The future of beef production in North America

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Implications

- North America accounts for more than one-quarter of the world's beef supply. Production per animal is highly efficient, particularly in the United States and Canada, but aspects of the long-term economic and environmental sustainability of the system need critical review.
- Production units, especially concentrated systems like feedlots, face substantial regulatory pressure related to air and water quality, food safety issues, and animal welfare/animal rights issues. These pressures will increase in the future, as will concerns about effects of beef production on greenhouse gas emissions.
- Public concerns for food safety will focus greater attention on animal traceability and liability associated with foodborne pathogens. Animal rights activism and consumer perceptions about "factory farming" production methods will challenge the use of concentrated feeding operations and pharmaceutical technologies in North American beef production systems.
- Animal protein sources should play an important role in meeting global food demands, but to benefit from this demand, North American beef producers must produce safe, wholesome products, while placing greater emphasis on environmentally sound practices that maintain the highest standards for animal well-being.

Key words: beef production, environment, feedlot, food safety, welfare

Introduction

In 2010, the United States of America, Canada, and Mexico produced approximately 26% of the world’s beef (Figure 1; USDA-FAS, 2011). Beef production in Mexico is more extensive and less developed than in the United States and Canada, but even within those 2 countries, components of the beef industry vary widely on a scale of consolidation. Feedlot beef production represents the most concentrated and likely most efficient component of the system in terms of production per animal, energy use per unit of beef produced, and land use (Capper and Cady, 2010; Capper, 2011). Despite overall high production efficiency, the North American beef industry faces numerous challenges to its long-term economic sustainability. Moreover, the resource and environmental sustainability of the system, particularly in the United States and Canada, are under increasing scrutiny and pressure from a variety of outside sources. This review will focus on issues facing beef production systems in North America and examine challenges to the industry in achieving economic and environmental sustainability in the future. Previous papers dealing with the future of intensive beef production systems in the United States (Galyean, 2010a,b) were a significant resource for the current review.

The North American Beef Cattle Industry

Background

Beef production in North America, particularly in the United States and Canada, is characterized by 3 major components: cow-calf, stocker, and feedlot operations. This 3-part approach relies heavily on forage resources and extensive production settings for the cow-calf and stocker segments. Depending on the length of the stocker phase, intensive feedlot production, with concentration of animals and heavy reliance on grains and high-energy by-product feeds, accounts for approximately one-quarter to two-thirds of the length of the production cycle from birth to market. Thus, the majority of beef production in North America, both in terms of quantity of beef produced and time required for production, occurs in the extensive, forage-based components of the system. Although increasing in importance, feedlots are not currently a major component of beef cattle production in Mexico, with the historical norm being that Mexico is an exporter of feeder cattle to the United States for finishing.

For most of the last century, the North American cow-calf industry has been characterized by smaller farms and ranches (in terms of land area) in the east and southern areas of the United States and Canada. Large ranching operations, which have their heritage in the haciendas of Mexico, are the norm in the western areas of the United States and Canada, as well as the arid and semi-arid northern and western regions of Mexico. Western United States and Canadian ranching operations rely heavily on the use of public lands that are managed by federal or provincial agencies. The situation in Mexico is somewhat different, with approximately 40% of the arable land in private hands (Peel et al., 2010). Common land, with ill-defined ownership and often limited or variable management practices, represents approximately 60% of Mexican land used for livestock production (Peel et al., 2010).

Stocker cattle operations, which involve the use of weaned calves to graze native and introduced forages (annuals, perennials, and crop residues) before entering feedlots are a common feature of beef cattle production throughout North America. The stocker system provides a bridge between cow-calf operations and feedlots, allowing for utilization of forage resources and spreading the cattle supply and thereby the marketing window for finished cattle more evenly throughout the year.
Feedlots developed largely during the 20th century. Increasing demand for beef after World War II spurred the growth of feedlots, as did regional supplies of relatively low-cost grains (corn in the Midwest United States and barley in Western Canada) and various by-products. In the Texas Panhandle alone, feedlot operations increased at a rate of 20 to 30% per year from 1961 to 1969 (Ball and Cornett, 1996). Packing plants moved to locate near the source of cattle (the Great Plains region of the United States and primarily Alberta and Saskatchewan in Canada).

Current Situation

Over the last 12 years, the US beef cow-herd has decreased from approximately 34 million to 30.9 million animals. Despite this decrease in cow numbers, yearly commercial beef production has stayed reasonably steady at around 11.3 to 11.8 billion kilograms, reflecting an increase in the body weight of mature cows over the last few decades (McMurry, 2009). Beef cow numbers also are decreasing in Canada, with a decline of 19% from 2005 to 2011 (5.28 to 4.27 million cows; Statistics Canada, 2011a). In contrast to decreases in the United States and Canada, cow numbers in Mexico have been fairly stable since 2005, averaging approximately 7 million animals per year (Index Mundi, 2011).

Not only is beef cow-calf production in North America geographically diverse, but it also is varied in scale of operation among producers. McBride and Matthews (2011) reported that approximately 765,000 US farms had beef cows, with many of these being part-time operations. Nearly 73% of US cow-calf operations had less than 100 cows, and operations that were categorized as only cow-calf averaged 79 cows

Table 1. Cattle on feed by state—January 1, 2011

| Rank | State        | Cattle on feed 2011 | Cattle on feed 2010 | % Change | % of Total |
|------|--------------|---------------------|---------------------|----------|------------|
| 1    | Texas        | 2,850,000           | 2,700,000           | +5.56    | 20.32      |
| 2    | Nebraska     | 2,550,000           | 2,500,000           | +2.00    | 18.18      |
| 3    | Kansas       | 2,400,000           | 2,370,000           | +1.27    | 17.11      |
| 4    | Iowa         | 1,380,000           | 1,360,000           | +1.47    | 9.84       |
| 5    | Colorado     | 1,100,000           | 1,020,000           | +7.84    | 7.84       |
| 6    | California   | 470,000             | 465,000             | +1.08    | 3.35       |
| 7    | South Dakota | 410,000             | 400,000             | +2.50    | 2.92       |
| 8    | Oklahoma     | 380,000             | 370,000             | +2.70    | 2.71       |
| 9    | Minnesota    | 320,000             | 290,000             | +10.34   | 2.28       |
| 10   | Arizona      | 258,000             | 288,000             | −10.42   | 1.84       |

1 Source: USDA National Agricultural Statistical Service; http://www.cattlerange.com/cof/states-cof.html). Updated from Galyean (2010a).

Figure 1. World beef production by country in 2011. Source: USDA, Foreign Agricultural Service, http://www.fas.usda.gov/psdonline/circulars/livestock_poultry.pdf.

Figure 2. Changes in the capacity of US cattle feedlots over a 40-year period in terms of animals sold per year in feedlots of various sizes (adapted from MacDonald and McBride, 2009, as presented by Galyean, 2010b).
Similarly, as of January 2011, Canadian cow-calf operations averaged 129 cattle and calves per operation (Statistics Canada, 2011b). In contrast to cow-calf sector, the feedlot industry in the United States is compressed geographically, with the Great Plains region being dominant (see US cattle on feed numbers by state in Table 1). Similar conditions exist in Canada, where Alberta is the leading cattle feeding province. Feedlot production in Mexico has increased in recent years, but as noted previously, it is still small compared with the United States and Canada (Peel et al., 2010).

Along with geographic compression, the feedlot industry has changed in size of individual feedlots. MacDonald and McBride (2009) noted that during the past 2 to 3 decades, livestock production units in the United States have become larger and more specialized. Indeed, significant growth in the US feedlot industry has been in larger feedlots (>32,000 animal capacity; Figure 2), and feedlot ownership has shifted to corporations or large privately held companies that control several feedlots rather than individual ownership of single feedlots. These companies often own most of the cattle they feed, reflecting a shift from the “custom feeding” model of the past in which ownership was often distributed over several individual clients. Using early 2011 US cattle-on-feed numbers of approximately 11.5 million as an estimate of the US one-time feedlot capacity, the 5 largest cattle feeding operations in the United States (Figure 3a) control approximately 20% of feeding capacity. The move to larger feedlots that own the cattle they feed likely reflects economy-of-scale advantages in cattle procurement and marketing, commodity purchasing, and risk management compared with individual “custom feeding” operations. Canadian feedlots tend to be smaller than those in the United States. A recent report (Canfax, 2011) indicated that the average feedlot capacity in Alberta and Saskatchewan ranged from approximately 8,200 to 8,400 animals. In Alberta, 64% of feedlots in the Canfax report had a capacity of <20,000 animals. At present, feedlots in Canada tend to be owned by individuals rather than corporations, but several privately owned companies control multiple feedlots, and the trend seems to be moving away from customer-based feeding to company ownership of cattle. In Mexico, feedlots are located primarily in the central and northern parts of the country (Peel et al., 2010), although the industry is relatively small with approximately 1.5 million cattle in feedlots per year (Peel, 2005). As the Mexican economy improves, increasing domestic demand for fed beef will likely drive additional growth in the feedlot sector; however, limited availability of grain or high-energy by-products is a potential constraint to growth.

As noted previously, beef packing plants in the United States and Canada are concentrated near supplies of feedlot cattle. Consolidation in the packing industry is even more evident than in the feedlot industry. In 2010, approximately 70% of the daily slaughter capacity was controlled by the top 5 beef packing companies (Figure 3b; AMI, 2010). The scale and spatial diversity of cattle feeding in Mexico have resulted in an industry based on several smaller packing plants (Peel, 2005) compared with fewer large plants in the United States and Canada that are located in limited geographical areas.

**Future Outlook**

**Industry Structure and Demographics**

North American forage-based cow-calf systems that primarily sell calves at weaning are inexorably linked to stocker cattle and feedlot systems. As a result, the future of any one segment is difficult to assess apart from the overall system. Some trends in the various industry segments are evident, however, and will be discussed briefly.

As noted before, the size of the US and Canadian cow herds has decreased in recent years. Although recent projections suggest some rebuilding of the US cow herd (an increase of approximately 10% is pre-
dicted by 2020; USDA, 2011), much of this change is projected to occur after 2014. Whether the US beef production system can continue to meet domestic and export demands without significantly rebuilding the cow herd is a serious concern for the industry over the next few years.

Current trends in the feedlot industry are likely to continue in the future. With ample supplies of lower-cost ethanol by-products, smaller feedlots in the Midwestern United States will be an important part of the industry, but overall, increasing corporate ownership (private and publicly traded companies) seems probable in both the United States and Canada. With generally favorable weather conditions, less-restrictive nutrient management and environmental concerns, and relatively limited urban encroachment, the Great Plains of the United States and the western provinces of Canada should continue to be the major of cattle feeding areas in North America. As suggested previously, growth of the feedlot industry in Mexico depends on the economic situation, but the more arid regions of the north offer the best feeding climate.

In contrast to feedlots, consolidation in the North American cow-calf industry is limited by the capital required for land, particularly in the semi-arid western cow-calf production areas. As a result, cow-calf production is likely to remain structurally diverse for the foreseeable future. With a decreasing cow herd for the next few years and significant feeding capacity, however, it seems plausible that an increase in contractual arrangements between feedlots, particularly the large cattle feeding companies, and the cow-calf and stocker operators who supply cattle will occur over the next few years. Such alliances should facilitate animal identification and traceability through the food chain, provide the opportunity for applying genetic selection tools in cow-calf herds that might benefit feedlot performance and marketing (e.g., markers for feed efficiency or carcass traits), and allow for implementation of pre- and early postweaning management strategies to improve animal health.

Feeding and Management Practices

Forage- vs. Grain-Based Finishing. From an input-output standpoint, cow-calf and stocker beef production systems that rely on a renewable pasture resource would seem to be generally more sustainable than feedlots, which require significant external inputs of nutrients and energy and produce concentrated outputs of nutrients that require disposal. Even so, grazing systems require important external inputs like supplemental feeds, fertilizer, and so on. Long-term sustainability of forage-based beef operations probably depends on the level of production achieved and the intensity of management and inputs associated with the grazing systems used. For example, finishing beef cattle by grazing forages is often touted as a “green” or environmentally sustainable alternative to feedlot production. Nonetheless, in a comparison of a corn-based (feedlot) vs. forage-based finishing, Capper and Cady (2010) calculated that energy use was increased 2.5-fold, and methane production and land area required per kilogram of beef produced increased by 2.8- and 12-fold, respectively, with forage-based vs. feedlot finishing. In addition to efficiency and carbon footprint issues, because of the decreased production per animal (Capper, 2011), forage-finishing systems would not be able to meet current domestic beef consumption and export demands.

Despite decreased efficiency of production, some North American consumers believe that forage-fed, “organically produced” beef is healthier and more environmentally friendly than feedlot beef. None-
nologies that save labor in feed milling and delivery and routine aspects of animal husbandry would be readily applied by the industry.

External Pressures

Environmental Issues. Significant environmental concerns for beef production, particularly feedlots, include nitrogen contamination of ground water and contamination of surface water by runoff of phosphorus. Similar issues with air emissions include ammonia, nitrous oxide, odors, and particulates; readers are referred to a recent review of the air quality area by CAST (2011). In the United States and Canada, federal, state, and provincial regulations require comprehensive nutrient management plans for concentrated animal feeding operations. Potential feeding strategies to mitigate negative environmental consequences of cattle feeding were reviewed by Vasconcelos et al. (2007). Strategies included precision feeding (Cole, 2003; feeding to maintain performance and limit nutrient excretion) and phase feeding (changing dietary nutrient concentrations over time to match animal nutrient requirements). At present, practical application of these approaches is limited. It is noteworthy, however, that US feedlot nutritionists have responded to environmental concerns by adjusting formulation practices, with 24 of the 29 feedlot nutritionists surveyed by Vasconcelos and Galvan (2007) reporting that they did not add supplemental phosphorus to finishing diets.

The FAO publication “Livestock’s Long Shadow: Environmental Issues and Options” (Steinfeld et al., 2006) stimulated considerable debate about the effects of livestock production on global climate change. Moreover, the announcement in December 2009 by the US Environmental Protection Agency that greenhouse gases are a danger to public health and thereby require regulation suggests the beef industry is a potential target. At present, US livestock producers are exempt from reporting greenhouse gas emissions, except for fairly large manure management facilities. Despite environmental concerns in some areas (e.g., nitrogen, phosphorus, airborne particulates, and odor), intensive beef cattle production systems like US and Canadian feedlots might offer advantages in terms of carbon footprint relative to less intensive systems. The US dairy industry was estimated by Capper et al. (2009) to have a carbon footprint (per billion kilograms of milk produced) in 2007 that was 37% of 1944 estimates. Capper (2011) evaluated changes in the US beef industry from 1977 to 2007 and estimated the carbon footprint decreased by 16% over the 30-year time frame. One important aspect of the decreased carbon footprint of intensive beef production systems is greater production per animal, resulting in fewer animals involved in production. Regardless of these positive trends in terms of carbon footprint, it seems clear that livestock production, and particularly ruminate production in which enteric methane is an issue, will be under greater scrutiny relative to greenhouse gas emissions (Moran and Wall, 2011).

Although typically considered less of a concern from an environmental standpoint than feedlots, forage-based cow-calf and stocker systems, notably those that use public lands in the Western United States and Canada, are under considerable pressure related to management of riparian areas (DelCurto et al., 2005). Cattle tend to concentrate in riparian areas, potentially overgrazing or damaging vegetation, and thereby increasing erosion, the potential for invading species, and contamination of surface waters. Approaches to mitigate possible negative effects of cattle grazing in riparian areas were reviewed by Bailey (2004) and DelCurto et al. (2005). Public land grazing is vital to beef production in the Western United States and Canada. Thus, future use of these lands will require approaches that allow producers to address concerns in a way that satisfies demands for effective stewardship but still permits use of public lands in beef production.

Animal Welfare and Food Safety Issues. Greater consumer interest and demand for “organic” beef production noted previously likely reflects public concerns associated not only with environmental impacts of beef production, but also with animal welfare and food safety concerns. Animal rights activist groups have led the charge in labeling intensive livestock production as “factory farming,” negatively affecting public perceptions. Reasonable self-evaluation by the industry would suggest that there is some degree of “factory” mentality to intensive production units. Indeed, the “factory-like” consolidation of processes and resources is in large part why the industry is so efficient. But producing beef is not akin to producing widgets in a factory. Widgets are not living beings that require concern for their well-being. Thus, intensive beef production must be done with a keen eye on the welfare of the “production units.” Highly publicized situations of animal abuse captured on video add fuel to the “factory farming” fire and have done untold damage to an industry in which the vast majority of those who work do so because of a great love for the animals and the lifestyle associated with livestock production. As a result, the industry must critically evaluate animal management practices and oversee animal care to a far greater extent than in the past. It is not sufficient to tell the public that rules are in place to ensure animal welfare; we must invest in the effort to enforce the rules. Cases of animal abuse will never be tolerated by the public and are not acceptable or defensible, under any circumstance, by the industry. The industry must build trust in the public that the welfare and humane treatment of livestock is top priority.

Product recalls, chiefly associated with the contamination of beef products with Escherichia coli O157 or other pathogenic bacteria, also are significant negatives for the industry. Although worries about bovine spongiform encephalopathy in the beef supply have diminished somewhat, this problem continues to be an area of concern, particularly in Canada, and has negative consequences for beef export markets. Beef packing plants have made major strides in decreasing the risk of pathogen contamination, and pre-slaughter interventions that can be applied at the feedlot level have been extensively evaluated in research studies. The beef packing industry has shouldered the burden of decreasing foodborne pathogens, which has worked well because beef packing plants are gathering points for cattle from several feedlots in a reasonably large geographic area. If the beef industry desires to achieve an even greater level of product safety, however, it seems likely individual feedlots will be called on to share responsibility for the risk and implement pre-slaughter measures to decrease pathogen loads (e.g., probiotics and vaccination to decrease the prevalence of E. coli O157). Further research is needed on methods for increasing the efficacy and decreasing the cost of such feedlot-level interventions.

Concerns for food safety and the spread of animal diseases highlight the need for traceability of animal products from “ranch to rail.” Mandated cattle identification and traceability regulations are in place in Canada and Mexico, but the US beef industry has focused on a voluntary approach (Murphy et al, 2008). Animal identification systems will no doubt become even more important in the future, both for domestic and export markers, and it seems likely that some type of mandatory or
Antimicrobial resistance is another issue that is subject to significant public scrutiny. Although it is clear that microbes develop antibiotic resistance, the extent to which antibiotic use in livestock feeding increases the prevalence of antibiotic-resistant organisms in humans needs further definition. The US Food and Drug Administration has recognized the value of the therapeutic use of antibiotics, but it also seems clear the agency would like to limit the use of antimicrobials for improving growth and feed efficiency (Sharfstein, 2009). As in the European Union, pressures to dramatically decrease or to remove antibiotics from animal feeds in North America are likely to increase in the future, which will require increased funding for research to develop alternatives to feed-grade antibiotics.

The Importance of Research

With a decreasing public base of financial support, agricultural colleges in North America are increasingly pressed to secure extramural funding to support research. Barring a change in the current funding model, the ability to expand academic research programs that serve the beef industry is limited. Moreover, many universities are emphasizing basic research, so applied research with immediate application to beef production is difficult to fund. To support academic research, beef industry professionals and organizations should be proactive in providing input on practical problems that need to be addressed in a basic context. As a means of offsetting the loss of public funding, research partnerships with commercial firms that sell products and services to beef industry are increasing and will likely become even more important in the future. Care must be taken to ensure that results of such cooperative efforts are not biased toward particular products or practices. Funds available through industry organizations (e.g., check-off funding) and foundations also will become more critical in supporting research to address applied problems in the beef industry.

Conclusions

The North American industry faces many significant challenges in the years to come. Cow-calf and stocker production requires a sizable capital investment in land, whereas feedlots require significant infrastructure and management inputs. These substantial inputs are not always met with significant rewards. For example, in the 10 years from 1999 to 2008, a report from Iowa State University (ISU, 2009) indicated negative returns in 6 and 7 of the 10 years for calves and yearlings, respectively. High risk and low financial rewards have driven the industry consolidation and corporate ownership of cattle feeding operations noted previously because large operations can manage risk more effectively, balancing gains in one area of the operation against losses in another. Thus, the trend for consolidation, particularly in the feedlot sector, has no end in sight.

Decreasing per capita beef consumption (US data are shown in Figure 4) is clearly a negative trend for the US beef industry, in part explaining the overall decrease in the size of the cow herd in the last few years. Decreasing per capita consumption of beef has also been the trend in Canada, with a drop from 30.5 to 29.3 kg from 2000 to 2007, whereas consumption increased from 20.5 to 23.6 kg over the same time period in Mexico (USDA, 2007). Although lack of domestic demand is problematic in the United States and Canada, on the upside, increasing worldwide beef demand is a positive factor for North American beef producers, as long as import-export policies do not stifle trade. Increasing world population should fuel greater demand for food in general, and as global economic conditions improve, the demand for beef is likely to increase. Nonetheless, the role that beef production plays in providing high-quality protein on a global scale will need to be balanced with environmental and greenhouse gas issues discussed previously, as well as consumer concerns about animal welfare and food safety. Beef production as currently practiced in North America, especially in the United States and Canada, is highly efficient. Combined with this ef-
efficiency, efforts to decrease the environmental footprint of beef production and to guarantee the highest possible standards of animal welfare and food safety will ensure the long-term future of the North American beef industry.

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- Each issue will have one or two guest editors to collaborate on the invitation process and to oversee the peer-review process. Guest editors should be knowledgeable of and respected in the field of the proposed theme, able to present a balanced view of the topic, capable of writing clear English, organized, and able to meet deadlines.

- A detailed theme proposal will include a list of potential authors, suggested article titles, and a brief description or outline of each paper. Five or six articles should be sufficient to cover each topic.

- To propose a topic for an upcoming issue of *Animal Frontiers*, complete our form (http://www.animalfrontiers.org/docs/IssueTheme.doc) and send to the editorial office (animalfrontiers@assoehq.org). The management board will evaluate each recommendation received.

**Issues in the pipeline**

**January 2012:** Animal selection: The genomics revolution  
Guest Editor: Andrea Rosati (EAAP, Rome, Italy)

**April 2012:** Animal production and water: A difficult relationship  
Guest Editor: Christiane Girard (Agriculture and Agri-Food Canada)