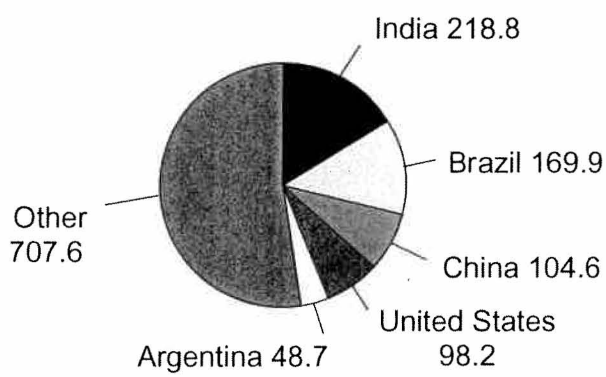
Beef *Bos* species

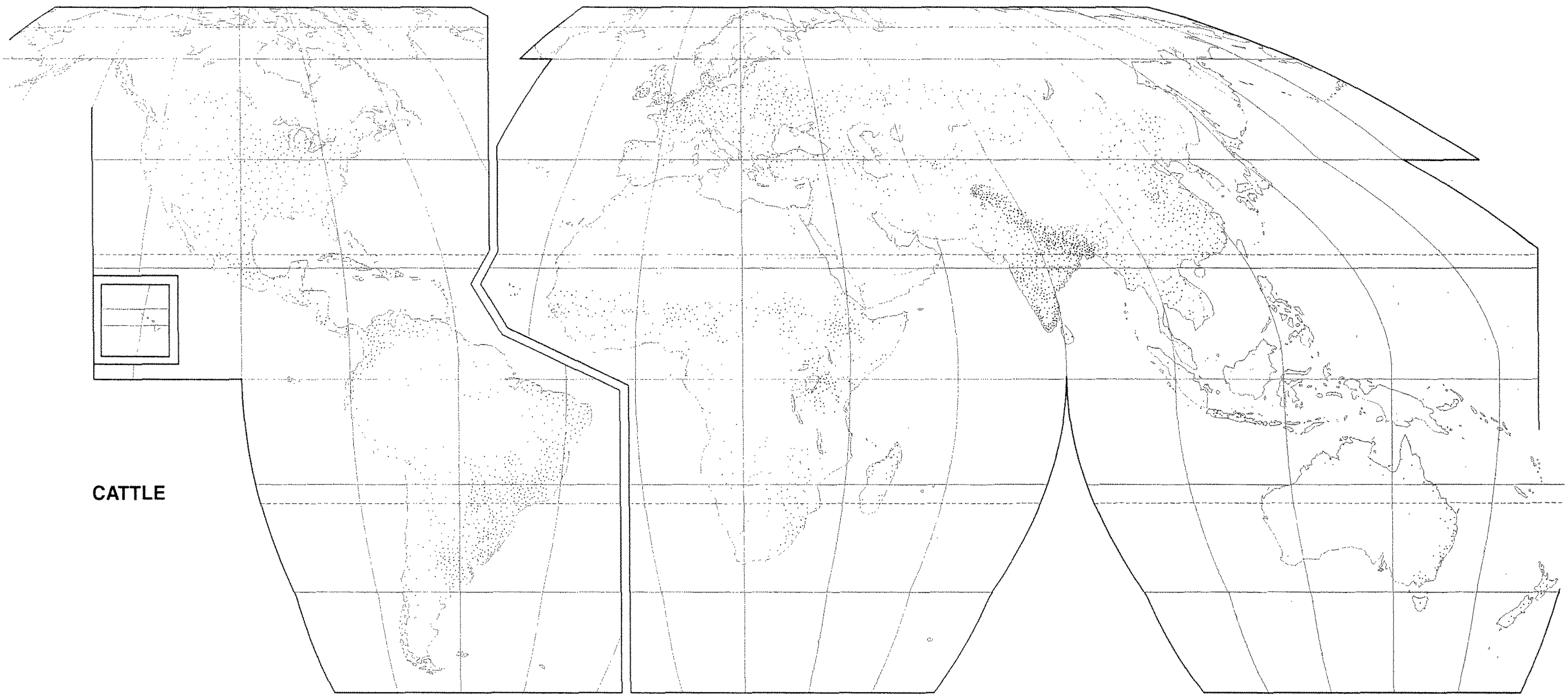
Production	
Area Under Cultivation	3,459.8 million ha
Herd	1,346.4 million
Meat	56.5 million MT
Slaughter	277.8 million
Milk	488.2 million MT
Average Productivity	21 kg/ha (meat) 203 kg/animal (carcass) 21% (slaughter/herd)
Producer Price	$1,309 per MT (meat)
Producer Value at Slaughter	$73,958 million
International Trade	
Share of World Production	23% (meat)
Exports	
Meat	13.1 million MT
Hides	2.0 million MT
Average Price	
Meat	$2,322 per MT
Hides	$1,675 per MT
Value	
Meat	$30,434 million
Hides	$3,325 million
	$59,833 million
Principal Producing Countries/Blocs (by weight)	United States, European Union, Brazil, China, Argentina, Australia, Russia, India
Principal Exporting Countries/Blocs	
Boneless	Australia, United States, New Zealand, Ireland, Canada
Bone In	Germany, France, United States, Netherlands, Ukraine
Principal Importing Countries/Blocs	
Boneless	United States, Japan, Mexico, Canada, Egypt, South Korea, Germany
Bone In	Italy, Russia, France, South Korea, United States, Greece
Major Environmental Impacts	Habitat conversion Overgrazing Feedlot pollution Production of feed grains

Potential to Improve	Good Organic guidelines exist Natural beef certification exists Grass-fed beef can reduce pressure for grain-fed beef Better practices known for some areas

Source: FAO 2002. All data for 2000.

Cattle Herd Size (Million animals)





CATTLE

Each dot represents 500,000 head

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Chapter 21

Beef

Overview

Cave paintings in France and Spain dating to 30,000 years ago show aurochs—wild cattle—and human hunters. Today's cattle are descendents of the giant aurochs, which were over two meters at the shoulder and had lyre-shaped horns.

Cattle were domesticated about 10,000 years ago in Mesopotamia, where they were both worshiped and sacrificed in religious ceremonies. World cattle breeds fall into two groups derived from two species. Cattle of the species *Bos taurus* were first yoked in Mesopotamia and used for traction to pull sleighs and wagons. *Bos indicus* was domesticated about the same time in India. The Indian cattle are better adapted to the tropics. Their genetic origins are separated from European and African cattle by more than half a million years, implying that genetic differences preexisted domestication. Today there are nearly a thousand cattle breeds, varieties, and crosses around the world, with some 270 recognized as the most important.

People have prayed to cattle as gods and have sacrificed them to gods. In fact, people prayed to cattle gods for more of history than to any other type of gods. Over the millennia cattle have provided food, clothing, fuel, and shelter. They have been beasts of burden and have plowed fields.

In India, some 200 million cows are allowed to roam freely because Hindus consider them the mothers of life. By the mid-1990s the government had created old-age homes for half a million cattle. Killing a cow in India is a crime punishable by life in prison, but that is better than the death penalty in effect until recently in Kashmir (Rifkin 1992).

Throughout history cattle have represented wealth. It is likely that cattle were one of the earliest forms of currency. In fact, through the middle of the twentieth century cattle were still used as money in parts of Africa. The word "cattle" has the same root as "chattel" and "capital." In Spain, the word for cattle also means property, and in Latin the word for money comes from the word for cattle. In Sanskrit the term for battle translates to the "desire for cattle," and a successful warlord was often referred to as a "lord of cattle" (Rifkin 1992).

The Phoenicians spread the worship of cattle throughout their colonies. They held cattle in such high regard that the first letter of their alphabet, A, was the image of a bull's head. The Minoan civilization of Crete also worshiped a bull god as did the Egyptians, Sumerians, Greeks, and even the Hebrews, who were praying to a golden calf when Moses descended from Mount Sinai.

The name for Italy, *Italia*, means "land of the cattle." In the days of the Roman Empire, the Mithraic myth of the ritual slaying of the bull attracted many Roman soldiers as followers. According to this myth, Mithra received divine guidance to kill the bull god. After he finally succeeded, a number of miracles occurred. The bull's body gave rise to all the plants and herbs that people use. The spinal cord was transformed into wheat, the staff of life, and the blood turned into the grapevine and wine. Evil, resentful of all this bounty for man, attacked the bull's testicles. In the process all of the animals on earth were created. Finally, according to the myth, the soul of the bull returned to the heavens, where it became the guardian of the herds (Rifkin 1992).

The cult of the bull god was so strong in the West that early Christians felt the need to demonize it, transforming the Mithraic bull into the new symbol of darkness. In effect, it became the devil incarnate (Rifkin 1992). In 447 A.D., the Council of Toledo wrote the first official description of the devil—"a large black monstrous apparition with horns on his head, cloven hoofs—or one cloven hoof—ass's ears, hair, claws, fiery eyes, terrible teeth, an immense phallus, and a sulphurous smell" (Rifkin 1992).

The struggle between the followers of cattle gods and the followers of other gods is mirrored in the struggle between herders and farmers, and even between East and West. About 4400 B.C. pastoralist horsemen from the Eurasian steppes first attacked and conquered Neolithic farmers in southern and Eastern Europe. After these positions were consolidated, central Europe was attacked from 3400 to 3200 B.C., and a third penetration into western Europe and Scandinavia occurred between 3000 and 2800 B.C. Beginning in the first century A.D., nomadic invasions from the east pushed through much of Europe as well as India, Persia, and the far east of China. Pastoralists were successful in these campaigns because of their speed and mobility against the people of the large grain producing areas of the Middle East and North Africa and the small village-based agriculturalists of Europe (Rifkin 1992).

In the West, pastoralists and agriculturalists have also been at odds historically over how land would be used. This conflict evolved along class lines. Elites tended to own cattle and eat meat while peasants depended on grains. As population increased, the competition grew more severe, leading to degradation of both pasture and agricultural lands. Only after plagues greatly reduced populations and labor became scarce did cattle increase to the point where meat was cheap and peasants could afford to purchase it. For the most part, however, land pressure had reached extreme proportions given the technologies of the day by the time of European colonization. The colonies not only provided an outlet for population but also a breeding ground for cattle, which, after slaughter, were salted and dried for export. After the development of the refrigerated steamer in 1878, beef could be shipped frozen. As many as 5,500 frozen carcasses of the 13 million cattle in the Pampas of Argentina were shipped to Europe in a single boat.

Today, livestock production remains an integral part of most food production systems, and its relative importance will increase if the projected increased demand for foods from animals in developing countries is to be met (Bradford 2001). What is interesting about cattle in particular is that they can transform materials that are inedible for humans into nutritious food. Thus from pasture, hay, crop residues, by-products from food and fiber processing, and waste products humans get meat, milk, and cheese in addition to leather and fertilizers such as bone meal.

The ability of cattle to serve as important nutrient recyclers clearly adds to the quantity and quality of human food supply. Feeding cattle waste products greatly reduces the cost of waste disposal, and it also reduces the environmental costs (Bradford 2001). When manure is returned to the soil, it increases the content of organic matter in the soil and reduces the need to use chemical fertilizer. This alleviates pollution and improves soil fertility.

The impact of cattle on the environment is enormous. A recent study by the World Wildlife Fund (Clay 2000) indicated that globally, cattle affect ecoregions of greater biodiversity than any other single agricultural commodity. More land is used for pasture than for any other single use. Some pasture is created from the direct conversion of natural habitat, as is the case throughout much of the Amazon. Other pasture is created only after land has been degraded by other agricultural activities.

In some instances, existing natural grasslands and open woodlands are used to pasture cattle. Where cattle have taken the place of other large ungulates, their overall impact on the ecosystem is relatively small. Only in this case is the elimination of cattle likely to yield biodiversity and ecosystem functions that are anywhere near their "original" state. In most instances, however, cattle are simply the final desperate attempt to wring a little more from an environment that has already been severely degraded. In general, research shows that the longer converted natural habitat is used for any agricultural or pastoral activities, the less likely it is ever to regenerate as anything like its original plant and animal communities.

Pasturing is not the only reason that cattle production has such a large impact on the world environment. About one third of the global cereal grain supply and protein supplements are used to feed cattle. This reduces human food supplies. On average, the ratio of the weight of grain fed to the weight of food produced is about 3:1 for meat, 2:1 for eggs, and less than 1:1 for milk (Bradford 2001). This latter ratio means that dairy cattle, for example, produce more than one unit of human food energy or protein for each unit of human-edible energy or protein in their feed. This can happen because the diet of dairy cows includes sufficient quantities of products inedible to humans (e.g. grasses, silage) that the animals convert to products that are palatable for people. In meat production, however, the amount of materials that could be utilized by people but that are fed instead to cattle (e.g. grains) is three times the weight of the final product.

The effect of animal production on human food supply depends on the species of animal, the product, the relative amounts of human-edible and human-inedible materials used as feed, the level of husbandry and management, and numerous other factors (Bradford 2001). According to Bradford, the best estimate is that feeding human-edible material to food-producing animals results in a slight reduction of total human food supply. This reduction perhaps is not as much as claimed by some who fail to recognize the quantity of inedible products that are used over the full life cycle for animals slaughtered after grain-intensive feeding operations in feedlots.

Producing Countries

According to the FAO (2002) the largest producer of cattle in the world is India, which has 218.8 million animals. Brazil is second (169.9 million), followed by China (104.6 million), the United States (98.2 million), and Argentina (48.7 million). These five countries accounted for 47.5 percent of all live cattle in 2000. These countries also accounted for 47.2 percent of all animals slaughtered and 49.4 percent of all meat produced. In the United States about 10 percent of the total cattle herd is for dairy. While all of these animals eventually end up being sold for meat, dairy operations and their environmental impacts are not the subjects of this chapter

Put another way, the total world cattle population is estimated at about 1.34 billion animals. About 33 percent are in Asia, 22 percent in South America, 15 percent in Africa, 13 percent in North and Central America, and 12 percent in Europe.

Total annual, global beef production was estimated at 56.5 million metric tons (carcass weight equivalent) in 2000 from 277.8 million animals slaughtered (FAO 2002). The major producers are the United States (37.6 million animals slaughtered), China (36.1 million animals), Brazil (31.1 million animals), the European Union (26.9 million animals), the countries of the former USSR (26.5 million animals), Argentina (12.3 million animals), Australia (8.6 million animals), and Canada (3.8 million animals). The largest net exporters of bone-in and boneless beef are Australia, the European Union, New Zealand, Brazil, and Argentina. According to UNCTAD data (1999), while the United States is one of the main exporters of beef in the world, it is, on balance, a net importer.

Consuming Countries

From the beginning of the 1970s to the middle of the 1990s meat consumption in developing countries increased by 70 million metric tons, almost triple the increase in developed countries (Delgado et al. 2001). The market value of the increases in beef and milk consumption totaled some $155 billion (in 1990 U.S.$), more than twice the market value of increased cereal consumption during the green revolution (Delgado et al. 2001).

The increases in consumption can be linked to population growth, urbanization, lower real commodity prices, and income growth. In East and Southeast Asia—where income grew at 4 to 8 percent per year from 1980 to 1998, population grew at 2 to 3 percent per year, and urbanization grew at 4 to 6 percent per year—meat consumption increased at between 4 and 8 percent per year. Such trends are expected to continue well into the millennium. If sustained over time these trends will create what has been labeled a livestock revolution, i.e. a dramatic increase in productivity *and* consumption (Delgado et al. 2001).

What is significant, too, is that the demand for livestock products is not limited to beef. In fact, the consumption of milk and milk products is much larger (in kg/person/year) and growing more quickly than the demand for meat. The consumption trends associated with the livestock revolution have implications for agriculture. Clearly, more land will be devoted to livestock use and to feed production. Much attention has focused on feed grains, but in India the increases in production of sorghum for silage for dairy animals is also quite high and increasing.

While the increased consumption of milk is mostly cow's milk, the increased consumption of meat is mostly of meats other than beef. Per-capita beef consumption is increasing in developing countries but declining in developed ones (Delgado et al. 2001). Overall, however, total beef consumption is increasing due to increased population.

Net meat imports into developing countries from developed countries are also projected to expand by a factor of ten by 2020. Beef prices are expected to fall by 4 to 7 percent, whereas milk prices are projected to fall by 12 percent during the same period (Delgado et al. 2001).

The main beef-importing countries are the United States, Japan, Russia, Mexico, Egypt, and South Korea. While large importers of beef, the European Union and Canada are both net exporters.

Production Systems

Beef production is becoming more intensive. Since 1970, the United States, for example, has fewer head of cattle and produces fewer calves each year but still produces more beef. The United States is the most efficient of the larger producers. With only 7.4 percent of the global herd, it slaughtered 13.3 percent of all animals and produced 21.6 percent of the beef in the world in 1999. However, by 1995 the average producer had to be about three times more productive to earn the same net income as in 1975 (Nations 1997), and it was estimated that less than 25 percent of beef producers made a profit ten years in a row.

Between 1970 and 2000 cattle numbers have declined by 12.6 percent in the United States, from 112,369,008 to 98,198,000 head. During the period from 1990–98, the total number of beef operations in the United States declined from 932,000 to 855,000 and those that remain became more intensive. The average herd size increased by 11 percent from 36 to 40. Texas, California, Kansas, and Arizona have 32 percent of all feedlots, but they contain 75 percent of all lots with 16,000 or more animals (Conner, Dietrich and Williams 1999).

In Argentina, too, the total herd size is declining, down 14 percent in the past ten years. This is in part due to falling prices (prices declined by one-third in 1998) and ranchers dumping animals on the market rather than to more efficient production. Meat packers and processors in that country are also in trouble. Consumption of beef has fallen by 34 percent in the country since 1980. Exports take up some of the slack (they rose 17 percent in 1998), but still they represent only 10 percent of total production. Traditionally, Argentines fed their beef only on grass on the pampas, arguing that it was leaner, tastier, and had less cholesterol. Quality issues aside, however, cattle come off the grass at only half the weight of North American animals, and the price per pound is only half as high. Many ranchers in the pampas are getting out of ranching. Since the pampas are fertile, this likely means a shift to agricultural crops that will cause more severe environmental problems than livestock (Giménez-Zapiola 1997).

To date, the expansion of beef production in developing countries has resulted primarily from a rapid increase in the number of animals rather than increased carcass weight (Delgado et al. 2001). This has resulted in a large number of animals in or near urban areas as well as in areas where land is "free" (e.g. the African Sahel). The number of animals in developing countries has increased for two reasons. First, intensification as well as the expansion of pasture areas, particularly in Latin America and Africa, has allowed herd size to increase. Second, the number of animals that are present throughout farming areas has increased as a way to recycle wastes and to make use of marginal grass areas. For the most part, these cattle represent income diversification strategies. In general, however, more intensive stocking of animals on the same land areas without other changes in management tends to degrade overall productivity and increase environmental impacts.

In 1997–98 developing countries accounted for only 36 percent of cereals used in animal feed, but they were projected to account for 47 percent by 2020 (Delgado et al. 2001). By contrast, cereal grain use in developed countries is expected to fall by 2020. Global use will continue to increase through 2020. On a per-capita basis, cereal feed use will be about 362 kilograms in developed countries in 2020 but only 71 kilograms in developing countries.

Intensive livestock feeding operations have mostly been established in countries where capital is cheap relative to land (e.g. the Netherlands and the United States). Intensive operations increase nutrient loading and other environmental problems, but the actual costs of the problems are not born by the producer (and passed to the consumer); rather, they are passed on to society at large (Delgado et al. 2001). Subsidized lending and subsidized grain production have aggravated problems that arise from feedlot operations.

A fundamental factor affecting investment patterns in the U.S. beef industry is the linkage between cattle feeding and the feed grain sector. In the United States, corn comprised more than 83 percent of feed grain fed in the last five years, with the remainder accounted for by sorghum, feed wheat, barley, and oats. Oilseed meal (e.g. soybean meal, among others) is also used as a feed ingredient (Flora 1999). About two thirds of beef cattle are fed on grains for most of their lives, so proximity to, and prices for, high-quality feed ingredients are key drivers of investment. As a consequence, feedlot operations are increasingly located near the sources of feed; likewise, slaughterhouses also tend to be located closer to the feedlots. It is more efficient (and it results in higher quality meat products) to move animals relatively short distances for slaughter, and it is cheaper to operate slaughterhouses in less populated areas than in areas that are more urban. This is due not only to the cost of land and labor but also to the costs of waste disposal and the conflicts over traffic, smells, and other factors that happen when such operations are located in more urban settings.

The trend in the more efficient feedlot operations is for buyers to buy calves by the truckload. Such buyers prefer truckloads of animals that are uniform in terms of size and genetics because for the most part, uniform animals will move through the system (e.g. growing, feeding, and marketing) more efficiently. This makes feedlot operations easier to run and more efficient, so truckloads of uniform animals are worth a higher price. In fact, a mixed truckload, if purchased at all, will often be valued at the price of the lowest-priced animals in it rather than the average, which penalizes producers who cannot create truckload lots of uniform animals. This, too, tends to encourage larger-scale production.

In 1999 in the United States there were a total of 50,000 feedlots. The largest 400 accounted for more than 65 percent of the nation's marketed fed cattle. Of these, about ninety, each with a capacity of more than 32,000 head, marketed 35 percent of fed cattle (Flora 1999).

Processing

In the developed world, typical beef calves are raised in cow/calf operations (i.e. enterprises that produce the calves that are subsequently fattened and slaughtered) on individual farms or ranches, sold to feedlots where they are fattened, and then sold to abattoirs that slaughter cattle and process the meat. Leather tanneries and other industries process the hides and other byproducts. In developing countries, by contrast, the animals are grown on farms and ranches until they reach the appropriate age or size to be sold directly to the slaughterhouse. Increasingly, though, animals are sold to pasture owners who specialize in finishing the animals, i.e. fattening them with grass or small amounts of grain for slaughter.

Processing beef begins when cattle reach the slaughterhouse. In developed countries most slaughterhouses are semi mechanized, and this makes the operations very quick and efficient. In many parts of the world, however, slaughterhouses are, in a word, gruesome. They are torturous for the animals, inefficient, and unhealthy. Such slaughterhouses are often major sources of localized, untreated pollution. Regardless of where the slaughter occurs, much processing still consists of the labor-intensive cutting up of carcasses. Meat is classified based on where on the carcass the cut came from. Entrails and other body parts are also separated and sold by type. Blood, hide, bones, etc. are sold separately and, in developed countries, are equal to the profit margin of most slaughter operations. In other words, if slaughterhouses didn't sell by-products, they would make no profit.

The meat-packing sector, to an even greater degree than the rest of the food industry, is becoming increasingly concentrated in the hands of a few companies. In 1980 in the United States, for example, four companies accounted for 41 percent of the nation's slaughtered cattle. In 2000 the top four companies (Tyson/IBP Inc., ConAgra Beef Companies, Cargill/Excell Corporation, and Farmland National Beef Packaging Co.) reportedly slaughtered 81 percent, and the single largest company slaughtered 35 percent of all feedlot cattle (USDA 2000, as cited in Hendrickson and Heffernan 2002; see also Table 1.5 in Chapter 1).

In 1997 the fourteen largest U.S. slaughtering companies, each with capacity of over 1 million head, processed 94 percent of the 192.3 million head slaughtered at federally inspected facilities. Only meat from federally inspected plants can be sold in interstate or international commerce. From 1991–1994, the number of firms slaughtering cattle fell 25 percent to 239, and twenty plants handled 58 percent of commercial slaughter.

The impact of U.S. companies extends beyond the country's borders. By 1999 two U.S.-owned plants handled more than 50 percent of all cattle slaughtered in Canada and 83 percent of all those slaughtered in Alberta (Flora 1999). While these trends were accentuated as a result of conditions established under the North American Free Trade Agreement (NAFTA), they also illustrate increased vertical integration globally that has its own economic rationale.

Slaughterhouses are equipped with cold storage to preserve the meat. A considerable amount of water is used to wash the incidental blood away. As the meat is cut up, the blood is then washed away. This water becomes effluent. Because of the blood, the effluent is loaded with organic matter. When the intestines are processed and cleaned another type of waste is generated. In some parts of the world, this waste is separated and destined for a "septic" tank where it generates methane gas, or it is applied to fields as fertilizer. Many slaughterhouses lack these types of operations, in which case fecal matter from intestines becomes part of the effluent stream. In the worst operations, this material is simply flushed into freshwater bodies, where it causes nutrient loading and consumes most of the oxygen in the water as it degrades.

In many developing countries, slaughter occurs very near the point of sale, and animals are cut up as needed or desired by the customer. In many instances the price of beef varies only depending on whether bones are included or not. Even when carcasses are shipped to other areas, they tend to be shipped as whole, half, or quarter carcasses and then are cut up at the point of sale.

In the past, processing plants were slaughterhouses. For the most part, animals were killed, skinned, and hung, usually as half or quarter carcasses. The carcasses were then shipped on to retail chains and others who cut the meat prior to sale to consumers. This is still the situation today in much of the developing world. However, in the developed world slaughterhouses have become automated meat factories (Flora 1999), which produce and pack specific cuts of beef in boxed lots. The cuts are then vacuum-packed and shipped in boxes to hotels, restaurants, institutions, and retail groceries.

In more developed countries meat tends to be processed into standard "cuts" at the slaughterhouse as a way to reduce the bulk of shipping carcasses as well as the labor costs at the point of sale. "Boxed beef," in which cuts are standardized, is sold directly from packing plants to retail operations. This allows slaughterhouses to be moved out of areas more directly linked to markets and into areas that are closer to where the animals are raised (Flora 1999). Iowa Meat Packers (IMP) began this process in 1960 and opened the first large-scale dedicated plant for boxed production in 1967.

The change in processing has had a number of implications. First, the cost of unionized labor in more established companies can be lowered by moving into rural areas. Second, less processing is undertaken in supermarkets, and thus supermarkets need to employ fewer, if any, butchers at their meat counters. Third, meat prices can be lowered because packers can shorten the supply chain and buy more directly from producers, eliminating middlemen and reducing transportation costs. In short, it has meant that processing was moved closer to the animals and, in the case of beef, closer to the sources of grain used in feedlot operations. This approach to processing has tended to encourage a clustering of intensive feedlot operations within easy transportation range of the plant to take advantage of the economics of the system.

This type of processing has eliminated more than 100 kilograms of fat, bones, and trimmings that were part of the carcass, but were of little value to the customer. Boxed meat has improved quality, provided quicker and easier merchandising, improved shelf life, saved energy costs, and reduced transportation and labor costs. Buyers can purchase only the cuts they want and only the amounts they can use. The value of meat prepared this way exceeds the costs of preparing it.

The slaughter of cattle results in a number of products and by-products, including retail cuts with or without bones (42 percent of live weight), organs (4 percent), edible fats (11 percent), blood (4 percent), inedible raw materials (17 percent), hide and hair (8 percent), and waste (4 percent) (Conner, Dietrich and Williams 1999). In the United States slaughterhouses are required to treat their waste effluent just as intensively as any other industry. Most solids are captured because they have economic value when turned into by-products. Even blood and other sludge have a market for use as fertilizer or land application (Verheijer et al. 1996, as cited in Conner, Dietrich and Williams 1999).

Product Substitutes

The main substitutes for beef are other meats (e.g. pork, chicken, or seafood), dairy products such as cheese, and vegetable-based products such as pasta and starches, which, in combination with vegetables such as beans, provide the same quality proteins that are found in meats. Globally, beef production is a close second to pork production, with 35 percent share of total meat protein. In terms of trade, beef exports are a distant second to poultry (26 percent versus 40 percent).

Much has been written about the decline in demand for red meat, particularly beef, in comparison to poultry. The consumption of poultry throughout the world has increased very rapidly during the past forty years while the consumption of beef, in developed countries at least, has remained fairly constant. Beef production relative to pork and poultry is declining for three reasons. First, the cost of production is higher than for poultry or pork. Second, cattle carcasses are large and not as easily divisible as smaller animals. Third, there is the perception that beef is not as healthy as poultry or pork. In fact, grass-fed beef has about the same amount of cholesterol as chicken.

It is quite possible that the biggest declines in beef consumption in developed countries are due to the substitution of pizza and pasta. In developing countries as incomes rise the consumption of meats (including beef) increases while the consumption of rice, wheat, cassava, and other vegetable staples declines as a portion of total caloric intake.

Wild game, buffalo, and water buffalo meat are the closest red meat substitutes for beef. Consumption of meat from game is increasing in developed countries, but only as a niche market. Unsustainable bush meat production is common in many areas of Africa and to a lesser extent in Latin America. The meat is destined for local markets, though, and the markets for bush meat decline when beef becomes more widely available. Buffalo from North America is destined for niche markets. Most water buffalo is produced on small farms in Asia, except where it is produced in large-scale operations in Brazil and Venezuela. Very little water buffalo meat is exported.

Market Chain

There has been considerable concentration of holdings within the cattle industry from ranches and cow/calf operations through feedlot systems all the way to the slaughterhouses. While much of the focus has been on the U.S. industry, this is common throughout the developed world and probably in the developing world as well, though there is far less documentation. In addition, the vertical integration of the beef industry simply reflects similar changes throughout the global food industry.

Case studies from Canada and Australia illustrate the consolidation and integration that is occurring in the beef industry. In 1987 ConAgra purchased the operations of the dominant beef processor in the northern Great Plains, Monfort. Shortly after, Cargill moved across the border into Alberta to set up a large beef slaughter system. At that time, Canadian Packers (CP) was Canada's largest manufacturer of livestock and poultry feeds, the largest cattle slaughterer, the only national poultry processor, and Ontario's largest hog slaughterer. Due to the new competition, CP began to experience difficulties and was sold to Hillsdown Holdings, Europe's largest fresh meat processor and manufacturer of value-added egg and poultry products and largest canner of fruits and vegetables. Hillsdown already owned Maple Leaf Mills, Canada's second-largest flour miller. Hillsdown Holdings then announced that Canadian Packers was getting out of the fresh beef markets. Mitsubishi has indicated it is interested in slaughter operations in Canada, but a large part of Canadian cattle still moves through ConAgra's feedlots, slaughter facilities, or both (Heffernan 1994).

At the same time as it was consolidating its operations in Canada, ConAgra purchased a half interest in Elders of Australia. Elders was the dominant beef slaughter operation in Australia and the largest exporter of beef and lamb in the world. Soon after ConAgra's move into Australia via Elders, Mitsubishi began to invest in the beef slaughter industry in Australia, and Cargill has purchased beef slaughter facilities in the country as well. Cargill currently has beef operations in Brazil, Honduras, and Mexico among others. ConAgra has trading offices in twenty-three countries, and Cargill currently operates in more than sixty. Three multinationals are moving into position to control the world beef industry (Heffernan 1994).

In the United States's meat-retailing sector, the number of grocery stores began a dramatic decline in the 1930s due primarily to the demise of small grocery stores, which were unable to compete with the larger grocery retailers such as chain supermarkets. By 1965 supermarkets were the dominant form of grocery business, accounting for 70 percent of total grocery sales. The United State's grocery store industry of the 1990s was characterized by large supermarkets representing less than 25 percent of the grocery stores but accounting for more than 75 percent of grocery sales.

It is generally thought that beef producers, like most other farmers, are price takers not price makers. They resign themselves to accept whatever prices the market has to offer. Ranch operations can be streamlined and increased in scale, and pastures improved, but beef producers who market beef conventionally still fall prey to low prices brought on by fluctuating cattle cycles, which affect herd sizes at regular intervals. Producers adopt many ways of marketing to sell beef. Direct marketing of the beef to the customers, cooperative marketing through coops, and niche markets that sell specialty meats such as organic, natural, or pasture-fed beef are some of the common marketing methods adopted by beef producers as a way to add value to their production or to avoid selling into conventional markets.

Market Trends

Between 1960 and 2000 the average consumer price of beef declined from $3.56 per kilogram to $1.92 per kilogram, or some 46 percent. Real beef prices have fallen by a third in the 1990s alone.

Demand for beef has declined in many countries in recent years, but global demand has risen due to growing demand in developing countries. Supply in Europe has declined 4 percent since 1997; likewise, Argentinean production has been declining for a decade. Global exports have started to decline as well. In China, on the other hand, production increased 8 percent in 1998 alone. Currently, growing demand from developing countries is balanced by shrinking demand in developed ones. However, as urbanization, overall population, and disposable income continue to increase, global demand for meat is predicted to rise by as much as 50 percent by 2020 (Delgado et al. 2001). Most of this growth will take place in developing countries, where beef imports are predicted to increase by 1 million metric tons by 2020.

Livestock production has been one of the main factors in stabilizing world cereal supply (Delgado et al. 2001). If the price of cereals goes down, the number of animals fed increases. If the price of cereals goes up, the number of animals fed decreases. While this would tend to reduce the amount of meat on the market and raise prices accordingly, this effect is mitigated by the culling of herds, which supplements meat supply and keeps prices down. If this relationship holds, meat will continue to be supplied without dramatic price increases. The issues then are not whether sufficient animal products and cereals will be available, but rather what impact increased production and consumption of both will have on the environment, human health, and the poor (Delgado et al. 2001).

The projected increase in animal protein consumption in developing countries by 2020 will require large net imports of cereals by developing countries, of about the same magnitude as the annual U.S. corn crop (i.e. 200 million metric tons). About half of these net imports will be corn and cereals other than rice and wheat. Net meat imports into developing countries from developed countries are also projected to expand (by a factor of ten), but from a smaller base (Delgado et al. 2001). This would amount to about 5 million metric tons per year by 2020.

These trends play out differently in different countries. Global trends, coupled with a 30 percent devaluation of the currency in Russia (the second biggest beef importer), resulted in a 25 percent decline in imports to Russia from the world's major exporters. It is doubtful that the Russian situation will turn around any time soon.

Local markets have also followed predictable historical trends, but it is not clear if these will continue with globalization. For example, in the United States, beef cattle numbers normally run on a ten-year cycle. As cattle numbers peak, prices of slaughter cattle and feeder calves decline. Reduced prices for feeder calves tend to cause more cows to be sold for meat. This increases the total meat supply and dampens overall beef prices. Reduced prices for feeder calves also tend to be linked to increased grain prices. When grain prices are high, feedlot operators (who tend to bid on calves at a rate that will give them a finished calf at about the same price as it had been historically) will purchase fewer calves, reducing demand. For the past three years, global corn production has been down and reserves are dwindling. This will tend to increase grain prices, reduce the price of calves, and force the sale of cows as ranchers cull their herds to prepare for the next upswing of the market.

In the United States the future of the cattle and beef industry will likely depend on such questions as:

1. How can the beef industry compete more effectively with other meat industries (especially chicken and pork and, increasingly, seafood) in consumer-driven markets that started in developed countries but are now spreading to less-developed countries as well?
2. How can it remain competitive and expand the sales of beef in international markets?
3. How can it produce a product that meets the concerns of health-conscious consumers while maintaining product quality and consistency?
4. How can it develop industry-wide technological and structural changes that reduce the cost of production?
5. How can it work more effectively with regulatory agencies to assure food safety, and animal disease control, and provide for the long-term integrity of the environment?

Environmental Impacts of Production

Beef production has several distinct and significant impacts on the environment. The impacts vary somewhat from one country to another and depend on the specific part of the beef production process being considered. Perhaps most important, unlike many other agricultural commodities, cattle have significant impacts on a wide range of ecosystems because they can be produced under such a variety of conditions and are literally capable of walking themselves to market.

Globally, the largest environmental impact of agriculture in general is the use of land for pasture. More pasture is used for cattle than all other domesticated animals and crops combined. In addition, cattle eat an increasing proportion of grain produced from agriculture, are one of the most significant contributors to water pollution, and are a major source of greenhouse gas emissions. Finally, processing cattle into meat, meat by-products, and leather is a major source of pollution in many countries.

Habitat Conversion or Modification

The most significant direct impacts of beef production on habitat are the conversion of forest habitat to pasture, the alteration of the composition of native plant communities in grasslands, and the wholesale removal of native vegetation (e.g. forests, scrublands, and grasslands) as habitat is converted to seeded or planted pasture. Currently two thirds of the world's agricultural land is used for maintaining livestock. One third of the world's land is suffering desertification due in large part to deforestation, overgrazing, and poor agricultural practices. An area of the world's rainforest larger than New York State is estimated to be destroyed each year to create grazing land. This not only alters the composition or existence of native plant communities, but also the species of wildlife that existed in those plant communities.

Plant communities are altered over much of the world, often as a result of direct intervention such as plowing native grassland vegetation and establishing either single-species or mixed-species pastures of introduced species. The species composition of natural grasslands is transformed by continuously overstocking native rangeland with livestock, enrichment planting (e.g. sowing seeds of introduced species in native grassland), and eliminating intentional burning.

Pasture can be created from temperate or tropical forests or savannas. This often involves converting native habitat and introducing grass and forage species that provide more food for cattle. In natural grasslands the biggest impact is the alteration of the native plant communities and the associated impacts on wildlife and other biodiversity. In addition, cattle are increasingly fed hay and grains to supply food during the dry or winter seasons, or to fatten them before slaughter. While forests have been cleared to make way for livestock throughout the world, the most significant impacts recently have been in the Amazon, where massive clearing of tropical forests has had a tremendous impact on biodiversity, ecosystem functions, and even local climate.

Maintaining desired pasture composition in created pastures often requires tillage, chemical fertilizers, and pesticides. Continuous grazing causes plants to produce more leaf biomass and less root biomass. This reduces their ability to survive during periods of stress (e.g. extended cold, hot, or dry spells). Watershed protection also suffers as plant cover and leaf litter diminishes, leaving the soil exposed and erodible. In areas where pastures are not maintained, woody plants tend to dominate over time, not only affecting ecological balance but also reducing the carrying capacity for cattle.

Another source of pasture is degraded agricultural land. In many areas, once land can no longer produce agricultural crops, it is used for livestock. Such land is already degraded. However, converting it to pasture degrades it even further, virtually ensuring that it will not return to anything near its natural state.

Cattle production can cause habitat conversion indirectly as well. In some instances cattle are a "push" factor, displacing the rural poor into fragile areas. In Central America, for example, the conversion of labor-intensive, cash-crop producing areas to cattle production caused many landless poor to move into and clear tropical forest areas for subsistence production. In a variation on this pattern, the rural poor and landless in the Amazon often clear land, grow a crop or two and then plant the land to pasture to sell to ranchers.

Cattle Feedlots

In the United States and, increasingly, in other parts of the world, cattle feeding operations present perhaps the greatest potential environmental threat of the beef industry. The reason feedlot production is of such concern is that it is one of the fastest growing beef production practices in the world. The direct impacts of cattle feeding include contributions to air pollution through methane, odors, and dust, and to pollution of surface and ground water through nutrient loading from improper handling of manure. In addition, other environmental impacts such as the use of antibiotics and growth hormones are intensified given the large concentrations of animals in a confined space.

About 1.4 billion metric tons of solid manure are produced by U.S. farm animals each year—30 times the amount produced by the human population. Put another way, U.S. animal feedlots produce 100,000 metric tons of manure per minute. This figure includes pigs and chickens as well as cattle, but even so cattle are the single largest source. In Texas 7.5 million head of cattle in feedlots consume more than 7 million metric tons of feed containing more than 150,000 metric tons of nitrogen and 25,000 metric tons of phosphorous. It would take 8,000 hectares of corn silage (or a similar crop) to absorb the manure from a feedlot with 50,000 head of cattle (Conner, Dietrich and Williams 1999). If the manure cannot be added as a soil amendment, it has to be treated and disposed of another way to avoid contaminating land or water.

Production of Feed Grains

One of the major impacts of the beef industry occurs indirectly, through the production of grain used to feed cattle. As discussed elsewhere in this book, the production of feed grains generates significant habitat conversion, soil degradation, water pollution, and other environmental impacts.

Competition for food resources (i.e. raising grain for cattle feed versus human food) is a serious concern about beef production. Globally, one third of the world's cereal harvest is fed to farm animals. While the use of feed is not broken out by type of animal, it is clear that a significant portion is used to feed cattle. In the United States, some 95 percent of soybean production (nearly 100 million metric tons per year) is used as feed. However, the U.S. beef industry utilized only about 11 percent of the U.S. corn supply in 1992.

The switch from grass to feed grain finishing results in a more consistent product, even when starting out with inferior animals or genetics. Consequently, the beef herds in the United States, for example, have shifted markedly away from genetically superior meat producers such as Angus and Hereford, which dominated United States markets in the 1950s until today, when they represent less than half all beef cattle. More and more, beef cattle are hardier species, but their meat is of inferior quality. Given that most beef is used for hamburger this is not a serious problem. These hardy animals can tolerate more heat, less water, and a wider range of less nutritious vegetation. This change in genetics of the beef cattle herd has resulted in the expansion of pasture-based beef production into harsher and more marginal, biodiversity-rich, and ecologically fragile areas.

Data from Sweden illustrate some of the trade-offs between the different beef production systems (e.g. grass-fed, grain-fed feedlot-fattened, or a combination of the two) and their overall impacts. Calves produced through intensive feedlot feeding systems can be slaughtered in twelve to thirteen months at a weight of 450–475 kilograms live weight. Fed protein-rich concentrates, such animals gain more than 1 kilogram per day and can be produced with less total feed (25 megacalories per kilogram slaughtered weight). By contrast, grass-fed beef live longer and eat more roughage (grass, hay, and silage); these animals reach 525–550 kilograms (live weight) at the time of slaughter, but this requires about 18 months. Because they take longer to reach slaughter size, their overall feed consumption is somewhat higher (35 mega calories per kilogram slaughtered weight) than that of feedlot-produced beef from feedlot production (Tengnäs and Nilsson 2002). The feed for grass-fed animals is cheaper, more locally produced roughage. However, grass-fed animals also require more land area for their production, even taking into account the land used for cereal production with more intensely fed beef. From an environmental point of view, the overall impacts depend on how the range is managed and how fragile and biodiverse it is to start with, versus how cereal production is managed and how the waste issue in feedlots is addressed.

Use of Antibiotics and Growth Hormones

Antibiotics and growth hormones are increasingly used in feedlots. Antibiotics are used in feed and water as well as in injections, vitamins, vaccinations, and parasite controls. Antibiotics are generally administered for ninety days or more in feedlots in the United States. Animals arriving to feedlots are given antibiotics in their water for eight days or so. In the United States, less than 20 percent of all animals in feedlots were given antibiotic injections, but about 60 percent received vitamin injections. Most cattle in U.S. feedlots are given growth hormones to increase their weight gain.

In short, there is significant use of antibiotics, vaccinations, growth hormones, and vitamins in the beef industry without sufficient understanding of their overall impacts. It is well known, however, that the prophylactic use of antibiotics can lead to bacterial resistance in the animals and in the environment, and that this resistance can even be passed on to bacteria that infect humans. Similarly, the effects of growth hormones in the production of meat can be passed on to people who consume the meat. Unfortunately, virtually no research has been undertaken on the impact of these inputs on the wider environment, either in the vicinity of feedlots or in areas where waste from feedlots or slaughterhouses is disposed.

Water Use and Quality

Dr. Jim Oltjen of the University of California at Davis and Dr. Jon Beckett, formerly of UC Davis, found that, including direct consumption, irrigation of pastures, and crops and carcass processing, it can take as much as 3,682 liters of water to produce 1 kilogram (2.2 pounds) of boneless beef in the United States. Given impending water shortages in many parts of the world, the price of water is likely to increase. This will either result in more expensive meat or, more likely, encourage more efficient use of water.

In addition to total water use, there is increasing concern about water pollution, especially the harmful effects on surface water and groundwater quality of pesticides used to maintain or improve pasture areas or to increase feed grain production. In addition to contaminating waterways, groundwater, and even marine environments, those who use pesticides and live in rural areas tend to contaminate not only the water supplies of their own livestock operations and those of their neighbors, but also their own water supplies. Most people living on farms in the United States cannot safely drink their own well water.

Soil Loss and Degradation

Livestock farming is one of the main activities responsible for soil erosion around the world. In 1994, for example, soil loss in Brazil's Alto Taquari watershed was estimated at 70.39 metric tons per hectare per year, which is a high erosion rate. The degree of erosion increases proportionally to the increase in deforestation in the basin. From 1977 to 1991 a 50-percent increase in habitat conversion was recorded. This has led to extensive degradation of the flooded valley-bottom vegetation. Pasture establishment results in the exposure of soil to the elements for several months, often during the rainy season. So while pasture itself may not result in as high soil erosion rates as annual agricultural crop production, the initial conversion to pasture can lead to extreme erosion with loss of topsoil and organic matter that could take decades or centuries to replace.

Overgrazing damages soil structure and causes erosion. In many parts of the world, larger herds of cattle are being kept on ever-smaller amounts of land, for longer periods of time. Overgrazing is a particular problem on slopes, where soils are more easily eroded and some grasses are crushed by the animals' hooves. This is the case in many parts of the world where hillsides covered with cattle show the contoured signs of erosion and soil displacement. Overgrazing also thins and eventually removes ground cover so that the impact of wind and rain erosion increases.

Another cause of soil degradation and erosion from cattle is their repeated trampling over the same areas. The result is compaction or "soil pugging" due to the impact of cattle hooves. Soil compaction can destroy soil structure and results in resistance to root penetration, reduced water infiltration, and reduced aeration. All of these impacts harm beneficial soil microorganisms. Compaction is considered to be inevitable with cattle production. However, the severity varies with the soil type, and is worst on wet soil that has a high clay content. Severe compaction provides a site for surface runoff that can result in serious erosion and even the creation of deep trenches, a process called gullying.

An additional environmental problem resulting from soil erosion is the intense degradation of surface waters. For example, some 80 percent of the cleared areas of the Brazilian Amazon and the cerrado (the savanna and forest-covered tableland that lies between the coastal forest zone and the Amazon) have been converted to pasture. Creation of these pastures has resulted in the increased siltation of streams and rivers.

Greenhouse Gas Emissions

Beef production has a considerable effect on global warming due to the emission of greenhouse gases such as methane, nitrous oxide, and carbon dioxide. Methane is released from the cow's rumen and manure. Nitrous oxide is released from the soil by the microbial decomposition of manure and artificial fertilizers. Carbon dioxide is released by direct energy consumption through mechanized feed crop production and the herding and movement of animals (the average beef calf sees more of the U.S. than the average cattle farmer).

Globally, ruminant livestock produce about 80 million metric tons of methane annually, accounting for about 22 percent of global methane emissions from human-related activities. Cattle in the United States emit about 6 million metric tons of methane per year into the atmosphere. The cow/calf sector is the largest emitter of methane within the U.S. beef industry. It accounts for 54 percent of the total methane emissions from cattle, while the feedlots and stocker calves account for 21 percent, and dairy accounts for 25 percent.

While cattle release huge quantities of methane into the environment, it is not clear that they produce more methane than similar wild animal populations did 200 years ago. Globally, however, as the number of cattle increases, it could well exceed historical levels of methane emitted by wild animals.

Impacts of Slaughter and Tanning Industries

The expansion of the global cattle industry has been paralleled by the vigorous growth of the beef slaughter and leather industries. The waste from both slaughterhouses and tanneries is rich in organic matter and hence poses serious public health concerns if discharged into the environment without appropriate treatment.

In the United States more than 20,000 cattle hides are tanned per day. Some 23.5 percent of these are processed with vegetable tannins. The remainder is tanned with chromium, a pollutant categorized as a heavy metal. Though tanneries in the United States are also required to treat their effluent before it is discharged (Conner, Dietrich and Williams 1999), tannery effluents in may parts of the world are high in chromium and biological oxygen demand (BOD) levels. Chromium contamination of the water sources of the surrounding areas harms both humans and wildlife.

Better Management Practices

There are a number of ways to reduce the environmental impacts of beef production. As with most operations, perhaps the key to reducing subsequent impacts is to site and construct operations well. Once built, however, there are still a number of management practices that can reduce environmental damage. These include maintaining vegetative cover, avoiding overgrazing, protecting riparian areas, reducing waste and disposing of waste in the least harmful ways, reducing the use of chemicals and antibiotics, reducing wastewater and improving water effluent quality, and reducing soil compaction.

There are several specific ways to address many of these issues. However, some of the important, more general approaches include aligning production needs with natural processes, improving the feed conversion of animals from any feed source, producing and marketing cattle with more meat and less fat, and integrating beef production with other activities to increase overall carrying capacity and productivity.

Site and Construct Operations Well

Where producers locate their operations is often the single largest factor that contributes to subsequent environmental impacts. Most nonpoint source pollution problems occur in the vicinity of watering and supplemental feeding and along fences or resting areas where cattle tend to congregate. Such concentrations can reduce vegetative cover and can compact the soil so that erosion is more likely and water percolation is diminished (Florida Cattlemen's Association 1999). There are several ways to manage the placement of such activities so as to reduce their impacts. For example, placing supplemental feeding and mineral stations a reasonable distance (30 meters) away from stormwater drains, streams, drainage canals, ponds, lakes, wetlands, wells, and sinkholes can prevent such problems. The development of alternative water sources can also attract animals away from streams, drainage canals, and lakes (Florida Cattlemen's Association 1999).

Leaving or planting small, scattered clusters of trees in upland areas of pastures can provide shade and keep cattle away from water sources as a way to keep cool. In general, feeding stations, portable water troughs, and shade structures should be moved periodically to prevent waste accumulation, loss of cover, and compaction of soil.

In some cases it is impossible to locate facilities outside of sensitive areas. In those cases, other techniques should be employed to help keep sediment, nutrients, and organic matter out of surface waters. Biological filters (biofilters) of marshes, ponds, or other natural or constructed wetlands can assimilate many nutrients and sediments. In some cases it will be necessary to reestablish natural flow patterns, plug drainage canals, or divert water to recreate the natural hydrology of an area to take advantage of bioremediation options.

Locations for any temporary holding areas should also be carefully planned, as they have the potential to concentrate large amounts of pollution. Cow pens and other temporary holding areas should be located more than 60 meters (200 feet) away from waterways and water sources to prevent runoff and contamination. For existing holding areas that cannot be moved and that are located near water bodies, filter strips, sediment traps, grass planting in seasonal waterways, retention and detention ponds, and planting or berms can minimize the transport of pollutants to water bodies.

Cattle are not the only causes of soil erosion or water quality problems in beef production systems, however. Human activities such as land clearing; culvert installation; road, ditch, and canal construction and maintenance; pasture renovation; and cultivation of forage crops can all expose soil and contribute to nutrient loading. Planting cover crops immediately after removing vegetation for infrastructure development should be standard practice. Strips of grass should be maintained along drains and ditches. The number of vehicle and animal crossings of streams and canals should be minimized. To discourage erosion, vegetation should not be cut too short near waterways and clippings should be kept from waterways.

Cow/calf operations are generally low-intensity forms of agricultural production with relatively low levels of pollutants discharged off the farms. Cow/calf operations may contribute to elevated levels of phosphorus, nitrogen, sediment, bacteria, and biological oxygen demand (BOD) in surface waters, though at much lower levels than feedlot operations. Manure from cow/calf operations can also contribute to water quality problems both from runoff and direct contamination (Florida Cattlemen's Association 1999).

The potential for discharges from cow/calf operations to cause water quality violations varies greatly, depending on soil type, slope, drainage features, stocking rate, nutrient management, pest management, or activities in wetlands. In general, areas where cattle tend to congregate or have access to water bodies have the greatest potential for pollution (Florida Cattlemen's Association 1999). Proper siting of these operations is the best way to maintain water quality. By contrast, low-density grazing on native range has the lowest pollution potential. There are better practices that minimize water quality concerns, but it will also probably be necessary to work with a number of ranches in a watershed to address cumulative impacts rather than working one ranch at a time.

Cattle can cause significant compaction of soils. One way to reduce this problem is to use mobile water, feeding, or mineral supplement locations. Rotating pasture use is also a way to avoid prolonged impacts. Some ranchers use moveable fences or herders to keep herds from compacting soils in key areas. Finally, some heavier, clay soils are more subject to compaction; if pastures are located on such soils, every effort should be made to move cattle onto lighter soil when heavy rain is likely.

Avoid Overgrazing

There are several ways to control grazing so as to mitigate environmental impacts. Controlled grazing or management-intensive grazing (MIG, also known as rotational grazing) can be adopted to check unlimited access of animals to pastures and also to manage the grazing land effectively. Sustainable pasture management practices, which include a balance of matching forage and livestock resources, resource management, proper breed selection, and looking for alternative feeds, can all help to reduce the deleterious effects of overgrazing.

Properly managed grazing can have some benefits. Cattle manure fertilizes pastures. In addition, grazing can encourage regrowth and prevent the spread of noxious weeds. In South Africa ranchers have found that native grasses germinate best in corridors where cattle have trampled the most. Ranchers have found that cattle hooves break up ground that left alone would be too hard for seeds to penetrate and find a place to germinate. Ranchers using this system have been able to double the carrying capacity of their pastures. Also they have a higher percentage of perennial grasses (which produce more biomass) as ground cover than land ranched conventionally (Spark 1994).

Properly managed grazing maintains healthy vegetation, which helps to filter pollutants from runoff, reduce runoff velocity, and control soil erosion. Management practices that help to maintain vegetative cover involve distributing cattle so that they do not overgraze portions of pasture and allowing for recovery of the vegetation following a grazing period. Using prescribed or rotational grazing systems can minimize the impact of grazing. Adjusting the stocking rate seasonally, particularly in sensitive watershed areas, can also reduce the impacts.

Protect Riparian Areas

Cattle ranchers need to protect the natural vegetation near streams from prolonged cattle grazing, as this vegetation keeps stream banks from eroding and prevents nutrients from entering and polluting streams. This can be done through fencing, creating alternative watering locations, building bridges over streams, and in general more closely monitoring pasture management. Sustainable resource management of riparian zones pays off in long-term environmental gains, reduced expenditures to repair stream-related infrastructure, and overall economic gains.

Improve Assimilation of Feeds

Cattle that produce less waste because they have an enhanced capacity to assimilate feed should be encouraged as part of an overall conservation strategy. There are at least two ways to address this issue. One way to is to identify microorganisms that break down feed more completely into amino acids and other nutrients that are more easily digested and utilized by cattle. Another way is to use breeding programs to create animals that have an improved capacity to assimilate feed, or plants that are more easily digested and assimilated by the animals. With better assimilation of feed, less land would be needed for the production of grains and for pastures.

Growth hormones that are injected in animals directly or put into feeds to stimulate rapid growth cause the animals to feed more and therefore grow faster. They do not, however, reduce total feed used. Another, perhaps more effective, strategy would be to use microorganisms to ferment the feed prior to feeding so that it can be utilized better by animals. This could potentially result in the same weight gain without the use of growth hormones. The fact that many markets are rejecting beef produced with hormones could be an added incentive to adopt better practices. In addition to a savings on feed from greater assimilation and a reduction in grain production areas, this system could result in a reduction in polluting wastes and the elimination of growth hormones.

Improve Waste Management

Water carries natural and chemical pollutants off of cattle production sites. While it is often in producers' interests to reduce waste and to manage it better, it is clear that nonpoint source pollution must be monitored and regulated. In many parts of the world, animal operations are the largest sources of pollution. As a consequence, development and implementation of strict environmental laws and regulations to monitor and check improper discharge of the wastes from animal feedlots, barns, slaughterhouses, and tanneries will be an important factor in reducing pollution from animal operations.

Regulations could begin by stipulating the size and the geographic distribution of feedlots based on the overall carrying capacity of a watershed or ecoregion to absorb the nutrients in feedlot waste. The most useful regulations would also encourage the development of technology for manure treatment, use, and disposal. Waste can be managed better in areas where animals are concentrated, e.g. barns and feedlot operations. All livestock holdings should be properly equipped with wastewater treatment equipment. Regulations could also be improved and tightened with regard to the creation and treatment of wastes from slaughterhouses and tanneries. Of course, even the best environmental regulations and policies are worth very little if they are not enforced.

In addition to regulations, there are a number of practices that producers can adopt to reduce both total volume and nutrient concentration of the runoff from their operations. The better practice guidelines prepared by the Florida Cattlemen's Association (1999) and the Queensland Dairy Farming Environmental Code of Practice (QDPI 2001) could be adapted for other cattle-rearing regions. They both cover farm planning and site selection; effluent collection, storage, and utilization; on-farm carcass and rubbish disposal; riparian land management; fertilizers; and soil protection.

Some specific examples of better practices include reducing the amount of water leaving a property or delaying the evacuation time to reduce off-site water quality impacts. Increased drainage also increases nutrient losses. By preventing overdrainage (e.g. the drainage of wetlands, the use of drainage tiles, or the reduction of organic matter in soil which reduces water retention), the production of off-site effluent can be reduced. Maintaining or increasing organic matter provides material to absorb water and to retain nutrients in effluent so that there is less overall runoff, the nutrient load of runoff is reduced, and runoff is spread over a longer period so that the impact at any one time is less. Structures, such as culverts or ponds, and dense vegetation can also reduce outflow of nutrients. Sediment and vegetation that is cleaned from ditches and watercourse edges should be moved back well away from the water so that it will not pollute the water again. The creation of ponds is also a way to keep cattle out of natural wetland systems. Ponds can hold the nutrients and sediment until they settle and thus pose little threat to freshwater systems (Florida Cattlemen's Association 1999).

Bio-remediation and the use of microbial inoculants such as effective microorganisms can reduce foul odors, eliminate flies, and facilitate the breakdown of manure. Regularly spraying the floors of enclosures where cattle are confined with effective microorganisms can eliminate odor problems by facilitating fermentation. Methane and ammonia cause the foul odors that are given off by manure. Effective microorganisms reduce production of these compounds because they are used by the microorganisms to generate amino acids and other organic substances that enrich the manure and enhance its value as fertilizer. Fermented cattle manure also does not have any substances that attract flies. Ground-water pollution due to the overload of nitrates can also be avoided because effective microorganisms can convert nitrates to amino acids, which are used in their biological processes. Amino acids dissolved in water are a major improvement in the quality of water, at least when compared to raw manure and urine.

The large volume of manure from cattle can be used to produce biogas. In many parts of the world, only a couple of head of cattle can provide most on-farm gas and heating needs far more cheaply than buying gas. With herds of 100 or more animals, it might be possible to generate sufficient gas to sell locally. This practice would reduce disposal costs and would also be a good source of on-farm energy. Biogas systems also generate end-of-the-pipe, nutrient-rich effluents that can be easily captured and used to produce integrated systems of vegetables, fish, and ducks.

Align Production Needs with Natural Processes

Changes in management can allow ranchers to take advantage of free, natural, seasonal availability of nutrients. Such strategies can also reduce the overall costs of trying to maintain production throughout the year or at times when it is not in parallel with the productivity of the natural ecosystem. Management changes can involve animal genetics, calf timing, or animals' needs for lactation or weight gain being timed to coincide with peak pasture productivity.

One way to manage natural resources and cattle production better is to align nutritional needs with natural processes through genetics. Whether for meat or milk, improved genetics can more closely align animal needs with the productivity of the environment. Some breeds gain more weight on grass; if producers want to move into grass-finished beef, they need to concentrate on the genetics of the breeds they use. If producers are going to avoid feedlot fattening operations and still produce choice carcasses, they will have to choose early-maturing breeds that can fatten on grass. Optimally, grass-fed beef should be slaughtered before their second winter. This means that late-maturing, "lean," continental or European breeds do not fit a grass-based system as well as early-maturing "fat" breeds like Angus.

Seasonal productivity can also help to increase income and reduce environmental impacts. Avoiding breeding during the hottest months of the year increases conception rates by 15 to 20 percent. In temperate regions, late spring and summer calving in combination with earlier weaning reduces feed requirements because it allows cows to winter largely from their own body reserves and dry grass. In many areas, late calving provides the best fit between the cattle's nutritional requirements over their production cycle and the ranch's naturally produced forage. One ranch in the United States was able to decrease its total cost per pound of calf from over $.90 to $.62. This was accomplished by understanding better the amount of forage available throughout the year, and the real costs of changing that by producing or buying forage out of season. Through this approach, the ranch was able to increase beef production while reducing overall costs.

Quality Assured Beef, a European eco-label for beef, has guidelines that encourage a closer alignment of beef production with natural processes. It requires grazing in the summer, limits total grain consumption to 250 kilograms during the life of the animal, and prohibits use of hormones, implants, or artificial growth stimulants.

Reduce Use of Chemicals and Antibiotics

Many feedlot operations use antibiotics routinely. This happens both when animals are first introduced to feedlot operations as well as at various times throughout the feeding operation. Prophylactic use of such medicines should be prohibited. Not only do they tend to reduce resistance in the animals treated, they can also have a more widespread impact on organisms in the environment.

The use and cost of medications can be reduced with improved overall management. Emphasis should be shifted to preventing diseases rather than curing them. Close observation is the key. Some of the better practices are quite simple. For example, people have significant impacts on the stress and well-being of cattle. If employees come to feedlots in a highly stressed frame of mind, it is better to send them home rather than have their mood affect the animals. Fast movement also stresses animals and should be avoided.

One operation in Canada found that adopting these simple practices in feedlot operations reduced the death rate to less than 1 percent. In addition, the drug bill for the feedlot fell from $20,000 per month to less than $200 (Nations 1997). Finally, the drugs used were more effective as vaccines are less effective with stressed animals or when overused.

Produce Cattle with Less Fat and Leaner Meat

The advent of feed grains in the cattle industry coincided with a growth in the market demand for marbled qualities of fat-laced meat. This demand has declined, at least in some areas, and there is now a shift to less fatty meats. Fewer carbohydrates in the diets of cattle make them less prone to developing fatty meats. This means that feed that has less corn and soybeans and more fibrous and woody materials is preferred. Thus, grasses, canes, and other materials rich in fibers but lower in starches can be increased in the feed. This will tend to result in corresponding changes in land used to produce feeds. Many of these materials can be produced on the farm. This is better for wildlife and wildlife habitat for two reasons. It reduces the pressure for greater areas to be converted to grain production to feed beef cattle, and it increases the amount of pasture areas seeded with more fibrous or woody year-round grazing plants. Such plants not only reduce soil erosion, they are also better sources of food and habitat for wildlife.

Finally, in addition to dietary changes, exercise is key to health and appetite. Exercise promotes more muscled meat as well as healthier animals that get sick less often and require fewer antibiotics, but animals should be worked slowly and quietly. Crews should use hand signals rather than talking loudly or shouting. Increasing the area of feedlots and rotating feeding in different parts encourages exercise and produces healthier animals. Many of these principles are difficult with a greater number of animals, however.

Encourage Integrated Farms with Higher Carrying Capacity

Integrated farms are those that produce multiple products that are related to each other. In some cases, integrated farm management allows farmers to turn waste into products that can be sold or substituted for inputs that would otherwise be purchased. In other instances, integrated farming allows producers to add value to a product rather than selling it as a raw material (e.g. feeding corn to animals). Finally, integrated farming practices allow producers to generate income from marginal areas (e.g. carry animals on marginal land during crop season and then allow them to graze stubble after harvest) or to reduce environmental impacts and increase productivity (e.g. build ponds to provide water for animals or fish for farmers).

More than anything, integrated farms are about waste management and efficient input use. An integrated farm is more likely to recycle waste products and minimize costs. Effluents are not discharged into streams. For example, effluents that are rich in organic matter can be pumped onto pastures as nutrients. Such integration can happen when management programs are in place to decontaminate wastewater by cleaning it. Revitalized pastures allow the cattle to enjoy grazing and chewing, activities they evolved to do. Such grazing may well be a key to maintaining the health of the animals.

Crop rotation also improves overall productivity. In Argentina and Brazil, for example, it is increasingly common for producers to have five to seven years of pasture production followed by three to five years in grain. Ironically, with no-till cultivation of crops, it is during the period of crop cultivation that organic matter is built up. This increases grain yields and minimizes weed and insect problems, but later it also improves pasture production during the rotation. This kind of rotation has two key advantages. First, it reduces the use of fertilizer, herbicides, and insecticides. Second, it allows producers to rehabilitate degraded land so that they can actually make more money from increasing the value of the land than they can from increasing their overall crop or beef production.

To date, integrated farms, by definition, have been about the management of resources on a single operation. However, integrated farming can take place at the landscape level as well. This would allow wastes and resources to be used more efficiently while also allowing farmers to specialize to achieve sufficient scale in areas where they have a comparative advantage over their neighbors so that they can compete in larger markets. Unless single operations are going to buy out all their neighbors, then scaling up integrated farming to the landscape level will require much better information management as well as waste and product flow systems.

Improve Pasture Management and Rotations

There are indications that improved pastures and pasture management can reduce the amount of open pastureland devoted to cattle. There is the possibility of increasing the current global carrying capacity of 1.5 head of cattle per hectare to as much as 10 head per hectare with improved pasture management and better feeding regimes. The strategy of semistabled, semigrazing projects in small farms has indicated that carrying capacities of 10 cattle per hectare can be achieved. Integrated systems of grazing and feeding and the use of wastewater for pasture fertilization improve the palatability and feed quality of pasture crops. With more efficient carrying capacities, former pasture areas can be liberated for other crops or for other uses entirely, including habitat restoration.

In addition, more and more farms are finding that different animals (e.g. sheep, goats, pigs, chickens, and rabbits) will eat different parts of the pasture, so sequential rotation patterns not only improve pasture over time, they allow farmers to better utilize the full economic returns from pastures.

Protect or Improve Water Quality

Improved control of input use and efficiency can minimize off-site discharge of pollutants and therefore improve water quality. Pollutants come from manure, organic matter, fertilizers, sludge application, pesticides, chemicals, and fuels. If these materials are properly stored, applied, and disposed of, there is less chance that they will become part of runoff. The development of nutrient management plans can reduce the nutrient loading in runoff. Nutrient tests that allow producers to determine the most appropriate timing and rates for application of fertilizers can reduce use of these inputs, which can reduce expenditures for inputs in addition to reducing the nutrient content of runoff. Fertilizers and pesticides should not be applied near water bodies and drainage ditches or prior to forecasted heavy rainfall (Florida Cattlemen's Association 1999).

An important strategy to reduce impacts from pesticide use on pastures is for producers to be able to compare overall pesticide toxicity. Information is not generally available to producers that would allow them to select pesticides that are less toxic and less likely to have negative impacts on water quality. In addition, information about which pesticides are better suited to solving which problems with which associated risks would allow producers to make more informed decisions about how to reduce the overall impact of pesticide use. Some of the most important factors to consider when selecting pesticides include the soil properties of the site in question, the mobility and persistence of pesticides, and the toxicity of pesticides to humans, wildlife, and aquatic species. The selection of the proper pesticides will decrease chances of adversely affecting surface and groundwater quality. For example, certain combinations of soil and pesticide properties (along with weather conditions) can pose a significant potential hazard to water quality (Hornsby et al. 1998).

Outlook

There is every indication that in the long term the global production of beef will increase. This will be driven primarily by increases in consumption in developing countries. There are also indications that consumption in developed countries will continue to decline, while production there will remain relatively stable due to an increased volume of exports to developing countries. Production in developed countries will be achieved with ever-smaller herd sizes due to improved overall management of herds and inputs.

There are two outstanding issues that could have considerable effects on beef production globally and ultimately on its environmental impacts. The first is changes in production and marketing subsidies in developed countries, either direct subsidies for beef or indirect subsidies for feed grain or pasture inputs. The elimination of such subsidies could encourage a rapid increase in the production of beef for export in developing countries. The second major issue that would affect global beef consumption is a dramatic change in the global economy. A depression would reduce overall consumption and trade of beef; economic growth in developing countries, particularly in China, would stimulate demand for beef.

If current trends continue, beef consumption will gradually continue to increase globally, with most increases coming in developing countries where consumers will prefer the cheapest products possible. Such demand will be met with inefficient production from inferior animals. And while there may be some instances of increases in herd efficiency, by and large production increases will be based on increased herd size, at least in the short term. Such increases in total numbers of animals will have increased impacts on the global environment, particularly in more marginal areas of developing countries where cattle farming will be considered a productive economic activity regardless of its environmental impacts.

Resources

Web Resources

www.beef.org/beef_handbook/
attra.ncat.org/attra-pub/beefprod.html
www.ers.usda.gov/briefing/cattle
www.agric.nsw.gov.au/reader2910

Additional resources can be obtained by searching on "cattle" on the WWF International Intranet:
http://intranet.panda.org/documents/index.cfm

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References

Conner, J. R., R. A. Dietrich, and G. W. Williams. 1999. *The U.S. cattle and beef industry and the environment.* A report to the World Wildlife Fund. Washington, D.C. May. Report CI-1-99. College Station, TX: Texas Agricultural Market Research Center.

Delgado, C., M. Rosegrant, and S. Meijer. 2001. *Livestock to 2020: The revolution continues.* Paper presented at the International Agricultural Trade Research Consortium (IATRC). Auckland, New Zealand. January 18–19.

Fang, L. 2000. *Environmental effects of the beef industry.* Agricultural and Natural Resource Economics Discussion Paper 4/00. St. Lucia, Australia: University of Queensland. Available at http://www.nrsm.uq.edu.au/agecon/pub/pub/discussion/2000/ANREDP400.pdf.

FAO (Food and Agriculture Organization of the United Nations). 2002. *FAOSTAT statistics database.* Rome: UN Food and Agriculture Organization. Available at http://apps.fao.org.

Flora, C. B. 1999. *The industrial ecology of beef production in the U.S.* A report to the World Wildlife Fund-U.S. Ames, IA: Iowa State University.

Florida Cattlemen's Association. 1999. *Water quality best management practices for cow/calf operations in Florida.* Kissimmee, FL: Florida Cattlemen's Association. June.

Giménez-Zapiola, M. Views on USA graziers from an Argentine colleague. *Grass Farmer.* 54(12) December. Jackson, MS: Mississippi Valley Publishing Corporation.

Heffernan, W. D. 1994. Agricultural profits: Who gets them now, and who will in the future? Paper presented at the Fourth Annual Conference on Sustainable Agriculture. Iowa State University, Ames, Iowa. August 4.

Hendrickson, M. and W. Heffernan. 2002. *Concentration of agricultural markets table.* February. Department of Rural Sociology. Colombia, MO: University of Missouri. Available at http://www.foodcircles.missouri.edu/consol.htm.

Hornsby, A. G., T. M. Buttler, D. L. Colvin, F. A. Johnson, R. A. Dunn, and T. A. Kucharek. 1998. *Managing pesticides for pasture production and water quality protection.* Gainesville, FL: University of Florida and the Institute of Food and Agricultural Sciences for the Pp(UF/IFAS). Available at http://edis.ifas.ufl.edu/SS032.

National Cattlemen's Association. 1997. The beef handbook: Environment. Available at http://www.beef.org/beef_handbook.

Nations, A. 1997. Allan's observations. *Grass Farmer.* 54(2) February. Jackson, MS: Mississippi Valley Publishing Corporation.

Oltjen, J. W., and J. L. Beckett. 1993. Estimation of the water requirement for beef production in the United States. *Journal of Animal Science* 71: 818–826.

Phetteplace, H. W., D. E. Johnson, G. M. Ward, and A.Seidl. 1999. *Greenhouse gas emissions and the beef industry.* Beef program report. Department of Animal Sciences. Fort Collins, CO: Colorado State University.

QDPI (Queensland Department of Primary Industries). 2001. *Queensland dairy farming environmental code of practice.* Queensland, Australia: QDPI.

Rifkin J. 1992. *Beyond beef: The rise and fall of the cattle culture*. New York: Penguin Books USA Inc.

Runge, C. F. 1994. *The livestock sector and the environment: Basic issues and implications for trade.* Rome: UN Food and Agriculture Organization. July 7.

Simmonds, G. n.d. Matching cattle nutrient requirements to a ranch's forage resource, or Why we calve late. Desert Land and Livestock.

Spark, D. 1994. Using cattle to repair the land. *Financial Times*. London. November 4. Page 40.

Tengnäs, B. and B. R. Nilsson. 2002. Soya bean: Where does it come from and what are its uses? A report prepared for WWF Sweden.

Turner, J. 1999. Factory farming and the environment. A report for Compassion in World Farming. Hampshire, England: Compassion in World Farming Ltd. 53 pages.

UNCTAD (United Nations Conference on Trade and Development). 1999. *World commodity survey, 1999–2000.* Geneva, Switzerland: UNCTAD.

USDA (U.S. Department of Agriculture). 2000. *Assessment of the cattle and hog industries.* Washington, D.C.: U.S. Department of Agriculture.