an unannounced review in March 2001. Regulatory officials visited SENASA offices to verify the presence of sufficient technical personnel, examine agency records, and visit a laboratory. Throughout the review, APHIS did not discover any irregularities or violations and, despite strong continued opposition from California, lemon trade continued.

A Challenge to U.S. Institutions

On March 30, 2001, California and Arizona citrus growers filed a lawsuit directly challenging APHIS' scientific procedures and asking that the final rule be overturned (Harlan Land Co. v. USDA, 2001). Complainants argued that the final rule was unlawful because of its inconsistency with the Plant Quarantine Act of 1912. On May 12, 2001, arguments were

An Extract of the Court Ruling

1. "Having reviewed the Risk Assessment, the court concludes that the final rule is arbitrary and capricious because it is based on a faulty risk assessment. The uncertain nature of the Risk Assessment is illustrated by the fact that the risk of citrus black spot introduction increased significantly under the revised Risk Assessment from one chance in 3.2 million to one chance in 763,000 for the mean and from one chance in 840,000 to one chance in 189,000 for the 95 percentile. Although the risk is still lower than the risk of fruit fly introduction, where there is one chance in 350,000 for the mean and one chance in 93,000 for the 95 percentile value, the fact that there was a four-and-a-half fold increase in the risk of citrus black spot introduction at the 95 percentile because of faulty assumptions made by the APHIS scientists suggests that APHIS needs to reevaluate the Risk Assessment."

2. "Although the Risk Assessment take (sic) human error into content (sic), it may have understated human error in light of SENASA's failure to report the foot-and-mouth disease. Frankly, the court is concern (sic) about whether SENASA can be entrusted to enforce the mitigation measures used by the systems approach."

ACCORDINGLY, IT IS SO ORDERED that plaintiffs be granted summary judgment and defendants be denied summary judgment. IT IS FURTHER ORDERED that the Argentine citrus rule is suspended until a new rule is in place. The final rule is remanded to APHIS to address the concerns raised by the court."

Source: Harlan Land Co. v. USDA (2001).

heard in an Eastern District of California court. Institutional uncertainty surrounding both APHIS and SENASA was raised as prosecutors argued that the risk assessment was confusing and internally inconsistent. Further concerns were reliance on a foreign regulatory institution (SENASA) to implement, verify, and enforce part of the systems approach since, in the recent past, this institution had concealed an outbreak of foot-and-mouth disease for several months. The distrust of California growers for international regulatory officials had been extended to include domestic scientists and regulators. The court ruled in favor of the prosecution and entry of Argentine lemons was again banned as of September 29, 2001.

The Story Continues

With imports to the United States halted, Argentina announced in February 2002 that citrus canker had been detected in the Northwest states. Continued discussions between the two countries postponed an official APHIS site visit until the week of March 10, 2003. The goal was to demonstrate that, despite the loss of canker-free status, systems approach safeguards were rigorous enough to meet phytosanitary standards. This argument was not fundamentally different than that posited by Argentina in the 1990s. By 2003, however, the Argentine claim had been strengthened by additional scientific and institutional evidence. Based on results of the visit, APHIS formally recognized the appropriateness of the systems approach in place, but criticized the Argentine government for not implementing a canker eradication program (Wager-Page et al., 2003). Growers and policymakers in Argentina rejected the demand for such a program and the process remained stalled.

A new development in this story took place in January 10, 2006, when USDA officials declared defeat in their own canker eradication process announcing that Florida hurricanes had "so widely distributed [the disease] that eradication is infeasible" (Conner, 2006). There is a sense among Argentine officials that this announcement may induce APHIS to abandon the request for an eradication program in Northwest Argentina and instead develop a new protocol along the lines of the systems approach policies currently in place for Europe and Japan. In early 2006, a group of APHIS and SENASA officials met to further discuss the issue (Enright, 2006).

Lessons Learned

The Argentine lemon case reveals important lessons regarding trust and confidence among trade partners and the difficulties involved in decreasing institutional uncertainty. There is a demonstrated need for developing countries seeking access to international markets to organize and establish strategies based on scientific evidence and enforcement programs. Sanitary and phytosanitary policies based on multiple safeguards appear to be a valid tool to decrease regulatory uncertainty while achieving a reduction in pest risk, allowing trade partners to build mutual trust and confidence.

Phytosanitary measures must be consistently enforced over time by the exporting country to reduce distrust from the importing country; however, the regulatory agency in the exporting country is not the sole place where such uncertainty may arise. The dynamics of the lemon case shifted attention to credibility of domestic, as well as foreign, institutions. In this case, while trust and confidence between regulatory agencies has been slowly building, the same cannot be said for the industries involved. Although institutional and scientific adjustments in the developing country were crucial to build mutual trust and facilitate advancement of the regulatory process, some adjustments are still needed to overcome political pressures at home and abroad.

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Invasive Species and the Depth of Bioeconomic Integration

David Finnoff, Chad Settle, Jason F. Shogren, and John Tschirhart

JEL Classification: Q0

An established species is not considered invasive unless it triggers costs that outweigh any attendant benefits. Numbers of invasive species are increasing worldwide. In the United States alone, Pimentel et al. (2000) estimated that 50,000 non-native species have been introduced. Of these about 5,000 have become established and about 500 have become invasive.

Invasive species are a leading cause of biodiversity loss in ecosystems, and especially in lakes. Invasive species promote large ecosystem changes, and they interact with many other drivers of global environmental change. Although agriculture has been long plagued by invasives and a voluminous literature on cost effective pest control exists, only relatively recently has the problem of invasives in natural systems been examined in a bioeconomic context.

In the past, researchers have used an approach that assumes the economic system and the ecosystem affect each other in a one-sided way, which causes them to separate risk assessment from risk management. A change in the economic system is viewed as only changing the pressure on the ecosystem, or a change in the ecosystem is viewed as only changing the economic system. This approach does not address the idea of *co-evolution* – the two-way interactions and feedbacks between human and natural systems. Ecosystem changes alter human behavior and productivity in the economic system. People recognize the change in their productivity, and they adapt to this change, either by adapting the environment or by adapting to the environment. When people adapt, they alter the pressure they put on the ecosystem leading to further changes in the ecosystem. The co-evolutionary cycle continues.

Co-evolution can be addressed by integrating ecological and economic modeling into a single cohesive framework. The motivation behind integration is to get more precise estimates of invasive species damages on human and natural systems. Integration accounts for interdependencies, or *feedback loops*. Traditionally, economists have captured the notion of feedback loops using dynamic models. With a few exceptions, most standard bioeconomic models consider at most one or two feedback loops and operate at a relatively aggregate level. In many cases such models provide the needed insight into the underlying problem at hand. In other cases, however, more ecological or economic detail is needed to help avoid the unintended consequences of poorly advised policy. This challenge of balancing model tractability with more realism is not new in science, but it hits with full force when addressing the economics of invasive species management.

Herein we address two common questions that arise when doing integrated bioeconomic modeling for invasive species management: (1) what do we gain by integrating the web of life into economic analysis? and (2) if integration is worthwhile, how deep should we go?

What do we gain by integrating the web of life into economic analyses?

Our work over the last decade has addressed whether an explicit accounting of these feedback links yields different policy-relevant results than does non-linked analyses. Consider three examples of linked systems.

i. Yellowstone Lake

Settle and Shogren (2006) constructed an integrated bioeconomic model to examine how invasive lake trout affect native cutthroat trout in Yellowstone Lake. The two key

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items included in this model are the stocks of lake trout and cutthroat trout. Their results showed how integration of the economic and biological systems lead to different population results compared to treating the systems as separate. Three scenarios were considered, each with and without feedbacks between the economic and ecological systems. The best-case scenario eliminates lake trout immediately and without cost. The worst-case scenario leaves lake trout without any interference from the Park Service, and both lake and cutthroat trout are left to reach their steady-state equilibriums. The middle-ground scenario has the Park Service expending a fixed budget to reduce the risk to cutthroat trout by gill netting lake trout, assuming the Service's current level of expenditures is continuous and perpetual.

Using the population of cutthroat trout as a yardstick, we found that ignoring feedbacks biases risk estimates by overestimating cutthroat populations in the worst case and underestimating them in the best case. The difference arises from fishermen behavior. Without feedback, fishermen continue to fish as before. With feedback, fishermen adapt by fishing less and visiting other attractions more. Interestingly, the findings also revealed a troubling result from a species protection perspective in that only a small difference arises between the net benefits between the best- and worst-case scenarios, which suggests that gill netting for lake trout is inefficient. People preferred improvements in other park amenities (e.g., roads, wildlife viewing) relative to increased populations of cutthroat trout.

ii. Zebra mussels

Finnoff et al. (2005) studied an economic system, composed of a Midwest lake ecological system experiencing a zebra mussel invasion with a resource manager and a powerplant, to determine whether integrating the systems is worth the effort. Two feedbacks were considered—one between the biological system and power plants based on the stock of zebra mussels, and one between the power plants and the manager based on the manager's expectations over the plant behavior. For both loops, the decision maker's beliefs about invasions are central. In the absence of the link between the biological system and power plants, a plant behaves as if its actions cause no change in the biological system. The consequences depend on whether there is an invasion in the initial period, and whether the power plant acknowledges the presence of the invader. For example, with no initial invasion, the power plant neither controls nor adapts, and as the biological system changes, the power plant either uses too few or too many inputs relative to the optimal baseline. In turn, output correspondingly either under- or over-shoots its targeted level; either way this results in opportunity cost losses from production shortages or surplus, determined ex-post.

The second dimension is the feedback between the resource manager and power plant. Removing the feedback causes the manager to act as if the power plant does not respond to changes. For example, following a successful invasion, the manager ignores the private control actions of the power plant. This has direct welfare consequences as resources may not be allocated efficiently, but the magnitude of the consequence depends on the actual response of the power plant. The results suggest that feedbacks can matter for this case—but not in every dimension and in varying degrees. Both biological and economic consequences of not addressing feedbacks are sensitive to the initial environment, behavioral perceptions about the state of the environment, and the completeness of the manager's beliefs.

iii. Leafy spurge

Finnoff et al. (2006) developed an integrated model of a grazing land ecosystem and cattle ranching. The ecosystem consists of native grasses, leafy spurge (an invader noxious to cattle and wildlife), and cheatgrass (another invader). This model considers the stocks of each plant and cattle. Plants in these three species are assumed to behave as if they are maximizing their photosynthetic energy intake minus energy lost to respiration. To photosynthesize, they grow green biomass that provides them access to light; however, the plants are competitors for space. Over time one species eventually will win the competition by driving out the other two.

The results show that without humans, the native grasses are most likely to win. When humans enter and introduce cattle to the grazing ecosystem, the native grasses are placed at a competitive disadvantage, and leafy spurge generally becomes dominant depending on grazing intensity. The model illustrates the importance of accounting for grazing decisions when forecasting the further spread of leafy spurge.

If integration is worthwhile, how deep should it go?

Integrating ecological detail into economic models raises many issues on different levels. The fundamental issue is deciding how deep the integration should go within and between the economic and ecological systems. The tradition in economics

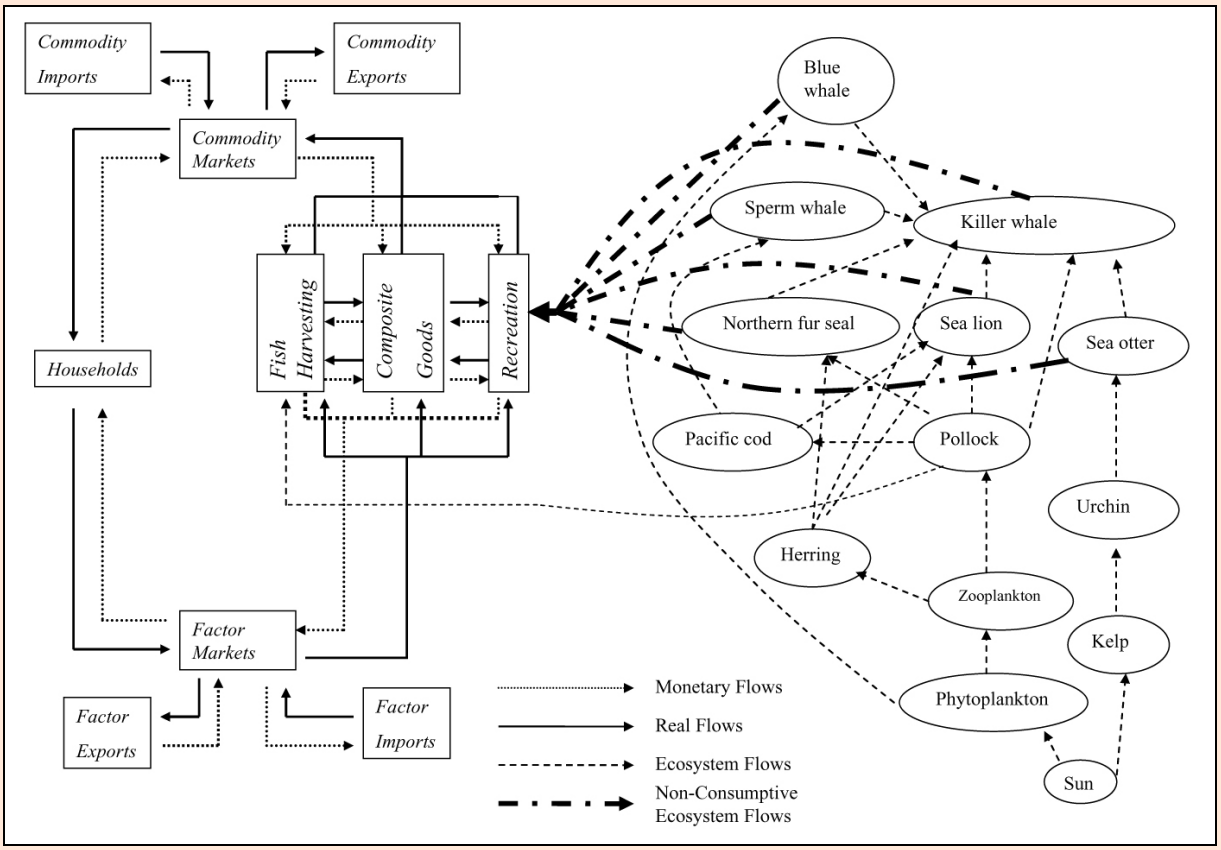

Figure 1. Bering Sea web of life.

is to represent ecological systems as a technical constraint, usually in the form of population growth for a single or aggregate species. The influence of all other species and other components of the ecological system are represented by a fixed carrying capacity. If the policies prescribed by these models do not impact other components of the ecological system, this representation may be appropriate. But if the policies do impact other components of the ecological system, the system can be "bumped" to different results with unintended consequences (Crocker & Tschirhart, 1992). Models not addressing these other components may miss important linkages between humans and nature and provide misguided policy prescriptions.

Deciding just how deep to dig within and between the economic and ecological systems depends on the number of contact points between the systems and the indirect effects within the systems. For cases with one or two points of contact, a *shallow*, or abridged form of integration might suffice. But in cases with multiple contacts or important indirect effects, a *deep* integration is necessary. But in doing so it is necessary to make other simplifying assumptions. Such deeply integrated models may not be more realistic if the feedback loop or other representations do not conform accurately to reality. Addressing the challenge of adding more realism and being forced to solve a problem computationally rather than analytically requires one to work with a solid theoretical framework that guides the depth of integration.

We illustrate the depth of integration challenge by using an example based on Finnoff and Tschirhart (2005) that examines the Alaskan economy and a marine ecosystem comprising Alaska's Aleutian Islands (AI) and the Eastern Bering Sea (EBS). Figure 1 shows the ecosystem and economic interactions and illustrates the thirteen key ecological descriptors and the feedback loops. The economy consists of Alaskan households and producing sectors linked to one another and the rest of the world through commodity and factor markets. All species in the food web are linked through predator-prey relationships and several species provide inputs to economic production. The prominent groundfish of the system, pollock, support a substantial fishery, and marine mammals including Steller sea lions (an endangered

species), killer whales, blue whales, sperm whales, northern fur seals and sea otters. All of these species provide non-use inputs to the state's recreation sector. For a policy issue, we focus on the endangered Steller sea lion recovery via alternative pollock harvest quotas.

The first level of analysis is to understand the behavior of the actors in Figure 1. Economists study the behavior of individual consumers and producers. Consumer behavior has people within the household sector box making choices over combinations of goods and services. In Figure 1 this is a focus. Producer behavior is likewise captured by individual firms within the fish harvesting sector box choosing both their optimal mix of inputs and their optimal output level. Alternative quota levels are interpreted as changes in the prices faced by the households or producers. Similarly, ecologists study the behavior of individual animals; they would consider an individual pollock's optimal foraging behavior, and how foraging changes impact pollock populations as depicted within the pollock box. The alternative quotas would be interpreted as changes in the pollock populations.

The next level of analysis is to integrate all economic and ecological agents directly affected by pollock quotas through a bioeconomic harvesting model. In the economic system, individual consumer demands for pollock are aggregated to derive market demand, required for producers' decisions. Producer supplies are in part determined by the availability of pollock, which is derived from the aggregation of individual pollock behavior and population dynamics. Therefore, this level requires integration *across* the household, fish harvester, and pollock components. Linking these three components allows the derivation of market demand and pollock supply, which allows an assessment of how alternative quota policies impact the whole system.

But this level of integration is insufficient if we are interested in how the repercussions of the policies impact all of Alaska. In this case, deepening the analysis a further step *within* the economic system is necessary to include the other producing sectors of the Alaskan economy (recreation and composite goods in Figure 1), all other household demands, and trade flows into and out of the region. A complication arises, however, because the recreation industry depends on the marine mammals. Still further depth of integration is needed *to* increase depth *within* the ecosystem to account for the predator-prey relationship shown in Figure 1.

Finally, another level of integration is needed with nonmarket valuation. Nonmarket valuation involves assessing the total values (e.g., existence values) associated with scenarios of reduced human and environmental damages posed by some invasive species so we can better understand the net benefits of policy. The idea is that valuation work needs integration models to develop credible valuation scenarios. In turn, integration models need the parameters as defined by valuation work to capture the full range of benefits associated with the web of life. For instance, in the Yellowstone Lake case, Settle and Shogren (2006) integrated a valuation experiment within their bioeconomic model. They developed the *Yellowstone Interactive Survey* to ask people to value alternative scenarios designed to inform their integrated model. They determined the value for seeing/catching each species and used these estimates to parameterize the value to see/catch each species in measuring the visitor's welfare from Yellowstone National Park. The disquieting result that people preferred fixing the roads to protecting the native cutthroat trout emerged directly from this integration. Both valuation and bioeconomic modeling can likely be more relevant for policy if the scenarios people are asked to value are valid and if the scenarios created were informed by values stated by actual people. There are gains from joint production of values and feedback loops between economic and ecological systems.

Concluding Comments

Over the years, traditional bioeconomic modeling has improved environmental and natural resource decision making. Today researchers are exploring the next level of integration by expanding the number of feedback loops within and between systems and by making a better link to nonmarket valuation work. This message applies in general to natural resource economics and in particular to invasive species economics. The open question is how to determine the appropriate level of integration for the problem at hand? Is a traditional damage function approach sufficient? Does a one or two state variable optimal control model provide enough guidance, or do we require an even deeper integration between and within disciplines that may only be solved computationally? Addressing these questions requires one to judge a method based on results, not by preconceived methodological principles. Our decisions on the depth of integration in invasive species economics should evolve from our experience about what works and what does not work.

For More Information

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Overview: The Future of Animal Agriculture in North America

Walter J. Armbruster, Steve A. Halbrook, Mary M. Thompson, Guest Editors

Animal agriculture in North America is undergoing significant change. As new products are developed to meet changing consumer preferences, new production systems are being put in place to reduce costs, and contracts are increasingly replacing open markets and redefining relationships among stakeholders in the system. Technological developments have increased productivity and efficiency at the producer level, and in processing, distribution systems and marketing. Participants throughout the animal agriculture supply chain, from genetics to retail to food service outlets, are adjusting to ongoing changes which bring opportunities but also controversy and challenges.

The issues arising from the various factors impacting animal agriculture go beyond matters of supply and demand, cost of production and transportation, and other economic factors. They include the structure of basic institutions, customs of trade and social factors that underlie the production, distribution, transformation, sale and consumption of animal products. These articles reflect the shifting forces of change, anticipate some of the direction and impacts, and identify options that will allow farmers and ranchers, meat processors, food retailers, policy makers, and consumers to make more informed decisions about the future.

Farm Foundation led an 18-month project–*The Future of Animal Agriculture in North America*. The goal was to develop a comprehensive, objective overview of the range of issues that will shape the industry over the next decade. This partnership of industry, government agencies, academics and nongovernment organizations explored the opportunities and challenges facing North America's livestock sector, the driving forces behind them, and their potential consequences. Funding for this effort was provided by industry, government agencies and foundations throughout North America.

Articles in this Theme:

Overview: The Future of Animal Agriculture in North America 153
The Future of Animal Agriculture in North America.....155
Economics of Animal Agriculture Production, Processing and Marketing 159
Consumer Issues and Demand.....165
The Global Competitiveness of the North American Livestock Industry 171
Environmental Issues in Animal Agriculture.....177
Community and Labor Issues in Animal Agriculture 183
Policies to Protect Food Safety and Animal Health 189
Animal Welfare 195

The final report was released in April 2006 and is available on the Farm Foundation Web page, www.farmfoundation.org. It was organized around seven Working Groups headed by academic experts and composed of industry, government, nonprofit and academic leaders. More than 150 individuals from Canada, Mexico and the United States actively participated in the development of the Working Group reports. The objective was to give all stakeholders a clear understanding of the current state of the industry, a glimpse into the future, ideas for change and their potential consequences, and an inventory of issues that need further research, industry actions or government policy.

These articles have been prepared by leaders of the Working Groups. The authors have drawn heavily, but not necessarily exclusively, on the Farm Foundation report.

In the first article, we identify a number of cross-cutting issues that will affect the future of animal agriculture in North America. These are topics on which we need to

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know more to understand the long-run competitiveness of the animal agriculture industry in North America.

Boehlje's analysis of the economics of production, processing and marketing summarizes implications of consumer demand, cost drivers, changes in market structure and government policy, and regulation for competitiveness in the North American livestock industry over the next decade. This leads to some critical future challenges and opportunities that merit further analysis and research.

Jensen addresses consumer demand and the related forces driving changes in animal agriculture. Developments in the production, processing, and distribution system are designed to meet evolving consumer demands worldwide. She looks at how these trends from both sides of the market may play out. The paper also examines some policy options for helping shape the future competitiveness of the industry in North America.

Rosson et al. look at global competitiveness and trade in the livestock economy, including a significant increase in market integration among the three NAFTA countries. Various segments of the animal agriculture industry are affected by different forces. To improve efficiency of the North American animal agriculture, harmonization of policies, programs, and regulations across NAFTA countries will be required.

Abdalla and Lawton address environmental issues in animal agriculture associated with new technologies and restructuring of the production and marketing system. Resulting private disputes and public issues concerning animal agriculture and the environment are leading to new costs and benefits. To resolve the complex issues involved requires increased understanding and involvement by all stakeholders.

Goldsmith and Martin look at community and labor issues in animal agriculture, finding them to be significant but very diverse. The animal agriculture processing industry has shifted from urban to rural locations and relies on substantial numbers of immigrants from Latin America to provide labor. The authors look at community and social impacts, explore some future options, and emphasize the need for animal processors to partner with the communities in which they locate.

Goodwin et al. address policies to protect food safety and animal health, noting that these issues are closely related, yet in some cases, require separate strategies. The authors identify a number of possible policy measures and their implications for assuring sound food safety and animal disease prevention systems to keep North American animal agriculture prosperous and competitive.

Blandford addresses the increasing role of animal welfare issues in wealthy countries. There are increasing initiatives in states, as well in the U.S. Congress, to pass animal welfare bills. Many of the practices being questioned are associated with animal confinement, and there is increasing interest in developing voluntary standards within the industry. The author considers economic impacts of various approaches and identifies some options for the future.

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The Future of Animal Agriculture in North America

Steve A. Halbrook, Walter J. Armbruster, and Mary M. Thompson

JEL Classification: Q18

Animal agriculture in North America constantly adapts to changes in markets in order to remain competitive for the future. New products are developed to meet changing consumer preferences. New production systems reduce costs. Private contract arrangements replace open market bids in public arenas and redefine the relationships among the stakeholders in the system. Technological developments increase farm-level productivity, processing efficiency, distribution systems, and marketing. Every facet of the animal food chain—from genetics to retail and food service outlets—is facing rapid change, accompanied by controversy and challenges.

Exploring opportunities in this environment requires going beyond matters of supply and demand, cost of production and transportation to examine basic institutions, customs of trade, law, and social factors, which underlie the production, distribution, transformation, and sale and consumption of animal products.

Farm Foundation recently completed a comprehensive analysis, *The Future of Animal Agriculture in North America.* The report examined the opportunities and challenges facing the livestock sector, the driving forces behind them, and the potential consequences of those forces over the long term in the United States, Canada, and Mexico. The focus of this analysis was on major animal segments of the North American food system—beef, pork, dairy, and poultry.

The report proposed key policy alternatives and business strategies for change and analyzed the potential impacts on key stakeholders. It identified gaps in knowledge, identifying potential research and policy questions for the future. The objective was to give all stakeholders a clear understanding of the current state of the industry, a glimpse into the future, ideas for change and their potential consequences, and an inventory of issues that need further research, industry actions, or government policy.

This analysis was unique in that it resulted from a partnership between Farm Foundation, government agencies, industry groups, other nonprofit organizations and foundations, and the academic community. More than 150 individuals from Canada, Mexico, and the United States actively participated in the development of this report. The project was divided into seven Working Groups, which are the basis for the reports that follow.

Farm Foundation's *Future of Animal Agriculture in North America* project identified a number of cross-cutting themes, strategies, and policy issues, as well as areas where the knowledge base is thin or nonexistent.

Markets, Structure, and Competition

Traditional open bid commodity markets for animals are fading in importance, but there will always be competition among different value chains offering a variety of products to consumers. The sale barn with multiple buyers and sellers is rapidly disappearing and most animals are marketed through contracts, cooperatives and a variety of arrangements that link production with processing and retailing of final products. Cooperatives play a key role in dairy.

Current production technologies and marketing arrangements have significant economies of scale that encourage large units for production and processing of beef, pork, poultry and milk. The result is that production units are getting larger across the board. Fewer large firms dominate the animal-processing industry in North America. While small, traditional production units are still a major factor in Mexico, the number of large-scale production units similar to those in Canada and the United States is growing rapidly in dairy, swine, and poultry.

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This economic environment challenges small- and mid-size producers. But opportunities do exist, and others are evolving. Because different consumers place different values on various product attributes, there will be markets for animal products with specific characteristics for which consumers are willing to pay premiums. For example, demand for niche-market products like certified organic products is growing rapidly. Many small- and mid-size producers can flourish if they are able to position themselves to competitively provide products that command premium prices in the marketplace.

The North American animal agriculture industry also faces competitive challenges from other world producers and processors, in part due to the transferability of technologies and increasing worldwide demand for animal products. This has implications for trade, labor, and the environment.

What we need to know about the future of markets, structure, and competition in animal agriculture includes: Who receives the value from technological and business management innovations such as supply chains and traceability systems? How is this value distributed among producers, processors, retailers and consumers? Are there better ways to identify relationships among parties in these systems? What are the long-term impacts of increased energy production from corn, other animal feeds, and animal waste on animal agriculture? To better understand the competitiveness of the North American livestock industry, a comparative analysis is needed of the cost of producing and processing various animal products in different geographic locales in the world. This analysis must use a standardized methodology to measure costs and analyze potential value of both commodity products, as well as higher-valued differentiated products.

Value in Integrated Markets

There is economic value in an integrated North American market for animal products. The dairy industry remains protected to different degrees in all three countries, and the Canadian poultry industry remains protected. But, there is significant evidence that NAFTA benefited the beef and swine industries in all three countries. Open borders allowed the industries to specialize with live animals, carcasses and processed products moving back and forth across all borders. The disruptions caused by the closing of the U.S.-Canadian border because of BSE demonstrated the degree of market integration in the cattle sector that had developed in recent years. While some parts of the livestock industry benefited from the border closing, the North American industry as a whole lost. Institutional mechanisms are needed to reopen borders quickly to prevent long-term economic disruptions.

What we need to know about the future of integrated markets includes: What are the true costs of border disruptions? Who benefits and who loses because of these disruptions? Have the "temporary" BSE-related border closings permanently altered animal trade flows in North America?

Increasing Demand

Demand for animal protein depends primarily on income and population growth. Predicted increases in income in developing countries, particularly in Asia and Latin America, will increase global demand for animal products during the next generation. In high-income regions like North America and Europe, consumers are demanding animal products with specific characteristics related to nutrition and health concerns and specific production practices. As noted previously, demand for organic products is growing rapidly.

What we need to know about the future of demand includes: What really influences consumer purchases of meat and animal products? How do consumers react to health and food safety concerns and to concerns about animal welfare? What are the economic impacts of consolidation in the food processing and food retailing sectors, especially impacts on farmers and on consumer choice?

Environmental Regulation and Litigation

Environmental regulations can be a significant cost factor for the industry and will likely be a major factor in future investment decisions by the industry. While predictions of a "race to the bottom" are made, the increasing variability of regulation from location to location will impact decisions concerning the location of future animal production and processing units. Differences in environmental regulation across countries, states, and provinces are problematic for animal agriculture. Broader multi-jurisdictional regulatory approaches may represent an opportunity for more efficient environmental management and lower industry costs.

Litigation related to environmental issues is a growing problem in the United States. While litigation is a symptom, not a cause of conflict, continued litigation can be expected unless there is meaningful legal reform that provides the industry with some "safe harbor" legal parameters in exchange for assuming greater responsibility for environ-

mental concerns. Litigation or legislative outcomes must provide legal rights and responsibilities that balance business practices with environmental concerns to resolve the issues. In the environmental arena, uncertainty is a greater problem than the level or type of environmental regulation.

What we need to know about the future of environmental regulation includes: What are the costs and benefits of various regulatory systems? What are the impacts of regulation on different size operations? What are the public health impacts of possible pathogens in air emissions from animal production facilities? How do we best measure the level of pathogens and their impacts?

Immigration and Labor

Many segments of animal agriculture in the United States and Canada depend on a foreign-born labor force. In the United States, many of these workers are from rural Mexico or Central America and are undocumented. The legal uncertainty associated with this undocumented work force has consequences for the workers and the companies for which they work. Workers may not receive full legal protections and may be reluctant to complain about working conditions. Employers are vulnerable to a variety of legal sanctions and risk the loss of a significant portion of their work force if immigration laws are strictly enforced. This legal uncertainty creates a "cost" that can be mitigated with revised government policies.

What we need to know about the future of labor and immigration includes: What are the labor market needs for animal agriculture? How will specific immigration reform legislation impact the industry?

Animal Identification and Traceability Systems

Animal identification and traceability systems have a key role to play in the future of the North American animal agriculture industry. Whether the underlying issue is animal health, food safety, animal welfare, process assurance, or quality attributes, animal identification and traceability are necessary. Canada is well ahead of the United States and Mexico on this issue. Identification and traceability systems will emerge rapidly during the next few years to enhance the industry's ability to respond to natural and intentional disease outbreaks, improve food safety, and provide assurances of food quality and wholesomeness. Some elements of these systems will be developed and managed by government, other parts may be purely private, and some elements may require public/private partnerships.

What we need to know about the future of animal identification and traceability includes: How could information generated by traceability systems be utilized to develop risk-management strategies to minimize impacts of animal disease outbreaks?

Community Impacts

There are no simple answers to the complex issues facing rural communities affected by animal agriculture. The issues are multi-faceted and link producers, processors, retailers, consumers, and the people living and working near farms and processing facilities. Reaching workable solutions requires patience, partnerships, information, and clear communication. Solutions may require the cooperation of industry and multiple levels of government.

What we need to know about the future of community impacts includes: What are the economic and social consequences of alternative regulatory systems for making siting/zoning decisions about animal production and processing facilities? What incentives or regulations can be instituted to encourage cooperation among industry, government, the public, and the various elements of the food supply chain? What are the actual economic multiplier effects of animal agriculture production and processing facilities on rural communities?

Shaping the Future

While it remains competitive in the world market, the North American animal agriculture industry faces significant challenges and opportunities. This series of articles offers a comprehensive look at the opportunities and challenges facing animal agriculture in North America today. How industry, government, and academia use the information compiled here will help shape the future of this industry in North America and around the globe.

For More Information

Farm Foundation.(2006). *The future of animal agriculture in North America*. Available online: http://www.farmfoundation.org/projects/04-32ReportTranslations.htm. Oak Brook, IL.

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Economics of Animal Agriculture Production, Processing and Marketing

Michael D. Boehlje

JEL Classification: Q13

The North American livestock industry (beef, pork, dairy and poultry) has and continues to undergo major structural change due to rapid evolution in product characteristics, worldwide production and consumption patterns, technology, size of operation, and geographic location. Production, once dominated by independent, family-based, small-scale firms, is now led by larger firms that are tightly aligned across the production and distribution chain, as evidenced for U.S. pork production in Figure 1 and U.S. beef production in Table 1. Slaughter of livestock is also increasingly dominated by larger firms, as indicated for the United States in Table 2.

Contracts, vertical integration and other types of marketing arrangements are increasingly important across nearly every market level—from input supply and seed stock to finished food product markets, as reflected for U.S. pork in Figure 2. Niche markets for differentiated products that may command a premium from some consumers are growing. Similar trends characterize the Canadian and, to a lesser extent, the Mexican livestock industry. As the industry has become more industrialized, specialized and managerially intense, production and processing plant location options have expanded beyond traditional production regions, with increased emphasis on global sourcing and selling.

There is great diversity in how livestock is produced in North America and the world, but common themes are emerging. As in North America, many countries are experiencing major structural changes in their production sectors, and environmental concerns in production are nearly universal. Technology adoption is rapid, and a "world standard" is evolving to greater commonality of technology, size of production units, processing and quality, particularly in the case of pork and poultry. This is less so for

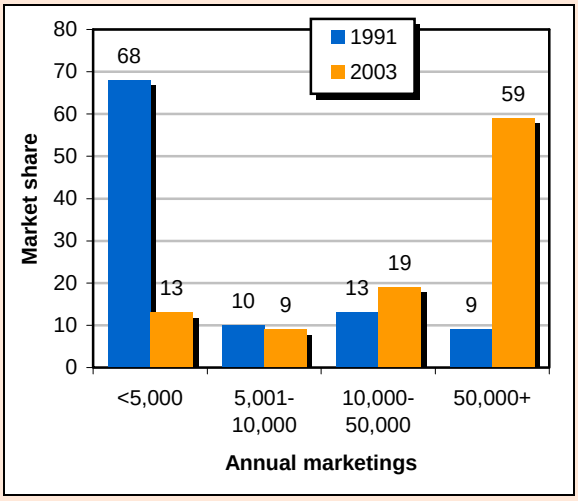

Figure 1. Change in market share by pork producer size for 1991 and 2003.
Source: Boessen, Lawrence and Grimes, 2004 Pork Industry Structure Study, June-July, 2004.

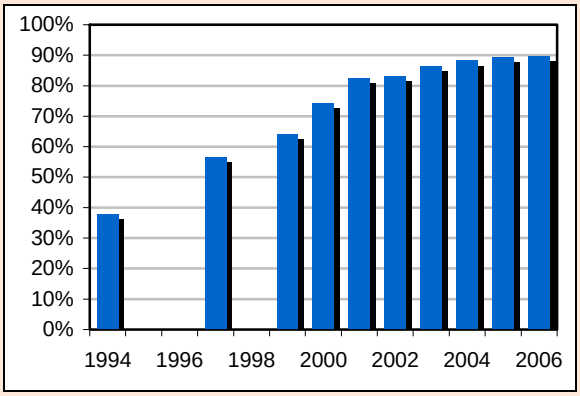

Figure 2. Percent of hogs sold under contract or vertical integration.
Source:1994 and 1997 studies by University of Missouri, Pork Magazine, PIC, DeKalb Choice Genetics, National Pork Producers Council, Land O'Lakes. 1999-2006 studies by University of Missouri, NPPC, National Pork Board. 2002-06 USDA/AMS data.

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Table 1. Cattle marketings by size of feedlot.

Head	2004	2005
	% of Annual Slaughter	
<1000	14.7	14.0
1-16,000	33.7	16.2
16-24,000	9.0	8.6
24-32,000	9.0	9.2
32-50,000	16.7	26.2
50,000 or greater	16.9	25.8

Source: USDA Cattle on Feed, NASS, February 2006.

Table 2. Four (4) firm concentration ratio for cattle, sheep, and hog slaughter.

	1980	1990	2000	2004
	% of Annual Slaughter			
Cattle	28.4	58.6	69.6	70.9
Sheep	55.9	70.2	69.8	66.9
Hogs	33.6	40.3	57.1	61.3

Source: USDA, Packers and Stockyards Statistical Report, G1PSA SR-06-01, February 2006.

beef, in large part because of its reliance on forage. Differences do exist across species and parts of the world that differentiate competing suppliers of animal proteins.

This article draws on a much longer report, *The Future of Animal Agriculture in North America* (Farm Foundation, 2006). It summarizes the implications of the fundamental forces of consumer demand, cost drivers, changes in market structure, and government policy and regulation for the competitiveness of the North American livestock industry during the next decade. Initial emphasis is on the expected future that would result from no major changes in public policy or private sector business strategies. Then alternative futures are described which would require public sector intervention or new private sector initiatives. Finally, some of the critical future challenges and opportunities are identified and discussed.

The Expected Future

The trend to fewer and larger livestock and poultry production, processing and marketing firms is expected to continue. The economies of scale in production and processing are significant and will drive larger scale optimal size of the facility, as well as the firms. Firm-level economies will be captured through effective supply chain management that improves cost efficiency and control, food safety and quality, and the ability to respond to consumer demands.

Quality concerns will also drive more systematic, micro-managed production and distribution processes to reduce product variability, and improve conformance with quality standards and consumer expectations of uniform product attributes. Technology, including genomics, nutritional advances, RFID and other tracing systems, will provide new efficiences and information to better manage the system. Concerns about food safety and a drive to qualified suppliers and traceback will increase pressures for and payoffs of tighter coordination along the production and distribution chain.

Successful small and mid-sized producers face serious survival challenges in determining how they fit into integrated supply chain structures. Higher revenue may be possible in value-added niche markets where consumers pay high enough premiums for differentiated products to offset the increased cost of producing, processing and distributing in small quantities. Small and mid-sized producers may be able to capture the market access and cost advantages of larger producers by joining a network or alliance that acts like a large producer. Both these options require a high level of cooperation and interdependence among producers.

The larger scale processing plants that will continue to be the norm require significant capital outlays and adequate supplies of live animals for efficient operations. Producers and their lenders are not expected to invest in production capacity if access is not assured to processing plants that can pay competitively for products. This interdependence will result in development of production-processing centers and supporting infrastructure as the optimal strategy for growth and expansion in the industry. The geographic location of such expansion will continue to be influenced by economics of scale and scope and the logistics of bringing feedstuffs to livestock and shipping livestock products to retailers. But capital and technology are increasingly mobile, and global livestock firms that locate production-processing capacity in different countries will increasingly dominate the industry. The implication is that the North American livestock industry will face even more competition in the future.

Alternative Futures

Alternative futures for the North American livestock industry include:

- changed global cost competitiveness resulting from regulatory reform;
- greater emphasis on differentiated animal protein products, rather than commodity production and distribution; and
- less concentrated, smaller firms, independent, open-market coordination, and more diversified production/distribution systems.

Regulatory Reform. Regulatory reform might include added restrictions on business models such as contract production or vertical integration, more restrictive immigration policies or worker safety rules, increased environmental regulation, or restrictions on use of feed ingredients/additives – all of which would generally increase costs for the North American livestock industry. Regulations can create benefits, as well as costs. For example, increased inspection, individual animal identification and other measures to monitor animal health and food safety will likely increase costs, but are increasingly critical to maintain and expand foreign market access. In general, regulatory reform that limits economic activity and/or increases private-sector costs will be disadvantageous to small-scale firms; decrease the innovation and adaptability of the industry to a changing business climate; discourage the private sector from investing and expanding; and undermine the industry's global competitiveness unless other countries or locales adopt similar regulations.

Differentiated Product Focus. Consumers have diverse preferences. Many affluent consumers are demanding extrinsic food attributes above and beyond food safety or federal grading standards. These attributes include animal welfare, organic, social responsibility, environmental responsibility, free-range production, locally-grown, and no use of antibiotics, synthetic growth hormones, or genetically modified organisms. Many of these differentiated production practices increase production costs relative to traditional commercial production methods. Differentiated markets and different pricing/product valuation structures are necessary to encourage such production practices.

In general, differentiated product or process markets originate as niche markets. These are generally small markets meeting particular consumer demands. Success in developing niche markets may provide market-based opportunities for some, but is unlikely to accommodate a large number of growers. Public support for the development and implementation of certification and verification programs (i.e., USDA Organic and PVP) may provide the necessary infrastructure. Niche markets may offer growth opportunities for independent, small producers and processors; however, at some volume or margin, these markets will likely attract investment from large-scale operators.

Maintaining Open Markets and Industry Diversity. There are concerns that marketing agreements, contracts and similar business arrangements are more conducive to larger operations; reduce spot market liquidity; reduce the availability of market information needed for efficient price discovery; and adversely affect smaller operations. The substantial horizontal contracting growth in hog production, for example, suggests contacts enable large production operations to get larger. However, numerous other factors contribute to horizontal (as well as vertical) integration in livestock production, including profits that attract external capital, and advances in genetics, health, nutrition and production management that increase economies of scale.

Contracting has enabled many smaller operations to remain viable by focusing on production and allowing integrators to provide services, capital, and risk management. For small and modest-sized operations, networking with other producers in a cooperative or other form of alliance is one way to increase competitiveness; increase access to markets and market premiums; and access high-quality genetics and other inputs, including genetics and better information and management skills. Public-sector interventions that limit business arrangements or size would make it difficult to capture the efficiency and other benefits of these business strategies.

A key argument for public-sector interventions is concern about monopoly or monopsony power in the livestock industry value chains. Assessments of market power in the U.S. livestock industry have generally been inconclusive, or indicate limited impacts. If the structural changes are the documented result of market power or similar behavior, aggressive pursuit of remedies under anti-trust or other regulations is appropriate.

There is a compelling argument that consolidation and vertical coordination in the livestock industry are driven by fundamental economic forces. Government regulations or interventions to recreate a smaller scale, independent firm, diversified livestock industry are likely to be ineffective unless carefully crafted and quite restrictive. If effective, the objectives or anticipated benefits of

consolidation and coordination will not be achieved, undermining the global competitiveness of the North American livestock industry.

Future Challenges and Opportunities

We identify here some key issues that will impact the global competitiveness of the North American livestock industry and merit further analysis and research.

Coordination and Value Chain Structures. Development of value chain coordination strategies and systems is a costly, time-consuming endeavor, requiring considerable cooperation among vertical partners and customers. More information is needed regarding attributes of effective coordination strategies; anticipated customer demands; and implications of various forms of vertical coordination strategies on economic efficiency, competitiveness, market access, and risk shifting.

Source Verification, Identity Preservation and Food Traceability Systems. It is critical to better understand the benefits, costs and functionality of food product traceability and identity preservation systems. In the absence of government edicts, economics will dictate the type of traceability system used in each segment of each industry. Developing technology continues to reduce costs and increase the technical feasibility of enhancing information collection and product and animal tracking. Increased assessment of market implications of government mandated vs. market-driven animal and/or meat product traceability systems is needed.

New Markets/Niche Markets. The scope of niche and highly differentiated markets for meat products is yet uncertain. Understanding consumers' willingness to pay for extrinsic attributes is critical to assess the implications of differentiated product markets on the competitive position and growth opportunities for North American producers and processors.

Regulatory Costs. The significant impact that regulatory costs have on cost competitiveness, relative to size of firm and location, is essential to understanding the global competitiveness of the North American livestock industry. Uniform regulations are not size-neutral because it is generally less costly per unit of output for larger firms to comply than it is for small firms. Different regulations in various communities or locales will differentially impact costs. Empirical estimates of regulatory costs by size and geographic location are generally unavailable; further work is clearly needed.

Cross Border Animal/Product Movement. Border disruptions in the North American animal and animal product markets change margins, and thus have an impact on investment location, production levels and trade patterns. Such changes are frequently more permanent than temporary. Reopening borders is a lengthy and complicated process, even when the foundation for international agreement is science-based. New rules and planning for such disease-related events are important to facilitate rapid restoration of trade, efficient investment decisions, and greater certainty in returns.

Energy Costs and Ethanol Production. Rising energy costs will have a significant impact on the North American livestock industry. Higher energy costs increase costs of livestock production, but also increase the value of manure as a fertilizer source. Energy from manure may be feasible. Another unknown is what will happen to corn prices and net feed costs as ethanol production increases. The potential for distiller's grains as a competitively priced and effective feed ingredient is substantial. Transportation costs for grain, distiller's grain and ethanol will be important factors impacting the location of both energy plants and the animal agriculture industry.

A Final Comment

North America enjoys highly efficient livestock production systems that have adapted and evolved to meet changing conditions. New products are available to meet changing consumer preferences. New production systems reduce costs. Contracts are replacing open markets and redefining the relationships among the stakeholders in the system. Technological developments increase farm-level productivity, processing efficiency, distribution systems and marketing. Every facet of the animal food chain—from genetics to retail and food services outlets—is adjusting to the rapid pace of change. The North American animal agriculture industry remains competitive today in the world market, but the competitive pressures will increase with the evolution of increasingly global livestock production, processing and marketing firms and systems.

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Consumer Issues and Demand

Helen H. Jensen

JEL Classification: D12, F13

Consumers worldwide are driving changes in animal agriculture. Rising consumer income, changing demographics and lifestyles, and shifting preferences due to new information about the links between diet and health all contribute to new demands for foods. At the same time, technological changes in production, processing and distribution, structural change and growth in large-scale retailing, and expansion of trade worldwide have contributed to a rapidly changing market for food products. Changes in demand for meat and other animal products reflect these developments.

Current Situation

Population growth in North America and the rest of the world is a major factor that drives demand for livestock and meat products. Population growth is expected to slow during the next 15 years (Table 1). Although in-migration and increased ethnic diversity have reduced the general slowdown of population growth in Canada and the United States, with slower natural population growth, future demand for North American food products will increasingly come from other parts of the world.

In addition to population growth, household income is also an important determinant of the amount and types of foods purchased. Higher income allows consumers to spend more on food and have greater discretion in spending, especially on such preferred foods as animal protein sources and specialized food products. On average, U.S. consumers spend only about 10% of disposable personal income on food; Canadian consumers spend approximately 14% of personal disposable income on food; and in Mexico, consumers spend an average 27% of total expenditures on food.

In general, higher income consumers have diets that are more varied and have a higher share of protein from animal sources. Higher income also leads to increased demand for other food attributes, such as variety, added food preparation and convenience, and intrinsic characteristics of the product, such as taste and how the food was produced and processed. Although per capita consumption of meat in Canada has remained relatively stable since 1990, consumption in the United States has increased by about 12% (Figure 1). The largest share of meat is from red meat sources. In contrast, consumption of meat in Mexico has increased more than 50% since 1990, and consumption of poultry has increased in importance (Figure 1). Demand for small-serving muscle cuts is the common preference in industrialized, urban regions. In contrast, demand for roasts, legs and quarters, especially of sheep and lamb, is strong by consumers with more time and less income available to purchase more processed muscle cuts. The global nature of the food market today expands market opportunities and allows markets to take advantage of consumers' varied preferences for meat cuts.

Major changes are occurring in retail markets. Twenty years ago, traditional groceries in the United States represented 90% of at-home food purchases; today, they represent less than 70%. Wal-Mart is the largest food retailer in both the United States and Mexico. In Canada, increased consolidation and concentration in retail food markets has

Table 1. 2005 Population and recent and projected growth.

	2005 Population Million	1990-2005 (%)	2005-2020 (%)
NA	438	19	14
Europe	728	1	-2
Africa	906	43	36
Asia	3905	23	17
SA	561	27	19
Oceania	33	24	18

Source: Population Division of the Department of Economic and Social Affairs of the United Nations.

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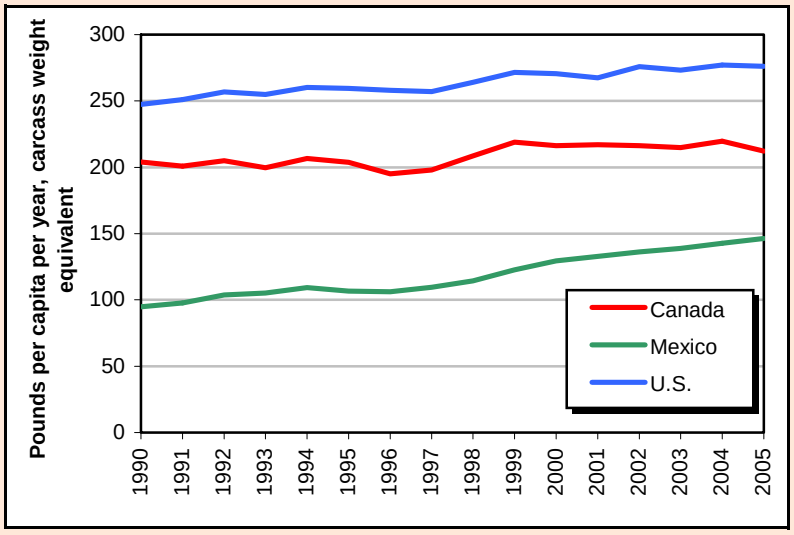

Figure 1. Meat consumption in Canada, Mexico, and the U.S. (1990–2005).
Source: USDA Foreign Agricultural Service (Production, supply & distribution data -- PS&D data). Note: Poultry is in RTC (ready to cook equivalent).

meant that the large retailers control a larger share of retail sales than in the United States or in Mexico. The increased power of nontraditional grocery retailers, combined with consumer preference for convenience, easy-to-handle, prepackaged meat and other food products, have resulted in low-cost, nearly-identical-quality products available to all customers. In addition, the food service industry has increasingly demanded prepackaged products and cuts to substitute for costly labor input at the service end.

Food retailing through the food-away-from-home category has also grown to meet the needs of higher income and time-starved consumers in North America who demand more convenience with their meals. In the United States, nearly 50% of food expenditures today are for food eaten away from home; in Canada the share of food expenditures spent on meals away from home has risen to 34% today (USDA-ERS, 2005; Zafiriou, 2005). In Mexico, consumption of traditional foods, such as tacos and tortas, has declined, and consumption from fast-food places has risen, especially in the rapidly growing urban areas.

Although the major change in retailing has been the dominance of large retail giants in the food retailing industry, new segmentation of the retail market is reflected in small retail units becoming an increasingly vigorous segment of the food retail market. Specialty stores, Internet-based markets, smaller-sized retail markets, and direct marketing methods for meats have strengthened the presence of this niche market segment of food retailing. Organics have become one of the fastest growing segments of the food market and, although organic meat and poultry have lagged behind in other areas, organic dairy and eggs are sold widely in conventional markets.

Forces and Drivers of Change

Several major trends affect consumption of animal products and are worth noting.

Income. As income levels increase, consumers buy more food and change the form and quality of food they purchase. The entry of women into the labor force contributes to the rise in consumer income. Consumers devote less time and effort to food preparation and reallocate spending away from raw food products to foods that are easy to prepare, require little preparation, and are convenient to eat.

Rising Obesity Rates. Prosperity, increased amounts of food, and less physical activity involved in work have contributed to the major dietary and health challenge today: obesity. Over 30% of adults in the United States, 14% in Canada, and 24% in Mexico are obese. Although the problem, and likely solutions, are very complex, the health problem has led new dietary guidelines, nutrition and health policies to focus on guidance that includes encouragement to consume fruits and vegetables, increase variety in the diet, increase whole grain consumption, and use low-fat dairy products. Other recommendations are to limit fats, especially saturated fats and transfats. The recommendations and related policies are likely to affect the amount and type of animal products consumed.

Population Growth and Changing Demographics. With a slowdown in population growth and aging of the population, aggregate demand for food is slowing in North America and other developed countries. Increased labor market participation of women has brought significant social and economic change and reduced the amount of time women have available in households for meal preparation. More than 60% of women are in the labor force in the United States and Canada today, and time-use surveys estimate that the average amount of time that meal preparers spend in food preparation and

cleanup during a week is less than one hour a day (Zafiriou, 2005; Statistics Canada, 1999; U.S. Department of Labor-Bureau of Labor Statistics, 2005). Consumers continue to look for ways to cut time in food and meal preparation. In Mexico, traditional homemade corn tortillas have given way to commercially processed corn tortillas. Roasts and broiler chickens have been replaced by steaks, ground beef, and chicken breasts.

During the next two decades, population growth in the United States and Canada will be strongly influenced by immigration. The growth of more ethnically diverse populations in the United States and Canada will result in new demand for different types of meat, including lamb and goat, and introduce changes in the types of foods and food preparations consumed throughout the population both at home and away from home.

Changing Food Markets and Foods. Increased consolidation and concentration in retail food markets and changes in food distribution channels mean retail food stores are larger, offer more variety and services, and are open more hours. At the same time, retail chains exert increasing control in the market, especially in Canada where the five largest supermarket chains have 90% of supermarket sales (Conference Board of Canada, 2005).

While the retail shopping experience seems to be losing its diversity, there is some evidence of an increase in market segmentation across a variety of products. In many markets, though primarily in metropolitan areas, there is growth in specialty stores for breads, coffees and deli items. Farmers' markets, which offer fruits, vegetables, and some animal-sourced products, meet the preferences of some consumers for local suppliers, organic foods, or other fresh products.

Technological innovations, as well as improved information and transportation technologies, have significantly changed the way food is produced, processed, transported, and delivered to consumers. Buyers are now associated with large retail food networks, where reputation, quality, and delivery are important attributes of the transactions. Larger, more coordinated systems enable food retailers to track food inputs through supply networks and demand products with more specific attributes. In such systems, retailer and brand name are often used to assure consumers of attributes that are difficult to observe or measure.

Fundamental attributes that drive consumer demand for animal products are that the foods are safe and provide nutrition, taste good, provide variety in the diet, are convenient, and contribute to good health. In general, consumers in both the United States and Canada are confident in the safety of their own country's food supply. Changes in retail food marketing are likely to lead to a more diverse market for animal products. Growing populations and incomes in developing economies will increase demand for safe, wholesome, and affordable animal protein products. Developed economies with higher, but still rising, incomes are expected to fuel demand for niche market products that are produced and marketed to deliver specific attributes for the consumer.

Implications

Where will these forces take North American animal agriculture?

1. Food safety will continue to be a paramount consumer expectation. While being relatively uninformed about how safe food is produced, consumers are intolerant of food safety failures. Regulation and product processing and packaging will continue to evolve to provide more guarantees of food safety. For many consumers, information on and the ability to trace product attributes (product and process) will substitute for food safety in product selection, leading to a wider variety of food safety/quality indicators—from home-grown, local farm, or animal welfare-friendly to contracted international suppliers. Although consumers in the United States and Canada have relatively high expectations for the safety of products and generally consider domestic production to be safe, Mexican consumers, especially those with less income, are less sensitized to issues of food product safety and choose animal products primarily on the basis of price. This may change with continued growth of supermarkets, greater control on marketing channels, and standardized inspection services (TIF), especially if the pricing differences in markets begin to narrow.

2. As North American incomes continue to increase, consumers will choose products on the basis of varied attributes, including taste, variety and convenience. Animal-sourced food product and process attributes have become very important for North American consumers. Though consumers may not be familiar with production methods, higher income consumers are likely to choose products on the basis of attributes related to production process, such as natural, organic or "family-farm," associating that process with product quality. Production methods, especially at the producer level, have become a shortcut for

consumers to high-quality attributes and safe food products. However, despite relatively high incomes and education levels, U.S. and Canadian consumers still demand low-priced food.

Labeling is an important tool to communicate product attributes, including food safety. To some extent, increased use of labels reflects the public's interest in informed choice regarding complex, and sometimes controversial, new agricultural technologies and the growing market for imported foods. Informing consumers may be a complicated and costly task. If labels provide large amounts of product information, or when the information is complex or requires understanding of nutritional and other science-based relationships, consumers may not be fully informed. Complex food ingredients or processes would require consumers to become more sophisticated in understanding product comparisons.

3. Continued concentration of large-scale processing, food distribution and retailing may reduce consumer choice in markets. Today's producers and processors are well-equipped to meet consumers' demand for quality, low-price food. Transnational firms have been growing and have advantages for providing lower costs and standard food quality sourced from around the globe. Large retailers will offer a variety of foods, though their market power presents the potential to restrict consumer choices and increase prices. Some newer retailers, such as Whole Foods and Wild Oats, have increased market share by offering alternative products to some—often high-end—consumer segments. In some markets, large firms will dominate food retailing and food distribution. At the same time, it is important to recognize that not all stores will be larger stores; small producers and retailers may serve specific markets, especially in urban areas. Where smaller store formats exist, the stores may be owned by large retailers, raising the potential for lack of competition in food markets.

Policy Options

There are four options for addressing the challenges facing the North American animal agriculture industry relative to consumer issues and demand.

1. Make product standards and certification programs more uniform across North America. Food safety is a public good across national borders. As production, processing, and distribution systems for animal-sourced foods become more integrated, food safety problems in one country can quickly pose problems in another country. One approach is to strengthen governmental regulation and public involvement in setting product standards, mandating testing, certification, and process control. Harmonization of standards across North America would enable firms within the three nations to operate on a level playing field with greater market transparency and maintain credibility within the integrated food systems. At the same time, increased governmental regulation imposes costs and does not allow firms the flexibility to develop their own food safety systems.

Alternatively, the growth of strong retailing chains can support private systems for food safety and quality control through internal mechanisms, e.g., vertically integrated food supply chains or private mechanisms such as brand names, contracting arrangements, animal identification and tracking systems. New technologies have allowed more rapid measurement of product attributes (e.g., fat content, drug residue) allowing the buyer to specify attributes of interest and better match consumers' tastes. It is important to recognize consumer preferences for food products are different in the three countries. Mexican consumers prefer animal cuts and products that differ from those preferred in Canada and the United States. Trade that takes advantage of differences in consumer preferences is likely to benefit consumers in all three countries.

2. Enhance the ability of consumers to obtain information on products and make use of labeling information. There is increased competition in providing various product and process food attributes, but consumers may not understand the attributes. Lack of or imperfect information leads to markets that do not work well and consumers who may lose confidence and trust in the quality of the food system. A challenge is to present a large amount of information, both in quantity and variety, to consumers in forms they can understand. This includes information on health and nutrition attributes, food handling and warnings, and product attributes such as country of origin. New methods and technologies (e.g., electronic information in the retail store environment) may provide alternatives to traditional media for educating consumers and allow highly motivated consumers to move from summary information on the label to more complete information available through the internet, for example. Although much of the information is regulated through federal agencies, private companies and brands also have incentives to promote desired food attributes through labels and

advertising. Public agencies may serve the role of deciding what type of information to provide to the general consumer.

3. Educate consumers about production agriculture. Consumers have become distant from production agriculture. Lack of information can lead to consumer misconceptions about production methods and techniques. At the same time, production agriculture is under increasing scrutiny from consumer groups. Both sources may threaten continued growth in animal product consumption and perpetuate lack of understanding about issues surrounding production agriculture. Educating consumers about commercial agriculture and enhancing the public's knowledge and awareness of food production methods may have long-term benefits in maintaining consumer confidence and growth in demand for animal food products.

The challenge is to use effective methods for communicating about the increasing scientific complexity of food production and processing, and to help consumers in making choices concerning more complex issues regarding nutritional content and health when there is scientific uncertainty.

4. Promote a competitive retail and distribution environment. Different food retailing environments exist within the North American market. The dominance of four or five large firms characterizes both the Canadian and U.S. markets, and nontraditional retailers are having a significant effect on retailing. This type of environment provides increased consumer product choice at low prices; however, it may reduce consumer choice over other products (or cuts) that may serve smaller consumer segments. In some markets, the presence of large merchandisers co-exists with smaller, niche segments. In other cases, the presence of large firms may limit the ability of smaller market segments, such as specialty meat markets with store-based operations, to survive. Some suggest that governments be more aggressive in preventing concentration in food retailing to preserve consumer choice. However, it is not clear that government action would actually result in more choice than is produced by an industry in rapid transition.

In addition to weighing policy options, there are continuing needs for information to allow informed policy choices. In an increasingly competitive and global environment, do consumers benefit or lose with consolidation of retailing? Consolidation among food retailers is relatively high in Canada and the United States and is increasing in Mexico. Yet, compared to other nonfood industries, concentration is not very high. Can smaller niche markets co-exist in the current retail environment, and under what conditions?

Many consumers have indicated a willingness to change eating habits to reduce weight, but so far the efforts have been relatively short-lived. What are the most effective approaches to reining in weight gain? How can long-term gains be made that meet consumers' preferences for variety, as well as food that is safe, tastes good, is convenient and meets more limited calorie requirements? Understanding how consumers obtain and process information is a major challenge. What will improve the consumer's ability to balance new information and conflicting messages from many different sources about complex scientific information?

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The Global Competitiveness of the North American Livestock Industry

Flynn J. Adcock, Darren Hudson, Parr Rosson, Harold M. Harris, and Cary W. Herndon

JEL Classification: F14, Q17

North American animal agriculture has undergone dramatic changes during the past two decades. Among the most important is the increased degree of market integration among all three NAFTA countries. Prices and trade flows are increasingly impacted by events, policies, and forces outside the continent. Global animal product markets are consumer-driven with product safety, wholesomeness, quality, and price being key determinants of international competitiveness. Processors, retailers, and food service corporations are expanding and integrating this global market, bringing efficiency and lower-cost food to both developed and developing countries around the world.

This article draws on a much longer report, *The Future of Animal Agriculture in North America* (Farm Foundation, 2006). Sources for figures and charts cited can be found in that report.

Three key global forces will shape the future of North American animal and product trade: animal disease outbreaks and discoveries, income growth in developing economies, and trade liberalization. Impacts of disease outbreaks, such as high-pathogenic avian influenza, have certainly disrupted trade in poultry meat and could have longer term consequences affecting consumption in some countries. Diseases such as *bovine spongiform encephalopathy* (BSE) may cause structural change in the industry. Consumer income growth in the United States and other developed countries has slowed, as has the growth rate in consumption of most animal products. In developing countries, however, there is a strong linkage between increased demand for animal proteins and consumer income growth. Expanded trade can also result from multilateral trade negotiations in the World Trade Organization (WTO) that reduce the effects of trade-distorting domestic policies used by developed countries, and result in much lower tariffs in developing countries and more consistently applied and science-based sanitary and phytosanitary (SPS) product standards.

North America is both a leading exporter and importer of animal products. The European Union (EU) is a larger exporter, but most of that trade is intra-EU. While Canada and the United States are important markets for each other's animal products, they also compete for export markets. Brazil is a rapidly growing export competitor in poultry, but competes less directly in beef and pork. China and Russia have significant potential as export customers, but inconsistent SPS regulations and policies have impeded the development of these markets.

Worldwide, demand for North American animal products is likely to continue to grow if consumer incomes rise and trade barriers are lowered. Meanwhile, both governments and the private sector face increasing pressure to assure consumers of product safety and quality. Market institutions, such as the World Organization for Animal Health, that help harmonize SPS regulations, may lessen the confusion about trading rules and facilitate more trade opportunities.

Beef and Beef Cattle Trade

Among the most significant trends in the North American cattle industry during the past 25 years has been the growth of the Canadian and Mexican cattle and beef markets relative to that of the United States. The period from 1980 to 1985 marked the high point for the U.S. beef cattle inventory, relative to Canada and Mexico; the number of U.S. cattle has trended downward ever since. During that same period, Mexican and Canadian beef cattle numbers increased.

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Historically, North America has accounted for nearly 25% of world beef exports in retail weight equivalent, and 50% of that trade was intra-NAFTA (Figure 1). The BSE incident in 2003, however, reduced NAFTA's world beef market share to 13% in 2005 and increased intra-NAFTA beef trade to 95%. Before the BSE case was identified in Canada in May 2003, 85% to 90% of Canadian beef exports were shipped to the United States and Mexico. For a period of months after the BSE incident, Canadian beef exports virtually stopped due to complete import bans by major customers.

Primary markets for U.S. beef exports before the BSE scare were Japan, Korea, and Mexico, accounting for about 80% of the total, with a smaller amount going to Canada. Post-BSE, the majority of U.S. beef exports are destined for Mexico and Canada. With Japan and Korea reopening their markets to U.S. beef, there is some optimism that a large share of those markets will be recaptured, but the United States is facing significant competition for those markets from other exporters, including Australia.

North America accounted for 42% of world beef imports in 2005, a level similar to that of the past five years. The United States accounted for about 81% of North American beef imports in 2005, Mexico 14%, and Canada 5%. The large U.S. share is due in part to a slight rise in U.S. beef demand, lower beef supplies, and more imports of beef trimmings to service the ground meat and fast-food markets.

Brazil has become a major beef trader, with exports of 1.1 million metric tons (mmt) in 2004 and 1.3 mmt in 2005, compared to 178 thousand metric tons (tmt) in 1996. Brazil's major export markets are the Middle East, the EU, and Russia. Other major beef exporters include Australia and New Zealand, which on average have exported a combined 1.3 mmt during the past five years, mainly to the United States, Japan, Korea, Taiwan, and Canada.

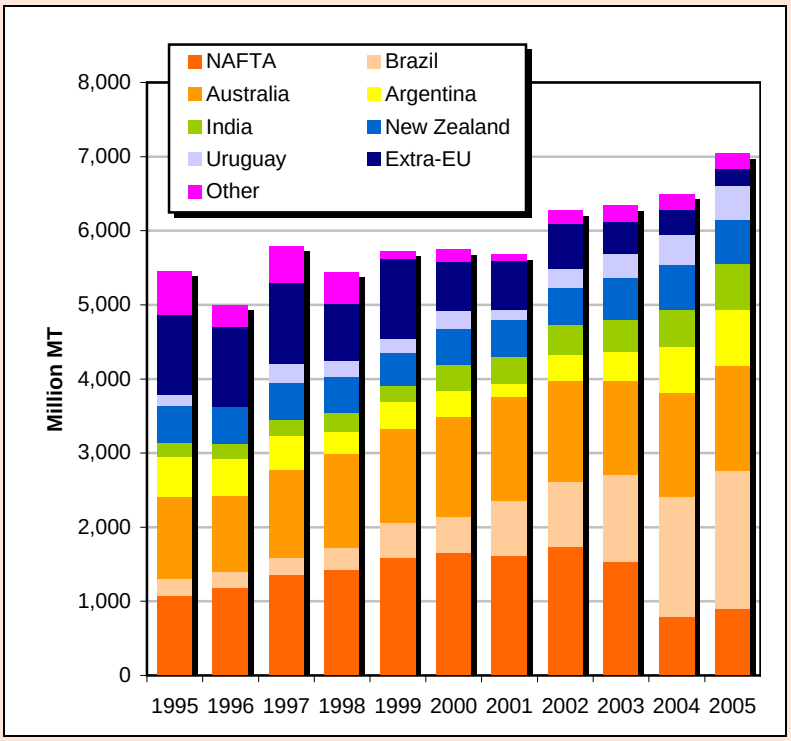

Figure 1. World beef exports.
Source: Production, Supply and Demand Database, www.fas.usda.gov/psd and Eurostat.

Before 2004, the main competitor for U.S. beef in the Japanese market was Australia. U.S. exports captured about 47% of the volume of the Japanese beef import market and Australia 45%. U.S. beef sells at a premium because it is grain-fed beef, which is generally considered to be of higher quality than the predominantly leaner, grass-fed Australian beef.

The United States dominated the Korean market prior to the BSE scare, typically capturing more than 65% of the market. Australia and New Zealand have both been able to increase beef exports to Korea following the ban on U.S. beef.

Mexico typically buys more than 90% of its imported beef from the United States and Canada, with U.S. beef dominating. Mexico mainly imports U.S. boneless beef, as well as about one-third of all U.S. beef offal exports.

The United States has more recently imported significant amounts of beef. Australia and Canada each typically account for 30% to 40% of total imports, with New Zealand in the 20% to 30% range. U.S. beef imports have increased due to more beef demand spurred by the low-carbohydrate diets and the popularity of fast-food.

Hog and Pork Trade

The most significant North American hog trend during the past 25 years is growth in the size of the Canadian hog herd relative to that of the United States. The period from

1990 to 1995 marked the high point for the U.S. hog inventory when compared to Canada and Mexico. The North American industry has become more efficient in producing pigs as the sow inventory has declined, while the pig crop continues to increase.

In 2005, Canada exported 812 tmt of pork, and the United States exported 907 tmt (Figure 2). About 750 tmt of the 1.8 mmt in North American pork exports were to NAFTA partners. Since 1995, more than half of Mexico's imports have come from the United States and Canada. Canada's main export market has been the United States and Japan. In 2005, the major U.S. export markets were Japan (343 tmt), Mexico (202 tmt), and Canada (113 tmt). The main competition for North American pork in the Japanese market is the EU, which exports slightly more than the United States or Canada. U.S. exports captured about 30% of the Japanese market, Canada 20%, and the EU 40%.

Following the implementation of the Canada-United States Free Trade Agreement (CUSFTA), Canadian exports of live hogs to the United States increased to 8.2 million head in 2005 from 1.1 million head in 1989. Canada accounts for all but a few hundred head of U.S. hog imports. North American live hog trade is more than 75% of world hog trade. Since 1995, Canadian exports of fed hogs to the United States have grown to 2.9 million head from 1.1 million head. Even more dramatic growth has occurred in U.S. imports of feeder pigs from Canada, increasing from 700,000 head to 5.6 million head over the same period. Canadian finishing capacity is limited when compared to advances in farrowing capacity and efficiency. The U.S. pork industry has a comparative advantage in hog finishing due to lower feed prices and lower transport costs of finished hogs to slaughter facilities. As a result, increased trade in live hogs between the United States and Canada has spurred the development of a well-integrated North American pork industry.

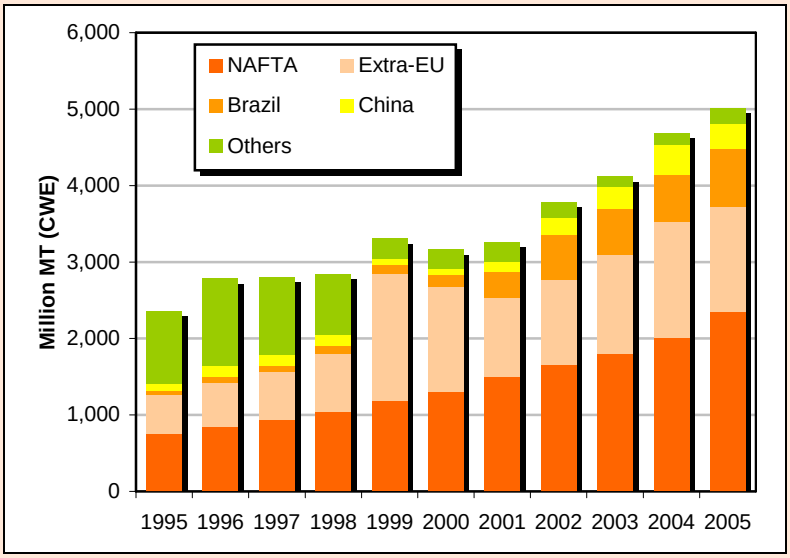

Figure 2. World pork exports.
Source: Production, Supply and Demand Database, www.fas.usda.gov/psd and Eurostat.

Poultry Trade

North America accounted for 35% of the 63.6 mmt world poultry meat production in 2005, down from a high of 39% in 1995 (Figure 3). The main reason for the decline in North American global market share was a 12.2 mmt increase in Chinese and Brazilian production combined. These increases are substantially more than the 7.7 mmt increase in poultry meat production that North America experienced during the same period. The other leading world supplier is the EU, producing 9.6 mmt in 2005, up 61% from 1990. Broiler meats account for 92% of world poultry meat production, up from 89% in 1990.

North American countries accounted for one-third of world poultry meat consumption in 2005 (19.9 mmt). Chinese and EU poultry meat consumption is balanced with production. North American and Brazilian production exceeds consumption by 2.1 mmt and 2.9 mmt, respectively.

Brazil has increased poultry meat exports by taking advantage of favorable exchange rates, disease outbreaks in other exporting countries, sanitary negotiations with Asian countries, and aggressive market promotion. Brazil is cost efficient in poultry production, but has limited transportation infrastructure. In 2005, Brazil and the United States exported 2.9 mmt and 2.6 mmt of poultry meat, respectively. The United States has a 36% market share of world poultry meat exports, Brazil 40%, and the EU, excluding intra-EU trade, 11%.

Historically, the majority of U.S. poultry exports have gone to Russia, China/Hong Kong, and Mexico. While Russia and Mexico have remained consistent markets during the past decade, China/Hong Kong

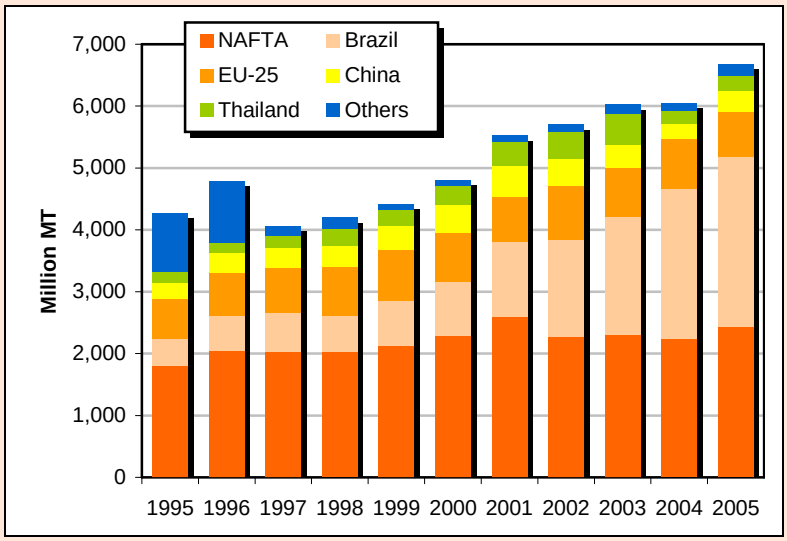

Figure 3. World broiler meat exports.
Source: Production, Supply and Demand Database, www.fas.usda.gov/psd

began decreasing imports of U.S. poultry in 1999, when it was the largest market for U.S. exports. Ukraine, Turkey, Cuba, Lithuania, and Japan are important poultry meat export markets for the United States, as well.

Milk and Dairy Products Trade

North American milk production was 98.1 mmt in 2005, compared to total world output of 483.7 mmt. The United States is the world's largest single country producer of cow's milk and accounts for 82% of North American milk output. Mexico produces 10.2%, and Canada 7.9%. During the past two decades, Mexican milk production has increased by 40%, while the output of the United States grew 23.6% and Canada declined 1.2%. These increases in output have generally come from fewer cows, except in Mexico where extensive dual-purpose production systems still predominate.

The EU makes up 75% of world dairy trade, followed by New Zealand and Australia. Most EU dairy exports are intra-EU, with only an estimated 16% of exports sold to non-EU countries. North America dairy exports totaled only 900 tmt in 2004, with the United States accounting for 75% of these shipments. U.S. dairy product exports were shipped to a large number of countries, including Mexico and Canada, in 2004. After removing intra-EU dairy exports, New Zealand was the largest single-country exporter, with nearly 15% of the world's total.

North America imported only 7.3% of the world's total volume of dairy imports in 2003. Of that, Mexico accounted for 48%, the United States 38%, and Canada 13%. World dairy product import volumes have increased by more than 50%, growing to 75.6 mmt in 2003 from 50.0 mmt in 1985. New Zealand has continued to increase dairy product exports and may be reaching its capacity to expand its dairy cattle herd. New Zealand simply may not have enough land area to further increase its dairy herd and milk output.

Strategies and Implications

Several strategies to increase the global competitiveness of North American animal industries emphasize the importance of economic growth in developing countries and the importance of having access to those potential markets. Others focus on ways to mitigate the negative impacts of animal disease outbreaks. The final two strategies emphasize the importance of industry efficiency and the need for regulatory consistency to enhance the overall competitiveness of the industry.

- Consumer income growth in developing countries may be the single most important factor in increasing North American meat exports during the next decade. The long-term payoff for the industry of policies aimed at growing the economies of developing countries is likely to be quite high. Such policies may be controversial since some may be aimed at improving the productive capacity of agriculture in the developing world as a first step in raising consumer incomes, because a large share of the population is employed in production agriculture. This strategy worked with four customers for North American animal products—Japan, Korea, Mexico, and Taiwan. However, improving agriculture in developing countries will be viewed by some industry participants as creating competitors.
- Brazil, and to a lesser extent its neighbors, is likely to remain a major force in world animal product trade. Brazil, in fact, may continue to increase its share of beef and poultry markets during the next decade. But periodic outbreaks of Foot-and-Mouth

Disease, should they occur, will limit this potential. However, if Brazil's per-capita income grows fast enough, a large proportion of its increasing production will be absorbed internally rather than abroad. Further, pursuit of a Free Trade Area of the Americas (FTAA) or other regional agreements will give the NAFTA countries the opportunity to integrate markets with Brazil, Argentina, Paraguay, and Uruguay within the MERCOSUR trading bloc. As has been learned from NAFTA, dealing with trade disputes and issues of competition within an established framework is often more productive.

- To maintain and improve the efficiency of the North American animal industry, greater harmonization of policies, programs, and regulations among countries is required. This may include, but is not limited to, animal and plant health, farm programs, environmental regulations, product safety, and animal identification rules. Regular meetings of NAFTA country agricultural and food agencies and legislative policymakers to discuss regulations and rule making may help improve transnational harmonization, but requires a commitment on the part of these groups to achieve a greater degree of policy harmonization as a means to increase efficiency of the entire North American industry.
- While it is important to mitigate the real risks of animal diseases, one of the greatest potential barriers to international trade in animal products is the perceived risk of such events. The temporary repercussions of short-term actions against another country's products may become permanent obstacles. Implications include the need for adherence to science-based principles, improved traceability from farm or feedlot to the consumer, and enhanced regulatory coordination among NAFTA countries.
- Large supplies of inexpensive feeds creating production efficiencies have been a major factor in the growth of animal product exports from the United States and Canada. However, changes in policy as a result of WTO commitments or budgetary pressures that reduce feed production incentives may serve to reduce the competitive advantage held by North America through increased raw commodity prices. Increased ethanol and bio-diesel production may further increase feed costs. To offset this, the development of new technologies and increased efficiency are important to maintain the competitiveness of the North American animal agriculture industry.
- Future growth in animal product trade will depend on industry success in creating branded/packaged, value-added products because local processing capacity in many developing countries is limited. Tapping into these markets will require creative marketing and packaging and will retain the value-added components within North America. To enhance the competitiveness of the products, government regulators and trade negotiators need to work closely with the food manufacturing and food service industries to assure a sound policy and regulatory framework to support future trade growth.

North American trade in live animals is largely intra-NAFTA, while trade in animal products relies on markets outside NAFTA. The North American livestock industry's future, therefore, is at least partly reliant on the competitiveness of meats and animal by-products production and trade. The extent to which the industry can compete globally will be shaped by the ability of the industry to mitigate the effects of animal disease outbreaks and discoveries, consumer income growth in developing countries, and the success of trade liberalization efforts to open markets and develop more consistent SPS regulations with current and future trading partners.

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Environmental Issues in Animal Agriculture

Charles W. Abdalla and Jennifer L. Lawton

JEL Classification: Q0, F2, Q25, Q30, R52

The evolution of animal agriculture in North America is focusing increased attention on its impacts on water and air quality. The adoption of new technologies and the restructuring of the food and agricultural system are generating new economic and environmental impacts and influencing public perception about animal agriculture. The expansion of livestock and poultry production, particularly larger confined animal operations, is increasingly leading to private disputes and public issues concerning agricultural production and the environment. These disputes are leading to new patterns of costs and benefits and, in some cases, public policies that are affecting competitiveness of this sector. The issues and options to resolve them are complex and require increased understanding and involvement by all stakeholders. While new technologies to improve environmental performance and monitor progress will be developed, constraints on resources may limit implementation.

This article draws on a much longer report, *The Future of Animal Agriculture in North America* (Farm Foundation, 2006).

Current Situation

Livestock and poultry farms generate manure, bedding, milk-house wash water, spilled feed and dead animals that, if not properly managed, can impact water quality. Animal manure and related byproducts contain elements that, under certain circumstances, might reach surface or ground water and cause pollution. The location of an animal operation plays a role in how pollutants may reach water and the magnitude of environmental damage. Animal production in grain deficient regions may generate manure nitrogen or manure phosphorus in excess of the assimilative ability of nearby land for manure application.

Air quality issues associated with confined animal operations are traditionally nuisance concerns, such as odors, but there is increasing focus on possible links between dust and other particulates, ammonia and hydrogen sulfide from animal operations and human health. Concerns include the possible effects of ammonia and particulates on respiratory systems (e.g., asthma) and prolonged exposure to odors on mental health effects (e.g., depression). Only a relatively few studies (e.g., Thu et al., 1997; Wing & Wolf, 2000) have attempted to measure health impacts of odors and air emissions on nearby residents.

There are scientific concerns about bioaerosols—tiny airborne particles that contain microorganisms or their byproducts—due to their potential for causing human and animal disease and microbial toxins. Bioaerosols may be released into the air by such practices as land application of animal biosolids, livestock wastewater spray irrigation, livestock wastewater injection or animal pen scraping. Other sources of bioaerosols include exhausted air from livestock confinement buildings, high winds that carry bioaerosols from open livestock wastewater systems and dust blown from outdoor livestock pens. Much more needs to be known about the possible connections between air emissions from animal operations and health of rural residents. The results from scientific studies of these linkages are likely to drive future environmental policies for animal agriculture in the United States.

In addition to direct emissions from cattle, the anaerobic decomposition of manure during storage produces methane, a greenhouse gas (GHG). GHG emissions from farm animals have increased during the last decades due to the overall increase in the number of livestock and the relatively low rate of adoption of technology to reduce emissions.

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Forces of Changes and Their Implications

Industry Concentration and Specialization. Economic forces influence the expansion in operations' size and geographic concentration of the animal industries. Regional clusters form around economic advantages, such as climate, processors, transportation access and costs, infrastructure, and proximity to inputs. In addition, industry marketing practices, such as contracting, have resulted in higher concentration of poultry and swine production in a few geographic areas (Vukina, 2001). Expansion into areas with existing nutrient surpluses may exacerbate the region's water quality pressures and possibly other environmental problems. Where contracting has become prevalent, producers have been responsible for manure management and dead animal disposal since these activities are not typically covered by the contract (Vukina, 2001). Thus, contracting has raised questions about producers' ability to afford and be rewarded for good environmental management and what role integrators should play in helping with such management and its costs.

Uncertainty about Human Health Impacts. As in many other environmental and public health issues, technology for detecting contaminants in the environment outpaces our ability to understand the human health implications. There are also emerging concerns over possible effects of endocrine disruptors, antibiotic resistance and air emissions from animal facilities. In the United States, the Environmental Protection Agency (EPA) is researching emissions from Concentrated Animal Feeding Operations (CAFOs), and the transport and fate of Food and Drug Administration-approved pharmaceuticals used in animals. It has called for National Pollutant Discharge Elimination System (NPDES) permits to include best management practices (BMPs) for pathogens.

Weak Federal Leadership and/or Policy Implementation Failures. In the United States, the responsibility for protecting the environment from the effects of animal agriculture has been shared between government levels. For example, in principal strong federal oversight has existed over permitting CAFOs under the federal Clean Water Act since the mid 1970s. In practice, however, the federal leadership role has been slow in developing and unevenly applied across the United States. It was also largely ineffective in dealing with emerging water quality problems from changes in animal industry structure and location in the last 20 years. To fill the void, some states and local governments have developed their own water and air laws. A patchwork of state policies and capacities for implementation now exist across the nation, resulting in difficulties for the industry in meeting differing rules, differences in the competitive economic environment of states, and an incentive to the industry to locate in states with less stringent environmental policies. While recent proposals by the federal government have attempted to improve and update its approach, they have been delayed due to court cases. Available evidence indicates that Mexican environmental rules also suffer from implementation shortcomings.

Technological Advances. New and improved technologies have historically generated tools to mitigate environmental problems in the animal agriculture industry. New treatments for manure can help reduce the loss of nutrients to the environment. Animal-feeding strategies have been developed to reduce nutrient excretions, emissions and odor from manure. Attention is being turned toward economically viable uses for manure that reduce the environmental impact. New methods have learning and adjustment costs, as well as some risks. Without a focused strategy for implementing new technologies, adoption may be slow.

Environmental Activism and Use of Information Technologies. Advances in information technologies have allowed neighbors of proposed large animal operations to communicate effectively. The Internet allows local groups to communicate, obtain information about issues and legal or political strategies, form alliances with groups across longer distances, and select their own sources of information to use in discussions and debates. In the United States, these developments add to the challenges of public policy decision-making and increase the potential for decision-making gridlock and delay.

Litigation. Litigation is a common strategy to settle disputes in the United States, but much less so in Canada and Mexico. Neighbors or environmental groups may continue to use litigation as a strategy to force implementation of regulations in the United States. Concerns regarding litigation relate to costs, delays, uncertainties, loss of control and loss of representation for all stakeholders. These problems may impact the size and number of animal operations, as small- and mid-size farms may not have the resources to challenge a lawsuit. Increasingly, a community's acceptance of animal agriculture is a key factor in where the industry can

expand. It may also impact the competitiveness of regions within the United States. If other countries, including Canada and Mexico, do not have these costs and uncertainties due to more stable regulatory regimes, an incentive exists for U.S. animal firms to relocate.

Perceptions of Agriculture. Farmers are traditionally viewed as good stewards of the land and the environment, and enjoy a large amount of good will among the public. The public may be less tolerant of environmental and nuisance impacts of animal agriculture, especially larger units. Improved scientific understanding of the impacts certain management practices have on the environment and human health may change public perceptions.

Environmental Monitoring. It is often difficult to attribute specific efforts of farms implementing BMPs to environmental outcomes. Measurement challenges include time delays, influences of weather, and difficulties measuring and monitoring smaller and diffuse sources of pollution. Advances in measurement technology have the potential to drastically change our understanding of pollution sources and to create new systems of accountability. Such advances will reduce monitoring costs and likely make resulting information accessible to watershed and/or other groups concerned about the environment. Bacterial source tracking has been proposed as a method to determine not only the species, but also to pinpoint the specific flock, herd or community causing any contamination. These developments can help inform the debate about the relative contributions of farming or other land uses (e.g., lawn fertilization or septic tanks) to pollution. Increased requirements for monitoring, along with decreased costs of doing so, will likely be a major driver of environmental policy for animal agriculture in the future.

Resource Constraints. Resource constraints have for some time been a limit in conservation and environmental programs affecting animal agriculture. These resources include personnel and funds for cost-sharing, research, technology development and technical assistance/education. There will be increased need for government agencies to set priorities. There may be an increasing role for the private sector, private-public partnerships, and multi-state and multi-national programs. Regardless of the origin of the resources, the priority must be on actively seeking practical solutions.

Uncertainty about Global Agreements, Kyoto Implementation. It is expected that the Canadian and Mexican efforts to implement the Kyoto Protocol for reduction of GHG emissions will continue to evolve. In Canada, a commitment exists to ensure that pollution credits can be supplied by projects under its offset system during at least the next eight years. As this system evolves, animal agriculture has the potential to be an important contributor by reducing its GHG emissions. Moreover, uncertainty exists about the future of Canadian and Mexican GHG reduction programs because the Kyoto agreement period ends in 2012. However, there is potential for a continuation beyond that date.

The Kyoto agreement on global climate change created a market for the reduction of GHG emissions. If a successful pollution credit trading market is established, there may be greater potential to reduce animal agriculture emissions than to do so through cropland management and carbon sinks. However, there are a number of important obstacles to the development of trading for GHG emissions. One of the major impediments is the need for the establishment of a regulatory limit or "cap" on total emissions in a particular region or air basin. If obstacles to market-based programs can be overcome, the potential may develop to create incentives for producers to adopt technologies and reduce overall environmental abatement costs.

Options for the Future

Five potential options for addressing environmental issues are discussed below. When making choices involving the five options below, it is important to recognize that none alone offer a single solution to address all environmental issues. The best choice may not be between different options, but deciding on the right mix of policy options.

Strengthen the public-sector role. The first option is establishing stronger federal, state or provincial policies to encourage responsible growth of the animal industry in locations with less environmental risk. A uniform regulatory playing field across countries, states and provinces could reduce overall environmental risk. This option could include increasing commitment to implementing regulatory and incentive programs, including adequate funding for staff.

Expand systems research. There is a need for more systems-oriented research by the public and private sectors on the environmental impacts of agriculture. Increased public funding for this type of research would give decision-makers better information about the interrelationships of envi-

ronmental/health, social, economic and legal/policy implications of animal agriculture. Results could identify solutions for different scales of farming and regional environments that take social/behavioral factors into consideration. There should be an emphasis on performance-based solutions to assure accountability. This research should be regional, national and global in scope, future-oriented and anticipatory of emerging challenges, multidisciplinary, and include agricultural universities, medical schools, and public and private partnerships. There is a need for information to reduce uncertainty concerning the relationship between animal agriculture and human health. Private research, with appropriate oversight to ensure objectivity, would be one way to fill this critical information gap.

Target best management practices to the highest priority environmental concerns. This approach would target efforts to areas and farms with the greatest water or air quality problems. Some types of animal agriculture provide a flow of goods or services that society values, including ecological services and possibly amenities. Payments from government to producers to provide ecological services—known as "green payments"—have been suggested as a major new direction for farm policy. This targeted policy option could utilize the green payments idea to integrate ecological goods and services into agri-environmental policy to reach desired broader environmental outcomes. Because the focus is on implementation, this option would use existing social and economic research knowledge on implementation and adoption, including incentive-based tools. It would require improved coordination among agencies and possibly other water or air quality monitoring groups, and development of information systems to assure cross-compliance with existing farm programs.

Use market-like mechanisms to "get the prices right". This option involves public and private cooperation to explore and foster promising innovative arrangements that internalize external costs of the fair, i.e., off-farm impacts on neighbors, communities and the environment. Such arrangements could more accurately reflect the off-farm costs of animal production in market prices, providing incentives to better manage manure and animal byproducts. Changes in government policies, such as new regulations or clarification of property rights, may be needed to help start a market in which the prices of agricultural commodities reflect true costs to the environment incurred in their production. This might provide an incentive for producers and processors to adopt systems that maximize profits while being environmentally friendly. This option could benefit from the trend among consumers and food retailers to demand products that are environmentally friendly. Public and private efforts to inform producers, agribusinesses, food wholesalers and retailers, and consumers about products produced in such a manner would complement such policy changes.

Legal reform. Many legal reform proposals have been put forward to provide the industry with some certainty or a "safe harbor." These reform efforts generally fail because they are perceived as taking rights from one group and giving them to another without compensation or required action by the industry. The crux of this policy approach is the need for multiple parties—industry, scientists and the public through government—to act together. In exchange for some protection against complex and costly litigation, the industry supply chain would take specific responsibility for the handling of animal manure and other environmental impacts using recognized science-based methods.

A second opportunity area for legal reform relates to the division of responsibility for manure management and dead animal disposal between the integrator and producer. Research indicates that the social benefits of greater sharing in responsibility of environmental management by the integrator depends on the relative bargaining power of the two parties (Vukina, 2001).

Summary

The expansion of animal production is increasingly leading to public policy issues concerning the environment. The options to resolve these issues are complex and require understanding and involvement by all stakeholders. While new technologies to reduce or eliminate the environmental impacts of animal agriculture will be developed, resource constraints of government agencies or producers may limit successful implementation of these technologies.

As animal agriculture evolves in North America, it faces new challenges and opportunities. Uncertainty in the face of possible regulation at the national, state/province or local level may hinder new developments or cause the industry to seek to locate in areas where environmental regulations are less stringent. New policies can create financial and technical burdens for producers and other firms and increase uncertainty. At the same time, successful policies will create benefits to farmers, neighbors

and more broadly, those in the community and society who benefit from improved water or air quality. It will be necessary to address environmental issues related to animal agriculture in a way which promotes stewardship of the environment and the well-being of the industry.

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Community and Labor Issues in Animal Agriculture

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Animal agriculture is undergoing fundamental change, driven by new production technologies, changing consumer demand, genetic improvements, new retailing pressures, and globalization. One significant outcome is a change in the relationship between farms and rural communities. Much production has shifted from independent operators to larger production units, which are more technologically advanced, using supply chains and marketing channels to link to the economy at large. These vertically-coordinated operations largely bypass community linkages. However, new operations may bring new resources, opportunities and economic growth to local economies. Large production or processing operations require a concentration of workers, who may not be highly paid and may have to be recruited from other locales. All this challenges the socio-economic structure of communities where these enterprises are located. New economic opportunities may impact the community's autonomy, norms, traditions, pace, culture, and control. These impacts include: (1) a diversification of the population that will add cultural richness to the area, but also increase demands on local government and institutions with regard to services for an expanding resident population; (2) creation of new jobs, but many that will place workers at the lower tier of the wage structure; (3) local entrepreneurial opportunities that could build on new value-added market niches; and (4) increasing possibility of conflicts arising from a different set of values associated with the changing composition of the population, or with animal agriculture-related practices.

This article draws on a much longer report, *The Future of Animal Agriculture in North America* (Farm Foundation, 2006). It provides a factual backdrop to the community and labor impact question, and suggestions for researchers and policy makers to help improve the relationship between animal agriculture and their communities.

Situation and Context

The community and labor impacts associated with livestock and poultry production and processing are significant, but very diverse. Labor is more mobile than is industry infrastructure and inputs that give a particular region a comparative advantage in animal agriculture. Livestock and poultry production adds value to local resources by creating jobs directly and indirectly as producers and workers purchase goods and services. The local economic impact of this industry will depend in part on the community's ability to meet the needs of producers or processors. In some rural communities where animal production and processing has expanded, there are more jobs than available local workers; immigrants increasingly fill these generally unskilled jobs. Regions of the United States and Canada are sometimes challenged to integrate new people and new cultures into existing communities. Mexico, whose rural communities often supply the immigrant workers to U.S. and Canadian companies, benefits from the remittances sent to families. However, the out migration, and subsequent reduction of human recourses to fill the jobs in the North, creates challenges in rural Mexico.

Over the last 20 years, four significant trends occurred in the U.S. livestock sector: growth and concentration, shifting geographic location, increasing scale, and, in meat processing, movement of employment to rural areas from urban locales. The share of meat processing employees in non-metro areas rose to 60% (300,000) by 2000, from less than half in 1980. Rural plants are larger. Estimates are that more than 85% of the beef, pork and chicken comes from large plants with more than 400 employees. Lower

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land and labor costs, less stringent environmental restrictions, and declining transportation costs explain the shift of meatpacking from urban to rural areas.

This portends an important policy issue on the horizon for policy makers and communities: the potential movement of meatpacking overseas in search of lower costs/less burdensome regulation. In recent years, U.S. foreign direct investment in the poultry and swine industry in Latin America has been increasing. Up until 1990, less than 6% of global poultry and pork production was traded internationally. Now almost 14% of poultry and 9% of pork is traded, and the portion is increasing rapidly. The next phases of the pork and poultry industry may involve significant offshore production. This would have important implications for local communities currently dependent on meatpacking and livestock for jobs and economic activity.

The makeup of the industry's labor supply has changed with the inclusion of a significant number of immigrants from Latin America. It is estimated that 10.3 million unauthorized foreigners live in the United States, including 1.7 million children less than 18 years of age (Passel, 2005). Fifty-seven percent come from Mexico and 24% from other Latin American countries. Unauthorized migrants represent an estimated 5% of the general U.S. workforce, but account for 29% of farm, 19% of food preparation, and 27% of animal slaughter workers.

The percentage of young people less than 34 years of age continues to rise in Mexico. These demographic conditions, combined with a relatively weak Mexican economy, have created a strong labor export market within the NAFTA community. The sizeable new supply of labor from Mexico complements the high rate of job growth over the last 10 years in the United States. The highly flexible labor market allows the United States to absorb a lot of immigration. Within the NAFTA context, it was expected that trade barriers would fall, allowing resources to be efficiently allocated. The labor exodus from Mexico though was not anticipated because of expectations for expanded foreign direct investment in Mexico. Most United States policy makers had concerns about opposite job flows, from the United States to Mexico. This raises an important policy question of what is preferred—a well-functioning NAFTA where capital and labor move freely, or somehow differentiating capital from labor in order to address important short-term social issues arising from migration.

The situation in Canada differs significantly from that of Mexico and the United States. In the past 30 years, immigrants have accounted for a progressively smaller share of a farm population in Canada. Today, in Canadian agriculture, an immigrant is likely to be a farm operator from the Netherlands, Britain, Switzerland or Germany. The number of immigrants moving to rural Canadian communities is still small in absolute terms.

Economic Impacts

In communities across North America, the economic benefits generated by the animal agriculture sector go beyond producers. Communities and regions where business is conducted receive indirect economic benefits through job expansion and enhanced entrepreneurial activity to serve the industry.

Economic multipliers reflect the effect of changes in one sector across a whole regional economy. Each dollar generated by economic activity in animal agriculture generates additional economic activity—directly through job creation, indirectly through the procurement of goods and services, and from increases in income and spending resulting from more active markets. While the magnitude of these effects differs by sector, animal agriculture has higher economic multipliers than such sectors as mining, textiles, forestry or crop agriculture (Goldsmith and Idris, 2001).

Jobs, taxes and other economic benefits of animal agriculture are realized beyond the local level. Global trade liberalization—including the inputs that supply livestock farms and products from animal agriculture—opens communities to outside competition, new market opportunities, and greater access to new resources and input supplies. This may affect economic multipliers by changing historical patterns in which inputs are sourced locally. As U.S. businesses compete globally, their suppliers and the business environments in which they operate must also be globally competitive. This implies that a community seeking industrial investment needs to assure its business environment is competitive with other communities around the globe. For example, information and communication technologies and infrastructure, critical for modern animal agriculture and processing businesses, have historically lagged in rural communities. Communities may receive technological spillovers that benefit other industries and consumers as they upgrade information infrastructure to better serve animal agriculture and processing.

Specialized support occupations in such areas as accounting, law, veterinary medicine, breeding, and mar-

keting may develop clusters of expertise surrounding communities that engage in new higher-technology meat and livestock businesses. These clusters of expertise create benefits for communities that include high-income employment and additional demand for information and communication technologies and infrastructure. Entrepreneurship in the form of technical services in the areas of veterinary care, nutrition, environmental and human resource management, construction and maintenance, information management, transportation and logistics, and marketing may add even more economic growth within the surrounding region.

Community/Social Impacts

The siting of large animal production operations can generate considerable local controversy at the same time economic activity expands. Issues of contention are: potential odor problems, water availability and use, manure disposal, and the desired structure and size of farm businesses. Common complaints are that:

- recipients of economic benefits are not local,
- jobs associated with animal agriculture are of poor quality,
- changed demographic makeup of the workforce is problematic,
- there is a negative impact on property values,
- there are negative health consequences for nearby communities due to changes in air and water quality,
- there will be a deterioration of infrastructure, specifically roads and bridges, and
- there will be traffic congestion and increased manure and dirt on the roadways.

In the United States, meatpacking attracted newcomer immigrants with relatively little education and sometimes few English language skills a century ago, but the meatpacking labor force was mostly U.S.-born as recently as 1970, when immigration was at historic lows. Since then, immigration has increased sharply, and a third of meatpacking workers today may be foreign-born. Hispanics were 15% of the U.S. meat industry's labor force in 1990, and 35% in 2000. The arrival of Hispanic or Asian workers quickly changes the face of rural areas that have not experienced significant immigration in recent years. Most areas, especially those losing people and jobs, welcome new residents because they buy homes and shop at local markets. But there are also tensions which accompany demographic change.

Positive impacts on communities from an influx of immigrant workers include:

- most workers are married, and while not known with any certainty, it is thought that increasing numbers of spouses are also in the United States since crossing the border has gotten more difficult,
- a higher proportion of Hispanic or Asian men participate in the workforce than from other population groups,
- workers do unwanted jobs that are necessary in today's society,
- repopulation of rural areas,
- a younger workforce, and
- replacement for aging baby boomers.

Potential negative issues with the changing labor force include:

- increased demand for social service resources in the community,
- increased need for bilingual workers in public safety, health and other key sectors,
- more students with limited English proficiency,
- low propensity to continue education because of English being a second language, a low education level, or limited access to educational resources,
- increased poverty among unauthorized migrants,
- greater demand for health care at local clinics and emergency rooms,
- lack of health insurance placing a strain on limited health resources in rural areas,
- a higher prevalence of infectious disease, diabetes and maternal health issues,
- fiscal stress on local governments as increased tax income may not keep pace with increased service needs, and
- strain on local housing stock as a result of an influx of immigrants (which at times results in immigrants being placed in poor, overcrowded housing).

Future Options and Implications

Economic Development

Rural communities in North America compete in a global environment. Provinces, states, regions and communities seeking investment need to assess how their location will potentially make animal agriculture operations globally competitive. This creates challenges in a world of varied wage and regulatory conditions.

Industry has a responsibility to the community in which it does business. Industry needs to be proactive and a responsible citizen, providing leadership in creating positive experiences for communities. The inability to create these positive community

experiences will only limit their ability to site or expand.

This phenomenon, whereby communities oppose the siting or expansion of livestock and meat facilities, is no longer unique to the United States. The opposition is structural and can be found in many communities around the globe. It reflects both direct concerns about changes to their neighborhoods and larger concerns about globalization, new technologies, large farms, and multinational food companies. At its heart, communities feel a loss of local control and see rapid change in the face of these large and sometimes unfamiliar neighbors.

As a result, the industry needs to complement the numerous economic benefits it brings with a set of positive social impacts. Some communities will always oppose the industry, but many would welcome a partner to help them socially and economically develop.

By no means inclusive, this article has highlighted some of the needs that industry can help address: the positive incorporation of immigrants into the fabric of the community, expansion of IT infrastructure, investment in entrepreneurial activities that add value to the current animal agriculture component of rural communities, and expansion of opportunities for education and training in order to strengthen the community's human capital resources.

There is potential for the animal agriculture sector to use many of the tools employed in industrial sector economic development:

General Tools.

- Government bodies should consider homogenized industrial policies, so animal agriculture is not singled out. Homogeneity of policy minimizes multiple levels of industry performance, improves efficiency in regulatory oversight, and ensures equal treatment across industries.
- Focus on rural economic development, not just animal agriculture development. Local communities should avoid trying to pick winners, but instead use evaluative tools and policies that are conducive to an overall healthy business environment that is attractive to a variety of industries and their suppliers.
- Develop industry strategies to create positive community impacts. Active communication about respective needs and strategies to address those needs is critical for a healthy industry-community relationship.
- Use provincial, state or regional economic development resources and streamline the regulatory process.
- Conduct research to better understand the type of contributions animal agriculture and processing makes to a community.

Specific Industry Offsets.

- Property tax reductions for neighbors.
- Service and infrastructure improvements for the community.
- Fiduciary bonds to dissipate risk borne by communities, such as new demands industry might place on water resources.
- Appropriately scaled public infrastructure investments, such as upgrading roads and bridges, increasing utility capacities, and augmenting highway access.
- Compensation for harmed parties from confined animal feeding operation impacts as is done with other industries.

Labor

Local, regional, and national government officials need to consider maintaining immigrant worker programs that ensure adequate labor supply to the animal agriculture industry. Helping immigrant workers adjust to a new location and culture and helping communities adjust to new immigrant populations can be advantageous to employers. For example, communities and industry can work together helping immigrants learn English, navigate the social services system, establish bank accounts and credit, obtain affordable housing, and adapt schools and their curriculum to an English-as-a-second-language student body.

Mexico and the United States are examining options to improve the legal movement of workers between the two countries. As workers attempt to earn a livelihood, they need to be able to take advantage of work opportunities without running the risk of violating the law. Potential options include illegal immigrant legalization, a guest-worker program, and exempting Mexico from visa quotas. The United States might consider a program similar to Canada's Seasonal Agricultural Worker Program (SAWP) to address seasonal worker shortages, though seasonality of work is not as common in the livestock sector. At the same time, Mexican and U.S. officials have also discussed improving conditions for unauthorized Mexicans in the United States by ensuring their human rights, access to health care and education resources, and providing opportunities to obtain legal status (Rodriguez-Scott, 2002).

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Policies to Protect Food Safety and Animal Health

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JEL Classification: Q16, Q17, Q18

Protecting food safety and animal health is critical for maintaining public health, consumer confidence, and profitability of animal agriculture. Several developments in North American animal agriculture have an increasing impact on food safety and animal disease risks and the methods used to manage these risks.

Demand for animal food production is increasing as world population increases and developing countries have more disposable income. Increased production to meet this demand has led to more confined, concentrated and intensified systems all over the world. In North America, this intensification is regional, especially with poultry, swine and cattle feedlots. Dairies are becoming fewer and larger and are concentrating in geographic areas not traditional to dairy production. As animal production costs increase without assurances of sector profitability, enterprise numbers continue to decline.

Driving forces in food safety and animal health across North America include questions about feed additives, biotechnology, foodborne diseases, links between animal and human diseases, and traceability. Animal health and food safety issues are closely related, yet in some cases require separate strategies. Even if there are similarities in the approaches that address animal diseases and food safety, it is important to recognize that objectives and desired outcomes are often different. Policies and practices meant to protect domestic food supplies and herd/flock health (breeding stock and egg/chick quarantines) may serve as "trade barriers," though they are not intended as such.

Food Safety Dimensions

Foodborne microbial pathogens, which may result in human illnesses, will continue to be the major focus of food safety concerns. Estimates of the costs of human illnesses and costs to the food industry attributed to foodborne pathogens are well-documented (Buzby et al., 1996; Crutchfield & Allhouse, 1998; Goodwin & Shiptsova, 2002; Unnevehr, 2003). Detailed treatment of this topic is beyond the scope of this paper, the purpose of which is to raise both new and ongoing issues related to food safety and animal health and the interface of the two. This paper draws on a much longer report, *The Future of Animal Agriculture in North America* (Farm Foundation, 2006).

Food safety and assuring consumers their food is safe will continue to be a challenge for the industry. Private sector efforts to minimize risks of recalls and protect brand equity are part of an effective food safety strategy. The processing sectors have adopted process control strategies (Hazard Analysis and Critical Control Point or HACCP) to reduce the risks of microbial contamination during slaughter and processing. The production sector is adopting quality assurance programs to address specific product quality and food safety issues, such as measures to reduce the presence of harmful microbes in the live animal before transport and slaughter.

The incidences of *bovine spongiform encephalopathy* (BSE) and *E. coli* contamination have brought demands for adoption of traceability and quality assurance systems to manage the animal products supply chain. The dominance of international food retailers has been a key factor in wide use of such systems, even when not demanded by regulations. The rapid growth of supermarkets in developing countries and trade agreements are also driving food safety concerns.

Globalization of food trade provides greater food choices, but presents the potential for confusion if consistent standards in safety and labeling do not exist. Increased

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consumer sophistication and advanced information technology pose both a challenge and an opportunity for firms and government to inform consumers and address their concerns. Maintaining consumer confidence requires not only minimizing the risk of foodborne illness, but responding to consumer concerns through increased education regarding safety of some practices and/or labeling policies.

Animal Health Dimensions

Animal health is closely linked to food safety and consumer confidence, but is also central to the profitability of the livestock and poultry production sectors, and in some cases, even national economies. In addition to increased production costs and lower revenues for farms with a disease, trade restrictions due to the presence of particular diseases have an economic impact on all producers in the industry. One cow testing positive for BSE in the United States resulted in the immediate loss of $3 billion in annual beef exports from 2003 to 2004 (Doud, 2006).

Joint efforts between research universities and public agencies have controlled and eradicated many animal diseases through advances in veterinary medicine, basic research, educational programs, and animal housing. However, without vigilance and effective surveillance systems, even eradicated diseases can return. Vigilance is also necessary to guard against potential terrorist attacks to the food system.

Several developments will play an important role in meeting the challenge of protecting animal health. Animal identification and tracking systems would potentially allow restricted animal movement within or between countries while controlling disease, thus minimizing trade distortions. Farm-level biosecurity measures to reduce disease risk and developments in vaccine research are also providing new tools to lessen the threat and impact of animal diseases to farmers.

Globalization has increased both export opportunities for North American livestock and poultry and the risk of introducing foreign animal diseases that could be economically devastating to these industries. Even if the disease is not deadly and is quickly contained, its presence can have a prolonged economic impact by disrupting exports and trade within North America. To protect animal industries and consumers from importing disease or food safety problems, sanitary and phytosanitary standards have become part of most trade agreements. Phytosanitary standards can be trade distorting and protectionist, accentuating the need for harmonizing standards and their enforcement within the North American Free Trade Agreement (NAFTA).

Providing traceability of animals through production, processing and marketing is an example of interactions between efforts to protect both food safety and animal health. Advances in information technology and improved infrastructure to trace animal disease threats will provide a vehicle to share more product information through the supply chain. Individual firms may utilize the information infrastructure as part of an enhanced process control system. Advanced supply chain management systems also allow for traceability of food products, which facilitates faster, more targeted recalls when needed.

Policy Measures and Implications

Animal health and food safety are important components of national security in each of the North American countries. They are public goods requiring public intervention or collaborative industry efforts rather than individual producer actions (Unnevehr, 2004). The challenge is to develop and implement policies that most effectively protect a safe and secure food supply and a competitive livestock and poultry sector in North America, given increasing concentration and intensification of animal agriculture. Some components of a comprehensive strategy for government, business and research efforts to protect food safety and animal health are identified here. Many of these will require additional resources. There are various vehicles for financing these measures that will help producers and consumers; check-off programs and reallocation of existing program funds are one possibility. Economic pressure in the industry could make it more difficult to obtain such funding, but increased concentration in the industry might make it easier to implement new measures because a smaller number of industry decision makers control more of the supply. Larger firms may be better able to cover the fixed costs associated with protecting food safety and animal health. Further, they have greater incentives to provide food safety, given that a bad publicity event that erodes a firm's reputation or brand could have a significant monetary effect. However, larger firms may be better able to weather temporary drops in revenue or increased costs, somewhat reducing this incentive.

Establish a NAFTA-wide, high-level, authoritative, and accountable coordinating mechanism for food safety

and animal health. Animal health threats go beyond impacts on single private entities to affect the entire animal production value chain and even the economy as a whole, under the right circumstances. National structures coordinated across NAFTA countries and appropriate to organizational and financial constraints faced by each could serve as a focal point for engaging and enhancing partnerships among local, state, and federal agencies and the private sector (National Research Council, 2005). In the United States, several federal and state agencies and various animal and human health organization programs are responsible for food safety and animal health policy, but there are implementation gaps, ineffective communications, and failures in information sharing. The 2005 report by the National Academy of Sciences National Research Council says the United States needs a new high-level mechanism to coordinate research and information exchange and dissemination efforts on new and emerging animal-borne diseases, such as BSE, avian influenza, and West Nile virus.

Strengthen publicly-funded basic research efforts. In the United States, state and federal government agencies could re-emphasize the practice of supplying formula funding on an intermediate or long-term basis to support ongoing basic research efforts. The recent migration toward predominately competitive funding tends to emphasize hot-button issues of an applied nature, rather than supporting long-term, system-wide innovations that would address the animal health and food safety issues outlined in this report. However, this base funding should not be supplied at the expense of Extension and public education programs necessary to effectively disseminate appropriate information.

As the risks to animal health evolve, so must mechanisms to address them. To develop and implement effective and efficient tools, work is needed to assess and predict this evolution of risks, evaluate the current system's response capabilities, identify areas where improvements may be warranted, and communicate them effectively. Attention should be given to risk research and assessment, as well as communication capacity among all stakeholders.

Develop a comprehensive NAFTA-wide diagnostic, monitoring and surveillance network. Such a cooperative and functional network would multiply the efficacy of networks in the United States and Canada and establish a comparable functioning network in Mexico. The network could share access to stockpiles of vaccinations and treatment agents for many of the most probable and virulent diseases and also serve as a clearing house for methods to limit disease spread by effectively utilizing quarantine and animal disposal protocols. Past cooperative eradication programs have set precedent and serve as models for such a network. Eradication programs established jointly between Mexico and the United States for Foot-and-Mouth Disease and screw worm successfully ended the extensive and adverse impacts of both animal health issues in North America.

Enhance capabilities for rapid and widespread information dissemination to industry and the public. Both government and the industry would benefit from fast and widespread access and dissemination of information when dealing with food safety or animal health hazards. This information is essential to retain consumer confidence in the food system at home and abroad. Establishment of national traceability systems is important. Increased public and private investment could help reduce disease transmission and enhance public and animal health. Public awareness supported by education and training programs is critical to food safety and animal disease prevention. It may be possible to develop training for the animal agriculture industry, including local, regional, or national associations, which focuses on strategic and tactical cooperation in the event of food safety, animal health, or biosecurity emergencies.

Increase government-sponsored, food-animal veterinarian positions. A National Academy of Sciences National Research Council report calls for stronger efforts to recruit more veterinarians and other scientists into veterinary research, noting that a growing shortage of veterinary pathologists, lab animal scientists and other veterinary researchers is making it more difficult to meet mounting challenges. These positions could be comprised of more private practice food-animal veterinarians, more government public health veterinarians, and more government veterinarians in research. Sufficient economic incentives attached to these positions would increase attraction and retention of qualified personnel. Food-animal veterinarians would be directly involved in import inspections, live animal auctions, and monitoring concentrated animal feeding operations.

Encourage and provide ongoing support for developing new scientific tools and technologies to enhance animal disease prevention, detection, and diagnosis in North America. The current animal health framework should evaluate, validate, and implement rapid prevention strategies to protect

the health of the nation's animal populations. A gap in the current border protection system is importation or unnoticed transfer of animals produced under nonstandard commercial conditions (exotic animals, backyard livestock, and poultry). There is a documented lack of inspection protocols and procedures involving health of these animals. Animals produced out of the mainstream put national herds and flocks at risk because they are not integrated into the food security network.

Establish indemnity insurance for animal agriculture. Although there are provisions for indemnity payments to producers for animals with value under $3,000, there are currently no government-backed insurance programs for animal agriculture that parallel those for crop agriculture. Consequently, livestock producers are subject to absorbing catastrophic losses (destroyed animals, market loss or collapse, business interruptions) that may be associated with animal health events, particularly for breeding animals with value over $3,000. Financial risk management of animal diseases is an issue that government and industry must effectively address in partnership to ensure that effective and efficient financial risk management tools are in place to deal with future animal disease outbreaks. A revised and strengthened indemnity program could address this issue, reducing private sector uncertainty, and thus increasing reporting compliances and cooperation. A broader production certification program addressing food safety, animal health, and emergency management could also be developed.

Gain international approval for full equivalency of food safety and animal health standards for trade. The present lack of consistency in international standards and their enforcement creates inequities in trade among potential partners and may well limit trading arrangements. It is necessary to eliminate this artificial trade barrier so that competitiveness may be accurately evaluated and gains from trade may be more fully realized. There are currently prescribed events and standards that signal conditions for which trade interruptions commence, but such signals to recommence trade are not readily apparent. A functioning mechanism establishing "triggers" to allow trade to resume once food safety and animal health concerns were alleviated, could be implemented.

Summary

Protecting the safety of the food supply is essential to all countries. Canada, Mexico, and the United States spend significant resources to assure that food is safe to eat and wholesome. Animal health is closely linked to food safety and consumer confidence and is also central to the profitability of the livestock and poultry production and processing sectors. The options discussed here offer a range of public-sector involvement and discretion on how to efficiently utilize scarce government resources. Many of these options will require increased funding, but the benefits of improved protection likely outweigh the costs. Because producers and processors all benefit from reduced risks, developing funding mechanisms to share the costs will be important. Successful financing approaches must also take into consideration the effect of cost pressures, consolidation, and vertical integration on incentives faced by both producing and processing firms.

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Animal Welfare

David Blandford

JEL Classification: Q13, Q17, Q18

Animal agriculture in North America has undergone a revolution since World War II. Productivity has increased enormously through the use of animal confinement, genetic selection, scientific feed formulation, and productivity-enhancing pharmaceuticals. There has been a shift to larger production units taking advantage of economies of scale. Critics contend that these changes have reduced the welfare or well-being of farm animals. Proponents argue that the system reduces mortality due to predators, the weather and the risk of disease.

Farm animal welfare is an increasingly prominent issue in many wealthy countries. Concerns are expressed about how farm animals are kept, some management practices, and transportation and slaughter. There is increased legislative activity and more buyer requirements for production and marketing practices.

This article draws on a much longer report, *The Future of Animal Agriculture in North America* (Farm Foundation, 2006).

Current Rules and Regulations

Legislation

Much of the legislation in North America deals with pets or companion animals, animals used for research, and those kept by zoos or circuses. Regulations for farm animals address humane slaughter and transport, but there is no comprehensive animal welfare law. A comprehensive bill was introduced in Mexico in 2004, but has not passed.

Canada has a federal law prohibiting cruelty to all animals and regulations dealing with the transportation and slaughter of animals for food. Each province has its own legislation dealing with animal welfare, which typically recognizes accepted humane production practices. Industry guidelines have been developed for each type of animal.

The United States has federal regulations dealing with the slaughter of livestock, but not poultry, and for the transportation of animals. Each state has an anti-cruelty statute, but most do not target farm animals or there is an exemption for accepted farming and ranching practices.

There has been a marked increase in the number of animal welfare bills introduced in the U.S. Congress in recent years. There is also much activity at the state level, although relatively few bills have been passed. Recent state initiatives include proposed prohibitions on the tail docking of cattle and on the use of stalls for sows and veal calves.

Codes of Practice and Third-Party Auditing

Codes of practice have been developed by the animal products industry, particularly in Canada and the United States. In Canada, codes have been defined for all major species of farm animals. The National Farm Animal Care Council was created in 2005. Several U.S. producer groups have introduced welfare programs, for example, the National Pork Board for swine and the United Egg Producers (UEP) for laying hens. Both of these are voluntary and rely on independent auditing by third parties. The costs are borne by the audited firms.

A major U.S. initiative has been spearheaded by the Food Marketing Institute and the National Council of Chain Restaurants. An expert advisory group developed a series of standards for production and processing. The focus is on the application of objective, measurable characteristics that can be audited. Suppliers to the food retailing and restaurant industry can voluntarily request an audit. The results can then be made available to retailers or restaurant chains who can determine whether their own requirements are being met.

Several animal welfare advocacy groups have developed welfare schemes. The Animal Welfare Institute promotes

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voluntary standards for a range of farm animals. Certification programs have been developed by the American Humane Association and by a consortium of animal welfare organizations through Humane Farm Animal Care.

Drivers of Change

Consumer and Public Attitudes

U.S. surveys of public attitudes generally show that there is substantial confidence in farmers and ranchers in the treatment of animals. However, there appears to be increasing concern about some practices, such as housing systems for veal calves, and intensive confinement for pigs and poultry.

Animal welfare issues are championed by a range of interest groups. Some of their views may not be widely shared, but the groups have been effective in raising the profile of animal welfare issues. Protection of the reputation and value of branded products is a key concern in the food industry, and firms respond to public pressures that threaten their interests.

International Developments

The European Union (EU) has been very active in the development of animal welfare standards, primarily through legislation. New rules will eventually result in the elimination of traditional cage systems for laying hens, and individual pens or stalls for calves and pigs, and may reduce the stocking density for broilers.

Key Issues for Change

Practices Being Questioned

Many of the practices being questioned are associated with animal confinement. Confinement can benefit animals by allowing better environmental control, but raises issues, particularly in terms of the ability to express "natural behaviors." The size of cages and whether these allow for nests or perches is central to the debate on the welfare of laying hens. The issue for swine centers on stalls that restrict the movement of sows during gestation or farrowing, and the provision of bedding material, such as straw.

Some management practices, such as restricting feed for laying hens to induce molting and a subsequent egg-laying cycle, and diets deficient in iron to produce white veal have been questioned. Other practices such as beak trimming and toe clipping for poultry, and tail docking, dehorning, branding, castration and early weaning for livestock are criticized.

The length of time animals are transported, the duration of rest periods, loading densities and the handling of non-ambulatory animals are issues. Concerns are also expressed about animal slaughter, particularly methods for stunning and handling, and culling to control disease outbreaks.

Finally, a range of issues relate to livestock breeding, particularly the impact of genetic selection on the reproductive efficiency, health and viability of farm animals.

The Development of Standards

A central question is what constitutes humane treatment for farm animals. The answer depends partly on beliefs and values that differ across individuals. Nevertheless, there is increasing acceptance of the Five Freedoms – freedom from hunger and thirst; discomfort; pain, injury, and disease; fear and distress; and any constraints on the ability to express normal behavior – as a basis for developing objective methods for evaluating animal well-being.

Public opinion will exert a major influence on the future development of standards in North America. A central issue is whether this will result in more legislation or if the industry will respond by developing and applying higher standards.

Legislation versus Collective Action

The use of mandatory standards, supported by legislation, has been the primary approach adopted in Europe. Public attitudes and perceptions about animal welfare are changing, and the science of animal welfare continues to evolve. Consequently, it is difficult to develop and apply detailed legal codes for production practices for farm animals.

The alternative is to develop voluntary codes which evolve as more is learned. The model that has been adopted so far in North America—the involvement of animal welfare experts in the development of standards and the use of independent audits—can address public concerns if those in the industry fully accept the process. Producers are the key to animal welfare practices and must be actively involved in developing standards.

Economic Impacts

Low animal welfare standards do not impose an economic cost on society unless they result in lower productivity and efficiency or pose a threat to human health. In fact, there may be gains if the prices of animal products are lower. Some argue that animal welfare is a public good, or that there are external costs not reflected in current prices of animal products. But there is little evidence of market failure. The decision to impose higher welfare standards in farming cannot be based solely on economic criteria.

Production Costs and Consumer Response

Some changes in practices can be relatively inexpensive to implement, but others are likely to increase production costs. Changes in confinement operations, particularly increased space requirements, may require the modification or construction of facilities. Extensive production systems require more land. Operating costs may increase due to higher labor requirements, increased energy consumption in larger facilities, and reduced feeding efficiency. Higher standards may also increase the costs of transporting and processing animals.

There may also be cost savings. Morbidity and mortality may decline and expenditures on disease control and treatment may fall. Greater reproductive efficiency may lead to cost savings. Product quality may improve through reduced stress.

It is difficult to generalize about the net effect, but available economic studies indicate a net increase in costs. A recent study of EU egg production suggests that unit costs under new systems are roughly 12% to 20% higher than conventional systems. Over the long term, producers might be able to adapt by adopting new technology or production techniques. However, this is unlikely to negate the adverse effects on costs and competitiveness, particularly if producers in other countries use lower standards.

Increased production costs will be reflected in higher product prices. Some consumers may be willing to pay a price premium for products that meet higher standards, others may respond by switching to products whose prices are not affected. European experience shows that estimates of willingness to pay for higher standards typically overstate actual willingness to pay in the marketplace. For welfare-friendly products to command a price premium, they must be clearly distinguishable. Labels need to be uniform and clearly understood. Research indicates that European consumers are confused by wide variations in labeling of animal-friendly products. Consumer welfare may decline if a proliferation of information makes informed choice difficult.

Welfare Standards and Competition

If all producers are required to adhere to a particular standard, they will all be on an equal basis in terms of competitive position. Product prices will tend to rise as higher costs are passed through to the market. Consumer response could affect the market share of individual products and their prices. Exporters will face a deterioration of their competitive position if other countries supply non-conforming products.

Producers who have difficulty differentiating their product face particular risks from non-conforming products. Domestic or foreign producers operating at lower costs may increase their market share. Domestically, this problem can be solved by requiring that all producers meet the standard. When non-conforming supplies originate from other countries, the situation is more complicated.

The General Agreement on Tariffs and Trade (GATT) and its associated agreements contain no specific provisions for animal welfare. The Agreement on Technical Barriers to Trade requires that imported products should be treated as "like" products of national origin. The Sanitary and Phytosanitary Standards agreement is limited to the protection of animal health and recognizes standards developed by the World Organization for Animal Health (OIE). In 2005, OIE agreed on four international standards for animal welfare and is currently working on others. This could go some way to addressing concerns over unfair competition from non-conforming products.

Options for the Future

The North American livestock industry is taking steps to address some of the concerns about the impact of current practices on animal well-being. Much of the effort centers on the voluntary development of standards and codes of practice. This is in contrast to Europe, where legislation and mandatory standards are playing a major role. Pressures for legislation are likely to intensify in North America if the general public perceives that self-regulation is not effective. A number of options could be used to strengthen the process.

1. Improve the flow of information to the general public.

Industry policies on animal welfare are not always visible. All stakeholders could develop a statement of principles and make this publicly available. Industry groups could support the development of educational materials.

2. Develop codes of practice.

The industry could ensure that standards and codes are developed for all types of livestock. Information dissemination and support for training could be made a high-priority activity. The industry could lend support to the development and application of appropriate science-based standards internationally.

3. Increase research and education.

Higher priority could be given to animal welfare issues in publicly funded research. Particular emphasis could be placed on developments that are both practical and economically viable. A further step would be to ensure that all educational programs in animal science, veterinary medicine, and related fields incorporate material on animal welfare—biological issues as well as ethical and socio-economic aspects. Animal welfare could be made a priority in public extension programs, particularly for the training of farmers and ranchers, and employees in the animal products industry.

The extent to which the industry voluntarily addresses animal welfare issues successfully will determine whether legislation will eventually require certain practices in animal husbandry. The above options in some combination may go a long way to quieting concerns about animal welfare.

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Comparison of a Fixed and Variable Corn Ethanol Subsidy

Wallace E. Tyner and Justin Quear

JEL Classification: Q48

When the government subsidizes a commodity, it normally intends to promote production and/or consumption of that commodity for either political, environmental, or economic reasons. Today one major subsidy is the ethanol program, currently with a $0.51 per gallon subsidy, which will in the near future amount to a bill of over $3 billion annually on 6 billion gallons of production. This paper investigates the effectiveness of the subsidy and asks whether a cheaper alternative could be developed.

Like any government expenditure, the value of a subsidy must be judged on how well it achieves its intended objective – in this case, stimulating the production/consumption of ethanol, and thereby increasing corn demand. How well the objective is achieved can be measured by the stimulus to production versus the cost to the government. Stimulus to production should be tied to the effect of the subsidy on expected profitability and the change in risk for investors.

A fixed subsidy could change the expected profitability simply by adding to the expected profit without the subsidy. However, if profit without the subsidy were already high, as at present, the subsidy might have a small impact on investment decisions and ethanol production. On the other hand, a subsidy that was larger with lower ethanol prices or higher input costs could reduce risk substantially and stimulate greater production through that risk reduction.

Today with ethanol prices near $3 per gallon, the industry is very profitable without a subsidy, and the added profit from the subsidy likely induces little additional investment. However, if wholesale gasoline and ethanol prices were to fall below $1 per gallon again, the subsidy would provide substantial incentive for additional investment. So, while we cannot predict the change in investment for any given subsidy approach, we can estimate the change in profitability and risk and compare that with the government cost for each approach.

The current ethanol subsidy is a flat 51 cents per gallon of ethanol paid to the agent that blends ethanol with gasoline. In the past it took the form of a partial or total gasoline excise tax exemption, but today it is a tax credit for the ethanol blender (Renewable Fuels Association, 2006). The subsidy is paid regardless of ethanol price or production cost.

It is possible to develop a subsidy that falls as the price of ethanol increases and increases as the price of corn falls. Here, we develop such a subsidy and compare it with the current subsidy, examining the difference in government cost, and ethanol producer risk and profitability with monthly data from the past ten years. As shown below, we find that government cost and ethanol producer risk is always lower with the variable subsidy, and expected profitability can be the same or lower compared to the fixed subsidy, depending on one of the subsidy parameters. The rest of this paper provides more details on the design of the variable subsidy program and the empirical comparison.

Subsidy Design

In order to set up a variable subsidy, we need to examine ethanol profitability under a wide range of corn and ethanol prices. Tiffany and Eidman's (2003) spreadsheet was used to estimate profitability. Ethanol production uses corn and generates byproducts and ethanol. That spreadsheet model provides a profitability estimate given an ethanol price, a corn price, and a price for byproducts. One item needed was a price for the main ethanol byproduct, distillers dried grain with solubles (DDGS). DDGS can be used in feeding to replace corn and soybean meal, and thus

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Table 1. Expected ethanol profit under the two subsidy systems over a range of corn and ethanol prices.

		Profit per gallon of ethanol		
			With Subsidy	
Corn Price	Ethanol Price	Without Subsidy	Fixed	Variable
2.00	1.25	0.04	0.55	0.20
2.00	1.50	0.29	0.80	0.29
2.00	2.00	0.79	1.30	0.79
2.00	2.50	1.29	1.80	1.29
2.00	3.00	1.79	2.30	1.79
2.50	1.25	-0.08	0.43	0.20
2.50	1.50	0.17	0.68	0.20
2.50	2.00	0.67	1.18	0.67
2.50	2.50	1.17	1.68	1.17
2.50	3.00	1.67	2.18	1.67
3.00	1.25	-0.20	0.31	0.20
3.00	1.50	0.05	0.56	0.20
3.00	2.00	0.55	1.06	0.55
3.00	2.50	1.05	1.56	1.05
3.00	3.00	1.55	2.06	1.55
4.00	1.25	-0.45	0.07	0.20
4.00	1.50	-0.20	0.32	0.20
4.00	2.00	0.31	0.82	0.31
4.00	2.50	0.81	1.32	0.81
4.00	3.00	1.31	1.82	1.31

Source: Author's calculations.

its price is highly correlated with corn and soybean meal prices. Using historic data, we estimated a relationship between those prices that explains 73% of the DDGS price variability:

DDGS Price = -9.205 + 1.037 (CornPrice) + .135 (SoyMealPrice),

where all prices are dollars per ton.

We then used the model to simulate profitability given corn and ethanol prices holding the soybean meal price at $223.42 per ton. In turn, the profitability data were used to estimate the dependence of ethanol profitability on corn and ethanol prices. The results for profits per gallon produced are

Profits = -.723 + 1.00* EthanolPrice - .243 * CornPrice,

where profits and ethanol price are in units of $/gallon, and CornPrice is $/bushel. The regression explains almost all the variance in the data (99.9%), which is a reflection of the linear formulas involving these prices in the spreadsheet.

Next, we develop a variable subsidy scheme. To do that, we introduce a profit level per gallon in excess of the standard 12% rate of return assumed in the Tiffany/Eidman model simulations (Profitpergallon), and calculate the subsidy needed to achieve that profit. The equation for the subsidy then becomes:

Subsidy = -.723 – Profitpergallon +1.00EthanolPrice - .243CornPrice.

Converting the subsidy to a positive value and rearranging terms, the subsidy equation becomes:

Subsidy = Profitpergallon – (EthanolPrice - .723 - .243 * CornPrice).

Thus, the subsidy is the difference between the above-normal profit level assumed (Profitspergallon) and the returns from the market (ethanol price less production costs). The variable subsidy with this formulation is constrained to be greater than or equal to zero.

Magnitude of the Subsidy in the Formula

Table 1 provides the expected profit from the Tiffany/Eidman model, plus the profit under the current 51 cents per gallon fixed subsidy and the variable subsidy (assuming the ethanol producer receives the entire subsidy).[1] If corn were $2.50/bu., ethanol $1.50/gal., and the specified above normal profit (Profitpergallon) 20 cents per gallon, then the variable subsidy would be equal to 3 cents per gallon. In other words, a subsidy of 3 cents per gallon is required to maintain profitability at

1. *It is unlikely that the ethanol producer receives the entire subsidy, since there are other economic actors in the system. However, there is no basis for calculating the share the ethanol producer receives. In addition, there is no reason to believe that the share, whatever it is, would differ between the two systems.*

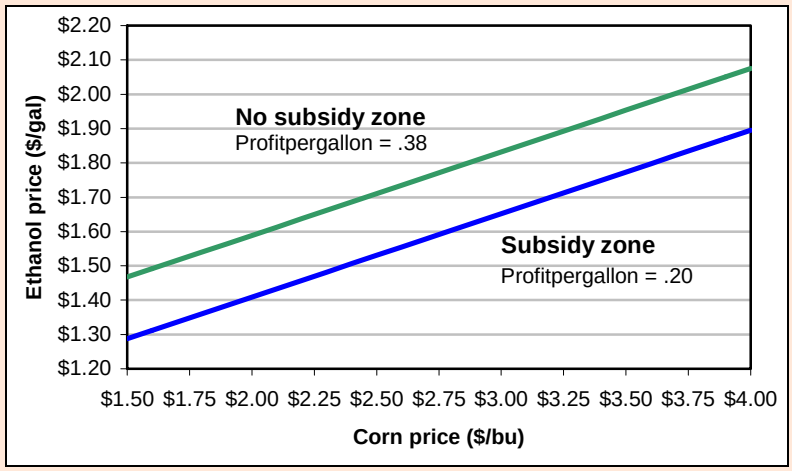

Figure 1. Locus of zero subsidy ethanol and corn prices.

Table 2. Ethanol profitability, risk reduction, and government cost.

Item	Fixed Subsidy	Variable Subsidy with Alternative Levels of Profitpergallon		
		$0.20	$0.30	$0.38
Average producer profit/gallon	$0.39	$0.21	$0.31	$0.39
Reduction in producer profit		-46%	-21%	0%
Variability of producer profit (CV)	0.43	0.34	0.23	0.18
Change in profit variability (CV)		-21%	-47%	-58%
Government cost per gallon	$0.51	$0.32	$0.42	$0.50
Change in government cost		-37%	-18%	-2%

Note: CV is the standard deviation of profits divided by the mean.

20 cents above standard economic return (assumed to be 12% on equity). The subsidy could be much higher. For example, if corn were $4.00 and ethanol $1.25 like in 1996, and Profitpergallon = 0.20, the subsidy would be 65 cents per gallon – higher than the current subsidy. Clearly, the variable subsidy reduces private sector risk by stabilizing returns.

When Would We Have Zero Subsidies?

Figure 1 illustrates the combination of corn and ethanol prices that result in zero subsidy with the above standard return (Profitpergallon) set equal to 20 cents per gallon and 38 cents per gallon. In Figure 1, any combination of corn and ethanol prices below the line will result in a subsidy, with the amount depending on corn and ethanol prices. Any combination of corn and ethanol prices on or above the line will result in no subsidy. In the no subsidy zone, a subsidy is not needed to maintain ethanol profitability at the given 20 or 38 cents per gallon level, and any subsidy provided by government is a substantial, perhaps excess, payment to producers.

Historical Comparison with the Fixed Subsidy

We also calculated private profitability and government cost with the variable and fixed subsidies using data on corn and ethanol prices over the past ten years. We did the analysis using a subsidy that changed quarterly and was based on either ethanol or gasoline prices. Table 2 summarizes the results of this analysis for different levels of above-standard profit (Profitpergallon).

The results show

- The variable subsidy reduces government cost uniformly across these data.
- The lower the value of Profitpergallon, the higher the cost savings for the government and the lower the expected profitability.
- The variability in private sector profitability (a measure of risk) as measured by the coefficient of variation (CV) of profit is always lower with the variable subsidy as compared with the fixed subsidy, as would be expected.
- Expected profitability is reduced or held constant depending on the value of Profitpergallon.

In other words, we can hold expected profit and government cost about the same and significantly reduce producer risk, or we can lower expected profit, government cost, and producer risk all at the same time, but to differing degrees. Figure 2 illustrates the results of this analysis with Profitpergallon set at 20 cents and Figure 3 with Profitpergallon equal 38 cents.

Concluding Comments

In 2007, ethanol production may be about 6 billion gallons. With the current fixed subsidy, the cost to the government of the ethanol subsidy will be at least $3 billion (6 billion gallons times the 51 cent per gallon subsidy). With the variable subsidy, and under current market prices for gasoline, ethanol, and corn, the variable subsidy cost would be zero, saving the government over $3 billion. At the same time, the private sector

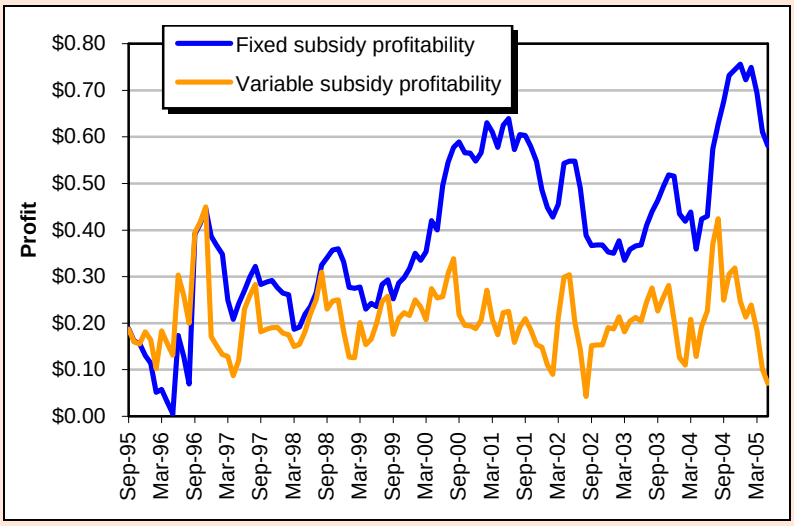

Figure 2. Fixed and variable subsidy profitability (Profitpergallon = 20 cents).

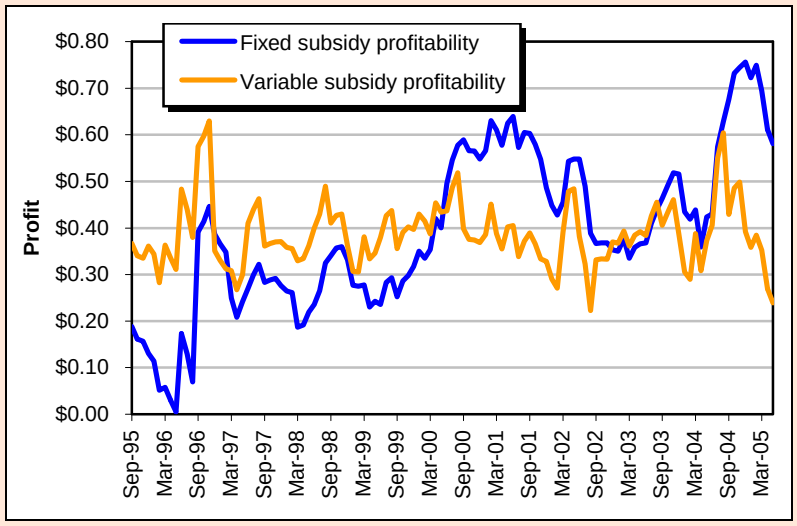

Figure 3. Fixed and variable subsidy profitability (Profitpergallon = 38 cents).

would have in place a mechanism to guarantee against any future adverse changes in corn or ethanol prices.

The variable subsidy clearly offers advantages over the current fixed subsidy. In our model, the additional profitability parameter, Profitpergallon, can be viewed as a political choice variable. The higher one sets Profitpergallon, the higher the industry profitability, the higher government cost, and the lower private sector risk. Under no circumstance was the variable subsidy more costly than the fixed subsidy over this historic period. To the extent there is a trade-off between expected profitability and risk reduction (that is, producers would give up some profit to lower risk), the government would be able to set Profitpergallon low enough to reduce expected government costs and substantially reduce private sector risk at the same time – a clear win-win. In a few years, the expected production of ethanol will be 8 billion gallons or more. The annual cost to the government with the fixed subsidy would be $4.08 billion. If oil prices remain high, the variable subsidy would cost nothing, but would provide a safety net for ethanol producers.

As described above, this variable subsidy would apply only to corn-based ethanol. This mechanism would need to be applied to a limited volume of corn ethanol or gradually converted to a subsidy that varies with gasoline prices alone. A different mechanism would need to be developed for cellulose-based ethanol and bio-diesel, probably based on gasoline and diesel prices. The point is that it would be relatively easy to extend the corn-based variable subsidy to the other products.

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Coming Attractions

Resources and the Environment

Setting the Stage for the Next Farm Bill: No Easy Choices

James Richardson, Guest Editor

The economic and political environment for debating and writing the 2007 farm bill has changed significantly since the 2002 bill was enacted. The changes and their probable impacts on the next farm bill are described by Stephanie Mercier and Vince Smith. Pat Westhoff and Scott Brown present a FAPRI analysis of what U.S. agriculture would look like if the next farm bill is a continuation of the 2002 bill, but with a substantial and real reduction in federal spending. Joe Outlaw and Otto Doering review previous arguments for justifying farm programs and address the question of what are valid justifications for continuation of farm programs. Mike Dicks reviews current land stewardship programs and suggests how a new farm bill that relies on stewardship, rather than price and income, supports would operate.

Agriculture and Trade

Animal Identification

David P. Anderson and Larry Falconer, Guest Editors

A comprehensive animal identification system continues to be a controversial subject. While plans have been developed and put forward, some continue to fight their development. This upcoming theme examines an overview of the issue, animal identification in other countries, legal issues, and some broader perspectives on the issue in the United States.

We are working on future theme coverage on Illegal Immigration, Water Quality, Returns to Research and Extension, and Produce Marketing. See our thematic coverage page for a complete list and planned schedule.

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