Issue Study 2. Feedlot Production of Cattle in the United States and Canada:

Some Environmental Implications of the North American Free Trade Agreement (NAFTA)

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Acronyms

BECC	Border Environment Cooperation Commission
BOD	biological oxygen demand
CCA	Canadian Cattlemen's Association
CEC	Commission for Environmental Cooperation
CNG	*Consejo Nacional Ganadero* (Mexico's National Livestock Council)
CRP	Conservation Reserve Program
CTIC	Conservation Technology Information Center
CWA	Clean Water Act (US)
CZARA	Coastal Zone Act Reauthorization Amendments
EPA	US Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
FAIR	Federal Agricultural Improvement and Reform act
FDA	US Food and Drug Administration
FDI	foreign direct investment
FSIS	US Department of Agriculture, Food Safety and Inspection Service
FTA	Canada-United States Free Trade Agreement
GAO	US General Accounting Office
GATT	General Agreement on Tariffs and Trade
GIPSA	Grain Inspection, Packers and Stockyards Administration
HACCP	Hazard Analysis and Critical Control Points
IBP	Iowa Beef Packers
NAAQS	National Ambient Air Quality Standards
NADBank	North American Development Bank
NAFTA	North American Free Trade Agreement
NAWWS	National Alachlor Well-Water Survey
NPDES	National Pollution Discharge Elimination System
NPS	non-point sources
NRCS	Natural Resources Conservation Service
OTA	Office of Technology Assesment
PFRA	Prairie Farm Rehabilitation Administration
Secofi	*Secretaría de Comercio y Fomento Industrial* (Secretariat of Commerce and Industrial Promotion)
TSS	total suspended solids
URA	Uruguay Round Agreements
USDA	US Department of Agriculture
USES	US Ecological Survey
USITC	International Trade Commission (US)
WGTA	Western Grain Transportation Act
WTO	World Trade Organization

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I. Introduction

The purpose of this issue study is to consider some specific environmental implications of expanded North American trade and investment under NAFTA; the analysis was carried out by implementing a general framework developed by the Commission for Environmental Cooperation's NAFTA Effects Project. The scope of this issue study is sectoral, focusing on the beef and cattle sectors of North America, particularly the US and Canadian fed-cattle industry. North American cattle feeding is an activity that joins agriculture to the industrial processing of beef products. Upstream from the feedlot is the feed-grains complex, where corn, sorghum and oilseeds are grown to produce the feed ingredients used to fatten cattle. Downstream from the feedlot are slaughtering and processing facilities that convert live cattle to meat and meat products. In the middle stands the feedlot, where cattle are held in partial confinement and fed during the final months before slaughter.

This study will not include in detail the dynamic and complex cow-calf and cattle-grazing industries. These industries play an obvious role in providing feeder cattle to the feedlot industry and have their own important relationships with environmental issues, including biodiversity, water quality in riparian areas, and nutrient cycling.[1]

Three observations are critical before beginning this examination. First, while NAFTA has an important connection to the expansion of North American beef production, its effects thus far do not support an argument that it is a main driver influencing this sector's impact on North America's natural environment. This exercise will address broad trade and environmental issues and use the NAFTA Effects Framework to pursue an analysis that anticipates potential environmental issues before they arise, so as to avoid responding to them *ex post facto*.[2]

Second, the negative environmental issues surrounding beef production in North America, while potentially serious, are all capable of remediation and prevention if adequate attention and resources are devoted to them? The purpose of this study is, in part, to draw attention to these issues and to suggest the types of resources that may be needed to respond to the challenges facing the sector.

Third, the patterns of production emerging from NAFTA-related changes in the beef sector will increasingly reflect the comparative advantages of Canada, Mexico and the United States. The broad conclusion of this study is that NAFTA will tend to reinforce existing patterns of trade in which the United States and Canada feed and slaughter cattle for

[1] In the United States, inclusion of the cattle-grazing industry would require an examination of the many issues involving grazing policies on federal lands, particularly in the western United States. It was therefore judged to be beyond the scope of this study due to considerations of time and cost. In future and further work, it would be useful to consider linkages between the cow-calf industry, NAFTA, and the environment, including examples of local and regional initiatives involving cow-calf operators addressing surface-water quality issues through the modification of grazing systems to reduce or avoid direct contact by cattle with flowing streams. See, for example, B. Adams and L. Fitch (1995) *Caring for the Green Zone: Riparian Areas and Grazing Management*, Report of the Alberta Habitat Management Project, Lethbridge.

[2] What is described in environmental policy as the "precautionary principle."

export to Mexico, and Mexico supplies feeder cattle to the United States.[3] This pattern of trade reinforces existing North American transportation networks and will allow the United States and Canada to better exercise regulatory oversight and exploit new environmental technologies that can reduce the negative environmental impacts of beef-feeding activities. In this respect, the expression of a comparative advantage in trade terms is also consistent with the capacity to internalize the negative environmental impacts of the fed-cattle sector. Thus, trade expansion and environmental improvement can be mutually reinforcing in this case if sufficient technological, policy and institutional innovations are forthcoming to meet the environmental challenges.

Two perspectives have resulted from discussions with experts and others as the study and framework of analysis has evolved. The first responds to the question: why study the North American fed-cattle sector to understand NAFTA's environmental effects? This sector has immediate and widespread effects on many dimensions of the air, water, land and biota that make up North America's ambient environment. The cattle issue study helps to develop a framework of analysis and uncovers effects on these environmental dimensions primarily because it looks at cattle feeding as a transformative process in which feed grains are converted to animal protein and then to beef products. By maintaining an industrial-ecology perspective on this process, the study is able to show how, at each stage in the transformation, different ecological impacts occur.

The second perspective is to look at this transformation from the point of view of both industrial organization and "pollution in space" as a narrowing funnel.[4] At the level of feed-grains production, many hundreds of thousands of individual producers make decisions about corn, barley, soybeans and other grains, the sum total of which have very important environmental effects. These effects relate to soils, water, and biota, and they pose challenges to governments at all levels in large part because they are spatially dispersed, or "nonpoint," in nature. By the time feed-grains are delivered to the feedlot, and heifers and steers arrive from thousands of cow-calf operators, the funnel has narrowed. Although thousands of firms are still involved, there are many fewer each year; feedlots continue to grow in size and fall in absolute number. Here, the transformation into a nearly industrial mode of production is approached, especially in larger units. The consequence is that environmental impacts on air, water and waste flows are much less diffuse and can be identified as "point-source." The final stage of production comes as beef cattle are converted to meat. Here, again, the number of firms drops, the funnel narrows, and the spatial locus of pollution allows for the intensive management and oversight of waste and other essentially industrial pollutants resulting from beef processing.

The cattle and beef sector is linked to environmental, economic, social and geographic factors that give context to this issue study. NAFTA is one factor among many conditioning the sector, and it will continue to have impacts on trade flows in the agricultural sector and the beef and cattle sector in particular. Indeed, analysis by the US International Trade Commission has concluded that NAFTA's effects on this sector are greater than those of the Uruguay Round, emphasizing that in some cases, regional trading agreements such as NAFTA loom larger than even global multilateral trade agreements (US ITC 1997).

[3] Some longer term shifts in slaughter and processing activity may occur as Mexico's consumption of beef and beef products grows.

[4] For a recent analysis of the spatial dispersion of pollution, see G. Hauer (1997).

The NAFTA connection in the cattle and beef sector is demonstrable, notwithstanding the impact of exchange-rate adjustments, cyclical behavior in cattle markets and weather fluctuation. Although US beef exports expanded due to income and population growth increases in Mexico in the 1980s and 1990s, a US International Trade Commission (US ITC) report, in a modeling exercise, concluded that, notwithstanding the peso devaluation of late 1994, which dramatically decreased Mexico's beef imports, these imports would have been substantially lower if NAFTA's tariff reductions had not been in place. More precisely, the US ITC model indicated that with the peso devaluation and with NAFTA, beef and cattle imports from the US would have been 267 million pounds in 1994, but could have fallen to 182 million pounds had the peso devaluation occurred and NAFTA not been in effect. Actual imports from the United States in 1994 were 282 million pounds; see Table 15 (US ITC 1997). Other analysts have shown that NAFTA helped significantly to offset the peso devaluation in the agricultural sector as a whole (de Janvry 1996). Perhaps more important than these initial effects, however, is the dynamic consequence of trade adjustments in further revealing the comparative advantages of the United States and Canada as large-scale cattle feeders and the comparative advantage of Mexico in supplying feeder cattle.

The major arguments in this study follow the line of analysis described in the NAFTA Effects General Framework (Phase II). Section II provides the environmental, economic, social and geographic context for the issue, and in that way serves as "baseline" against which to assess NAFTA-associated changes. Section III describes the major NAFTA rule changes affecting the beef and cattle sector, as well as some of the institutional changes resulting from NAFTA's provisions. It then discusses the trade flows and investment patterns in the sector and presents several econometric estimates of the impact of NAFTA on these flows. While other economic forces have been important, the impact of NAFTA alone has been both discernable and significant, clearly establishing the NAFTA connection. Section IV takes up the main linkages from these changing patterns of trade to the natural environment through production, management and technology, physical infrastructure, social organization and government policy. Section V then moves to a more technical level, offering estimates of the environmental impacts in the sector that are most amenable to measurement and proposing the use of various indicators for their ongoing monitoring and evaluation. Finally, the study offers some brief conclusions.

II. The Issue in Context: Environmental, Economic, Social and Geographic Conditions

This section considers the environmental, economic, social and geographic context of the cattle issue study. The cattle and beef sectors of the United States and Canada represent major parts of a global livestock sector that is expanding to meet growing international demand. This sector touches not only the natural environment, but is part of a web of economic and social activity that will define global and continental challenges in the next century and beyond. One of the central themes of this study is that the transformation of grain into animal protein, especially from the feedlot forward into beef processing, is less and less an agricultural and more and more an industrial process. Environmental responses to the challenges posed by the sector are thus more likely to succeed if they recognize the industrial scale of the later stages of beef production. These responses will require realistic appraisals of the different stages of the transformation process and of the technologies and policies most appropriate at each stage of production.

A. The Environmental Context

The fed-beef sector of North America, concentrated largely in the central United States and the prairie provinces of Canada, is a useful issue for study because it links various parts of agriculture: cattle are fed on grains and oilseeds, which account for a large share of North American crop acreage. After leaving the feedlot, these cattle are processed to become beef products. The cattle feedlot is thus a nexus at which grain and oilseed inputs are transformed into fattened cattle and then into meat products for consumption. Because so much of this activity occurs in, on, or close to soil, water, air and biota, it has important environmental impacts. The cattle-feeding industry thus offers a relatively wide window through which to examine the environmental implications of expanded trade in the agricultural sector under NAFTA.

The full range of the environmental impacts of beef production must include the production of forage and grain to feed cattle. Despite the many agroclimatic advantages of producing feed and forage in North America, using land to support a basic cattle industry and a feed-grains industry to increase production by the cattle industry has consequences for water quality and quantity, pesticide and fertilizer use, soil quality and biodiversity. Once the environmental impacts of supporting a feed-grains sector are recognized, a second tier of environmental impacts involves both cattle feeding itself and further cattle processing. Feedlots are a source of air and water pollution, which may be multiplied by improper disposal and the mismanagement of manure. Beef processing represents the final stage of production and completes the transformation of an agricultural enterprise into an industrial one, with attendant environmental impacts. Beef processing and rendering produce a variety of wastes and byproducts, some of which may pollute either the air around packing and rendering plants or the water from rendering facilities.

1. Feed Grains

The feed-grains complex includes corn (maize), grain sorghum, feed wheat, barley and numerous oilseeds such as soybeans, rapeseed (canola) and cottonseed. All of these crops are used to feed beef, principally during its finishing stages.[5] The proportion of these crops going to beef is substantial (especially in North America), although the beef sector does not account for a majority of their uses. While it is an overstatement to attribute the environmental effects of feed-grain production to a "culture of beef" (see Rifkin 1992), feed for beef, pork and poultry represents the main non-industrial uses of feed grains. Table 1 indicates the consumption of various feed grains by different animal category in the United States for the last year in which these statistics were calculated. Cattle on feed and other beef cattle accounted for 27 percent of feed-grain consumption, compared with 31.5 percent for hogs and 17 percent for poultry. It is notable that a growing share of the total usage of these crops is industrial.

Table 1 Consumption of Feed-grains by Type of Livestock in the United States (1985)

Animal Type	Feed Grains	Total Concentrates	Corn	Soybean Meal
Dairy	25.8	33.1	20.7	1.7
Cattle on Feed	29.9	35.6	20.0	0.9
Other beef cattle	6.6	9.5	4.8	0.8
Hens, pullets and chickens	8.0	12.0	6.6	1.9
Broilers	12.5	20.9	11.9	4.1
Turkeys	3.2	6.5	2.9	1.8
Hogs	42.5	51.7	39.8	5.2
Other livestock	1.1	15.1	1.8	1.8
Total	134.6	184.4	108.5	18.2

Figures in million metric tons. *Source: USDA, Economic Research Service, December 1985, 52-54.*

Beef-feeding, accounting for roughly a quarter of feed-grain and ten percent of oilseed-meal use, is thus an important part of the demand for these crops and is linked to their environmental impacts. This is especially true of corn, soybean, feed-wheat and barley production. Of these, corn for livestock feed (generally grown in rotation with soybeans) is the most important as a user of land, water and potentially polluting chemicals. Cattle on feed and other beef cattle account for about 25 percent of total US corn consumption. Over half of all fertilizer and crop chemicals in the United States are applied to corn. Land-use decisions for these crops (as well as some forage crops such as alfalfa) have implications for water quality and quantity, total pesticide and fertilizer concentrations, soil losses and biodiversity. These will be considered in turn, focusing primarily on the Corn Belt of the United States.

In a survey conducted by the US Department of Agriculture (USDA) in 1994, experts examining agricultural and environmental interactions ranked water quality first in importance (USDA, cited in Faeth 1996). This ranking reflected the fact that water is linked to numerous other issues, including soil erosion, land conversion, pesticide management, and animal-waste and nutrient management, all of which contribute to water-quality concerns. Aggregate data shown in Table 2 indicate that agriculture is the primary cause of surface water quality impairment nationwide in the United States (Puckett 1994; EPA 1994). Changes in both water quality and quantity may result in dramatic effects on water and water-borne plants, fish and organisms, often through long-lasting impacts on the entire hydrological system.

[5] In some areas, beef are fed rations of citrus pulp or sugar beet byproducts and even surplus breakfast cereals, none of which will be considered here.

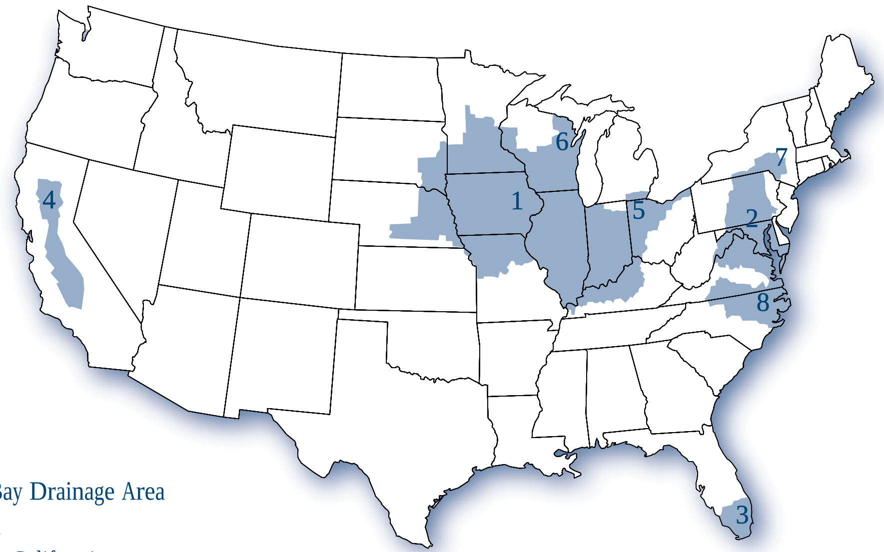
Table 2 Primary Causes of Water-Quality Impairment

	Rivers	Lakes	Estuaries
Source of Impairment (%)			
Agriculture	72	56	43
Hyrdo/habitat/modification	7	23	10
Storm runoff/sewers	11	24	43
Land disposal	not available	16	not available
Municipal/industrial	22	21	76
Cause of Impairment (%)			
Siltation	45	22	12
Nutrients	37	40	55
Pathogens	27	8	42
Organic enrichment	24	24	34
Pesticides	26	9	7
Suspended oils	13	6	11
Salinity	12	< 1	7
Metals	6	41	4

Source: ERS/USDA 1994, 60-61.

The Office of Technology Assessment determined more specifically where these problems were most severe (OTA 1995) (Figure 1). The impairment of surface water was identified as particularly significant in the Corn Belt, at the center of the feed-grains complex, where fertilizer and pesticide residues are concentrated in many streams, rivers and lakes. Some of these concentrations flow into the huge Mississippi River watershed, and hundreds of thousands of agricultural contaminants end up in Louisiana's Gulf Coast estuaries, contributing to an off-shore "dead zone" that is of growing concern. The US Geological Survey (USGS), investigating the sources of this dead zone, traced it directly to the nutrients that flow into the Gulf from the Mississippi, consuming oxygen and producing a very large "hypoxic" area of low-dissolved oxygen. The USGS then estimated the origin of point and non-point nutrients from 430 upstream watersheds, using a statistical model based on data for these watersheds.

Figure 1 Surface-water Quality

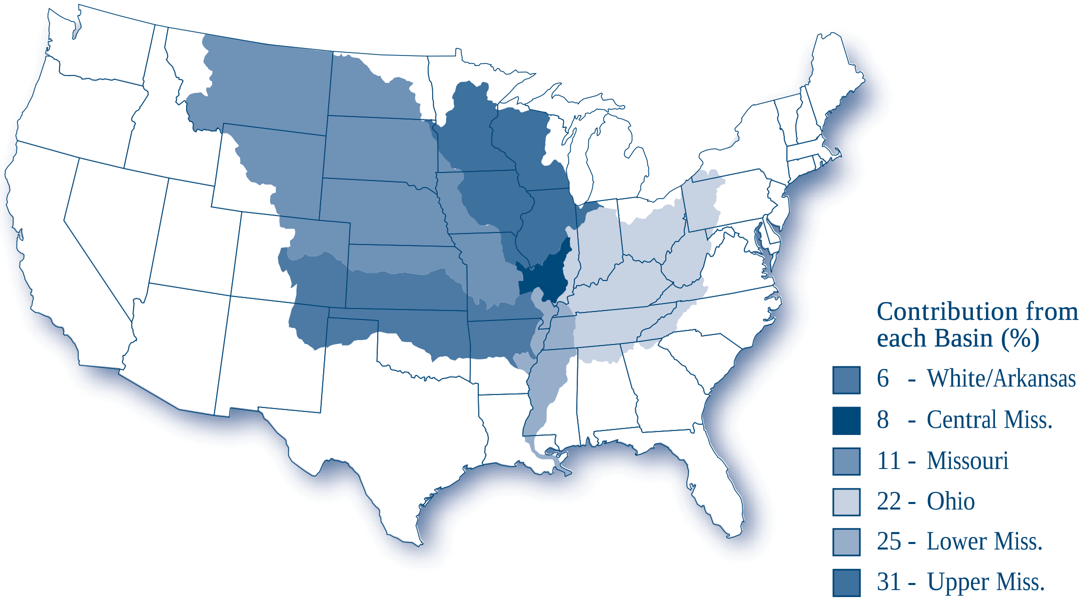


Key
1 - Corn Belt
2 - Chesapeake Bay Drainage Area
3 - South Florida
4 - Central Valley, California
5 - Lake Erie Drainage Basin
6 - Eastern Lake Michigan Drainage Basin
7 - Watershed Containing NY City Water Supply
8 - Albemarle/Pamlico Sounds Drainage Basin

Source: OTA 1995, 12.

The USGS concluded that 70 percent of the total nitrogen delivered to the Gulf of Mexico originates above the confluence of the Ohio and Mississippi Rivers; it is thus transported over distances of a thousand miles or more (Alexander et al. 1996). The Upper and Central Mississippi basins, including Minnesota, Wisconsin, Iowa, Missouri and Illinois, together accounted for 39 percent, while 22 percent originated in the Ohio and 11 percent in the Missouri River Basins. About 25 percent originated in the Lower Mississippi Basin, including parts of Tennessee, Arkansas, Missouri, Mississippi and Louisiana. The White/Arkansas River Basin contributed about 6 percent (Figure 2). Some of this nitrogen originated from point sources such as factories or municipalities, but the USGS estimated that approximately 90 percent of all nutrients, including nitrogen, came from non-point sources, primarily agricultural runoff and atmospheric deposition. Much of the cropping base of this huge watershed is devoted to corn and soybean production.

Figure 2 Percentage of the Mississippi River Total Nitrogen Flux to the Gulf of Mexico from Interior Basins



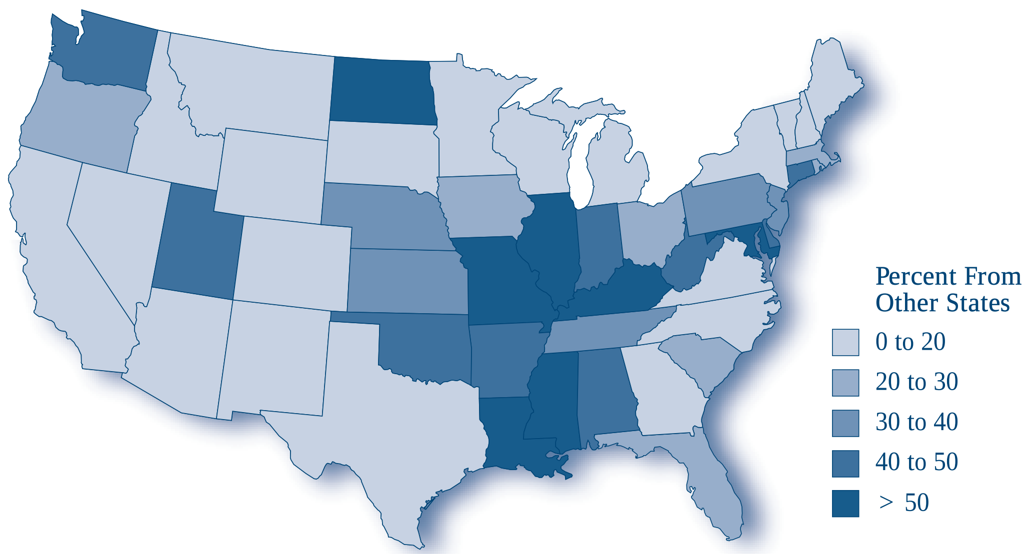
Source: Alexander, R.B., Smith, R.A., and Schwarz, G.E., US Geological Survey, Reston, VA, 1996.

More recently, reported evidence on the dead zone in the Gulf of Mexico has prompted a scientific assessment overseen by the US National Oceanic and Atmospheric Administration's Coastal Ocean Program (Yoon 1998). In December 1997, results were reported of a research initiative by the White House Office of Science and Technology Policy at a meeting of the American Geophysical Union, in which river-born nitrogen, in particular, was identified as the probable cause of summer explosions of algae that lead to hypoxia. The role of agricultural runoff in the Mississippi watershed was further revealed by the natural experiment of the 1993 floods, following which the dead zone doubled in size. In 1988, a year of midwest drought, the dead zone virtually disappeared.

Using core samples from the seabed of the hypoxic zone, researchers have developed a 200-year time series that indicates that oxygen levels have been falling strikingly since the 1950s, which matches the time series of increases in farm fertilizer use. In addition to fertilizer, a Senate Agriculture Committee Report in December 1997 estimated that 1.37 billion tons of nitrogen-rich manure were produced by livestock in the United States, at least some of which found its way into water courses leading to the sea. William Battaglin, of the US Geological Survey in Denver, stated in early 1998 that, although agriculture is not the only culprit, "[w]e're all fairly convinced that it's going to be agriculture that's going to have to kick in and change to some degree to make a big difference" (Yoon 1998, B14).

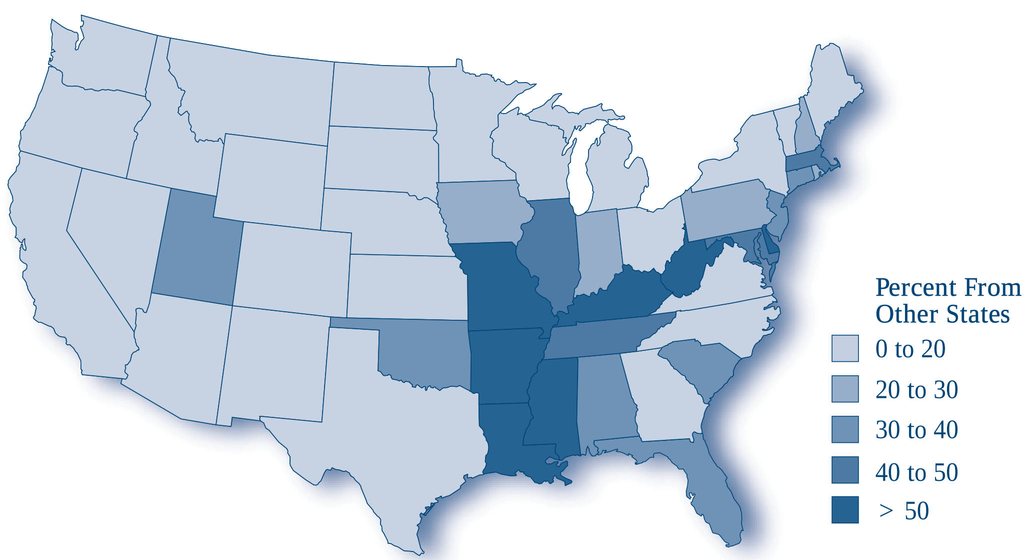
Part of the difficulty of managing waterborne agricultural pollution is that it travels across multiple public jurisdictions and thousands of private property boundaries. The US Geological Survey has also shown how much the agricultural pollutants—such as nitrates and phosphorus, or herbicides such as atrazine—found in rivers of each US state originate in other states (Smith et al. 1996). For example, in eight states, more than half of the phosphorus in rivers comes from other states (Figure 3). In seven states, more than half of the nitrate has out-of-state origins (Figure 4).

Figure 3 Percent of Total Phosphorus in Rivers Coming from Other States



Source: Smith, R.A., Schwarz, G.E., and Alexander, R.B., US Geological Survey, 1995.

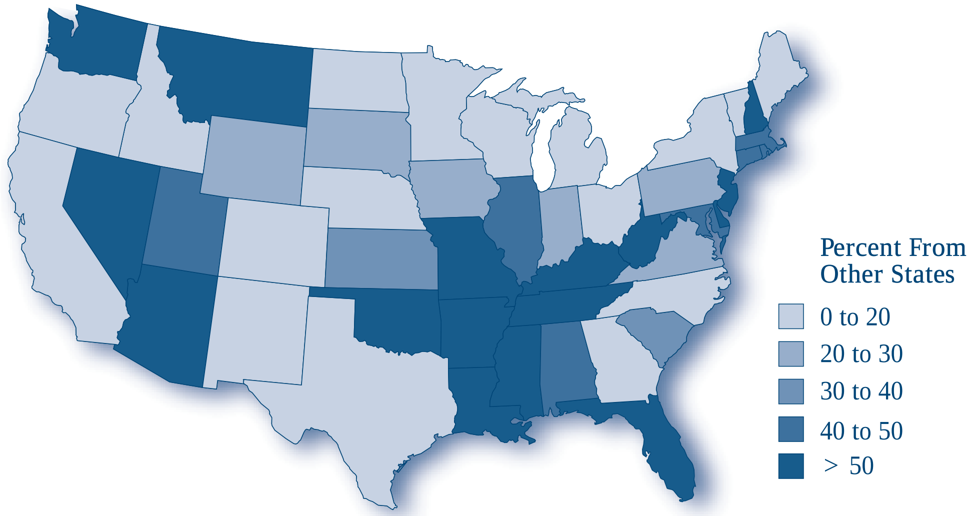
Figure 4 Percent of Nitrate in Rivers Coming from Other States



Source: Smith, R.A., Schwarz, G.E., and Alexander, R.B., US Geological Survey, 1995.

In the case of the corn herbicide atrazine, more than 16 states receive over half of their concentrations via watersheds from elsewhere (Figure 5), based on US Geographical Survey data. Generally, the spatial dispersion or mobility of these agricultural pollutants is a function of how easily they dissolve in water and are transported in waterways. Figures 2 through 5 show that waterborne pollution carried across state boundaries is not restricted to the Mississippi watershed or the Corn Belt.

Figure 5 Percent of Atrazine in Rivers Coming from Other States



Source: Smith, R.A., Schwarz, G.E., and Alexander, R.B., US Geological Survey, 1995.

In addition to surface-water quality, the feed-grains complex has also had significant (but more difficult to trace) impacts on groundwater quality and quantity. Groundwater supplies half of the US population with drinking water; it is the sole source for most rural communities. Groundwater is especially susceptible to nitrate contamination originating in inorganic fertilizer and manure. The risk of nitrate groundwater contamination is a function of both soil drainage and the levels of fertilizer and manure application, which rise in direct proportion to agricultural activity, especially corn production (Nolan and Ruddy 1996).

In Canada, there is also growing concern regarding the impact of agricultural production on ground- and surface-water quality in the prairie provinces. This concern prompted the Prairie Farm Rehabilitation Administration (PFRA) to undertake a comprehensive assessment of the available evidence and seek expert opinion on the impacts of non-point source agricultural activities on water quality in the region. Harker et al. (1997, vii) concluded that:

> Within the context of the Canadian Water Quality Guidelines, there is no significant body of evidence to indicate the widespread contamination of surface and ground waters from agricultural activities on the prairies.

This is not to say that there are no local problems of contamination, or that such problems cannot or will not occur in the future. Sediment loadings in major rivers in the region are identified as a seasonal problem. Few pesticide residues have been detected in surface or groundwaters, and concentrations have only rarely exceeded current guidelines. Nitrate contamination of groundwater was identified as one of the more common water-quality problems associated with agricultural production on the prairies, especially under intensively fertilized and irrigated croplands. Phosphorous in surface water is evident in the region, although attribution of phosphorous loadings to the various sources, including agriculture, has been problematic. Available data suggest that atrazine is not a problem in Canada, possibly because corn is not grown extensively on the prairie provinces.

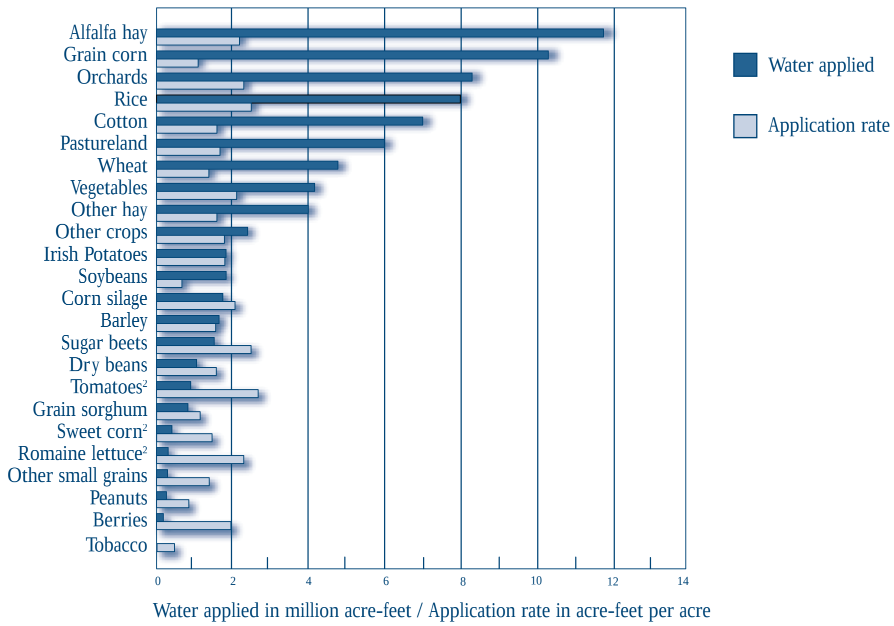
The PFRA assessment is based in part on the lower intensity of agricultural-input use in the Canadian prairie provinces relative to western Europe, the United States or even other parts of Canada. For example, the average application of pesticides per hectare of agricultural land in Canada, in terms of kg/ha, is only about 40 percent of the corresponding value in the United States. And the average application level on the prairie provinces is only about 25 percent of that of Ontario. In addition, the drier climate of the prairie region results in lower overall runoff and leaching rates. On the other hand, it has been suggested that the relatively short frost-free period for the region may retard pesticide degradation and lead to seasonal concentration of the runoff and leaching that does occur (Harker et al. 1997).

In the United States, the sheer quantity of water used in the feed-grains sector is also an issue of significance. In the case of groundwater, the most high-profile case is the huge Ogallala aquifer, stretching across the states of Kansas, Nebraska and Colorado. The aquifer, largely composed of ancient water left behind by glaciers, has been drawn down over time by the intensive irrigation of feed-grains, which indicates a potential for significant future shortages (see Opie 1993; White 1995). As that water disappears, or when it is gone, feed-grain production in the area now irrigated will decline over time. Cattle feeders currently relying on grain produced nearby for half their supplies will find their costs increased.

Further west, US Bureau of Reclamation projects have dammed river systems, such as the Colorado and Columbia, and diverted billions of acre-feet of water to agricultural irrigation at prices averaging one-tenth of those charged to nonagricultural uses (Frederick 1990). Such water use, much of which is implicitly or explicitly subsidized by the US federal government, raises questions of whether the true scarcity value of America's water resources is being recognized. The main use of water for feed-grain production is for irrigation, which is concentrated in 17 western states. An estimated 80 million acre-feet (2.265 million cubic metres) of water was applied on US irrigated cropland in 1994, equal to 325,851 gallons per acre (499,187.85 liters per hectare). Alfalfa hay and corn for grain accounted for the largest amounts of irrigation water applied, as shown in Figure 6.

Thus, feed-grain production in the United States has major environmental impacts on water use and waterborne pollution, especially in the west and the Mississippi watershed. Those impacts are felt through direct runoff from fields, the use of pesticides and fertilizers, and erosion.

Figure 6 Total Water Applied and Average Application Rate, by Crop, United States, 1994[1]



[1] Conterminous United States excluding institutional, experimental, research, Indian reservation, and horticultural specialty farms.
[2] Also included in vegetables.

Source: USDA, August 1996, 4.

Related to water quality are the pesticides and agricultural chemicals used to protect feed-grains from weeds and insects. The use of these chemicals goes beyond issues of water alone and relates to concerns over residues on food and public-health impacts for agricultural workers. In the early 1990s, 368 million pounds of active ingredients (ai) of herbicides, 51 million pounds (ai) of insecticides and 33 million pounds (ai) of fungicides were applied on major US crops (Table 3).

Table 3 Pesticide Use on Major US Crops, 1991

Crops	Herbicides	Insecticides	Fungicides
	(1000 pounds active ingredients)		
Row crops			
Corn	210,200	23,036	0
Cotton	26,032	8,159	701
Grain Sorghum	14,156	1,140	0
Peanuts	4,510	1,913	8,114
Soybeans	69,931	445	0
Total	324,829	34,693	8,815
Small Grains			
Rice	16,092	309	426
Wheat	13,561	208	73
Total	29,653	517	499
Vegetables			
Potatoes	2,547	3,597	3,172
Other vegetables	4,496	4,261	12,527
Total	7,043	7,858	15,699
Fruits			
Citrus	6,331	4,145	3,750
Apples	411	3,841	4,349
Total	6,742	7,986	8,099
1991 Total	368,267	51,054	33,112

Source: Whittaker et al. 1995, 353.

These levels, which have fallen somewhat since the early 1980s, are nonetheless significantly above levels in the 1960s. In the feed-grains complex, between 1964 and 1991, US herbicide use on corn grew from 26 million pounds of active ingredient to 210 million pounds, and on soybeans from 4 to 70 million pounds. USDA analysts attribute this growth not only to substantial increases in planted acres of these crops (from 66 to 76 million acres of corn and from 32 to 70 million acres of soybeans), but also to substantial increases in the proportion of fields treated (now about 95 percent) and rates of application (from 1.23 to 2.94 pounds of ai for corn and 1.03 to 1.23 of ai for soybeans) (Whittaker et al. 1995). However, active ingredients (ais) have become less durable and more selective.

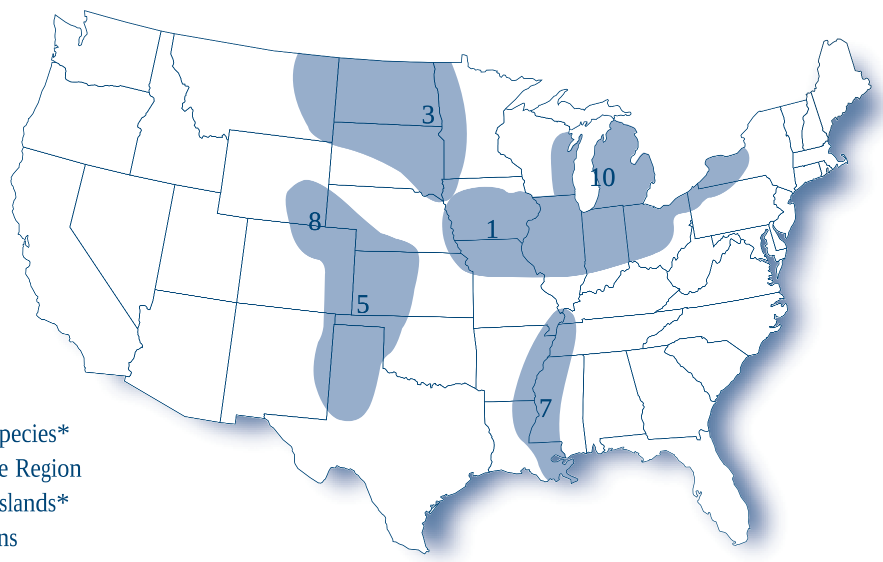
Reductions in the use of these pesticides have been urged by advocates of more sustainable agricultural methods. Such changes in production methods are not without cost, however, and they appear to affect the profits of farms of different sizes in different ways. Pesticides on larger farms, for example, are substituting for other inputs, such as labor or mechanical weeding. There is nonetheless scope at the farm level for the substitution of other production methods for pesticides, especially information technologies that allow better targeting of chemicals, depending on soil types and field conditions, and conservation tillage methods that reduce runoff (CTIC 1997b). Another potentially important chemical-saving technology is genetically engineered corn and soybeans, which in combination with soil-conserving tillage methods can reduce insecticide and herbicide use. These technologies are still in their infancy but may prove to be of major environmental importance. Biotechnologies, together with "precision farming," aided by computer-driven field and farm machinery, are only now emerging as potential technological innovations. Other, more traditional approaches to pesticide management include both crop rotations and integrated pest and crop management (see Altieri et al. 1995). Although these methods are still underutilized, they can be augmented by agricultural chemicals that are as closely tailored to the needs and environmental constraints of feed-grain producers as possible.

For many years, agricultural conservation efforts focused primarily on soil erosion as the major threat to agricultural sustainability, especially from row crops in the feed-grains complex, such as soybeans and corn. As experience accumulated in the United States with programs such as the Soil Bank of the 1950s and 1960s, and the Conservation Reserve Program (CRP) of the 1980s and 1990s, it became apparent that the programs designed to reduce erosion were poorly targeted and often ineffective. In the 1970s, it was concluded that 70 percent of erosion was occurring on only 8 percent of tillable land; yet by the 1980s, over US$900 million was still being spent in a largely untargeted fashion, with results that were difficult to monitor and assess (Potter 1996). In many respects, these programs were simply other means to transfer income to farmers, rather than being primarily focused on environmental sustainability. In a comprehensive summary of agro-environmental priorities, the US Office of Technology Assessment (1995) proposed that key priorities be established in which attention focused principally on the roughly 10 percent of US cropland, pasture or rangeland suffering from severe degradation. Moreover, the primary focus should shift from erosion per se to the related issues of water quality, pesticide use and biodiversity. Finally, the OTA noted that it is not always necessary or desirable to deal with the constraint of soil erosion by taking land out of production. The constraint may be more effectively broken through conservation tillage methods, more precise applications of farm chemicals, and integrated pest management.

As feed-grain demands imposed increasing pressures on North American agricultural landscapes, many grasslands and wetlands were converted to crops, field sizes were increased, crop diversity was reduced, many woodlands and field edges were eliminated, crop rotations to grasses such as clover or alfalfa declined, and fertilizer and pesticide use increased. These trends, while mitigated somewhat by the US Soil Bank and CRP programs, have had dramatic impacts on animal and plant populations, even among species well-adapted to agricultural land uses such as cottontail rabbits, quail and ground-nesting birds (OTA 1995). Species dependent on grasslands felt the most dramatic declines of key threshold levels of area and to the fragmentation of the pockets of grassland remaining (see Knopf 1994; Samson and Knopf 1994).

Samson and Knopf (1994) report that in the Great Plains of the United States, 99.9 percent of native tallgrass prairie and 30 percent of short-grass prairie has been converted to intensive crop production, much of it corn, soybeans and wheat. At least 55 grassland wildlife species are now listed as threatened or endangered as a direct result, and 728 are candidates for listing. Reflecting these and other findings, the US Office of Technology Assessment (1995) identified 10 priority areas where US agriculture has major effects on the quality and distribution of wildlife habitat, shown in Figure 7. Some are regional, others more localized. Regional areas include the Corn Belt, wetlands in the "Prairie Pothole" region, the Southern Plains and Platte River Headwaters, and the Great Lakes basin. More localized issues involve endangered species and habitats, national grasslands, wildlife management areas, and riparian areas.

Figure 7 Wildlife Habitat



Key
1 - Corn Belt
2 - Endangered Species*
3 - Prairie Pothole Region
4 - National Grasslands*
5 - Southern Plains
6 - State/Federal Wildlife Management Areas*
7 - Lower Missisippippi Valley
8 - Platte River Headwaters
9 - Riparian Buffer Strips*
10 - Great Lakes

** Localized rather than regional impacts. Not shown on map.*

Source: Office of Technology Assessment 1995, 18.

Knowledge about the potential benefits of preserving threatened species and the potential costs of eliminating them is so limited that one returns to broad questions of whether the risks of their wholesale destruction, while unknown, are not sufficiently large in possibility to merit “precautionary principle” efforts at protection and preservation (see Bishop 1978; Ready 1991; Pachauri and Damodaran 1992). In the case of plant diversity, there exists more compelling historical experience. Historical examination of the systematic elimination and propagation of plant varieties, at first through selective cultivation (Runnels 1995) and then by plant breeding, have shown that a narrowed genetic base can have catastrophic consequences because it creates susceptibility to a variety of plant diseases (Duvick 1996). In 1970, southern Corn Leaf Blight attacked the US corn crop and was turned back through the use of plant varieties held in storage by seed companies. The modern awareness of the need to conserve a diverse store of germplasm not only in natural environments (in situ) but also in “banks” (ex situ) grew correspondingly (see Tripp and van der Heide 1996). The feed-grains complex, to be robust, must be prepared to maintain and expand the genetic foundation on which it rests.

Despite the environmental challenges posed by feed-grain production, the following points should be kept in mind when evaluating it from the perspective of sustainability. First, the production base of the North American continent, despite the widespread environmental issues, is arguably the most sustainable production region for these crops in the world. Second, the activity of grain-feeding of beef and other livestock will naturally be drawn to such a grain surplus region. Third, if instead of being fed feed-grains, cattle were placed entirely on grass, the pressure on range resources, many in ecologically fragile regions, would increase dramatically. There are thus important ecological as well as economic efficiencies in feeding animals grain. Fourth, aggregate environmental consequences—for water quality and quantity, pesticide and fertilizer use, soil erosion and biodiversity—all occur due to site-specific management decisions. Fifth, there is therefore reason to believe that better targeting of technology and environmental management can significantly reduce many of these site-specific impacts. Finally, biotechnology can play a role in this process by helping to tailor seeds and farm chemicals to the agro-ecological environment in which they are best used, thus expanding production while reducing the ecological impacts of the feed-grains complex.

2. Beef-feeding

From the feed-grains complex the process moves to the place where these grains are transformed into animal protein by beef: the feedlot. In 1964, half of all beef cows in the United States were on lots of fewer than 50 animals. By 1996, nearly 90 percent of direct cattle feeding was occurring on lots of 1,000 head or more, with some 300 lots averaging 16,000-20,000 head and nearly 100 lots in excess of 30 thousand head. These feedlots represent waste management challenges equal to small cities, and most are regulated as point-source pollution sites under the authority of the US Environmental Protection Agency (EPA).

Prior to grain feeding, cattle are raised on grass and forage crops. Many lands, especially in the western United States and Canada and parts of Mexico, can best and sometimes only be utilized as grazing areas and would otherwise be unavailable as a source of human nutrition. While considerable criticism has been leveled at grazing policies and their impact on range quality, recent evidence suggests that problems of erosion and water infiltration associated with overgrazing in the western United States have abated in many areas. In any case, cattle numbers declined from 132 million on 1 January 1975 to 104 million head at the beginning of 1996, reducing aggregate grazing pressure. At the end of the 1980s, the US General Accounting Office (GAO) concluded that many rangelands in the western United States were in better ecological condition than at any time in this century. However, just as in feed-grain production, increased grazing pressure can lead to rapid increases in site-specific erosion in particular areas. In such vulnerable rangelands, soil losses can increase from one ton per hectare on lands that have good ground cover to as much as 53 tons per hectare with heavy grazing pressure. On the other hand, well-managed rangeland can be sustained while encouraging diversified plant growth and reduced levels of erosion (US GAO 1988).

Once cattle are brought into feedlots, their concentration raises questions of manure disposal, water consumption and pollution, and air and atmospheric pollution that do not arise with similar intensity on the range.[6] Unlike the feedgrains complex, where many environmental problems arise from the joint decisions of highly dispersed farm units that flow together to create environmental impacts (nonpoint sources), the majority of US feedlots are treated as point sources and are regulated under the provisions of the Clean Water Act, as amended, by the US Environmental Protection Agency. Table 4 shows the preponderance of beef feedlots and dairy operations in the point-source permitting process in 1995.

Table 4 Livestock and Poultry Operations with Point-source Permits

Livestock or Poultry Sector	Operations as of April 1995
Beef feedlot	632
Broiler	5
Dairy	992
Hog	324
Layer	24
Turkey	10
Total	1,987

Notes: (1) EPA does not track the inventories of livestock and poultry production operations that have been issued point-source permits. Therefore, we cannot report the number of animals covered by these permits. (2) EPA reported permitted operations in three other livestock and poultry categories: beef cattle (not including cattle on feedlots); general livestock (mixed livestock operations, except dairy and poultry); and poultry hatcheries. A total of 326 operations in these categories had point-source permits as of April 1995.

Source: US General Accounting Office. Animal Agriculture: Information on Waste Management and Water Quality Issues *June 1995, 58.*

Table 5 shows statistics and accompanying data, compiled by the American Society of Engineers, for manure produced on beef feedlots. Together, dairy and cattle in feedlots account for 39 percent and 31 percent, respectively, of all economically recoverable dry manure, compared with 11 percent for hogs, 6 percent for laying hens, 5 percent for broilers, 3 percent for sheep and 2 percent for turkeys. Recently updated figures indicate that beef cattle and calves in the United States produce approximately 97 million tons of dry manure per year. The majority (88 percent) is produced on grazing production systems, and 12 percent is attributable to feedlots. However, levels of manure solids, nitrogen, and phosphorus production on feedlots are several times higher as a function of animal spacing per unit of live weight (CAST 1995, 56; Sweeten and Reddell 1978).

Water pollution and water use on feedlots is a concern because of the concentrated nature of the animals and the potential for waste discharges with high levels of nutrients, salts, pathogens and oxygen-demanding organic matter. Runoff from feedlots is an increasing function of rainfall, requiring different levels of holding-pond capacity depending on average and maximum rainfall events. Once collected, runoff is then applied to lands directly, "dewatered" by diverting some water to irrigation uses, or evaporated. Problems of nitrogen, phosphorus, ammonium and salt accumulation occur in any of these applications (CAST 1995, 59-60). However, many of the nutrients contained in feedlot manure and runoff can be effectively recycled in cropping of grain crops such as sorghum and corn.

[6] Apart from these concerns, feedlots are also the focus of objections that grain fed to cattle, or the land which produced it, could otherwise be devoted to the production of food crops (see Cheeke 1993, Chapter 3). It would be an exaggeration to say that the feeds used in animal production would be acceptable for human consumption, at least without substantial further processing, although cereals or oilseeds other than corn and soybeans could be produced in their place. Beef production's additions to the humanly consumable protein pool also come in a form with higher energy value than the protein directly available to humans from feedgrains (Oltjen and Beckett 1996, p. 1409).

Table 5 Daily Production of Fresh Manure by Beef Cattle in Feedlots, based on American Society of Agricultural Engineers, Engineering Standard D-384.1

Parameters	Per 1,000 lb liveweight		Average manure per 1,000 head feedlot cattle (850 lb/hd) (lb/day)
	Mean (lb/day)	Mean + SD* (lb/day)	
Total wet manure	58.0	75.0	49,300
Total solids (dry matter)	8.5	11.1	7,225
Volatile (ash-free) Solids	7.2	7.77	6,120
Biochemical Oxygen Demand	1.6	2.35	1,360
Chemical Oxygen Demand	7.8	10.5	6,630
Total Kjeldahl nitrogen	0.34	0.413	289
Ammonia	0.086	0.138	73
Total phosphorus	0.092	0.11978	78
Potassium	0.21	0.271	179
Calcium	0.14	0.25	119
Magnesium	0.049	0.064	42
Sulfur	0.045	0.0502	38
Sodium	0.030	0.053	26
Iron	0.078	0.0137	7
PH	7.0	7.34	–

*SD: standard deviation

Source: CAST, October 1995, 56.

In addition to water quality, issues of concern include the quantities of water used in beef-feeding. Beckett and Oltjen (1993), of the University of California, Davis, have modeled the water requirements for beef in the United States. Interestingly, the consumption of water by breeding herds, stockers and feedlots accounted for a very small proportion of the total water used for beef production, compared with irrigation for grains and pasture. The model estimated that 3,682 liters of water are required to produce a kilogram of boneless beef. While seemingly high, this is much less than previous estimates by Robbins (1987) and Kreith (1991), of 20,864 and 20,559 liters per kilogram, respectively. The model was most sensitive to the percentages of water used in dressing and producing boneless yield in carcasses of feed-lot cattle. A 10-percent change in either variable translated into an 8.6-percent change in water required.

A third area of environmental concern in connection with feedlots is air pollution, notably particulates and methane, but also reactive organic compounds and ammonia (see Morse 1995). Air pollution due to feedlot dust is a particular problem in hot dry areas in late summer at the end of the day when cattle activity increases. Dust concentrations are inversely related to moisture levels, so that water sprinkling, the cleaning of feed yards and the careful monitoring of stocking rates all reduce air-pollution problems (Sweeten 1990). Methane produced by all livestock is estimated by EPA to contribute roughly 16 percent of total methane releases, which are considered second only to CO_2 as a source of possible global climate changes. Methane from cattle is a direct response to the digestion of fibrous grasses and other roughage; the less roughage and the more grain is fed, the less methane is produced, other things remaining equal. Roughly 80 percent of the methane produced is estimated to come from digestive fermentation, the remainder from manure-management facilities. Reducing methane emissions per unit of beef produced depends primarily on improved breeding and feeding technologies that increase the efficiency with which feed is converted to meat. Manure storage in covered ponds or lagoons and the conversion of manure to biogas are other possible responses, at least on feedlots.

3. Beef Processing

The final stage in the production of beef is slaughtering and processing. This stage, while historically highly polluting, is now regulated in the United States and Canada. Because it occurs in specifically adapted facilities, it lends itself to intensive environmental management. Apart from the slaughtering for sale of beef parts, the further processing of prepared meats, such as canned cooked products, luncheon meats and other ready-to-eat beef products, results in waste products that include animal parts, blood, hide materials, offal, fat and bones. Beginning a quarter-century ago, however, the development of boxed beef allowed customers to buy only the beef cuts needed; consequently, much unwanted fat and bone remained at the processing plant for centralized rendering. The US market is now almost entirely dominated by boxed-beef products (Klein 1995, 16). On a per volume basis, beef processing contributes substantially more to water consumption and pollution levels than the processing of turkeys or chickens, due primarily to the size of the animals involved and the corresponding volume of skins, fat, bones and offal (see Table 6).

Figure 8 illustrates the process for a beef-slaughtering operation. The handling of wastes and byproducts from these operations focuses on managing, recycling and reusing as many as possible.

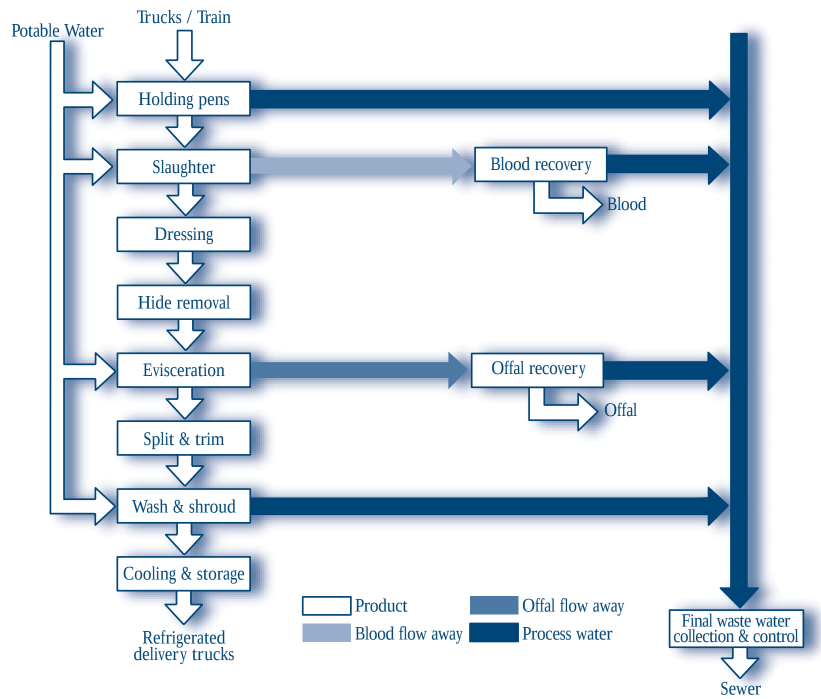
Table 6 Water Consumption and Pollutant Contributions for Beef, Turkey and Broiler Processing

Animal type	Pollutant contribution (lb/1,000 animals)			Water (gal./animal)	Source
	BOD_5[a]	TSS[b]	FOG[c]		
Beef	6,710	6,860	440	350.0	Stebor et al. 1989
Turkey	170	260	60	26.0	Sheldon et al. 1989
Broiler	49	57	8	5.8	Valentine et al. 1988

[a] BOD_5 = five day biochemical oxygen demand;
[b] TSS = total suspended solids
[c] FOG = fats, oils, and grease;

Source: CAST, October 1995, 90.

Figure 8 Process Flow for Beef-slaughtering Operations



Source: CAST, October 1995, 90.

B. The Economic Context

The North American Free Trade Agreement (NAFTA), which entered into force on 1 January 1994, is a signpost along a much longer road of economic integration in the Americas, beginning with Mexico's decision to join the General Agreement on Tariffs and Trade (GATT) in 1985, and propelled by the Canada-United States Free Trade Agreement (FTA), which became effective 1 January 1989. NAFTA has solidified and advanced a process of integration that reaches beyond Canada, Mexico and the United States and includes much of the western hemisphere (Runge et al. 1997). It is also linked to a global process of trade liberalization, marked by the successful completion of the Uruguay Round Agreements (URA), establishing the World Trade Organization (WTO), which entered into force on 1 January 1995.

NAFTA is only one factor among many affecting the agricultural sectors of North America, and the cattle and beef sector in particular. Other factors of importance include weather, currency adjustments, the cattle cycle, and domestic policy decisions other than trade. This study will show how NAFTA fits into this complex at three levels of analysis: the feed-grains that support cattle, the feedlots that fatten them, and the processing facilities that slaughter and package beef for sale.

As Section III elaborates in greater detail, the economic context for this analysis is one in which exchange rates, macroeconomic and domestic policies, and international trade with the rest of the world all figure largely in linking the economies of Canada, Mexico and the United States. It would be incorrect to attribute the majority of this economic activity to NAFTA alone. This is especially true for the US economy, the size of which suggests that NAFTA plays only a marginal role in affecting aggregate trade flows. Nonetheless, even from the US perspective, Canada and Mexico are key trading partners, a partnership now anchored and advanced by NAFTA. In 1996, nearly one-third of US two-way trade in goods with the world was with Canada and Mexico, equal to US$421 billion. Two-way trade between Canada and Mexico grew by 44 percent between January 1994 and June 1997, compared with a 33 percent growth rate with all non-NAFTA countries (Executive Office of the President 1997). Canada remains the largest US trading partner, while US-Mexican trade is vital to Mexico and of growing importance to the United States.

C. The Social Context

The rapid consolidation of grain, cattle and beef production into fewer farms, larger feedlots, and a few large processing firms has not gone unchallenged by social critics. This criticism is related to environmental concerns, but can be distinguished from purely environmental challenges.[7] The principal social processes that inspire criticisms of the "culture of beef" revolve around the increased concentration of production, human health, and animal welfare concerns (e.g. Rifkin 1992). In the case of greater concentration, it is argued that smaller family farms are increasingly disadvantaged by the buying power of large producers and purchasers of cattle and beef (see USDA 1996, October). There is, however, evidence that new contractual arrangements are shifting risks in the livestock industry away from primary producers (Martin 1997). In the case of human health, arguments against beef revolve around cardiovascular health and fat (Keys 1965). Finally, animal-welfare activists find the treatment of live cattle and their ultimate slaughter unacceptable on humanitarian grounds (see Cheeke 1993).

As a result of these concerns, activist groups have organized opposition to animal agriculture and trade, at least in high-income countries. For example, Fox (1992) argues that animal suffering is generally underestimated and unaccounted for in scientific circles (see also Krimsky and Wrubel 1996, 203-211). Illustrative of the politics of this trend were proposals in May 1996 by USDA's Grain Inspection, Packers and Stockyards Administration (GIPSA) for livestock care and handling guidelines, prompted by more than 8,000 letters from groups concerned about the treatment of stockyard animals. Reaction by industry to the proposals was mixed, but observers noted that industry had already voluntarily adopted guidelines for the treatment of downed (or "nonambulatory") animals, which were found at fewer than 5 percent of markets in a 1991-92 USDA investigation (Jones 1996, 2). Even so, consumer concerns about the treatment of animals have prompted growing attention to the issue.

Some have dismissed animal-welfare activists as a fringe group, posing little in the way of true opposition to expanded production of beef. Yet in an evaluation of this question, Jamison (1992) concluded that:

> Animal rights activists are demographically much more mainstream than previously anticipated. They are not marginal to the political system, and their political values are based on classic American ideals of equality. Similarly, they are urban dwellers whose experience with the life and death processes inherent to animal production are severely limited. Ultimately, the debate over the rights of farm animals has little to do with the reality of their treatment. Instead the debate is about the perception of what is real, and in public policy, perception becomes reality. Agriculturalists and animal rights activists have different realities (quoted in Cheeke, 201).

A related concern is the increasing use of migratory labor in the meatpacking industries. Technical advances in meatpacking have reduced the demand for high-cost skilled labor, especially meat cutters, and raised demand for lower-cost workers in meat processing. The result has been an influx of migrants, especially Hispanic and Asian workers, into the meat-processing centers of the midwest. In general, these new residents are attracted by the high level of public services, education and social infrastructure in these areas (Huffman and Miranowski 1996).

[7] Indeed, there may well be economies of large scale in waste processing and pollution prevention in the cattle and beef industries, and in the reduction of pollution from feed-grains production.

D. The Geographic Context

Cattle feeding occurs in many parts of North America but is increasingly concentrated in the central United States and the Canadian plains of Alberta, where feed grain availability and range are combined. This study will thus focus on these key geographic locales.

The historical center of cattle feeding in the United States has shifted northward in the last two decades, reflecting the abundance of feed-grains, from near Amarillo in the High Plains of Texas toward Colorado, Kansas and Nebraska, with a new epicenter at Garden City, Kansas (Melton 1997). In Canada, the main cattle-feeding activity is centered in Alberta, which accounts for over 40 percent of Canadian beef-cow production (Ross et al. 1990).

Important questions surround the further concentration of cattle-feeding facilities in the central plains of the United States and prairie provinces of Canada. This is not just an economic phenomenon; it has social and regulatory implications as well. When examined over a 25-year period, beginning in the early 1970s, the largest cattle feeding states in the United States—Texas, Nebraska, and Kansas—all showed major increases in cattle on feed from 1972 to 1992. More important than cattle numbers per se is the fact that in states such as Nebraska, as in the other large feeding states, feedlots of less than 1,000 head fell dramatically, while major growth occurred in feedlots with 8,000 to 32,000 head and above. These trends are shown in Tables 7 and 8. On the one hand, these concentrations may tend to aggravate environmental problems associated with the sheer scale of beef feedlots, notably waste disposal. On the other hand, they may create opportunities to recycle and reuse manure and other wastes that might be more difficult on smaller, undercapitalized units. Furthermore, the concentration of fed-cattle facilities may make regulatory oversight simpler and more cost-effective.

Table 7 Beef Cattle Feeding in the Great Plains States, 1972-1992

	Cattle on Feed, 1 January (thousands)		
State	1972	1982	1992
New Mexico	188	127	120
Texas	1,781	1,660	2,180
Oklahoma	250	270	345
Colorado	983	750	930
Kansas	1,100	1,100	1,820
Nebraska	1,550	1,640	1,990
Wyoming	37	52	105
South Dakota	325	335	290
North Dakota	53	36	65
Total	6,432	6,033	7,935

Source: Vanderholm 1994, 2.

Table 8 Feedlot Numbers in Nebraska and the Thirteen Largest Beef-feeding States[1], 1981-1991

Size of Feedlot	Number of Feedlots			
	1974	1981	1986	1991
Nebraska				
under 1,000	14,910	11,250	9,050	6,890
1,000-7,999	420	303	391	432
8,000-31,999	35	42	54	74
32,000 & over	5	5	5	4
Thirteen States[1]				
under 1,000	–	68,890	46,699	45,150
1,000-7,999	–	1,623	1,485	1,318
8,000-31,999	–	206	328	302
32,000 & over	–	73	80	81

[1] AZ, CA, CO, ID, IA, IL, KS, MN, NE, OK, SD, TX, WA.

Source: Vanderholm 1994, 3.

III. The NAFTA Connection

A. NAFTA Rule Changes

NAFTA's impacts on the North American cattle and beef sector derive principally from tariff concessions by which US and Canadian beef imported by Mexico receives a rate of duty of "free," compared with a 25 percent *ad valorem* duty on non-NAFTA frozen beef and a 20 percent *ad valorem* duty on non-NAFTA fresh beef.

These concessions expanded on those granted by the Canada-United States Free Trade Agreement (FTA), which provided for the reciprocal phase-out of duties over 10 years on imports of live cattle, including cattle for immediate slaughter, as well as fresh, chilled, or frozen beef and veal between the United States and Canada. These provisions were accelerated under the FTA, with "free" duties applicable to fresh or chilled beef and veal carcasses on 1 April 1990, and frozen beef and veal carcasses and fresh, chilled or frozen other cuts with bone-in and boneless beef and veal on 1 July 1991. Frozen boneless beef and veal received a "free" duty effective 1 July 1993 (US ITC 1997, 4-3).

The NAFTA agreement was based on these FTA provisions, carrying forward the duty phase-outs, with Canada, Mexico and the United States agreeing to a duty of "free" on trade in live cattle, including cattle for immediate slaughter, and fresh, chilled or frozen beef and veal effective 1 January 1994. This move to "free" duty compared with a general rate of duty applicable to US shipments of live cattle to Mexico of 2.2 US cents/kilogram in 1994, which declined to 1.8 US cents/kilogram in 1996 as a result of the Uruguay Round Agreements. General rates applicable to fresh, chilled, or frozen beef were 4.4 US cents/kilogram, equal to 4 percent *ad valorem* or 10 percent *ad valorem*, depending on the harmonized tariff schedule subheading.

B. NAFTA's Institutions

In addition to these tariff schedule changes, NAFTA also affected a variety of other institutional arrangements and ongoing discussions related to the cattle and beef trade, notably quantitative restrictions, beef grading systems in the three countries, sanitary and phytosanitary standards, and import regulations related to bluetongue disease. Briefly, these issues concern the application of the quantitative limitations to cattle imports under the US Meat Import Act of 1979 and Canada's Meat Import Act, (1982). Mexico did not have a comparable law at the time of NAFTA's passage. Under Article 704 of the FTA, the United States and Canada agreed to prohibit these quantitative restrictions on meat imports on a bilateral basis. Article 704 of the FTA was wholly incorporated as NAFTA annex 702.1:1; in addition, in NAFTA annex 703.2 (sec. A para 9), the Parties agreed not to seek voluntary-restraint agreements from the other Parties concerning meat exports. The US Meat Import Act was repealed by the Uruguay Round Agreements, effective 1 January 1995, and replaced with a tariff-rate quota system.[8]

[8] Mexican beef grading systems are state-based, rather than national in scope, and apply in both the state of Sonora and Sinaloa. In general, these grading systems are similar to those in the United States, although they are not applied to US boxed beef. US interests have argued that the effect of these standards has been to discriminate against US boxed-beef shipments to these Mexican states. Although NAFTA did not specifically address grading systems, it has prompted further discussions of the need for equivalency in such systems in all three countries (US ITC 1997, 4–14; Hayes et al. 1996).

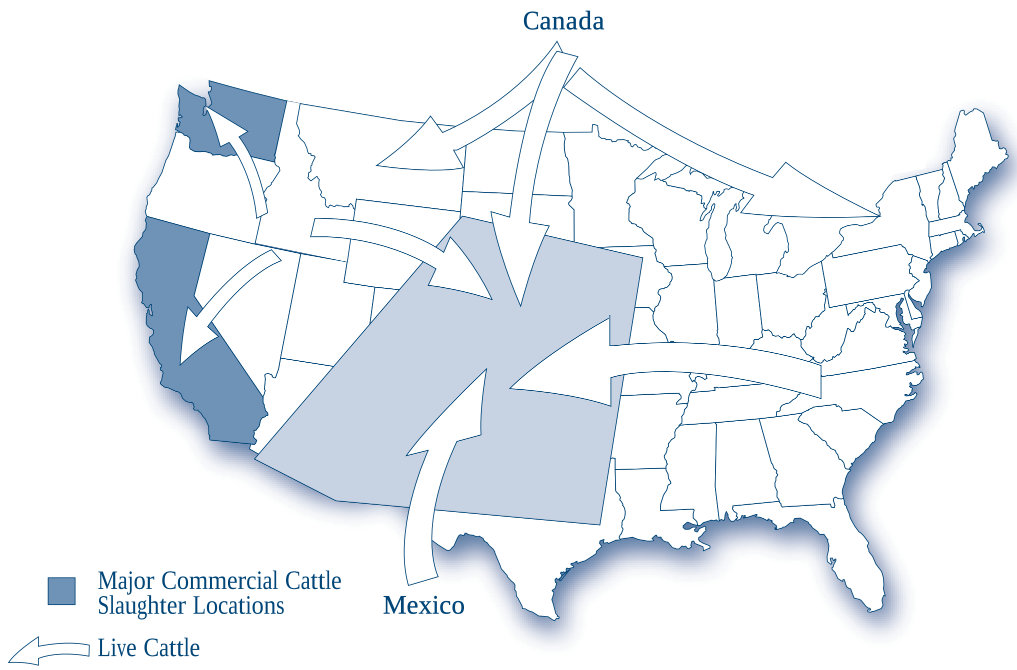
NAFTA has also intensified the scrutiny of sanitary and phytosanitary standards in the three countries. Sanitary and phytosanitary standards have arisen primarily in relation to beef imported to the United States from Canada. The US Department of Agriculture, Food Safety and Inspection Service (FSIS) considers the inspection system of eligible foreign countries to be the primary sanitary and phytosanitary control point, although every shipment receives some level of US inspection at the border. Issues have arisen between the United States and Canada over the stringency of border inspections and the fees charged to Canadian exporters, related to the adoption under FTA of "streamlined" procedures effective 1 January 1989. However, a fully open border has eluded the United States and Canada, and a number of memoranda and technical working groups to develop a system of inspection have resulted. A new FSIS system for reinspecting Canadian red meat carcasses was instituted on 16 February 1997 (US ITC 1997, 4-19).

Finally, after the passage of NAFTA, discussions between the United States and Canada intensified over differences in testing procedures for bluetongue disease, a virus debilitating mainly to sheep but carried by cattle and other ruminants and transmitted through insect bites, especially in warm weather. Bluetongue occurs in the United States but has not been established in Canada. However, Canada maintains import restrictions based on testing requirements for bluetongue disease, effective 18 October 1995. These requirements resulted from Canadian consultations with an Animal Health Working Group under the FTA, including private-sector and government representatives (US ITC 1997, Appendix J).

C. Trade Flows

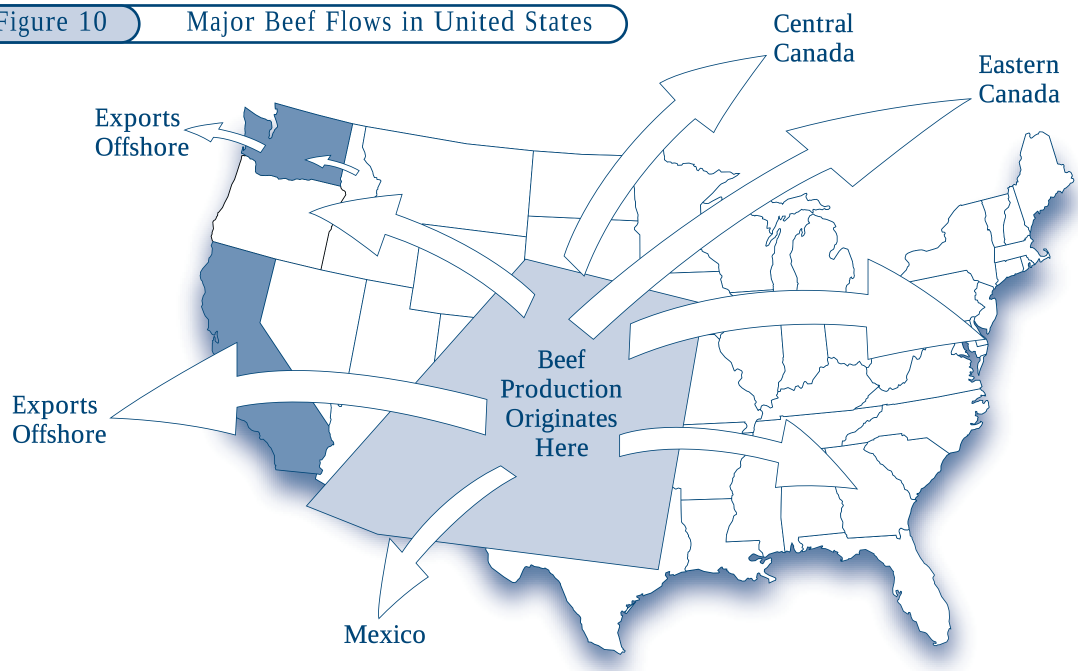
The US and Canadian beef industries are increasingly integrated with the United States, the dominant player, making it "difficult if not impossible to look at the two industries in isolation" (Canadian Cattlemen's Association 1997). Figures 9, 10 and 11 show major beef flows in the United States and major inflows of feeder cattle from Mexico and Canada, as well as overall North American beef flows.

Figure 9 Major Live Cattle Inflows in United States



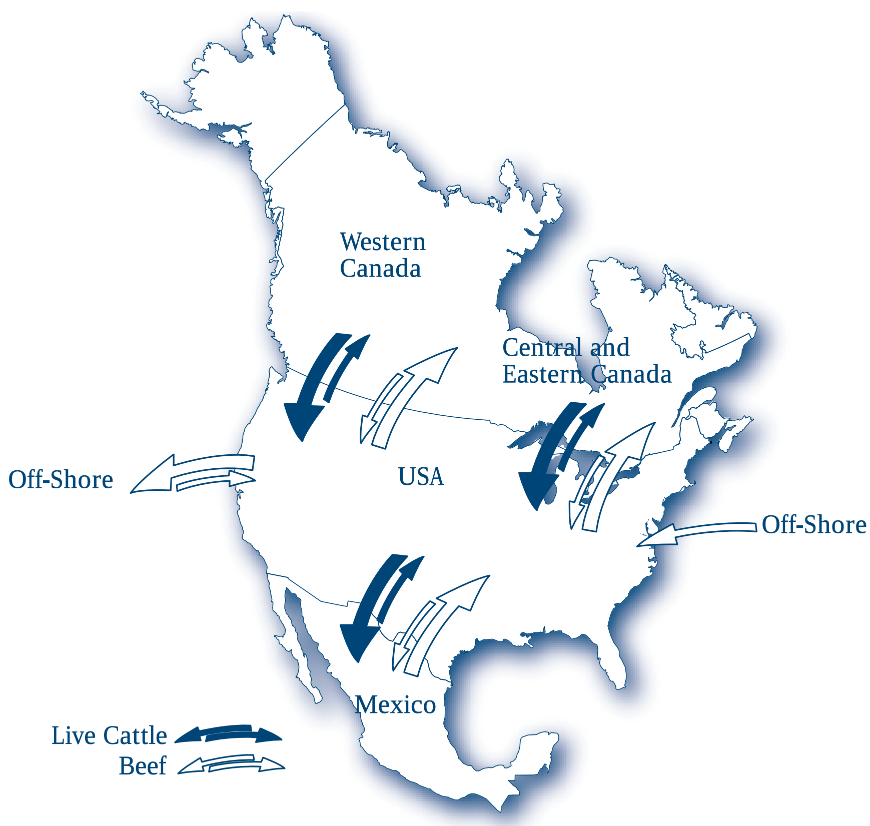
Source: Canadian Cattlemen's Association 1997, 5.1-2,3 and 4.

Figure 10 Major Beef Flows in United States



Source: Canadian Cattlemen's Association 1997, 5.1-2,3 and 4.

Figure 11 Major Live Cattle and Beef Flows in North America



Source: Canadian Cattlemen's Association 1997, 5.1-2,3 and 4.

Trade flows in cattle and beef between Canada, Mexico and the United States were subject to substantial fluctuations both before and after NAFTA, attributable to a variety of factors including not only border measures and tariff treatment but also exchange rates, weather, and cyclical changes in the price of feed-grains and livestock. Overall trends in trade are driven by trends in beef consumption and production. Table 9 shows consumption trends from 1976 to 1995.[9] In both Canada and the United States, consumption per capita fell from about 40 kg per year in 1976 to levels of 22.9 kg in Canada and 30.6 kg in the United States in 1995. In Mexico, in contrast, consumption per capita rose by over 50 percent, from 10.87 kg in 1976 to 15.24 kg in 1993. Mexican consumption measured as total domestic disappearance increased more than two-fold: from 505 thousand metric tons to 1.394 million metric tons in 1993. These consumption trends indicate that, with growing incomes and an increasing population, Mexico represents an enlarging market for beef, much of which will come from the United States or Canada.

Table 9 Consumption of Beef: Canada, United States and Mexico (1976-1995)

Year	Canada		United States		Mexico	
	Total[1] Domestic Disappearance (thousands of metric tons)	Total[1] per caput Disappearance (kg)	Total[2] Domestic Disappearance (thousands of metric tons)	Total[2] per caput Disappearance (kg)	Total[3] Domestic Disappearance (thousands of metric tons)	Total[4] per caput Disappearance (kg)
1976	1,182.3	39.1	12,611.7	40.3	505.0	10.87
1977	1,137.9	37.1	12,389.9	39.2	546.0	11.41
1978	1,076.3	34.8	11,911.8	37.4	560.0	10.89
1979	948.3	29.5	10,775.1	33.4	546.0	9.70
1980	951.9	29.3	10,686.5	32.7	583.0	11.09
1981	989.3	30.0	10,892.1	33.0	644.0	12.28
1982	992.4	29.9	10,964.7	32.9	661.0	12.35
1983	996.6	29.8	11,296.3	33.6	762.0	13.13
1984	959.5	28.4	11,361.6	33.5	923.0	12.51
1985	980.5	28.8	11,577.1	33.9	935.0	12.38
1986	997.1	27.8	11,788.0	33.8	1246.0	16.12
1987	959.2	26.4	11,456.4	31.6	1271.0	16.08
1988	972.3	26.4	11,454.1	31.1	1779.0	16.03
1989	963.1	25.7	11,035.9	29.7	2184.0	14.57
1990	941.3	24.7	10,899.8	29.0	1848.0	13.82
1991	933.7	24.2	10,937.9	28.7	1333.0	15.40
1992	917.4	23.5	11,004.6	28.6	1400.0	15.83
1993	891.8	22.5	10,889.0	28.0	1394.0	15.24
1994	919.1	22.9	11,961.8	30.4	N/A	N/A
1995	929.3	22.9	12,087.0	30.6	N/A	N/A

1 See Appendix Table A-1.
2 Appendix Table A-2.
3 United Nations. (1995). *United Nations Conference on Trade and Development Commodity Yearbook,* New York and Geneva: United Nations. The data represent total bovine meat consumption; however, the range of meat included in the summary is not available.
4 United Nations. (1976-1994). *Food and Agricultural Organizations of the United Nations Yearbook: Trade and Commerce,* Rome: Statistics Division of the Economic and Social Department. Per capita consumption includes indigenous bovine meat.

9 Mexican data for 1994 and 1995 were unavailable.

Moving from consumption to production, the patterns that emerge reflect the cyclical nature of cattle inventory, shown in Table 10. Cattle slaughtered in the United States increased 12 percent from 1992 to 1996, from 34.5 to 38.4 million head, reflecting increasing feed-grain prices and declining profits. Canadian slaughter also increased, from 3.2 to 3.6 million head, while Mexican slaughter rose from 5.9 to 6.5 million head, affected by drought among other factors. Increased slaughter was accompanied by increased beef and veal production in all three countries.

When trade statistics are tabulated for the three countries, and the NAFTA period is laid over them, the following patterns emerge. First, and most significantly, reductions in duties to "free" allowed the United States to supply 97 percent of Mexican beef imports in 1996, compared with 51 percent in 1993. This is a striking increase, not accounted for by the factors noted above. Declines in both the quantity and value of US beef exports in 1995 mainly reflect the peso devaluation and its consequent macroeconomic impacts on consumer demand in Mexico. As a result of tariff reductions under the FTA and its incorporation as part of NAFTA, US trade with Canada in fresh, chilled and frozen beef has made Canada the leading supplier to the United States and the United States the leading supplier to Canada, accounting for over half of Canadian imports in 1996 (US ITC 1997, 4-2).

Live cattle for slaughter, meanwhile, have been little affected by NAFTA. Canadian live cattle for slaughter shipped to the United States accounted for only 3 percent of US commercial cattle slaughter from 1992-96, although under duty-free treatment such shipments increased in value from US$733 million in 1993 to US$895 million in 1996, and in quantity from 724,100 animals to 1,037,600 animals over the same period. Direct foreign investment by US slaughtering interests in Canada are expected to reduce trans-shipments. Mexican cattle for slaughter were negligible over the same period, although they briefly surged in 1995 (Tables 11 and 12).

Trade in beef products, however, rose markedly, although it was reduced by the Mexican peso devaluation. US exports of beef and veal to Mexico (Table 13) rose from 39.4 million metric tons in 1993 to 72.3 million metric tons in 1994, fell back to 29.2 million metric tons in 1995, but rose again to 58.6 million metric tons in 1996. In value terms, this meant a doubling from US$112 million in 1993 to US$227 million in 1994, the first year such exports received a duty of "free" under NAFTA. In 1995, US exports fell in value to US$85 million, but recovered to US$162 million in 1996 (US ITC 1997, Table D-20, D-15). US exports of beef and veal to Canada, meanwhile, changed from 85.4 million metric tons in 1992 to 96.3 million metric tons by 1994, 102.5 million metric tons in 1995 and 96.6 million metric tons in 1996.

Canadian exports to the United States, shown in Table 14, increased from 133.6 million metric tons in 1992 to 187 million metric tons by 1994, 190 million metric tons in 1995 and 253 million metric tons in 1996. Canadian imports of US beef and veal were also growing: from 80.6 million metric tons in 1992 to 104.2 million metric tons by 1996. Canada's exports to Mexico over the same period were negligible.

Table 10 Production of Beef and Veal: Canada, Mexico and United States (1970-1996)

Year	Canada		United States		Mexico	
	Head of Cattle Slaughtered[1] (thousands)	Beef and Veal Production[2] (thousands of metric tons)	Head of Cattle Slaughtered[1] (thousands)	Beef and Veal Production[2] (thousands of metric tons)	Head of Cattle Slaughtered[1] (thousands)	Beef and Veal Production[2] (thousands of metric tons)
1970	4,021.3	850.6	39,559.0	10,102.8	3,049.0	511.1
1971	4,211.1	896.3	39,730.0	10,182.2	2,987.0	495.8
1972	4,037.3	897.6	39,335.0	10,374.1	3,049.0	501.0
1973	3,953.7	906.3	36,402.0	9,813.0	2,834.0	476.7
1974	4,283.7	953.1	40,499.0	10,715.6	2,871.0	491.5
1975	5,200.5	1,087.7	46,870.6	11,271.3	3,302.0	569.6
1976	5,480.0	1,165.6	48,726.0	12,166.2	3,841.0	677.9
1977	5,351.5	1,142.1	48,072.5	11,844.6	4,292.0	746.8
1978	4,764.0	1,063.1	44,272.3	11,281.7	4,092.0	732.5
1979	3,966.9	947.5	36,931.5	9,925.0	3,584.0	652.3
1980	4,057.1	970.7	36,794.9	9,999.0	3,936.0	740.8
1981	4,253.0	1,013.7	38,149.0	10,353.0	4,545.0	835.8
1982	4,385.8	1,025.2	39,258.0	10,425.0	4,818.0	861.9
1983	4,327.6	1,032.5	40,135.6	10,746.0	4,872.1	944.3
1984	4,217.8	990.7	41,269.0	10,927.0	4,751.0	925.0
1985	4,234.8	1,028.8	40,048.0	10,996.0	4,664.2	926.8
1986	4,103.0	1,028.2	41,046.0	11,292.0	6,302.0	1,247.9
1987	3,704.3	953.4	38,792.0	10,884.0	5,919.0	1,272.6
1988	3,577.7	947.4	37,889.0	10,879.0	5,414.0	1,271.0
1989	3,623.9	951.9	36,329.0	10,633.0	5,550.0	1,162.8
1990	3,354.3	900.1	35,277.0	10,465.0	5,300.0	1,113.9
1991	3,156.5	866.9	34,368.4	10,534.0	5,940.0	1,188.7
1992	3,236.9	897.6	34,489.0	10,612.0	5,930.0	1,247.2
1993	3,036.0	860.3	34,746.0	10,584.0	5,800.0	1,256.5
1994	3,082.7	903.8	35,691.0	11,194.0	6,490.0	1,364.7
1995	3,148.0	928.5	37,146.0	11,585.0	6,725.0	1,412.3
1996	3,600.0	1,025.0	38,350.0	11,986.0	6,450.0	1,355.0

[1] The number of animals slaughtered relate to animals within national boundaries, irrespective of origin.
[2] The production of meat includes the meat equivalent of exported live animals and excludes the meat equivalent of imported live animals.

Source: United Nations. (1970-1996). Food and Agricultural Organizations of the United Nations Yearbook: Trade and Commerce, *Rome: Statistics Division of the Economic and Social Department*.

Table 11 Canadian Exports and Imports of Live Slaughter Cattle and Calves: United States and Mexico (1976–1996)

Year	United States		Mexico[2]
	Exports[1] (thousand head)	Imports[1] (thousand head)	Exports[3] (thousand head)
1976	286.7	185.8	56
1977	278.0	41.5	35
1978	277.4	55.8	245
1979	201.3	19.4	214
1980	170.9	52.7	97
1981	156.5	171.1	579
1982	199.5	85.4	147
1983	208.7	82.4	66
1984	267.4	36.9	601
1985	181.7	52.9	1,888
1986	175.4	59.0	216
1987	193.8	70.4	171
1988	398.5	35.3	2,792
1989	417.4	39.5	1,493
1990	516.0	11.3	1,526
1991	468.2	28.1	2,738
1992	731.6	14.5	2,394
1993	724.1	31.7	1,313
1994	700.0	52.2	1,084
1995	743.3	32.9	N/A
1996	1,037.6	48.1	N/A

[1] Agriculture and Agri-Food Canada. (1976-1995). *Livestock Market Review*, Ottawa: Market and Industry Services Branch. Canadian import and export statistics are derived by the International Trade Division of Statistics Canada from administrative records collected by Revenue Canada. The one exception to this process is Canadian exports to the United States and the imports from United States into Canada. As of 1 January 1990, Canada and the United States have been using the other's import data to replace their own export data. Exports and imports of slaughter cattle include steers, heifers, cows and bulls. Slaughter calves include males and females. The data exclude any breeding stock and feeder stock.

[2] According to the Canadian International Trade Tribunal (1993), *An Inquiry Into the Competitiveness of the Canadian Cattle and Beef Industries*, Canada imports relatively small quantities of live slaughter cattle and calves from Mexico.

[3] Statistics Canada. (1976-1995). *Exports by Commodity:* DBS Monthly Statistics, Ottawa: Minister of Industry, Catalogue No. 65-004. Slaughter cattle include steers, heifers, cows and bulls. Slaughter calves include males and females. The data exclude any breeding or feeder stock.

Source: US ITC 1997, D-9.

Table 12 US Exports and Imports of Live Slaughter Cattle and Calves: Canada and Mexico (1981-1996)

Year	Canada		Mexico	
	Exports[1] (thousand head)	Imports[2] (thousand head)	Exports[1] (thousand head)	Imports[2] (thousand head)
1981	N/A	338.0	N/A	321.0
1982	16.9	494.5	7.7	509.7
1983	10.4	359.0	1.8	561.7
1984	12.0	362.9	20.2	390.3
1985	7.4	358.6	27.8	476.5
1986	17.0	247.3	19.1	1,157.5
1987	27.9	262.1	25.5	937.9
1988	13.8	487.5	212.9	844.2
1989	20.8	584.7	60.4	873.5
1990	33.1	873.8	21.2	1,261.2
1991	86.7	904.9	210.1	1,034.2
1992	55.7	1,273.2	251.5	982.0
1993	66.0	1,202.3	76.9	1,296.6
1994*	92.4	1,010.3	128.6	1,072.1
1995*	67.4	1,132.7	14.6	1,653.4
1996*	40.7	1,510.3	115.2	456.2

[1] United States Department of Agriculture. (1982-1994). *Dairy, Livestock, and Poultry Division: U.S. Trade and Prospects*, Washington: Foreign Agriculture Service. Exports of live cattle and calves, excluding beef and dairy breeding stock (male and female).

[2] United States Department of Agriculture. (1994). *Red Meats Year Book:* Supplement to the Livestock, Dairy, and Poultry Situations and Outlook, Statistical Bulletin Number 885, 52. Import values include all cattle and calves, excluding beef and dairy breeding stock (male and female).

* All 1994, 1995 and 1996 values are provided by United States Department of Agriculture (1997). *Dairy, Livestock, and Poultry Division*, Foreign Agricultural Service. The table describes US Cattle Trade with Canada and Mexico.

Table 13 US Exports and Imports of Beef and Veal: Canada and Mexico (1981–1996)

Year	Canada		Mexico	
	Exports[1] (thousands of metric tons)	Imports[2] (thousands of metric tons)	Exports[1] (thousands of metric tons)	Imports[2,3] (thousands of metric tons)
1981	7,220	54,139	N/A	683
1982	5,220	56,693	N/A	260
1983	6,344	57,490	79	64
1984	11,644	74,135	87	233
1985	8,930	86,409	184	1,263
1986	7,313	78,720	336	N/A
1987	13,176	71,116	4,044	N/A
1988	18,384	63,069	13,209	N/A
1989	34,463	75,062	30,759	N/A
1990	68,924	75,938	28,542	N/A
1991	90,892	80,013	64,234	562
1992	85,413	120,683	69,147	301
1993	83,847	151,096	39,444	1,093
1994	96,384	173,881	72,341	1,254
1995	102,559	177,444	29,221	2,102
1996	96,603	233,837	58,651	4,544

[1] United States Department of Agriculture (1981-1994). *Dairy, Livestock, and Poultry: Trade and Prospects*, Washington: Foreign Agriculture Service. According to the U.S. Department of Commerce, Bureau of the Census, the category of “beef and veal” includes beef and veal; fresh chilled, frozen, canned, prepared and preserved.

[2] United States Department of Agriculture (1981-1994). *Dairy, Livestock, and Poultry: Trade and Prospects*, Washington: Foreign Agriculture Service. According to the US Department of Commerce, Bureau of the Census, imports of “beef and veal” include: bone-in, boneless beef, bone-in veal, prepared (not canned), canned corned beef, and other beef and veal, including sausage.

[3] From 1986 to 1990, the US Department of Commerce reports no imports of beef and veal from Mexico.

Table 14 Canadian Exports and Imports of Beef and Veal: United States and Mexico (1976–1996)

Year	United States		Mexico[3]
	Exports[1] (thousands of metric tons)	Imports[1] (thousands of metric tons)	Exports[2] (thousands of metric tons)
1976	37,611	10,359	4
1977	34,918	6,143	0
1978	27,616	7,680	0
1979	36,042	5,328	282
1980	44,950	5,328	1,075
1981	54,118	9,125	1,848
1982	56,505	8,664	73
1983	59,333	10,294	467
1984	78,400	20,163	1,016
1985	90,267	18,645	1,695
1986	79,435	19,780	1,338
1987	71,712	27,423	1,630
1988	66,745	36,198	2,300
1989	90,458	51,500	2,370
1990	84,170	66,155	1,250
1991	84,808	87,646	470
1992	133,603	80,595	830
1993	164,236	77,691	1,420
1994	187,466	101,986	750
1995	190,367	108,880	755
1996	252,878	104,270	696

[1] Agriculture and Agri-Food Canada (1976-1995). *Livestock Market Review*, Ottawa: Market and Industry Services Branch. Beef data are based on dressed carcass weight basis and include carcasses, cuts (bone in), cuts (boneless), pickled and cured, cooked and canned, prepared, trimming, edible offal, other, and canned. Veal data include carcasses, cuts (bone in), cuts (boneless), trimmings, edible offal, and other.

[2] Canada. (1976-1994). *Exports by Commodity: DBS Monthly Statistics*, Ottawa: Minister of Industry, Catalogue No. 65-004. Canadian beef and veal exports to Mexico are calculated according to Statistics Canada International Trade Division. The earlier data (1976-1986) include beef and veal: fresh or chilled (boneless), frozen (boneless), fresh or frozen (NES), fresh or frozen (boneless), fancy meats, and bovine fresh or frozen. From 1987 onward, they calculate beef and veal under the following categories:

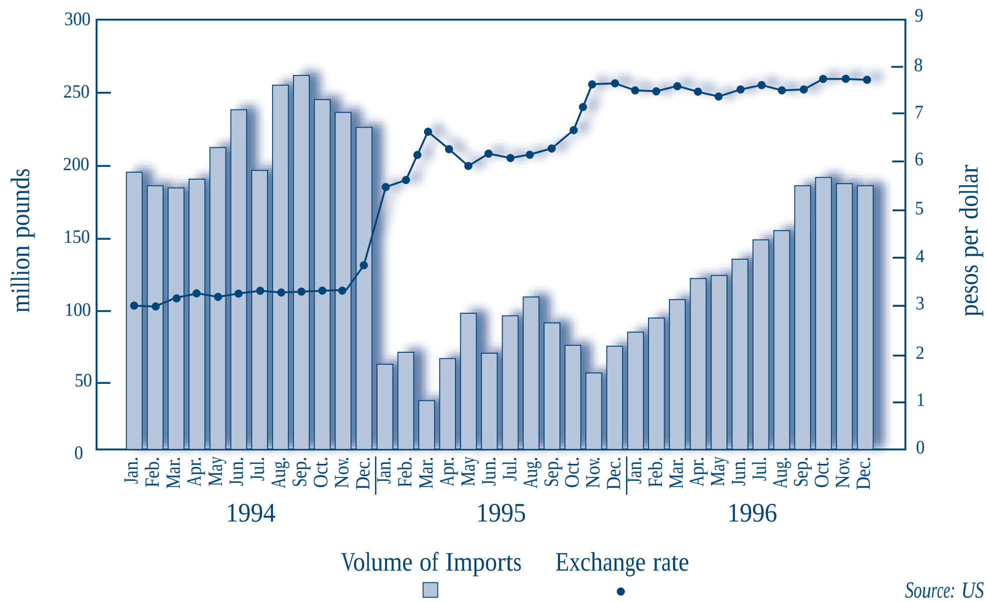
- 0201.10 - Bovine carcass and half carcasses fresh or chilled.
- 0201.20 - Bovine cuts, bone in, fresh or chilled.
- 0201.30 - Bovine cuts, boneless, fresh or chilled.
- 0202.10 - Bovine carcasses and half carcasses frozen.
- 0202.20 - Bovine cuts, bone in, frozen.
- 0202.30 - Bovine cuts, boneless, frozen.
- 0206.10 - Bovine edible offal, fresh or chilled.
- 0206.21 - Bovine tongues, edible offal, frozen.
- 0206.22 - Bovine livers, edible offal, frozen.
- 0206.29 - Bovine edible offal, frozen NES (not elsewhere specified).
- 0210.20 - Bovine meat cured.
- 1602.50 - Bovine meat and meat offal nes, excluding livers, prepared or preserved.

[3] Data describing imports of beef and veal from Mexico are not reported.

Among the most important variables affecting the relationship between this sector, US trade and NAFTA was the devaluation of the peso in late 1994 and 1995. Although US exports of fresh, chilled or frozen beef expanded sharply to Mexico in the first year of NAFTA, the peso devaluation beginning in November 1994, and the subsequent steep decline in purchasing power, cut deeply into expanded demand. Falling from about 3.2 pesos/US dollar in most of 1994 to 3.9 pesos/dollar in December 1994 and 7 pesos/dollar by 1996, peso devaluation contributed to higher levels of Mexican inflation, rising interest rates, declines in GDP/capita, and declines in consumer expenditures (see Figure 12) (USDA, FAS 1997). Mexican purchase prices for imported beef rose 20 percent, and Mexican beef imports fell between

1994 and the end of 1995 by about 65 percent. Average US beef exports to Mexico fell from 201 million pounds, valued at US$227 million in 1994, to 85 million pounds, valued at $85 million in 1995, with a rise in the United States share from 76 percent of Mexican imports in 1994 to 93 percent in 1995. However, in 1996, average US exports of fresh, chilled or frozen beef rose to 164 million pounds. An often overlooked fact is that the weak peso may actually have augmented sales of beef in Mexico's hotel, restaurant and institutional sector (as distinct from its negative effect on retail sales) by making tourist spending more attractive (US ITC, 1997, 4-24).

Figure 12 Mexican Beef Imports and Peso/US Dollar Exchange Rates, by Month, Jan.1994–Dec. 1996



Source: US ITC 1997, 4-23.

In a detailed assessment of this issue, the US International Trade Commission concluded in 1997 that NAFTA expanded Mexican imports of US beef between 1994 and 1996 by 187 million pounds, valued at US$180 million, despite the peso devaluation. However, there is no question that exchange rate effects substantially reduced trade expansion in the short run.

In order to distinguish the NAFTA connection from exchange-rate effects, the 1997 ITC empirical analysis compared four different cases using a standard econometric model:

(1) Mexican beef imports *with* NAFTA, *with* peso devaluation;

(2) Mexican beef imports *without* NAFTA, *with* peso devaluation;

(3) Mexican beef imports *with* NAFTA, *without* peso devaluation; and,

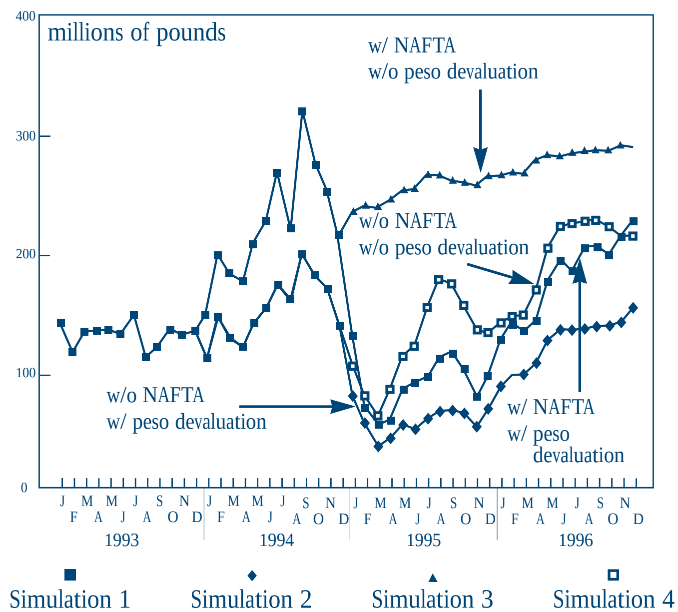
(4) Mexican beef imports *without* NAFTA, *without* peso devaluation.

These cases are compared in Figure 13 and shown in Table 15. Compared with the base case (1), the second case, (2), estimates of beef trade *without* NAFTA but *with* the peso devaluation show that Mexico would have imported about 182 million pounds of beef from the United States in 1994, compared with 267 million pounds estimated under the agreement (and an actual figure of 282 million pounds), and that the United States would have held only a 73 percent rather than an 86 percent share. In 1995, Mexico would have imported 70 rather than 108 million pounds of beef from the US (the actual figure was 112 million pounds), and in 1996, 147 rather than 211 million pounds (actual imports were 202 million pounds). In case (3), a scenario *with* NAFTA but *without* the peso devaluation, 1994, 1995 and 1996 imports of beef by Mexico from the US were estimated at 267, 301 and 332 million pounds, respectively. Finally, in case (4), *without* either NAFTA or the peso devaluation, Mexican beef imports from the United States were estimated at 182, 149 and 233 million pounds in 1994, 1995 and 1996, respectively.

These results lead to the conclusion that NAFTA was significant in expanding US beef exports by 187 million pounds in its own right even after accounting for the peso devaluation between 1994 and 1996. Moreover, despite the fact that US-Mexican beef trade was substantially affected by the peso devaluation, which caused an estimated loss of about 314 million pounds of beef shipments, NAFTA played an important role in offsetting these losses, which would have been far more pronounced in the absence of tariff removals under the agreement.

There is strong support for the contention that NAFTA will increase production possibilities for the North American fed-beef industry, including meat processing, in the years ahead. Early assessments of NAFTA indicate the complementarity of US and Canadian cattle feeding, finishing and processing in relation to the Mexican production of young feeder cattle. In quantitative terms, the performance of US exports in the animal sector to Mexico has confirmed these expectations and followed the general trend: initial increases in trade after NAFTA's passage, followed by sharp downturns in the wake of the peso crisis during 1995, followed in turn by increases and steady growth in 1996, 1997 and beyond. Mexican demand for beef products is growing, while Mexico's cattle herd is down in response, in part, to drought and recession (USDA April 1996).

Figure 13 Impact of NAFTA and Peso Devaluation on Mexican Beef Imports from the United States, by Month, Jan. 1993-Dec. 1996



Source: US ITC 1997, 4-26.

More specifically, the US International Trade Commission analysis showed that NAFTA helped to reduce the impact of the peso devaluation. In 1996, US cattle exports to Mexico were 115,249 head compared with 14,641 in 1995, up by nearly 700 percent. In processed products, US beef and veal exports to Mexico were 172,246 thousand pounds by carcass weight in 1996, up 87 percent from 92,302 thousand pounds in 1995 (USDA 1997).

Hence, in the absence of NAFTA, the impact of the peso devaluation would have been far worse. This is reinforced by the 1996 findings of de Janvry, who concluded that US agricultural exports as a whole (animal products were not estimated separately) would have been stagnant in 1994 without NAFTA when, with NAFTA, they increased by 18 percent. In 1995, US agricultural exports would have fallen by 28 percent without NAFTA, but fell only 14 percent with NAFTA: "The agreement thus helped avoid 52 percent of the fall in exports due to the peso crisis" (de Janvry 1996, 4).

Table 15 Impact of the NAFTA and Peso Devaluation on Mexican Beef Imports from the United States, 1994-1996

Model simulation	Scenario		1994			1995			1996		
			Total imports	US Share	Imports from US	Total imports	US Share	Imports from US	Total imports	US Share	Imports from US
	NAFTA	Peso devaluation	Million pounds	%	Million pounds	Million pounds	%	Million pounds	Million pounds	%	Million pounds
1 (base)[1]	with	with	308	86	267	111	97	108	216	98	211
2	without	with	249	73	182	84	84	70	173	85	147
3	with	without	308	86	267	310	97	301	340	98	332
4	without	without	249	73	182	177	84	149	275	85	233
Actual[2]	with	with	328	86	282	114	98	112	206	98	202

[1] Simulation 1 is referred to as the "base" in the discussion of the results.

Source: US ITC 1997, I-10

[2] Source: Compiled from official statistics of Mexico's Secretariat of Commerce and Industrial Promotion (Secofi); other export statistics in this report are derived from official statistics of the US Department of Commerce and are not directly comparable.

Based on this evidence and the record to date, export activity in the US beef sector has increased and is likely to continue doing so under NAFTA. Mexico is a non-trivial element in the demand for US cattle and processed beef. The NAFTA connection is real and measurable. However, several non-NAFTA factors have also affected short-term dynamics in the fed-cattle industry. First, the Mexican cattle herd was seriously reduced over 1995 and 1996, and was about 15 percent lower at the end of 1996 than in the previous two years, due to a serious drought in northern Mexico. This, in combination with the peso devaluation, made it attractive to sell live cattle into the United States, so that a surge of Mexican imports into the United States occurred in 1995, rising by 55 percent, including a significant number of culled cows and bulls in addition to the usual feeder cattle. In addition, Mexican herd reduction allowed Mexican authorities to rebuild the beef herd and improve its genetic stock with US breeds, supplemented by a US GSM-103 credit of US$125 million (USDA 1996, April, 12). Also, in early 1996, Mexico's National Livestock Council (CNG) dropped anti-dumping charges against beef imports from the United States, and an agreement was reached between the CNG and the US National Cattlemen's Association to exchange information and promote beef consumption in Mexico. A trilateral agreement was also reached with Canada to pursue joint cattle export opportunities in Asia and Europe (USDA 1996, 18). Despite these complicating factors, longer-term forces affecting production under NAFTA suggest that Mexico will continue as a supplier of feeder cattle to the United States, and that the United States and Canada will continue as suppliers of live cattle and beef products to Mexico.

D. Transborder Investment Flows

Trends in post-NAFTA foreign direct investment must be considered in the context of investment in the sector as a whole. Investment in the North American beef and cattle industry is increasingly concentrated in the central United States and the high plains of Alberta, although beef cattle are raised throughout the continent. Numerous analysts, reported below, attribute an important role to NAFTA in encouraging this pattern of investment activity. Most investments in the industry involve commercial cow-calf operators raising steers (castrated male bovines) and heifers (young female bovines that have not calved) that are slaughtered for meat, except for those kept for breeding. These operations are concentrated in the Plains and Corn Belt, where feed and forage are abundant. Investors in stocker-yearling operations feed weaned calves or graze them, ultimately finishing them in feedlots. Feedlots allow beef cattle to be kept on regular high-energy rations, usually until they reach 900 to 1,300 pounds and are about two years old, at which time they are ready for slaughter. In the United States, about 90 percent of all beef cattle are finished in feedlots, and about 10 percent go to slaughter after being fed on grass and pasture. In addition, about 10 percent of US beef is produced from dairy cows that are culled and slaughtered, or bull dairy calves that are either slaughtered for veal shortly after birth or are castrated and raised as beef steers. Apart from feedlot activities, cattle-sector investments are made in meatpackers that slaughter, box and ship meat, or sell meat to other processors for further division into retail cuts. Meatpackers have increasingly shipped beef directly in boxed form; the main cuts and the grinding of beef trimmings occur at the plant. These beef parts are then shipped in plastic-lined boxes directly to retailers.

The total number of cattle operations in 1996 in the United States numbered about 1.2 million, although this liberal definition includes any livestock operator with one or more animals on hand at any time of the year. In fact, cow-calf and stocker-yearling investments are dominated by a considerably smaller number of large commercial herds in the Midwest and western range areas of the United States and Canada, most of which are family-owned and operated. Feedlots are more concentrated; in 1996, 1,770 feedlots in the United States marketed 74 percent of all fed cattle (Table 16).

Slaughtering facilities and meatpacking are the most concentrated investments in the beef industry. Between 1991 and 1994, the number of US firms slaughtering cattle fell 26 percent, to a total of 239 (USDA Oct. 1996, 14). As shown in Table 17, in 1992, 20 plants handled 58 percent of commercial slaughter; by 1996, 23 plants handled 63 percent. The number of firms controlling these plants is smaller still; in 1994, four firms accounted for 68 percent of slaughter.

Table 16 US Cattle on Feed: Number of Feedlots and Marketings, by Size of Feedlot Capacities, in Cattle-Feeding Corn Belt States and Cattle-Feeding Western Rangelands States, 1996

Year and Area	1,000-7,999		8,000-31,999		32,000 and over		Total	
	Lots	Cattle marketed	Lots	Cattle marketed	Lots	Cattle marketed	Lots	Cattle marketed
	(#)	(thousand head)	(#)	(thousand head)	(#)	(thousand head)	(#)	(thousand head)
1996:								
Corn Belt	1,016	2,728	163	4,830	21	2,340	1,200	9,898
Western Rangelands	354	1,002	153	4,261	63	5,959	570	11,222
Total	1,370	3,730	316	9,091	84	8,299	1,770	21,120

Feedlot capacity in number of head. *Source: US ITC 1997, D-4*
Note: In 1996, cattle-on-feed reporting procedures changed, so as not to disclose the confidentiality of individual operations.

A fundamental factor affecting investment patterns in the US beef industry is the backward linkage from cattle feeding to the feed grains sector. Since about two-thirds of beef cattle are fed on grains for most of their growth cycle, proximity to and prices for high-quality feed ingredients are a key part of the pattern of investment. In the United States, corn accounted for over 83 percent of grain fed in the last 5 years, with the remainder accounted for by sorghum, feed wheat, barley and oats. In addition, oilseeds are used as a feed ingredient, as in soybean meal.

In Canada, investments in the beef sector are concentrated in the prairie provinces, again due to the proximity to feed ingredients, including wheat, barley, and oilseeds such as canola, as well as forage crops. Alberta, in particular, dominates investment in the industry, accounting for 40 percent of Canadian beef cattle inventory for the years 1993-97. Given the tight integration between US and Canadian operations, it has been suggested by market analysts that USDA should include Alberta in the seven US state cattle-on-feed reports (Klein 1995, 15). According to the Canadian Cattlemen's Association (1997), Alberta is the major site of expansion in the industry, due especially to large supplies of low-cost barley. This trend has been supported by the removal of the Western Grain Transportation Act (WGTA) subsidies on prairie grains, which had held western grain prices higher (Canadian Cattlemen's Association 1997). Slaughtering facilities are also concentrating in Alberta, led by direct investments by Iowa Beef Packers (IBP) in an expanded plant at Lakeside, Alberta, in 1996 and a Cargill plant at High River, Alberta, initiated by a 1989 investment and expanded in 1992, which together are expected to increase cattle slaughter in the province by one-third (Melton 1997)[10]. Data on cattle and on feed and slaughtering facilities from 1992-95 in Alberta and the rest of Canada are shown in Tables 18 and 19.

The number of cattle on feed in Alberta has fluctuated with the cattle cycle. The expansion of cattle-feeding in the province has almost doubled the number of animals on feed since the mid-1980s. As Ross et al. (1990) indicated the relocation of cattle feeding and growth has occurred mainly in southern Alberta, particularly since the 1980s. Regional relocation of cattle feeding within the province of Alberta has been from northern regions of the province to southern areas. By 1995, Chang (1997) estimated that the Lethbridge North Irrigation District alone, with an area of approximately

[10] In the United States, Cargill's beef processing operations (Excel Beef) are located in four top cattle states: Nebraska, Texas, Kansas and Colorado, with headquarters in Wichita, Kansas (Klein 1995, 15).

175,000 acres, had 119 feedlots with a total capacity of 331,610 head of cattle, as well as 61 dairy farms, 63 hog farms and 17 poultry operations. Van Raay Farms alone, one of the largest cattle feeding operations in Alberta, accounts for 92,000[11] head capacity in the Lethbridge North Irrigation District. This facility is located on a land base of 8,500 acres of irrigated land. This land is used to produce barley silage. Only time will reveal whether this expansion represents an upswing in the cattle cycle or a response to changes in the underlying fundamentals of the economics of cattle feeding in the North American market.[12]

Support exists for the claim that investment has been more than a response to the cattle cycle, and has been affected by the FTA and NAFTA. In High River, Alberta, the US$55 million Cargill facility, which opened in 1989, was expanded from a slaughter capacity of 2,500 to 3,400 head per day in 1992, with new investments totaling US$28.2 million, in part in response to the FTA and in anticipation of NAFTA (Klein 1995). In 1994, Iowa Beef Packers (IBP) purchased Lakeside Farm Industries in Brooks, Alberta, for purposes of major expansion, making it the most modern plant in North America. After paying US$42.5 million for Lakeside Farm Industries, IBP invested US$75 million in a new plant. The plant now runs continuously, killing an average of 14,000 head per week (*Cattle Buyers Weekly* 1997).

The effect of the Cargill investment at High River and the probable impact of NAFTA liberalization was stated clearly by Bill Buckner, the general manager of the plant: “We started out as a Canadian packer serving largely Canadian customers, but High River has grown beyond that to become part of a North American beef company and an international beef trader.” Marketing manager Barry Reimer, describing the “North Americanization” of the beef trade, added: “The dynamics of trade are changing from west-east movements to north-south…over the next five years, the traditional west-east flow will change even more to a North American freight-advantaged pattern determined by proximity to a particular market.” These markets, in the case of High River, are Portland, Seattle and the Pacific, notably Korea and Japan, although some at Cargill expect Mexico to rival Japan in the future as a destination for North American beef (Klein 1995, 12).

[11] Photocopied information sheet, Van Raay Farms, Iron Springs, Alberta.

[12] Alberta Agriculture (1997) has recently released growth targets for the hog- and cattle-feeding industries in Alberta. A doubling of the size of the cattle-feeding industry and a three - or four-fold expansion of the hog industry in the province are indicated in the targets. However, research data supporting the practical feasibility of the expansion of these industries at this scale are weak.

Table 17 US Cattle: Number of Federally Inspected Slaughter Plants, by Sizes, Number of Cattle Slaughtered in Such Plants, and Shares of Total Commercial Slaughter Accounted for, 1992-96

	Number of Cattle Slaughtered					
Year	Under 1,000	1,000 to 9,999	10,000 to 49,999	50,000 to 499,999	500,000 to and more	Total
1992: Plants	694	144	53	60	20	971
Quantity slaughtered (thousands)	187	458	1,334	10,694	19,182	31,849
Share of commercial slaughter (percent)	0.6	1.4	4.1	32.5	58.4	96.9[1]
1993: Plants	667	145	42	60	20	934
Quantity slaughtered (thousands)	182	452	1,066	11,306	20,056	33,062
Share of commercial slaughter (percent)	0.5	1.4	3.2	33.9	60.2	99.2[1]
1994: Plants	637	124	42	57	22	882
Quantity slaughtered (thousands)	183	378	995	10,082	21,845	33,483
Share of commercial slaughter (percent)	0.5	1.1	2.9	29.5	63.9	97.9[1]
1995: Plants	602	115	39	56	24	836
Quantity slaughtered (thousands)	182	360	1,010	9,893	23,435	34,880
Share of commercial slaughter (percent)	0.5	1.0	2.8	27.8	65.8	97.9[1]
1996: Plants	561	131	39	58	23	812
Quantity slaughtered (thousands)	190	391	1,013	11,578	22,898	36,070
Share of commercial slaughter (percent)	0.5	1.1	2.8	31.6	62.6	98.6[1]

[1] Remainder accounted for by state inspection.

Note: Because of rounding, figures may not add up to the total shown.

Source: US ITC 1997, D-4.

Table 18 Canadian Cattle on Feed in Alberta, (1 July Estimates)

Year	Heifers for Slaughter (thousand head)	Steers (thousand head)	Total (thousand head)
1976	368	770	1,138
1977	318	660	978
1978	320	645	965
1979	325	650	975
1980	306	600	906
1981	325	607	932
1982	320	580	900
1983	300	540	840
1984	298	540	838
1985	264	492	756
1986	255	426	681
1987	271	465	736
1988	287	526	813
1989	319	571	890
1990	320	568	888
1991	330	575	905
1992	348	631	979
1993	410	549	959
1994	359	567	926
1995	374	564	938
1996	459	653	1,112
1997	550	670	1,220

Source: Alberta Agriculture, Food and Rural Development, based on Statistics Canada, Agriculture Division data.

Table 19 Canadian Cattle: Slaughter by Provinces and Regions, 1992–95, (in thousands of head)

Province/Region	1992	1993	1994	1995
Alberta	1,372	1,436	1,486	1,537
Saskatchewan & Manitoba	266	158	164	194
Prairie Provinces[1]	1,638	1,594	1,660	1,731
British Columbia	67	59	51	51
Western Canada, Total[2]	1,705	1,653	1,701	1,782
Ontario	720	648	633	632
Quebec	234	215	217	202
Central Provinces[3]	954	863	850	834
Maritime Provinces[4]	135	25	111	89
Eastern Canada, total[5]	1,089	888	961	923
Canada Total	2,794	2,541	2,662	2,705

[1] Alberta, Saskatchewan and Manitoba
[2] Includes prairie provinces and British Columbia
[3] Ontario and Quebec
[4] Nova Scotia, New Brunswick, Prince Edward Island and Newfoundland
[5] Includes Central and Maritime Provinces

Source: U.S. ITC 1997, D-22.

Investment in the Mexican beef and cattle sector is concentrated in the northern Mexican states, where range conditions are similar to those of the US southwest. As of January 1996, there were 27 Mexican plants approved to ship meat to the United States, of which 19 were in the northern states. Mexican cattle inventories declined markedly between 1992 and 1996 due to a severe drought, but herds were being rebuilt in 1997. The overall conclusion of most analysts of investments in the Mexican cattle sector is that the United States has a comparative advantage in the production of fed cattle and beef, while northern Mexico has a comparative advantage in the production of stocker and feeder cattle and calves. The reasons relate directly to the abundance of feed-grains in the United States relative to Mexico (which is a net grain importer) and synergies in bringing feeder calves into the United States in the spring to be pastured on winter wheat in the southwestern and south central United States (US ITC, 3-5). Winter wheat grazing of feeder cattle is more economical than feedlot feeding, allowing calves to be moved to feedlots only when they achieve optimal weights of 600–800 pounds.

These investment patterns support the basic thesis that under NAFTA, the geographic concentration of investments in beef-feeding and processing activity will continue in the central plains of the United States and in southern Alberta. Mexico will remain primarily engaged in feeder-cattle production, exporting these cattle to the United States for further finishing, at least in the next decade and probably beyond. Analytical support for this point of view comes from a simulation model of capital investment in livestock by Williams and Garcia-Vega (1996), who implemented an econometric model of Mexican livestock, meat and feed markets fitted to data over the period of historical liberalization in Mexico from 1986 to 1991, then applied these results to estimate the impacts of NAFTA. They concluded that Mexico's comparative advantage under further liberalization will remain in the production of feeder cattle for export rather than for domestic feeding and slaughter, even as lower-cost imported feed from the United States becomes available (Williams and Garcia-Vega 1996, 17).

This point of view is reinforced by Peel (1996), who emphasized the inherent advantages of the United States over potential competitors in the Mexican beef market due to geographic proximity and the impacts of NAFTA. The small Mexican feedlot will remain at a competitive disadvantage in attracting foreign direct investment (FDI), according to Peel, as Mexico continues as a grain-deficit nation where corn remains largely a food grain. As Mexican incomes expand and population growth continues, the demand for beef will increase, leading to a growth in demand for grain-fed beef from the United States. Under NAFTA, investment will show a pattern of continued growth in Mexican feeder-cattle exports to the United States and US exports of additional beef and process meats to Mexico (Peel 1996, 13).

A long-run econometric analysis undertaken by Melton and Huffman (1993) considers the possible impacts of new investments in technology, such that Mexican cow-calf production, feeding and meatpacking all approach levels of technology employed in the United States and Canada. Huffman (1997) notes that large feedlot facilities, in contrast to cropland, are capable of migrating to areas of lower costs so long as technology is transferable. Their analysis assumes not only fully modern beef-industry technology transfers but also the standardization of US and Mexican food safety and health inspections. Under this scenario, which could take decades to play out, increased beef herds in Mexico and Mexican beef exports to the United States could result as production and processing costs are lowered and new capital investments in Mexico occur. It is probable that most such investments would be in the form of FDI from the United States. However, if this technology transfer is plausibly accompanied by increases in real Mexican wages and incomes, Mexico's comparative advantage returns to its status as an exporter of feeder cattle rather than retail beef (Melton and Huffman 1993, 16).

The NAFTA connection to trade and investment in the fed-beef sector, as in many other areas of North American trade, is that it represents a culmination and reinforcement of an enduring commitment to changes that have affected the macroeconomies of North America for a decade or more.

E. Other Economic Conditioning Factors

In the years since NAFTA was signed, it is arguable that other factors, notably the peso devaluation, weather cycles, dropping US cattle prices, and high feed-grain demands, have all influenced the fed-beef sector more than NAFTA itself. Moreover, the patterns of comparative advantage leading the United States (and to a lesser extent Canada) to be favorably situated as feeders, producers and exporters of processed beef, and Mexico to be an exporter of feeder cattle, were established in the period from 1986, when Mexico began unilateral tariff reductions, up to and beyond the signing of NAFTA. As a result, US beef exports to Mexico have grown, doubling from 1987 to 1988 and again from 1990 to 1991, when Mexico eliminated tariffs on meat, except variety meats. Tariffs on chilled and frozen beef were reimposed in November 1992 and removed again with the beginning of NAFTA in 1994. Mexican demand for beef resumed its upward trend in 1994, fell in response to the December 1994 peso devaluation in 1995, and recovered strongly in 1996 (Peel 1996).

Yet, despite these other macroeconomic forces, one cannot minimize the connection of NAFTA to North American trade and investment in beef and cattle. The Canadian Cattlemen's Association (CCA) (1997), as well as the US International Trade Commission (1997), clearly concluded that both the US and Canadian beef industries have benefited from NAFTA tariff reductions, which increased access to Mexican markets. The most significant impact of NAFTA has been the dramatic increase in exports of high-quality US beef. The specific contributions of NAFTA were to continue and expand the reduction of barriers to beef trade among the United States, Canada and Mexico, including the removal of beef from the provisions of meat import laws in each country, and the establishment of tariff-free access for US and Canadian beef exports to Mexico. In addition to reductions in tariffs on live cattle to zero and reductions in tariffs for beef, NAFTA also identified a range of animal-health issues needing to be addressed and a procedure to reduce and eventually align meat and plant-inspection procedures. Unfortunately, many of the animal-health and plant inspection issues have proven less easy to implement than tariff reductions (CCA 1997, 23). Finally, building on the FTA, NAFTA has continued to encourage cross-border investment in beef-processing facilities, notably in Canada.

The NAFTA rules have thus reinforced a continued pattern of trade and investment that was underway. NAFTA has also encouraged additional foreign direct investment in beef-feeding. In so doing, it has reemphasized the comparative advantages revealed during Mexico's pre-NAFTA liberalization. As a result, US and Canadian cattle and beef markets will continue to become more closely integrated, and the dominance of the United States as an exporter of beef will grow.

IV. Linkages to the Environment

As the North American beef and cattle sector expands in response to North American and global demands for animal protein, concerns have arisen over the potential environmental consequences of this expansion. This study has analyzed the ways in which NAFTA is linked to the North American beef sector, and how expanding activity in the sector will pose a variety of environmental challenges. This section reviews ways in which these related economic trends can affect the environment through the processes and technologies used in beef production, the physical infrastructure that supports it, and the social and governmental policies that relate to it.

A. Production, Management and Technology

From an ecological perspective, the cattle industry poses a variety of challenges, beginning with the feed-grains complex, extending to cattle-feeding operations, and ending with beef slaughtering and processing. This section will consider the main environmental challenges posed by the feeding of beef and its relationship to the patterns of trade and investment evolving under the North American Free Trade Agreement (NAFTA). As identified above, NAFTA's rule changes are allowing a more complete expression of comparative advantage by concentrating more of the continent's processing activity in large, profitable, US-owned firms in the US midwest and Alberta. These firms are generally using and developing state-of-the-art production methods, technology and management systems, and thus mitigating the environmental effects of concentration. This trend by US producers is largely a response to forces other than NAFTA, but the scale economies and enhanced profitability resulting from NAFTA assist in sustaining it. At the same time, increased concentration by firm and geographic locale make it easier to exercise regulatory oversight over the environmental pressures that emerge.

These trends are evident in all stages of the production, management and technology that transform grains into beef. First are those arising from the supply of feed-grains, most of which are nonpoint-source pollution issues. Second are problems of waste management and point-source pollution on beef feedlots. Finally, there are environmental management issues confronting beef-processing facilities.

1. Feed Grains

In the feed-grains sector, three areas of technological innovation are emerging from practical experience and advanced research that promise to improve substantially the environmental impacts of modern feed-grains production. First are "precision farming" methods that optimize fertilizer and pesticide use through the development of the computerized mapping of soils and farm fields and the calibration of agrochemical applications to fields in ways that are most efficient and least environmentally damaging (see Munson and Runge 1990). Many farmers have begun using these methods, but speeding up their rate of adoption would have major effects on the technology of feed-grains production (Daberkow 1997). These methods are being adopted first by larger, better-capitalized producers, suggesting that there are economies of scale in their use. NAFTA's intensification of comparative advantage should reinforce this trend.

The second area of rapid change in feed-grains, occurring after almost two decades of relatively slow progress, is in crop biotechnology. The development of genetically engineered crop varieties offers considerable environmental opportunity and may even revolutionize the input-output dynamics of crop production (Carlson et al. 1997). This is because instead of applying numerous pesticides to crops to "cover one's bets," the new "super-seeds" can be designed to respond optimally to fewer, and in some cases only one, highly targeted pesticide. Alternatively, the seeds may be designed so that the plants themselves carry resistance to various pests. The result can be the far more efficient use of such inputs. Here too, the experience with such technologies is very recent, but rates of adoption of such seed varieties suggest that major changes are underway.

The third area of change in feed-grains production, linked in important ways to "precision farming" and some of the new biotechnologies, is in conservation tillage methods in which soils are left relatively undisturbed before planting and after harvesting. Despite some additional herbicide requirements, resulting reductions in erosion and the retention of water and soil carbon are potentially of great significance to water quality and even to global atmospheric changes (CTIC 1997a). The Conservation Technology Information Center (CTIC) reported in October 1997 that US conservation tillage increased in the 1997 crop year by six million acres (2.43 million hectares), based on USDA Natural Resources Conservation Service (NRCS) surveys (CTIC 1997c, 1997d, 1997e). The number of no-till acres increased most in the US states of Illinois, Iowa, Indiana, Ohio, Missouri and Nebraska.

These steady gains in conservation tillage, especially no-till, are recognized as a major shift in farm-level production technology (see CITC 1997b, 155-174). The major effect of this shift in tillage practices is that farmers rely less on mechanical cultivation to plant and manage crops. From an agronomic perspective, no-till also has complementary effects that conserve resources, resulting in systemic changes in whole-farm resource conservation. Plant residues, such as stems, stalks and leaves, are left on the surface of the field after harvest, protecting the soil against erosion. The decomposition of plant residue adds organic matter to the soil. Increased organic matter contributes to soil fertility, decreases soil compaction and improves soil structure. A larger aggregate soil size (tilth), facilitating the most desirable mix of air and water, characterizes soil with high organic matter, thus enhancing crop-rooting ability. The result is improved water infiltration, as crop residues impede water from running off fields. Erosion is estimated to fall by 90 percent or more, as soil moisture rises due to the increased absorption of water, cutting runoff into surface water bodies (CTIC 1997a). Crop residues also provide food and shelter for wildlife. Finally, they help capture carbon in the soil, which, when added to reduced emissions from farm equipment due to fewer passes, further reduces CO_2 emissions.

2. Beef Feeding

Throughout North America, the most striking trend in cattle-feeding and meat-packing is growing concentration. In the United States, of roughly 50,000 total feedlots, the largest 400 now account for over 65 percent of the nation's marketed fed cattle. Of these about 90, with a capacity of over 32,000 head each, market 35 percent of fed cattle. Concentration in the US packing sector is even more striking. In 1980, four companies accounted for 41 percent of the nation's fed cattle. This trend toward concentration has continued since NAFTA took effect. In 1996, the top four will slaughter 83 percent, and the single largest will slaughter 35 percent (Ritchie et al.1997). In Alberta, by the late 1980s, seven of the largest plants slaughtered 99 percent of all cattle. In 1997, two US-owned plants handled over 50 percent of all cattle slaughtered in Canada and 83 percent of those in Alberta (Canadian Cattlemen's Association 1997, 6).[13]

[13] In contrast to the United States and Canada, cattle feeding in Mexico is a relatively minor industry. Historically, most Mexican beef has been grass-fed. A small but growing feedlot industry in the central and northern regions of Mexico has been based on grain, sorghum and corn, including US imports. But Mexico remains a grain-deficit nation in which corn is mainly a food grain rather than a feed grain, so that the Mexican feedlot industry is likely to remain at a competitive disadvantage to those in the United States and Canada for the foreseeable future (Peel 1996, 7). In 1993, Mexico had fewer than a dozen modern meatpacking plants, although technology transfers may increase this activity in the years to come (Melton and Huffman 1993).

As the number of cattle held in concentrated feeding units multiplies, the nature of the waste disposal problem increasingly resembles that of human population centers rather than farming units. Accordingly, industrial and municipal-style waste treatment will soon be necessary, rather than schemes that only attempt to recycle these wastes as fertilizer on surrounding cropland. Such pressures are revealed by indicators such as phosphorus loadings (see Section V). An imperative exists to develop technologies for this purpose that are as efficient and low-cost as possible. While feedlots are often described as too big by social opponents, there may well be economies of scale in waste treatment that accompany the economies of beef production itself, especially if the initial fixed costs of waste treatment are high. Thus, from the point of view of environmental management, it may be easier to have fewer, larger facilities than multiple smaller sites.

Taken together, manure disposal, water consumption and pollution, and air pollution are important environmental constraints to feedlot beef production. Hence, technologies are critically needed that treat and process animal waste, since spreading them back on fields will ultimately face limits in the absorptive capacity of soils. There is special reason for concern over concentrations of heavy metals in such soils. It is important to recognize that these waste treatment technologies will be important to the cost structure of feedlot fattening, making the search for low-cost technologies key. Most of the water used on feedlots, analogous to municipal water use, can also be recycled, reused and treated under existing technologies. When looked at in the large, the vast bulk of water used in cattle feeding occurs in the prior production of feed grains. Air pollution can be minimized by proper siting and management. From a global environmental perspective, methane remains a challenge as long as ruminants such as cattle are produced (although prior to beef cattle, millions of bison also produced methane). However, beef-feeding efficiencies, combined with genetic selection of the beef herd, can reduce total methane loadings.

In Canada, the expansion of the cattle feedlot sector, notably in Alberta, reflects an adjustment to patterns of regional comparative advantage in feed-grain production, grazing and cattle feeding. The anticipated demise of grain transportation subsidies in the prairie provinces, as well as growth in demand for meat in the western United States, combined with favorable climatic conditions, meant that southern Alberta was well positioned to respond to changing market opportunities in cattle feeding in the increasingly integrated North American markets for cattle and beef. With the increased number and average size of cattle feedlots in the province, however, have come a number of complaints related to water-pollution problems from cattle-feeding operations (Alberta Cattle Commission undated, 1). According to a report prepared by the Alberta Cattle Commission:

> The beef cattle industry faces two clear alternatives in trying to resolve the problem: voluntary action by the industry and individual producers; or increasing regulatory controls initiated by others. The Alberta Cattle Commission endorses the concept of voluntary action by producers both at the individual and industry level.

3. Beef Processing

Finally, there has been rapid modernization of production and technology in beef processing, especially in large plants such as Cargill's High River facility in Alberta. This includes the increasing use of slaughtering and beef-processing methods that minimize carcass contamination, such as steam-vacuum treatment and organic-acid rinsing. Steam-vacuum treatment was approved by the USDA in 1996 and is being rapidly adopted by the industry.[14] The steam-vacuum injects 195ºF water (which kills bacteria) around a vacuum nozzle, destroying contaminants. High temperature vacuuming works by spraying

[14] In recent years, meat contaminated with infectious bacteria in the United States resulted in high-level attention to beef-processing technology. An outbreak of E-coli 0157:H7 in Jack-in-the-Box restaurants in 1992 was followed by the Hudson Foods beef contamination episode of 1996, which resulted in bankruptcy for the company. It is estimated that as of 1997, one in 500 beef carcasses was still contaminated by E-coli. The beef industry has set a goal of reducing this incidence to one in 5,000,000. R. F. Eustice (1997), of the Minnesota Beef Council, recently reviewed a number of technologies introduced to respond to this challenge. These include steam-vacuum treatments, acid rinses and hot-water washing of carcasses, the use of steam pasteurization cabinets, chemical dehairing and irradiation.

either steam or hot water on the carcass. The heat kills microorganisms on the carcass, then the vacuum removes the bacteria-contaminated water. Gross contamination (defined as one inch or greater in its greatest dimension) is still trimmed with a knife. Contamination of lesser dimensions is steam-vacuumed first.

The organic-acid rinse procedure uses acetic and/or lactic acid in a 2-percent solution that is sprayed on the carcass (pre-evisceration) and effectively reduces pathogens. The use of hot water alone (no trimming) effectively reduces the microbial contamination on carcasses, but the average reduction in bacteria counts is slightly less than that achieved by trimming and washing or trimming and washing combined with hot-water rinsing. This process is widely used in modern packing plants.

Cargill/Excel, in cooperation with the Frigoscandia Company, has recently introduced steam pasteurization to lower the microbial counts on carcass surfaces. This process has been shown to dramatically reduce pathogens. USDA's Food Safety and Inspection Service (FSIS) approved the use of the Frigoscandia steam-pasteurization process in 1995. IBP has recently announced plans to install steam-pasteurization cabinets in all of their beef plants, including those in Canada.

Steam pasteurization works through the following steps. First, a blower removes excess water from the carcass. Four sides of beef then enter the left side of a chamber. The doors of the "car" close, and the whole car moves forward at regular line speed. While the doors are closed, the surface of the beef is exposed to a blast of steam for a few seconds. Once pasteurized, the four sides of beef enter the right chamber where they are sprayed with chilled water before entering the cooler.

For several years, Monfort has been working on a de-hairing process that removes mud, dirt and hair from the carcass before hide removal. The company has submitted a petition, which was approved, requesting operation of a prototype facility. This process can potentially remove the source of most trimming to improve the safety of the product.

There is perhaps no process in the US food manufacturing industry that is as controversial as food irradiation. Irradiation was approved by the US Food and Drug Administration (FDA) in 1983 for use in dried spices and dehydrated vegetable seasonings. In 1987, the FDA allowed the irradiation of pork, and in 1992 approved irradiation for frozen packaged poultry to control salmonella and listeria. The FDA received a beef-use petition in 1994. Because irradiation has already been approved for poultry and pork, it is likely that treatment of beef will be approved by the FDA and regulated by the USDA. Groups such as the National Food Processors Association and the American Meat Institute are aggressively seeking approval for the irradiation of beef. In August 1994, the Blue Ribbon Task Force of the National Livestock and Meat Board called for governmental approval of irradiation for beef. Minnesota state epidemiologist, Dr. Michael Osterholm, describes the technology as *ionized pasteurization* (Eustice 1997).

These methods are part of a broader transformation of food-industry environmental accounting stimulated in part by the internationalization of environmental standards: the ISO 9001/2 process (Bolton 1997). The move from carcass sales to boxed beef has also centralized the rendering of unmarketable beef byproducts, improving the industrial ecology of the waste streams from beef. As a reflection of its own commitment to recycling and reusing of waste streams, the High River, Alberta, facility has also joined forces with environmental groups (Ducks Unlimited and local environmental activists) to reclaim a large wetland (Frank Lake) and reuse millions of gallons of treated wastewater. The High River facility uses about 500,000 gallons of water per day, which is treated by industrial methods before release into Frank Lake, restoring lost waterfowl habitat (Yeager, 1990).

B. Physical Infrastructure

The increasing scale of production by US-located or -owned facilities to serve expanding export markets in Mexico and elsewhere will require enhanced use of the region's transportation and production infrastructure, with potential increases in associated environmental stress. But such stresses are likely to be minimal given the geographic concentration of this increased production where transportation and supporting systems already exist. In Alberta, however, a rapid expansion of new production facilities is causing major strains on, and demanding upgrades to, existing infrastructure.

In the United States, one of the most important reasons for this benign longer-term prospect involves the placement and character of physical supporting infrastructure that is well-suited to a growing trade with Mexico. The US fed-cattle industry, and the feed grains sector that underlies it, is supported by physical infrastructure allowing the economical production and transport of feed grains, feeder cattle, and finished cattle and beef products. In most respects, the level of development of these infrastructures in the United States and Canada is such that they will continue to serve as the primary locations for both feed-grain production and beef-feeding. Shifting this activity to Mexico to any appreciable extent would not only be inconsistent with the natural-resource endowments of Mexico (with fewer suitable growing regions for feed grains, less abundant water resources, and more limited transportation routes), but would also strain existing infrastructure. In contrast, these natural resources and infrastructure already exist where feed-grains production and beef-feeding is currently practiced (Williams 1997).

In the case of feed grains, the United States and Canada possess one of the most efficient grain handling systems in the world. Midwestern and prairie producers move huge quantities of corn, soybeans, wheat, barley and other grains from farm to market through a system of roads and highways, railroad lines, grain elevators, barges, locks and dams, port facilities and ocean vessels unmatched for their size, efficiency and handling expertise (Fruin 1995). In the United States, substantial fixed public and private investment in these facilities has occurred in the last 50 years, since the completion of the locks, dams and channel system on the Mississippi in the 1930s.

Turning from feed grains to fed-beef, the primary modes of transport are by truck and rail. The transportation of meats to Mexico is almost entirely by truck because most Mexican rail cars are unrefrigerated. US exports of both cattle and meat move by truck through the Texas border points of Laredo, Hidalgo, El Paso and Santa Teresa. In some cases, rail cars are used to move live cattle. Much of the cross-border trade in live cattle involves breeding stock suited to warmer and drier climates and destined for private ranches. Trucks and rail cars hauling this stock must be cleaned and inspected by Mexican customs, and the Mexican National Cattlemen's Association is empowered to manage cross-border transactions. Feeder cattle moving into the United States are inspected by US Department of Agriculture officials at Brownsville, Texas. Cattle holding pens at Laredo and El Paso are sometimes cited as environmental hazards because of their proximity to these urban areas (USDA 1996, April, 41), while trucks idling at congested border crossing points can cause local environments atmospheric stress.

A final factor influencing investment patterns and the continuing advantages of US and Canadian beef-feeding and production under NAFTA is the transportation infrastructure allowing the rapid movement of cattle and processed beef from the central United States to Mexico. Since the majority of this cargo moves by truck, the particular advantages conveyed by the US interstate highway system are critical. This highway infrastructure forms an axis that has its center at a point that coincides almost exactly with the epicenter of beef-feeding—in central Kansas. Stabler (1997) has referred to Interstate 35, running from Duluth, Minnesota, through St. Paul-Minneapolis, Des Moines, Kansas City, Wichita, Oklahoma City, Dallas-Fort Worth, Austin, San Antonio and on to Laredo as the "River of Trade." Along this central spine moves 74 percent of all goods traded between the United States and Mexico by truck. It is connected in turn to lateral Interstate Routes 30, 40, 29, 70, 80 and 94, as well as the Pan-American Highway and the Trans-Canada Highway. Kansas City is at the center of "NAFTA territory" along this corridor, where more than 300 motor freight carriers are headquartered, including the largest publicly held less-than-truckload carrier, Yellow Freight Corporation (Stabler 1997).

The institutional and physical infrastructure necessary to respond to environmental externalities in the fed-beef sector is strong in the United States and Canada, implying that the pattern of production most likely to be reinforced by NAFTA is consistent with environmental protection.

C. Social Organization

The increasing concentration of NAFTA-intensified and -sustained production in large US-located or-owned firms has several consequences for social organization that ultimately affect the environment. It places pressures on family-owned firms and farms and the rural communities they have long sustained. It increases awareness of animal welfare and more humane practices, and of industry efforts to strengthen them. Lower prices make beef products more available to low-income consumers. The large feeding and packaging operations attract a migrant labor force that can affect local communities.

While per capita consumption of beef has fallen in the United States and Canada (especially relative to poultry), due in part to health and dietary attitudes, beef remains an important part of the North American diet. It is a growing part of the diet of lower-income consumers whose budgets have expanded with economic development.

On the health issue attitudes are also changing. The Minnesota Beef Council, for example, highlights its partnership with the American Heart Association in the search for lower-fat beef consumption (Eustice 1997). Finally, growing attention to cattle handling and slaughtering methods, related to both humanitarian and health and safety issues, is occurring throughout the beef industry (Klein 1995, 5).

These trends suggest that efforts to promote the humane treatment of animals in the beef industry are likely to grow in importance for feedlot operators, along with growing attention to sanitary and phytosanitary standards.[15] Industry strategies may also focus on the technology of beef production and responses to those who perceive cruel and inhumane treatment of animals in the industry as a whole.

There are also social challenges raised by concentrated feedlot production in the United States and Canada that define the social context of the industry. To many advocates of protection for smaller family farmers, concentrated cattle-feeding epitomizes the movement toward "industrialized agriculture" and the vertical integration and concentration of animal processing. The threats to traditional livestock production were the focus of a recent Advisory Committee report to the US Secretary of Agriculture, Dan Glickman (USDA 1996). The report considered in detail trends in feedlot numbers (cited above) in which feedlots with 8,000 to 32,000 head increased from 206 to 302, and those with 32,000 and over increased from 73 to 81 over the 1980s and 1990s (Vanderholm 1994). In a minority report, six members of a twenty-member committee succinctly stated the concerns of smaller family farm advocates:

> The record before the committee and the report itself are replete with evidence showing the growing concentration of all aspects of agriculture. This concentration varies at different levels of the food production chain and its effects likewise differ. The only common thread is that the upper levels

[15] It is now recognized that careful and humane handling in the time of transit from feedlot to slaughter (which may be as short as six hours) reduces stress discolorations in muscle tissue, known as "dark cutters" (Klein, 1995, p. 15).

maintain profit margins of various sizes within the production cycles, and the lowest, least concentrated levels have become the primary shock absorbers for fluctuations in the commodity cycle (USDA 1996, October, 29).

Concerns have prompted an increase in voluntary, multistakeholder environmental standardization. For example, in the spirit of pro-active voluntary action, the Intensive Livestock Operations Committee, consisting of representatives from the Alberta Cattle Commission, the Alberta Cattle Feeders Association, several other provincial livestock producer organizations as well as five provincial government departments and two associations of municipal governments developed the aforementioned 1995 Code of Practice for the Safe and Economic Handling of Animal Manures (Alberta Agriculture, Food and Rural Development 1995).

The Code of Practice was developed to replace the 1982 Confinement Livestock Facilities Waste Management Code of Practice. The aims of the Code are to reduce conflicts arising from the operation of new livestock facilities through the appropriate siting of those facilities and to assist producers in selecting alternative manure storage and use practices that minimize the incidence of nuisance and other environmental problems. The Code was written for producers as well as for municipalities and planners concerned with the siting and the management of livestock facilities.

Thresholds are defined for the minimum sizes of livestock operations considered to be “Intensive Livestock Operations” (Code 1995, Table 1, 5). For a beef feeder-cattle operation, this is a capacity of 300 head. Minimum Distance Separation guidelines were developed to provide guidance for the location of intensive livestock operations (Code 1995, Section 3 and Appendix D) to mitigate nuisance problems arising from odor. For example, the minimum distance separation for a 10,000 head beef feedlot ranges from 2897 ft. to 4828 ft. depending on the type of adjacent land use activity. Guidelines for reducing the risk of contamination of groundwater from inappropriate manure storage facilities or practices are included in the Code (Section 4 and Appendix B). In addition, land-base requirements and manure application rate guidelines for the safe disposal of livestock manure from intensive livestock operations are also provided (Section 6 and Appendices E and F). Many rural municipalities in Alberta have incorporated or are in the process of incorporating the Code into municipal bylaws and land-use planning procedures.

The proposed guidelines for land area for manure disposal on cattle feedlots of various sizes require adjustment for the nutrient content of manure. Chang (1997, 3) estimated that long-term manure application from cattle feedlots should be limited to 14 tons per acre per year if the leaching of nitrates to groundwater is to be avoided. Clark (1997, 60) reported anecdotal evidence of manure application rates of 500 metric tons per acre, but he does not indicate how widespread such practices might be in prairie agriculture. Modifications to the Code of Practice to reflect recent research findings are currently being discussed (Swihart 1997). One of the modifications under consideration is the addition of phosphorous as a constraint on manure application. Guidelines based on the phosphorous content of manure were not included in the 1995 Code, but more recently it has been suggested that this omission should be addressed. Phosphorous is primarily a surface water quality issue. The reduction of phosphorous from agricultural sources in the Great Lakes basin has been the object of numerous conservation programs over the past quarter century. Given the relatively arid climate of southern Alberta and the lack of large bodies of standing water, phosphorous has not been a prominent conservation issue there until recently. Surface water quality issues have focused on isolated instances of the deliberate or accidental deposition of manure into streams or rivers, access by grazing cattle to riparian areas, and non-agricultural sources, especially municipal waste.[16]

[16] For example, the City of Lethbridge lacks tertiary sewage treatment. Waste from the city is released into the Oldman River.

Perhaps the most important process suggesting that the NAFTA-associated concentration of production can be accompanied by environmental oversight is its location in firms and areas where there is already substantial sectoral and environmental regulation by federal and subfederal authorities. There are, however, challenges in ensuring that regulatory oversight keeps pace with new technological developments and that environmentally enhancing public investment is sufficient to support the new scale of production activity.

The emerging patterns of beef and cattle trade complement environmental regulatory oversight of the sector. Regulatory oversight in the US fed-beef industry occurs at the federal, state and local (county or township) levels and has been largely unaffected by NAFTA except at the border inspection stations. The general relevance of NAFTA is that the patterns of trade it has engendered will continue to cause the United States—the dominant player—to exercise the greatest environmental impact on the sector through its regulatory structure. An important feature of this regulatory framework is the so-called "California effect," in which California regulations have often led the way in a process of "upward harmonization" involving other states and the federal government (Vogel 1995). In general, however, federal regulations are the least stringent, allowing state and local authorities leeway to define stricter standards and requirements (Morse 1996). In Canada, nearly all regulatory oversight is led by the provincial governments (Willis 1997). It is thus particularly relevant how the levels of environmental regulation and support compare in various jurisdictions.

The primary implementing authority at the federal level in the United States is the US Environmental Protection Agency (EPA), operating through its regional offices. In some cases, EPA delegates regulatory authority to the region, or it may delegate to states. Two main federal laws govern this process: the Clean Water Act (CWA) as amended (Public Law 92-500, 1972), which focuses on point-source pollution. Beef livestock operations with more than 1,000 head with no waterway present or 300 head in the presence of a waterway are considered point sources. These point sources must receive discharge permits through Section 402 of the CWA, the National Pollution Discharge Elimination System (NPDES). The CWA requires that wastewater and runoff from livestock facilities, including manure wastes, be storable in relation to 25-year storm events of a 24-hour duration. US Department of Agriculture criteria are used to construct storage facilities and in some cases to design liners or other impermeable barriers for lagoon storage of manure and wastewater. In the last few years, attention has moved to nonpoint sources (NPS) of pollution, including manure, focusing on groundwater, but regulatory oversight in this area still lacks the full authority of the Clean Water Act (US General Accounting Office 1995).

The second federal law governing livestock is the Coastal Zone Act Reauthorization Amendments (CZARA) of 1990, together with EPA implementing guidelines for coastal states, which required states to have plans implemented by 1 January 1996. While implementation has lagged, the CZARA process is expected to set the terms for rewriting the CWA and to be extended to all states in the future. The application of the CWA and CZARA to livestock units of various sizes is shown in Table 20.

Table 20 Number of Livestock Present to Qualify as a Concentrated Animal Feeding Operation based on the Clean Water Act (CWA) and the Coastal Zone Act Reauthorization Amendments (CZARA)

Category	CWA no discharge[a]	CWA with discharge[a]	CZARA (small)[b]	CZARA (large)[b]
Slaughter/feeder cattle	1,000	300	50-299	300
Mature dairy[c]	700	200	28-97	98
Swine (>25 kg)	2,500	750	40-79	80
Horses	500	150	200-399	400
Sheep or lambs	10,000	3,000	NL[f]	NL
Turkeys	55,000	16,500	900-2,474	2,475
Laying hens or broilers[d]	100,000	30,000	165-494	495
Laying hens or broilers[e]	30,000	9,000	50-149	150
Ducks	5,000	1,500	NL	NL
Animal units	1,000	300	NL	NL

[a]Units are animals
[b]Units are animal units
[c]Milking or nonlactating
[d]Facility has continuous overflow watering
[e]Facility has a liquid manure system
[f]NL = not listed

Source: Morse 1996, 3104.

In addition to these laws, livestock facilities are also subject to the 1955 Clean Air Act (Public Law 84-159) and its National Ambient Air Quality Standards (NAAQS) for six compounds: carbon monoxide, ozone, particulates, sulfur dioxide, nitrogen oxides and hydrocarbons. The main issues for livestock facilities are ammonia emissions from manure and dust.

Finally, the 1996 farm bill, the Federal Agricultural Improvement and Reform (FAIR) Act, provided new environmental spending support for livestock facilities seeking to comply with the above legislation. The Environmental Quality Incentives Program (EQIP), part of the 1996 legislation, was specifically targeted to smaller livestock facilities facing costs for the construction of lagoons and other water-protection infrastructure.

While the actual costs and benefits of compliance with these regulations are not known, it is clear that they constitute a level of oversight increasingly capable of responding to the environmental issues of the fed-beef sector. In the environmental regulatory area, the United States has a superstructure of federal laws, reinforced by numerous state and local requirements, that constrain point-source pollution from the sector. The primary challenge will be to extend this structure to encompass nonpoint-source pollution arising not only from livestock facilities, but also from the feed-grains sector. In agricultural policy more generally, the 1996 FAIR Act provides additional financial incentives for livestock operations to invest in pollution-reducing infrastructure.

The recent expansion of cattle-feeding in Alberta, especially in southern Alberta, has been attributed to several factors. Beginning in the mid-1980s, the provincial government began to pay producers the "Crow Offset," which was intended to counteract the higher feed-grain prices in the province brought about through the implicit transportation subsidy in the so-called Crow Rates. Artificially low rail freight rates for grain moving off the prairies into export markets distorted the farm-level demand for grain and increased feed costs in Alberta, Saskatchewan and

Manitoba. The Crow Offset program was the beginning of the end for distorted feed-grain prices in the region. Since the mid-1980s, livestock feeding has increasingly begun to reflect underlying comparative advantage. Additional factors that have stimulated growth in the sector are the availability of irrigation water[17] at attractive producer costs,[18] the reduction of tensions in the beef and cattle trade between Canada and the United States, lower feed-grain prices in southern Alberta relative to northern Alberta[19] and a dry, comfortable climate.[20]

In Canada, environmental regulation occurs mainly at the provincial level. In Alberta, waste disposal in general is regulated under the Environmental Protection and Enhancement Act. The Act applies to the release of any substance capable of causing an adverse effect on the environment. Activities related to cattle production that could be considered offenses under the Act include:

- bedding, feeding or watering directly on/from a river, creek or lake where the activity is causing an impact;
- allowing manure to enter directly into a river, creek or lake or onto public or private property;
- allowing surface water run-off to become contaminated with manure and allowing that runoff to enter a river, creek or lake or onto public or private property (Alberta Cattle Commission, undated, 4).

Penalties under the Act range from C$100.00 to C$1,000,000.00, depending on the severity of the offence.

[17] See Freeze (1993) for an assessment of the impact of the availability of irrigation water on the growth of the cattle-feeding industry in southern Alberta. Freeze estimates that approximately 1 million feeder cattle from Alberta would move into the northern United States annually if irrigation water were not available in the province.

[18] Producers pay an annual assessment or per-acre charge for irrigation water. This charge finances the maintenance of canals, but does not cover the costs of reservoir construction or maintenance. In the Lethbridge North Irrigation District, annual charges for irrigation are in the range of $14-$16 per acre.

[19] See Freeze (1993).

[20] Most cattle in feedlots in southern Alberta are kept outside, with modest windbreaks to protect them from winter conditions. Chinook winds in southern Alberta bring warm air from the Pacific Northwest that moderates winter temperatures.

V. Environmental Impacts and Indicators

Overall, trends in the fed-beef industry toward large, concentrated feedlots, and their integration with beef processing, will continue in North America. While this trend poses environmental challenges, and will be met with some resistance from advocates of smaller farming operations and animal rights groups, it is unlikely to be reversed. As a consequence, it is important to highlight the need for direct attention to the environmental consequences of feed-grain production, cattle feedlots and beef-processing facilities.

Two positive developments bear emphasis. First, there is reason for optimism over changes in farm and regulatory policies that will assist in meeting these environmental challenges. Second, there is evidence to suggest that despite these challenges, North America has the capacity to sustain a highly competitive feed grains and beef sector for many years to come while reducing negative environmental impacts. Moreover, trade between the United States, Canada and Mexico is establishing a pattern in feed grains, live cattle, cattle feeding and beef processing that exploits abundant resources in each country and allows for the effective regulation of environmental impacts where it is most needed.

Environmental-impact analysis concerns itself with the definition of thresholds beyond which production systems will not function sustainably (see Norton and Toman 1995). These thresholds are often difficult to determine a priori. Although the exact threshold may be difficult to gauge, key indicators can nonetheless be developed and analyzed. In the case of cattle-feedlot activity and its antecedents in feed-grain production, several indicators may be useful in formulating environmental policy responses. Indeed, a number of specific scientific indicators will allow the continued monitoring of the main environmental impacts of the beef sector, allowing oversight of the ways in which the sector may affect water, air, land and biota. This section focuses on four such indicators: two for feed-grain production, one for beef feedlots, and one for beef-processing facilities.

A. Feed Grains: Nitrates and Atrazine

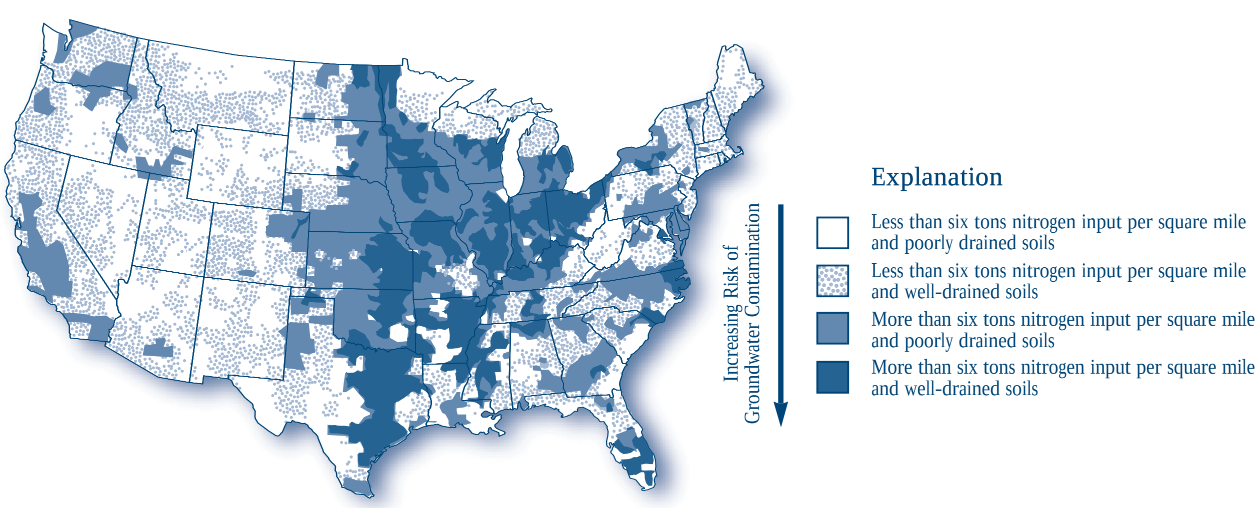
Feed-grain production in the United States has major environmental impacts on waterborne pollution, especially in the Mississippi watershed. While these impacts are important, they are also capable of significant remediation if government, in partnership with private property owners, promotes the use of agricultural lands in ways that buffer watersheds from direct runoff from fields, encourages the responsible use of pesticides and fertilizer, reduces erosion, and promotes species preservation. There is evidence of considerable progress in all of these areas over the past decade.

1. Nitrates

Nitrates come from nitrogen, the most commonly used fertilizer ingredient in the feed-grain sector, and one that is applied on nearly all corn acres. Nitrates also result from manure applications in which corn and other plants do not fully utilize available nitrogen. Nitrates move through surface-water systems over long distances. In addition to surface waters, nitrate concentrations in domestic wells are much higher in areas of intensive agricultural activity. Nolan and Ruddy (1996) have recently analyzed the relative occurrence of nitrates in the groundwaters of the United States. Groundwater provides drinking water for one-half of the US population and is the sole source of water for many rural residents (Solley et al. 1993). Lands vulnerable to nitrate contamination are shown in Figure 14. Using 10,370 samples collected nationally in the United States in 1992, Nolan and Ruddy found that nitrate concentrations in natural groundwaters were usually 2 mg/L (2 ppm) or less. The EPA has established a drinking water standard of 10 mg/L. Yet in agricultural areas with well-drained soils ideally suited to corn and oilseed production, much higher nitrate levels were observed, especially where wells were shallow (see Figure 15). Once groundwater is contaminated with nitrates, it is very difficult and expensive to remediate (National Research Council 1993). Hence nitrate levels of 10 mg/L or more may be considered a key indicator of the threshold of environmental stability for feed-grain producing areas.

Nitrate contamination is also an issue in and around cattle feedlots. In Canada, nitrates originating from livestock manure are difficult to isolate because of high background levels of nitrate nitrogen in groundwater in the prairie provinces (Harker et al. 1997, 44). For example, high groundwater nitrate levels, from 100-500 ppm, have been detected in some shallow soils, but these levels are attributable to geological not agricultural sources. Similar concentrations of geological nitrate have been observed in Nebraska (Boyce et al. 1976). With respect to groundwater quality in Alberta, Harker et al. (1997, 45) report findings by Henry (1995) that in one survey of 12, 342 well-water samples collected on farms in Alberta over a six-year period prior to 1995, 4 percent of the wells sampled exceeded the 10-ppm limit for nitrate concentration. Long-term evidence summarized by Henry (1995) and Henry and Meneley (1993) indicates that the incidence concentrations of nitrate in groundwater on the prairies has remained roughly constant since the 1940s. Nevertheless, baseline data for individual aquifers is limited and further research is indicated, especially for areas of intensive land use, for locations where aquifers are shallow, and for areas with high precipitation or where irrigation is used intensively (Harker et al. 1997, 49). The combination of high levels of manure application and irrigation has been linked to nitrate levels of 500 ppm in groundwater in an experimental trial near Lethbridge, Alberta (Chang and Entz 1996).

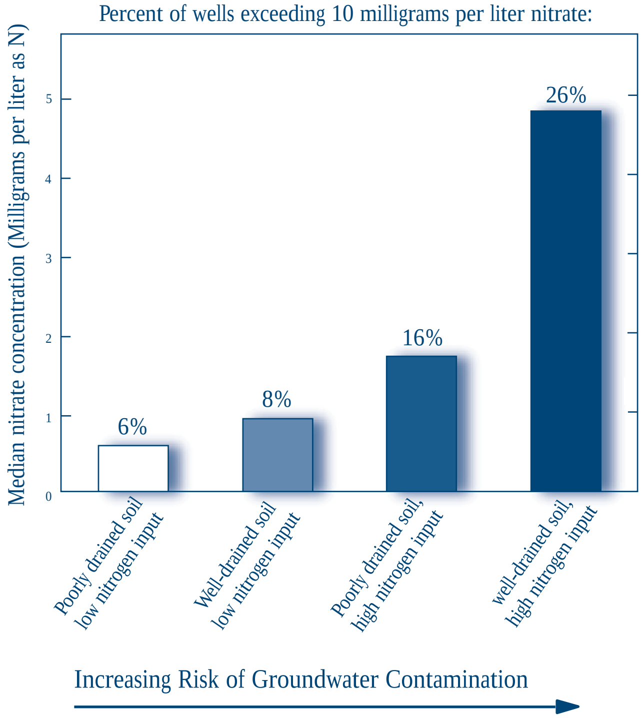
Figure 14 Areas in the United States Most Vulnerable to Nitrate Contamination of Groundwater



Source: Nolan and Ruddy 1996, 5.

Areas in the United States most vulnerable to nitrate contamination of groundwater (shown darkest on the map) generally have well-drained soils and high nitrogen input from fertilizer, manure, and atmospheric deposition. High-risk areas occur primarily in the western, midwestern, and southeastern portions of the nation.

Figure 15 Nitrate Concentration in Shallow Groundwater beneath Agricultural Lands



Nitrate concentration in shallow groundwater beneath agricultural lands varies by soil permeability and the amount of nitrogen applied to the land surface.
(Data shown are for shallow wells in agricultural areas.)

Source: Nolan and Ruddy 1996, 6

2. Atrazine

A second indicator involves the herbicide atrazine, which is widely used on corn. Like nitrates, atrazine was shown in Section II to move into surface waters. And like nitrogen from fertilizers and manure, atrazine has been found in groundwater. In 1992, nearly 70 percent of corn acres were treated with atrazine (Ribaudo 1993). Cornfield weed suppressants as a class of farm chemicals (of which atrazine is one) accounted for 47 percent of total agricultural pesticide use in the United States in the early 1990s and were applied to about 95 percent of all US corn acres, as noted above (USDA-ERS 1991; 1992). Atrazine is a "class C" compound, according to the US Environmental Protection Agency, meaning that it is a possible human carcinogen. It is 10 to 20 times more frequently detected during water-quality monitoring studies than the next most commonly detected pesticide (Ribaudo 1993). Atrazine persists in the soil and has a high potential to leach through porous soils into groundwater.

Studies have observed positive correlations between the frequencies of pesticide occurrence (or pesticide concentrations) in groundwater, including atrazine, and the intensity of nearby agricultural activity (Table 21). McMahon et al. (1994) observed detectable concentrations of atrazine in groundwaters of the South Platte River Basin in areas where irrigated agriculture was the predominant land use within 0.6 mi, but not in areas where the predominant land use was forest, rangeland, or urban development. Kolpin and others (1994) observed a highly significant increase in the frequency of corn-and-soybean herbicide detections as the percentage of forest land decreased within two miles of the sampled wells. Additional analysis (Kolpin 1995a) showed pesticide concentrations were correlated with agricultural land use where shallow wells (less than 50 feet deep) were common. Data from the National Alachlor Well-Water Survey (NAWWS) showed an increase in the percentage of sampled wells containing detectable levels of alachlor, metolachlor, and atrazine as a greater percentage of the area within 0.5 mi of individual wells was devoted to corn and soybeans.

The capacity to monitor pesticides in and around agricultural activity suggests the growing accuracy of these indicators of agricultural pollution. Studies of both existing (Eckhardt et al. 1989a) and newly acquired data (Eckhardt et al.1989b) on groundwater documented strong relations between the frequencies of pesticide detection in wells and the presence of agricultural activities nearby. For their analysis of existing data, Eckhardt and others (1989a) classified the area within a 0.5-mi radius surrounding each of 903 wells into one of 10 different categories on the basis of the predominant land use during the period of interest (1978-1984). Consistent with its use as an agricultural insecticide, carbofuran was detected with high frequency (42 percent) among wells in predominantly agricultural areas, but in only one well in another land-use category (recreation).

Table 21 Principal Features of Studies Relating Pesticide Occurrence in Groundwater to Land Use in Agricultural versus Non-Agricultural Settings

Reference	Study Location	# Wells	Pesticides Examined	Parameters Used to Characterize: Pesticide Occurrence	Parameters Used to Characterize: Land Use	# of Land-Use Categories Examined	Statistical Tests Employed
Greenberg et al. 1982	New Jersey (statewide)	40	Organochlorine insecticides	Percent of wells containing 1–5 ppb pesticides	Percent of area in land-use category (R = 1)	17	Comparisons of land use among "contaminated" wells
Fishel and Lietman 1986	Pennsylvania (Upper Conestoga River)	42	Atrazine, alachlor, metalachlor, simazine, and several unidentified herbicides	Detection frequency	Predominant land use	2	None
Barton et al. 1987	New Jersey (central)	65	Organochlorine, organophosphorus, and triazine pesticides	Detection frequency	Predominant land use Presence/absence (R = 0.25)	3	Kruskal-Wallis
Rutledge 1987	Florida (Orlando area)	32	Organochlorine, triazide, organophosphorus, phenoxy-acid pesticides, and EDB	Detection frequency	Predominant land use	4	None
Pionke et al. 1988: Pionke and Glotfelty 1989	Pennsylvania (Mahantango Creek)	21	Atrazine, simazine, alachlor, metolachlor, 2-4-D, dicamba, chlorphyrifos, fonofos, and terbufos	Concentration (atrazine only)	Corn Production Intensity (see text)	Not appli-cable	None
Eckhardt et al. 1989a	New York (Long Island)	903	Aldicarb, carbofuran, DDT, heptachlor epox-ide, and chlordane	Detection frequency	Predominant land use (R = 0.5)	10	Parametric tests, non-parametric tests and contingency-table analyses
Eckhardt et al. 1989b	New York (Long Island)	90	Carbamate, organochlorine, and organophosphorus insecticides, triazines and chlorophenoxy acids	Detection frequency	Predominant land use	5	Nonparametric tests, contingency-table analyses
Grady 1989	Connecticut (drift aquifers)	83	Atrazine, 1,2-dichtoro-propane, and at least 5 others	Detection frequency	Predominant land use	4	Analysis of variance, contingency-table analyses
Helgeson and Rutledge 1989	Kansas (south-central)	82	Atrazine, 2, 4-D	Concentration	Predominant land use	2	Wilcoxon-Mann-Whitney
Kross et al. 1990 (SWRL); Halberg et al. 1992b	Iowa (statewide)	686	27 pesticides (atrazine most common)	Detection frequency (atrazine; any pesticide)	Presence of area in land-use category (R = 0.5)	8	Comparisons of 95% confidence intervals among land-use categories
Holden et al., 1992 (NAWWS)	Nationwide (89 counties)	1430	Alachlor, metolachlor, atrazine, cyanazine, and simazine	Detection frequency	Percent of area growing row crops (R = 0.5)	Not appli-cable	One- and two-tailed comprarisons among means
Koterba et al., 1993	Delmarva Peninsula	100	36 pesticides and 4 degradates	Detection frequency	Predominant crops	2	Mann-Whitney, Kruskal-Wallis
Kolpin et al., 1994 (MCPS)	Midcontinent (12 states)	303	11 herbicides and 2 atrazine degradates	Detection frequency	Percent of area in land use category (R = 0.02, 0.25, 2)	9	Spearman's rank correlation, Mann-Whitney, Kruskal-Wallis
McMahon et al., 1994	South Platte River (Colorado, Nebraska, and Wyoming)	24	Atrazine and its transformation products (via immunoassay)	Concentration	Predominant land use (R = 0.6)	4	Kruskal-Wallis
Szabo et al., 1994	New Jersey (southern coastal plain)	36	Organochlorine insecticides, triazines, acetanilides, and carbamates	Detection frequency	Percent of surrounding land in agriculture (R = 0.5)	Not appli-cable	Discriminant analysis

Source: Barbash and Resek, 1996, pp. 261-262.

Several other studies detected significant relationships between the occurrence of pesticides in ground water and the presence of agricultural lands nearby. Using a 0.25-mi radius for characterizing land use in central New Jersey, Barton et al. (1987) found the frequencies of pesticide detection to be higher in groundwater beneath agricultural areas than beneath either urban or undeveloped areas, based on the sum of all detections of organochlorine, organophosphorus, and triazine pesticides. Consistent with these observations, Szabo et al. (1994) detected a significant, positive relation (a = 0.05) between the proportion of agricultural land within 0.5 mi of individual wells and the frequencies of pesticide detection. Greenberg et al. (1982) found that wells containing 1-5 mg/L of organochlorine insecticides were surrounded by a disproportionately high percentages of agricultural land within a 1-mi radius, relative to residential, commercial, industrial, or other urban land uses. Since atrazine is an especially widely used agricultural pesticide on feed-grains, especially corn, it is a useful chemical for purposes of choosing an indicator of agricultural pollution.

This study has emphasized the need in the feed-grain sector for attention to four main environmental issues: water quality and quantity, pesticides and agricultural chemical use, soil losses, and biodiversity. It is clear that despite increased attention to all of these issues at the national level, much more remains to be done in both Canada and the United States. While a complete discussion of needed innovations in agriculture and the environment is beyond the scope of this study (see Runge 1997), a summary of these changes would include the more precise and accountable standard-setting for critical thresholds, such as nitrates and atrazine (or phosphorus) at each level of administrative enforcement, from farm to county to state to federal policy. One would expect these changes in policy to occur first in Canada and the United States. This is consistent with the primary location and intensity of feed-grain production in the Corn Belt. The very fact that the United States and Canada hold strong competitive advantages in feed-grain production and a tradition of environmental programs affecting (if marginally) the agricultural sector suggests that they are capable of innovative responses to environmental damages without seriously constraining competitiveness. Policy intervention should be targeted on fertilizer and chemical use, especially nitrates and atrazine in groundwater, by focusing on nonpoint-source pollution.

Because input intensity in Canadian agriculture, measured in terms of quantities of plant nutrients or plant protection inputs applied per hectare or in terms of animal units per unit of land, is typically lower than in US agriculture, the nature and incidence of environmental issues arising in the Canadian context are somewhat different from the US situation. The most widely recognized environmental problem attributed to Canadian agricultural production is the degradation of surface-water quality. This degradation primarily takes two forms. Eroded sediment, often with adhered phosphorous, is the most serious problem (van Vuuren and Fox 1989; Fox et al. 1990; Fox et al. 1995). Excess sediment deposition and consequent high phosphorous loadings have been linked to agricultural production practices in the Great Lakes basin. (Fox and Dickson 1989; 1990). A second category of surface-water degradation occurs in the form of the bacteriological contamination of surface-water supplies from improperly handled livestock waste. Given that this mode of contamination is usually attributed to improper management, there is no regional pattern to this form of surface-water contamination.

Giraldez and Fox (1995) cite recent groundwater quality research in Ontario that indicates that bacteriological contamination is also the most common form of groundwater contamination in rural areas. A significant share of the observed instances of this bacteriological contamination has been attributed to poor well construction and inadequate maintenance or to poor selection of well locations. According to recent water quality assessments in Ontario, nitrates are the second leading cause of groundwater contamination. The incidence of pesticide residue contamination is quite low.

The Canada-Alberta Environmentally Sustainable Agriculture Water Quality Committee has recently released the findings of its five-year study of the effects of agricultural production on water quality in the province (Paterson et al. 1998). This study was motivated, in part, by the significant growth in the agricultural sector in the province in the last

25 years and by the apparent prospects of continued expansion. Ground- and surface-water quality sampling was carried out at hundreds of locations in the rural areas of Alberta over the five years of the study. Samples were analyzed for compliance with federal and provincial water-quality standards for drinking water, livestock watering, aquatic life, irrigation and recreation. Tests were conducted for bacteriological contamination, pesticides (mainly herbicides) and nutrients (primarily phosphorous and nitrogen). The study findings indicated that agricultural production practices are contributing to the degradation of water quality in Alberta, and that degradation is correlated with the intensity of agricultural production in a region. Consistent with the water-quality study results from Ontario, most of the observed contamination was in the form of bacteriological contamination or excessive phosphorous or nitrate levels. Pesticides from agricultural sources were found to be a significant contaminant of water for human or livestock use and for aquatic life.

Most of the major drainage systems that could potentially be adversely affected by agriculture in Canada drain to the Atlantic Ocean through the Great Lakes and the St. Lawrence River, to Hudson's Bay and the Arctic Ocean from the Saskatchewan River system, and to the Pacific Ocean via the Fraser River. Emissions from Canadian agricultural sources could have only a negligible impact on water quality in the Gulf of Mexico via the Mississippi River system.

B. Beef-feeding

In the beef-feeding sector itself, manure management in relation to nitrates is key, as are phosphorus loadings, given the probable expansion of facilities to treat and manage these wastes in an industrial or municipal mode as beef feedlots continue to grow larger. The increasing size of cattle feedlots and longer periods in which cattle are kept on feed substantially increase the land area needed if manure is to be applied to surrounding cropland. At some point, additional treatment will be required, as well as the transport of wastes off-site. These waste-management methods and technologies to promote them may well require new and substantial levels of investment, in which a public role may be considered because of the negative external effects and market failures involved. This is the reasoning behind sections of the 1996 farm bill dealing with livestock wastes, discussed above. However, these programs have been restricted to smaller feedlots, presumably because subsidies paid to large feedlots to assist in waste management would be criticized as "corporate welfare." Yet it is precisely on the larger feedlots that problems of waste management are most severe. Unless governments are prepared to counter the trend toward larger facilities (which shows few signs of abating) or to compel, through civil or criminal liability, large facilities to fully internalize the cost of waste management without subsidy, additional public funds are likely to be needed to support new technologies and management. In the beef-processing sector, most of the wastes associated with this industrial activity are already recycled or reused (Franco and Swanson 1996). No new national policies are needed to respond to the environmental consequences of these actions, apart from general support for public-sector research into the application of hazard analysis and critical control points (HACCP) and the utility of the ISO 9001/2 process in "harmonizing upward" for environmental protection.

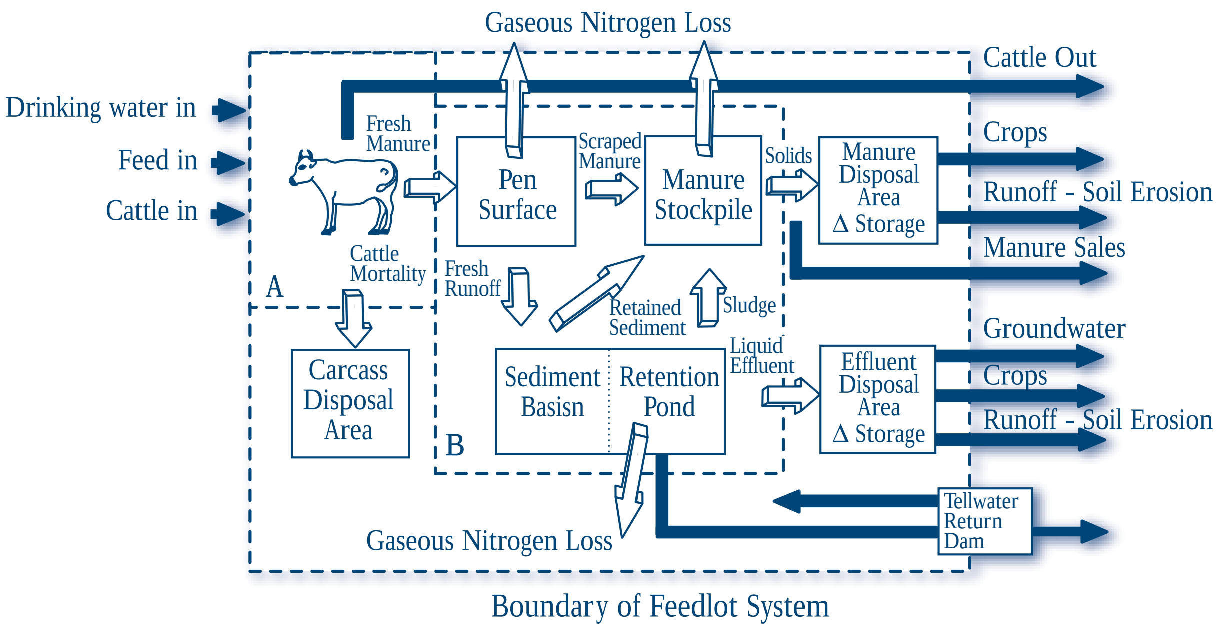
1. Phosphorus Cycles

In the case of feedlots, nutrient cycles have been analyzed using a mass-balance approach to establish thresholds defining the sustainability of different feedlot operations. Nitrates are an issue in and around feedlots, and their importance as an indicator has been noted above.[21] Phosphorus (P) also provides a relatively clear indicator of feedlot impacts. In addition to nitrogen, it is one of the major contributors to algae growth in water bodies and a main concern in feedlot

[21] In Alberta, Chang (1997) has estimated that long-term manure applications from cattle feedlots to surrounding fields be limited to 14 tons per acre per year to avoid nitrate leaching, and Clark (1997) reports anecdotal evidence of rates as high as 500 metric tons per acre.

management. Algal blooms, leading to oxygen depletion in water and eventually to eutrophication, can be triggered by P concentrations of as little as 0.05 mg/L. Figure 16 shows the nutrient balance of a cattle feedlot, in which P is determined either as a function of fresh manure deposits (shown as "A" in Figure 16) or, more completely, by calculating P deposited minus P disposed of (shown as "B" in Figure 16).

Figure 16 Nutrient Balance of a Cattle Feedlot



Source: Watts et al. 1994, 28.

Using the second method, Watts et al. (1994) calculated the P cycle for two hypothetical feedlots of 10,000 head, each with a manure utilization area of 250 hectares. Rainfall, stocking density and mortalities were the same at both sites, but feed rations were higher in P in Feedlot B than in A, and less P could be taken up around it by crops due to soil conditions. In this comparison, Feedlot A could operate for 132 years before the ability of soils to absorb P was exceeded, while Feedlot B must either have increased its land utilization area from 250 hectares to 10,000 hectares, or else have found its P limits exceeded within 8 months. Alternatively, it must have sold 12,400 tons of manure out of 12,700 produced each year (see Table 22).

Table 22 Phosphorus Balance for Example Feedlots

Item	Feedlot A	Feedlot B
Cattle Weight In (kg)	220	450
Feeding Period (days)	90	200
Average Daily Gain (kg/day)	1.4	1.2
Cattle Weight Out (kg)	346	690
Feedlot Occupancy (%)	70	90
Annual Turnoff (head)	28,250	16,340
Total Average Liveweight (t)	1,980	5,130
Feed Intake (kg DM/hd/day)	7.8	13.7
Annual Feed Intake (t DM)	19,940	45,060
P Content of Ration (g/kg DM)	3.54	4.63
Incoming P (t/yr)		
Cattle	50	59
Feed	71	208
Outgoing P (t/yr)		
Cattle	78	90
P in Manure (t/yr)	42	177
P in Carcass (t/yr)	0.3	0.4
P onto Utilization Areas		
Effluent (t/yr)	2.3	2.3
Manure (t/yr)	40	175
(kg/ha/yr)	159	699
Crop Uptake (kg/ha/yr)	100	14
Soil Accumulation (kg/ha/yr)	59	685
Soil P Capacity (kg/ha)	7,800	440
Sustainable Life (years)	132	0.6

10,000 head capacity, 250 ha manure utilization area.

Source: Watts et al. 1994, 32.

C. Beef Processing

1. Biological Oxygen Demand and Total Suspended Solids

In the case of beef processing, it is more difficult to isolate specific indicators. However, as shown in Table 23, beef slaughtering generates a variety of pollutants, measurable as biological oxygen demand (BOD), total suspended solids (TSS) and fats, oil and grease. Of these, probably the most easily measured and monitored are BOD and TSS. From the point of view of oversight and monitoring, BOD and TSS are especially important and are already key components in environmental monitoring and compliance under EPA regulations.

Based on these indicators, estimates can be made of the impact of beef production on various ecological systems. As noted in a previous analysis of indicator development by Masera and Maclaren (1996), those environmental pressures of greatest salience are on air, biota, water and land. The indicators identified above are currently in use as a basis for environmental monitoring and compliance, but merit increased attention and resources to be most effectively employed. They are summarized in tabular form below.

Table 23 Indicators of Environmental Pressures on the Feed-grains Complex, Beef Feeding, and Beef Processing

Environmental Pressure*	Indicator(s)
A. Feed-grains Complex	Nitrate levels in surface and groundwater (in comparison to 10 mg/L EPA threshold) Atrazine levels present in surface and groundwater Sediment and phosphrous loadings from cropland erosion
B. Beef Feeding	Phosphorus nutrient balance (length of facility operation before P absorption threshold exceeded)
C. Beef Processing	Biological Oxygen Demand (BOD) Total Suspended Solids (TSS)

* In all cases, data exist and can be utilized to estimate pressure-state-response functions for each aspect of the industry. Further monitoring and oversight can thus be based on these main indicators.

Conclusions

This study has drawn attention to the horizontal linkages in the transformative process from feed-grains to feedlots to beef processing. Historically, however, government policies have tended to focus vertically on each part of this process in isolation; they have formulated certain policies for grains; others for livestock facilities; and still others for slaughtering, rendering and packing. By recognizing the process as a whole, polices can be designed that reflect the consumers' growing concern with the entire "life cycle" of food production, from farm to table.

From a trade perspective, there is a natural complementarity between Canada and the United States on the one hand as feeders and producers of processed beef, and Mexico on the other as a supplier of live feeder cattle. The emergence of this trading pattern implies that beef will not necessarily be produced most efficiently where it is to be consumed. The economic capacity to raise and feed beef competitively is in the center of the United States and in western Canada. Both countries have documented that per-capita demands for beef have declined, but concerns over the social and environmental impacts of beef and feed-grain production have grown. In Mexico, meat is being added to diets as incomes expand from low levels. Hence, the plains states of the United States and prairie provinces of Canada have the range resources, feed grain availability, and technical infrastructure necessary to competitively produce and feed cattle. They are also in many ways better positioned to respond technically and, from a regulatory standpoint, directly to the environmental challenges that concentrated beef production raises, and to establish a pattern of more sustainable agriculture that can be emulated in other parts of the world.

There is nothing about comparative advantage in trade terms that guarantees that environmental protection will be actively pursued. Such protection is highly farm- and firm-specific. What is required is a specific commitment, at the level of farms and firms, to environmental improvements and technologies at all three stages in the transformation from the feed grain sector to feedlots and then to beef processing. Such supporting institutional and technological improvements are largely in the domain of the private sector. Private-sector technological and managerial innovation is already serving as, and can be a further and significant, engine of environmental improvement, linked to the emergence of comparative advantage in trade terms in the beef sector under NAFTA. There is also, however, a role for public and governmental policy in stimulating research and investment in these areas, and in monitoring key indicators of environmental health.

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Appendix

Beef Consumption for Canada and the United States

Table A-1 Beef Consumption for Canada (excluding veal) for the Period 1976-1995

Year	Animals[1] Slaughtered (thousand head)	Estimated Dressed Weight (thousands of metric tons)	Beginning Stock (thousands of metric tons)	Imports for Consumption (thousands of metric tons)	Total Supply (2+3+4) (thousands of metric tons)	Total Exports (thousands of metric tons)	Ending Stock (thousands of metric tons)	Total Domestic Disappearance (thousands of metric tons)	Total Per-caput Disappearance Retail (Kg)
1976	4,476.3	1,111.9	22.6	141.4	1,275.8	58.4	35.2	1,182.3	39.1
1977	4,374.4	1,092.1	35.2	87.0	1,214.2	50.7	25.6	1,137.9	37.1
1978	3,992.5	1,024.0	25.6	97.3	1,146.9	44.3	26.2	1,076.3	34.8
1979	3,433.8	917.8	26.2	83.1	1,027.2	51.9	27.0	948.3	29.5
1980	3,525.7	938.8	27.0	78.2	1,043.9	65.0	27.4	951.9	29.3
1981	3,691.3	978.1	27.4	78.7	1,084.2	79.2	15.7	989.3	30.0
1982	3,788.1	986.4	15.7	86.3	1,088.5	82.8	13.3	992.4	29.9
1983	3,708.8	992.7	13.3	90.7	1,096.7	82.4	17.7	996.6	29.8
1984	3,565.9	948.4	17.7	113.6	1,079.7	104.5	15.7	959.5	28.4
1985	3,603.0	985.3	15.7	113.6	1,114.6	116.5	17.6	980.5	28.8
1986	3,511.4	985.1	17.6	109.8	1,112.6	102.3	13.2	997.1	27.8
1987	3,194.5	913.0	13.2	133.6	1,059.7	88.9	11.6	959.2	26.4
1988	3,086.3	906.7	11.6	153.1	1,071.6	82.5	16.7	972.3	26.4
1989	3,121.0	908.4	16.7	158.4	1,083.6	104.0	16.4	963.1	25.7
1990	2,892.0	857.9	16.4	158.8	1,059.2	104.9	12.9	941.3	24.7
1991	2,729.1	823.7	12.9	217.4	1,054.0	105.3	15.0	933.7	24.2
1992	2,835.5	855.3	15.0	217.4	1,088.1	156.1	14.7	917.4	23.5
1993	2,686.4	822.7	14.7	265.8	1,103.1	188.0	23.8	891.8	22.5
1994	2,727.1	861.8	23.3	280.7	1,165.8	216.6	30.1	919.1	22.9
1995	2,791.8	888.1	30.1	252.2	1,170.4	215.4	25.6	929.3	22.9

[1] Excluding calves, dairy and beef breeding stock (male, female).

Source: Statistics Canada (1996). Agriculture and Agrifood Canada: Livestock Market Review, *Agriculture Division, Cat. No. 23-603-UPE.*

Table A-2 Beef Consumption for United States (1976-1993)

Year	Beef[1] Production (thousand head)	Beginning Stock (thousands of metric tons)	Imports for Consumption (metric tons)	Total Supply (2+3+4) (thousands of metric tons)	Total Exports (thousands of metric tons)	Ending Stock (thousands of metric tons)	Total Domestic Disappearance (thousands of metric tons)	Total Per-caput Disappearance Retail (kg)
1976	11,779.4	206.8	940.3	12,926.5	39.5	274.9	12,611.7	40.3
1977	11,466.4	274.9	879.5	12,620.8	44.5	186.9	12,389.9	39.2
1978	10,955.5	186.9	1,041.9	12,224.3	72.6	240.0	11,911.8	37.4
1979	9,728.2	240.0	1,090.9	11,058.6	75.8	208.2	10,775.1	33.4
1980	9,817.1	208.2	936.2	10,961.5	78.5	196.0	10,686.5	32.7
1981	10,155.5	196.0	790.6	11,142.1	980.0	152.0	10,892.1	33.0
1982	10,222.7	152.0	879.5	11,254.1	113.4	176.0	10,964.7	32.9
1983	10,542.9	176.0	895.4	11,614.2	123.4	194.6	11,296.3	33.6
1984	10,703.9	194.6	826.9	11,725.8	149.2	214.1	11,361.6	33.5
1985	10,762.9	214.1	939.4	11,916.3	108.0	190.5	11,577.1	33.9
1986	11,054.5	190.5	965.7	12,210.7	236.2	186.9	11,788.0	33.8
1987	10,689.4	186.9	1,029.2	11,905.4	274.0	175.1	11,456.4	31.6
1988	10,699.8	175.1	1,079.1	11,953.5	308.4	191.4	11,454.1	31.1
1989	10,472.1	191.4	987.9	11,651.4	464.0	152.0	11,035.9	29.7
1990	10,316.1	152.0	1,068.7	11,536.7	456.3	180.1	10,899.8	29.0
1991	10,395.0	180.1	1,091.8	11,666.7	539.3	190.1	10,937.9	28.7
1992	10,471.6	190.1	1,106.8	11,768.0	600.6	163.3	11,004.6	28.6
1993	10,454.9	163.3	1,089.1	11,707.2	578.3	240.0	10,889.0	28.0

[1] Excluding calves, dairy and beef breeding stock (male, female).

Source: Statistics Canada (1996). Agriculture and Agrifood Canada: Livestock Market Review, *Agriculture Division, Cat. No. 23-603-UPE.*