AGRICULTURE

# Losing the Links Between Livestock and Land

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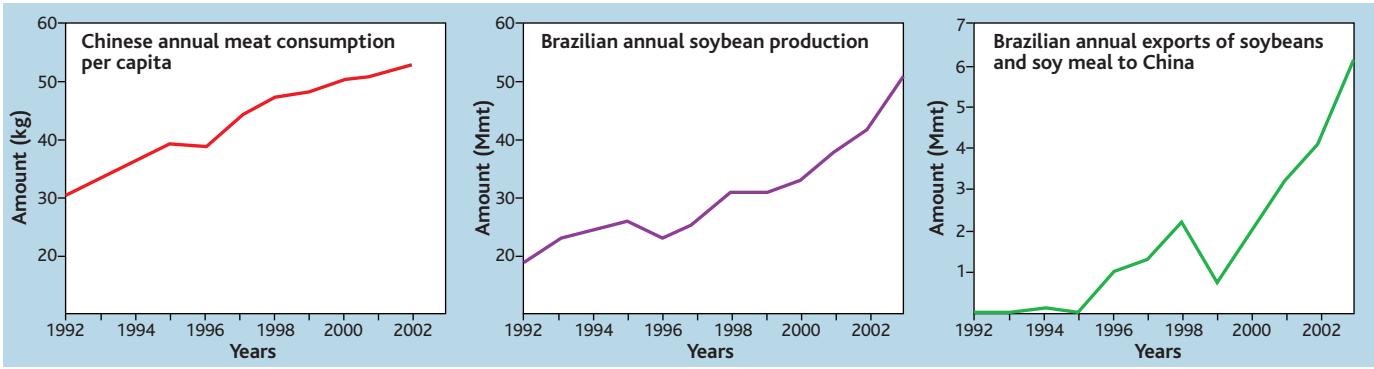
The industrial livestock sector has become footloose—no longer tied to a local land base for feed inputs or to supply animal power or manure for crop production. Spatially clustered within and among countries, this sector is expected to meet most of the income-driven doubling in meat demand forecast for developing countries by 2030 (*1*). Large-scale, intensive operations, in which animals are raised in confinement, already account for three-quarters of the world's poultry supply, 40% of its pork, and over two-thirds of all eggs (*2*). International trade in meat is also expanding; during the past 15 years, annual trade volumes have increased by 5.5% for pork and 8% for poultry (*3*). Livestock remains the world's largest user of land, but its use has shifted steadily from grazing to the consumption of feed crops. Unfortunately, environmental and resource costs of feed-crop and industrial-livestock systems—often separated in space from each other and from the consumer base—remain largely unaccounted for in the growth process.

Industrializing and globalizing livestock systems have hinged on declining real prices for feed grains; advances that have improved feed-to-meat conversion efficiencies, animal health, and reproduction rates; relatively cheap transportation costs; and trade liberalization. The most dramatic shift has been toward the production of monogastric animals, such as chickens and hogs, which use concentrated feeds more efficiently than cattle (or sheep) and which have short life cycles that accelerate genetic improvements. The average time needed to produce a broiler in the United States was cut from 72 days in 1960 to 48 days in 1995, and the slaughter weight rose from 1.8 to 2.2 kg (*4*). Meanwhile, feed conversion ratios (FCR, kg feed per kg meat) were reduced by 15% for broilers and over 30% for eggs (*5*). Annual growth in hog and poultry production in developing countries was twice the world average in the 1990s (*2*). By 2001, three countries—China, Thailand, and Vietnam—accounted for more than half the hogs and one-third the chickens produced worldwide (*1*). Brazil is also a major producer and is expected to become the world's leading meat exporter.

Virtually all of the growth in livestock production is occurring in industrial systems—a trend that has been evident in the United States for several decades. Industrial poultry and pork operations are largely uniform worldwide, which facilitates a rapid transfer of breeding and feeding innovations. Larger firms typically control production from animal reproduction to the final product, mainly to minimize economic and pathogen risks. As these firms increasingly supply major retail chains, corporate attention is directed toward food safety and the production of homogeneous (yet diverse), high-quality products. In addition to scale, industrial livestock operations have become concentrated geographically in areas where input costs are relatively low; infrastructure and access to markets are well developed; and in many cases, environmental regulations are lenient (*6*).

The most striking feature of this geographic concentration is the delinking of livestock from the supporting natural resource base. Feed is sourced on a least-cost basis from international markets, and the composition of feed is moving up the chain from agricultural by-products to grain, oil-meal, and fish-meal products that have higher nutritional and commercial value. Although FCRs for chickens and hogs on an edible weight basis are roughly one-fifth and one-third, respectively, that of cattle (whose diets include rangeland forage, crop residues, and by-products) (*7*), monogastric diets are richer in cereal and legume feeds, which compete with food crops for land and water.

Future land needs for industrial livestock production are potentially great. For example, a balanced Chinese diet of the early 1990s containing 20 kg meat per capita per year was produced from an average land area of just over 1000 $m^2$/capita, whereas a typical Western diet required up to four times that area (*7*). China's meat consumption, consisting mainly of pork, is increasing rapidly with income growth and




**International linkages in supply and demand of livestock products, 1992–2003 (*3*).** Mmt, millions of metric tons.

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urbanization; it has more than doubled during the past generation (*3*). If the world's population today were to eat a Western diet of roughly 80 kg meat per capita per year, the global agricultural land required for production would be about 2.5 billion hectares—two-thirds more than is presently used (*4*). Continued crop intensification could offset some of this land requirement, but would also have consequences for water use and nutrient pollution even if precision agriculture were widely practiced.

Land conversion in the Brazilian *cerrado* (grassland) and rainforest exemplifies the large impacts of such growth on ecosystems and the environment (*8*). Cultivated soybean area in these parts of Brazil doubled over the past decade to 21 million ha and is expected to expand by another 40 million ha, or perhaps more if current Amazonia deforestation rates continue (*9*). These areas are supplying feed to the growing livestock industry in Brazil, China, India, and other parts of the world with unmeasured and often irreversible consequences on biodiversity, climate, soil, and water quality (see figure, page 1621).

Industrial livestock operations also require large amounts of water, especially for feed production, and water quality is reduced through the release of nutrients, pathogens, antibiotics, and other chemicals via return flows. Nitrogen and phosphorous run-off results from both crop fertilization and animal production with the delinking of production systems. Animal waste consists mainly of water, which makes long-distance transportation of untreated manure from livestock facilities to fields unprofitable. Nitrogen volatilized and leached from field crops and animal wastes has become a major source of aquatic dead zones, noxious odors, and ecological change (*10*). Industrial livestock expansion in China, Thailand, and Vietnam along the South China Sea is contributing to red tides and degrading water and sediment quality in one of the world's most biologically diverse shallow-water marine areas (*1*).

Expanding trade in meat products obscures the environmental and resource costs of livestock production, particularly for meat importers. Globally, trade in livestock products as a share of total production has almost doubled to 11% during the past 25 years (*3*). Steady growth in meat trade has resulted from advances in transportation, container systems, and cold storage technology; increasing specialization of production and processing operations; heightened consumer demands for product cuts, quality, and safety; low energy costs; and reduced trade barriers (*2*). Meat importers pay the direct costs of production and transportation, but do not pay the external resource costs, such as degraded water quality or biodiversity loss, which remain largely unaccounted for in the delinked livestock-crop systems.

A recoupling of crop and livestock systems is needed—if not physically, then through pricing and other policy mechanisms that reflect social costs of resource use and ecological abuse. Such policy measures should not significantly compromise the improving diets of developing countries, nor should they prohibit trade. They should focus instead on regulatory and incentive-based tools to encourage livestock and feed producers to internalize pollution costs, to minimize nutrient run-off, and to pay the true price for water. They also need to be accompanied by other methods to reduce the waste burden, such as the use of enzymes and synthetic amino acids to improve feed conversion (*11*). Without improved policies on waste treatment and on land and water pricing, net importers of meat and feedstuffs will continue to tax the resource base of exporting areas, either within the same country or abroad.

As an example of recoupling, the Netherlands has experimented with a set of policies that includes a tradable quota for hog production, manure disposal contracts, and a nutrient accounting system that tracks nitrogen inputs and outputs per farm (*12*). The cost to producers has been roughly $4/hog—33% more than in the most restrictive U.S. states (*2*). Owing to high administrative and production costs, these output controls will be replaced by limits on fertilizer and manure use in agriculture in 2006 (*12*). In the United States, the Environmental Quality Incentives Program in the 2002 Farm Bill provides funds for livestock producers to redesign manure pits and treat wastes (*13*). Cost-sharing programs exist at the federal and state levels to improve water management, to plant buffer strips, and to introduce combined chemical and irrigation systems. Waste discharge from livestock systems is regulated through the Clean Water Act at the federal level, and some states, such as Nebraska, enforce tougher restrictions than the federal standards (*14, 15*). Although these measures are a step in the right direction, other states, such as North and South Carolina, have more lenient environmental restrictions on livestock, and producers throughout the United States do not pay the true economic and ecological cost of water use and nitrogen runoff.

Although efforts to recouple are being pursued in some rich countries, the challenge is more daunting in developing countries where environmental legislation tends to be weak and funds for incentive-based programs are limited. Introducing codes of conduct, including careful siting of livestock operations, could reduce waste problems, and certification programs could be developed to encourage improved husbandry practices. In areas where new land is being cleared for feed crop production, such as Brazil, the costs of losing biodiversity and ecosystem services such as climate regulation should be considered explicitly in development plans. A strong political will is needed in all cases to implement conservation and environmental policies at the partial expense of producer income and foreign exchange earnings.

At a global scale, linking livestock to land would require the difficult task of harmonizing production, resource, and waste standards at higher levels than are seen in most countries currently. If the major meat- and feed grain–producing countries were to invoke strict environmental and resource standards, international meat prices would almost surely rise, perhaps slowing the increase in demand. Such a transition would be made easier politically if consumers increasingly demanded meat products based on sound environmental practices. In a global economy with no global society, it may well be up to consumers to set a sustainable course.

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