

By Adam Teitelbaum

"We serve as stewards of the animals, land, and environment entrusted to us." -Tyson Corporation Core Value

Since the first settlers of the Jamestown Colony, livestock management and consumption has been socially and economically important. Americans like to eat meat and they consume more than any other nation in the world, about 200 pounds per capita a year (Bi ). Through aggregate purchasing habits Americans have shown that we prefer a lot of meat, and prefer it cheap explicit costs. However, recent studies have shown that the consumers, some more than others, are realizing a greater cost from purchasing meat than is printed on the label. These costs arise from increasing efficiency in meat production and the failure of producers to internalize these costs results in a market failure.

The market failure is due to the externalities the livestock industry poses on the environment. It is difficult to quantify the environmental impact the industry induces, however, recent estimates claim that the environmental ethical principles should be taken into account. Some environmental ethicists are more extreme than the average American, so for the purposes of this analysis the relatively modest philosophies of Aldo Leopold will be employed. Leopold stresses the importance of individual elements of an ecosystem are not important until they begin to significantly affect the ecosystem. Leopold also stresses the inclusion of the environment into our community or society, and, while assumptions cannot be made of the environment's preferences, ecosystems should be considered to have holistic value (Leopold). Consumers should not only realize the moral value to Leopold's philosophy, it also has economic value in terms of preserving resources and recreational activity.

This paper defines livestock as beef cattle, dairy cattle, buffalo, swine, chicken, turkeys, and lamb, although cattle and swine constitute the majority of the statistics. Livestock feed will also be taken into account, in particular corn, wheat, barley, and soybeans (Livestock's Long Shadow, 87). The two types of environmental context will be described are point source, which is characterized by a confined and observable discharge and non-point source, characterized by diffuse discharges over large areas. The following will introduce the livestock industry, specify major environmental externalities, and in conclusion provide plausible mitigation for those externalities.

#### The Livestock Sector

The livestock industry began in America with open grazing animals that were slaughtered on a comparison of the nation grew and moved west, herds of domesticated livestock followed and became an integral aspect of the nation's economy. Over the years, improved breeding techniques and technology such as the refrigerated railcar, increased the efficiency of production and distribution helping producers meet growing demand. Following World War II, congress imposed a tariff on imported ethyl alcohol products and placed incentives to increase domestic ethyl alcohol production in the form of excise tax exemptions (Bandyk). Meanwhile, livestock producers found that using cereals as feed generated higher-grade meat. The common link between the legislation and cereals is corn that now constitutes the majority of livestock feed, which became relatively cheaper; as a result large feedlots began to appear. In 1963 the United States Department of Agriculture (USDA) estimated 9 million livestock cattle were using cereal feed as opposed to grasses and natural vegetation (Livestock History).

Feed was now a significant cost in livestock production, today 40% of poultry costs is due to feed (Bandyk). A larger and larger share of crop output was devoted to feed as a result and presently constitutes one third of the global cereal harvest (Livestock's Long Shadow, 12). Cereals promote growth rates and lower costs, especially in poultry; therefore there is a Pareto improvement. However, a recent increase in domestic demand for ethyl alcohol has increased the price of corn, combined with increasing international emand for meat and a sinking American dollar, livestock producers are experiencing rough times (Mullins). The livestock industry faces business pressures to maintain low prices for their products, still according to a 2007 study conducted by Iowa State University economists states that "the direct effects of higher feed costs is US food prices increasing by a minimum of 1.1% over baseline levels (Bandyk)." Financial pressures often clash with environmental pressures and the USDA enforcement agency has had to

intervene in livestock operation numerous times alr in 2008 (Livestock, Meat, and Poultry: Enforcement actions).

Today the livestock industry can be segmented into extensive and intensive production. Extensive production involves grazing, domestic animals. This form of production requires large amounts of land, however, has low input levels. At the supermarket these products come at a relatively higher price. Intensive livestock production epitomizes increased efficiency in the industry and is typically characterized by high levels of external inputs. Also known as factory farms, intensive production facilities condense area and require broader levels of management Intensive facilities employ concentrated feed inputs and additives often transported over long distances. Currently, 4% of cattle feedlots in the US represent 84% of cattle production (Livestock's Long Shadow, 114). Environmental activists and extensive livestock producers have targeted intensive facilities for negligent environmental practices, some arguments are more valid than others.

### The Effect of Livestock Production on the Environment

From the seed planted on feed-cropland to the steak on the consumer's plate the livestock industry effects three major areas of the environment: air and ozone quality, land management, and water availability and quality. Although in many cases the environmental deterioration has not exceeded the level where regeneration of the resource is impossible, the assumption that the average American citizen holds Aldo Leopold's utility toward the resource's ecosystem will remain a determinant factor in the level of xternalities the industry produces.

#### Air and Ozone Quality

Through the long line of livestock production several emissions become an environmental concern: carbon dioxide, methane, and nitrous oxide. All are considered greenhouse gases and affect the quality of air respiration. Carbon dioxide is the main contributor to greenhouse gases; there are several sources for carbon dioxide in the livestock production process. In feed production, carbon dioxide is produced in the machinery used on the farm as well as in fertilizer production. Corn, constituting over one half of the cereals in feed, requires high nitrogen levels in the soil. A process using high pressures creates an artificial fertilizer high in nitrogen, but the high level of energy input into the process yields large levels of carbon dioxide emission. In feed production alone, it's estimated that the industry emits 11,711,000 metric tons of carbon dioxide a year in the US (Livestock's Long Shadow, 88). It is difficult to estimate the amounts of carbon dioxide emissions in the rest of the livestock production process; emissions take place in transportation, feedlot machinery (facility heating, waste removal), processing, and refrigeration. In 1995, Minnesota (considered a livestock "hot spot") reported that livestock processing and refrigeration alone accounted for 702,000 tons of carbon dioxide emissions (101). Internalizing this amount of carbon dioxide output is difficult, however, many Americans have bought carbon offsets to internalize their costs. In which case, the feed production industry would be charged \$127,801,172.46 by the carbon-offset company TerraPass. This approach does not actually reverse carbon dioxide emissions, it merely invests in carbon reduction projects, so it would be difficult to justify carbon offset purchase as a means of directly internalizing production costs.



Methane is the second largest player in global warming and emissions mainly come from two sources: manure and enteric fermentation. Although methane levels are second in abundance in the atmosphere to carbon dioxide, methane has twenty three times the global warming potential (Knickerbocker). For the past few decades, total methane output has been steadily increasing, and unless the growth is stunted it could have devastating effects on the environment. According to the Environmental Protection Agency, in 2003 manure management accounted for 7% of total anthropocentric methane emissions and enteric fermentation accounted for about 21%, so together a total of approximately 28%. Humans contribute to about 60% of the total global methane output, the rest are from natural sources such as the wetlands and permafrost (Methane: Sources and Emissions, Tab. 1). Taking this into consideration the livestock industry is responsible for 16.8% of total methane output. However, the animals create the methane outputs themselves naturally and when attempting to internalize the environmental cost, making a legitimate claim could be hard to quantify, holding demand constant.

The third most abundant greenhouse, nitrous oxide, contains nearly 296 times the global warming potential of carbon dioxide (Knickerbocker). Naturally the earth produces around ten million metric tons of nitrous oxide a year, anthropocentric emissions amount to between seven and eight metric tons, 70% of which derive directly from feed and livestock production (Livestock's Long Shadow, 102). Livestock in

intensive production tend to have lower nitrogen assimilation efficiency than extensive. The low efficiency in nitrogen assimilation by feed production is mainly due to over fertilization and the form and timing of the fertilizer application. Livestock consume the high-nitrogen feed and, a minimal diet coupled with lack of exercise, results in a relatively low retention rate. The nitrogen exits production as animal waste and, if the waste is dispersed on cropland, much of the nitrogen is returned to the soil at the benefit of the environment with a low rate of nitrous oxide conversion (106-107). However, when waste is stored and deprived of oxygen the nitrous oxide conversion rate becomes much higher (109). US livestock produce over 900 million tons of waste per year, for intensive producers this often implies storing mass amounts of manure for long periods of time (Bittman). In 2004, North America was estimated to produce .3 million metric tons of nitrous oxide emissions can be altered by changes in waste management, large stockpiles of manure increase outputs and internalizing the costs would start by converting the waste to fertilizer in a timely fashion.

The scent of chemicals released by livestock can reduce surrounding land value and, for anyone who has lived in northeastern Colorado, it can also limit outdoor activities. These scents are mainly from intensive livestock production and can be limited, resulting in cleaner air and better living conditions. A hore pressing concern is the effects on global warming. Many ecosystems will lose much of their biodiversity as global temperatures continue to rise. Globally, livestock contribute 80% of all greenhouse emissions in the agricultural sector and 18% of the total greenhouse gases emitted as a carbon dioxide equivalent per year (Livestock's Long Shadow, 112; 271). Reduction of emissions from the livestock sector will slow the effects of global climate change.

#### Land Management

The livestock sector is the largest anthropocentric land user in the world; roughly one third of the ice-free land is involved directly or indirectly to livestock production (Livestock's long Shadow, 133; 4). Managing that land is an arduous and sometimes ignored task. Land is composed of soil, vegetation (including crops), and the hydrological and ecological systems that operate on that land. Extensive livestock production uses large plots of land and, although livestock waste can benefit ecological systems under these conditions, it promotes soil compaction and erosion. Often the capital needed to restore land degraded from compaction and erosion exceeds the satisfactory return estimate and lands are left to desertify (30-31). Changes in the seasons require a variety of grazing areas and therefore an invasive species is introduced into a variety of ecosystems, adversely effecting biodiversiy (31-32).

Extensive grazing practices yield a low per unit of land output; the solution for this low efficiency is land intensification. With less pressure to convert natural ecosystems to agricultural use and allowing the econversion of other once natural areas, this appears beneficial to the environment. If the livestock sector segoing to inherently degrade land it makes sense confine the adverse effects. In feed production, intensification has greatly increased output efficiency. Croplands are the most prone to erosion due to the removal natural soil-binding vegetation, mechanical impact, and inappropriate cultivation practices (Livestock's Long Shadow, 73). However, places where bulk growth have previously occurred will experience further growth at diminishing rates and require larger levels of inputs (fertilizer and other soil components) (32).

The livestock sector has decreased the amount of grazing lands by 20% in the US since 1950 to the benefit of society and the environment (Livestock's Long Shadow, 32). Combined with improved distribution, the livestock sector has apparently become more profitable to the benefit of natural ecosystems. However, this profitability attracts new livestock firms, especially with feed demand and international demand for US beef increasing (42). Hence, this leads to the intensification of more land, negating the environmental benefit. Non-developed land can provide several economic benefits including non-wood forest products, recreation, hunting, watershed protection, and passive use. Decisions on land use are usually calculated on a profit per unit of land basis consisting of tradable goods and services (26). Unfortunately, this means external costs are often imposed on society. Improvements on land management include ensuring the long term sustainability and integrity of that land. Further land degradation could impose constraints on future food production and permanently destroy many natural ecosystems. Unfortunately, property rights allow such activities in most cases and internalizing these costs can be legally unsubstantiated (Cain, 134).

#### Water availability and quality

One of the largest environmental concerns in the US today is water depletion and pollution. Wetland areas are particularly at risk, which contain the most species diverse ecosystems on land. The global environment is estimated to be worth around \$33 trillion, of which, wetlands account for about \$14.9 trillion (Livestock's Long Shadow, 127). Agriculture requires 70% of freshwater resources and freshwater demand from the livestock industry exceeds human use by 8% (5; 137). With freshwater demands growing, the preservation and management of the resource is of great importance. Water depletion reaches its extreme under the conditions of desertification; the US experienced this occurrence in nature during the early twentieth century known as the "dust bowl." Strong measures should be taken to ensure such an event doesn't occur again.

The livestock sector accounts for 55% of water depletion for agriculture in the US (Livestock's Long Shadow, 165). Extensive livestock production represents the most efficient consumption of freshwater exercised; intensive production contributes to the majority of freshwater loss. Water is used in intensive systems for cleaning animals, removing waste, cooling facilities, and as drinking water for animals. Due to the nature of feed, an adult cow under an intensive program will consume 120% more water than an adult cow under and extensive program, and an adult pig will consume twice the amount of water compared to an extensive program pig (129). Reduction of inland water resources stresses food production and leads to higher food prices and, for nearby areas, higher water prices.

When water returns to the environment from intensive facilities, most is categorized as wastewater, which contains nutrients (nitrogen, potassium, and phosphorous), heavy metals, and pathogens. Wastewater leaves a portion of these elements in soil while passing through it and has negative effects on the ecosystem. A point source instance would be rain runoff from intensive facilities or waste system management failure. A non-point source would include rain runoff from grazing lands or croplands (Livestock's Long Shadow, 136). However, animals in intensive programs excrete more nitrogen, heavy metals, and pathogens than extensive animals do (138).

Nitrogen entering the environment stimulates plant growth also known as eutrophication. Moderate levels of eutrophication can be healthy to ecosystems providing them with a wider food base. But, in excess, nitrogen over-stimulates eutrophication and can crowd out certain types of wildlife and can produce toxins from excess algae. When this occurs society experiences a loss of recreational space, clogged rivers/canals, and the replacement of economically desirable fish by less desirable fish (Livestock's Long Shadow, 138). High nitrogen levels in drinking water have been linked to "blue baby syndrome" and sudden abortion, as well as being toxic to infants and elderly. In 1987 a study found over 300 water wells contained dangerous nitrogen content from livestock production in Delaware (140). Even moderate levels of nitrogen and other nutrients can make drinking water less desirable, while posing no direct health concern.

Pathogens such as e-coli and salmonella have been the reason behind many large meat recalls. Pathogens can be transferred in infected water to plants (if in high levels) and to animals. Not only can food contain these dangerous bacteria, but also if our drinking water is infected, human victims could be numerous (Livestock's Long Shadow, 141). Also drug residuals, mainly antibiotics and hormones, passed into water systems could adversely effect the environment. Antibiotics pose no direct adverse environmental impact, although their presence in the environment reduced their inherent effectiveness. Hormones used to stimulate growth in livestock have been shown to affect vegetative growth, including crop yields (142). Pollutants in the water supply damage the integrity of surrounding ecosystems and have potential to cause health problems in humans.

## **Conclusions and Mitigation**

Humans are introducing pollutants into the air, soil, and water faster than environment can dissipate or lecompose them. The livestock industry has scientifically proven to be a major contributor to these pollutants on a domestic and global scale; therefore intervention in livestock production, in particular ensive livestock production, is necessary. The environmental externalities directly involved in livestock production do not appear on the price tag at the supermarket for the consumer resulting in a textbook case of market failure.

But, the answer may not be that simple. "Free range" meat and dairy products are available at the grocery store that effect the environment minimally and would not be considered part of this market failure. et consumers are not willing to pay the explicit cost for more environmentally friendly products even though for some people the externalized cost is piped directly to their homes. This could mean that the







average meat consumer values 2.2 pounds of meat more than powering a 100-watt light bulb for twenty days, or that society hasn't fully realized these costs (Bittman). While the livestock production market is becoming increasingly efficient, external costs have been imposed on society. The USDA prosecutes livestock producers who pollute beyond a certain threshold, but this is after the damage has been realized. Society appears to take this same stance by preferring to consume cheap livestock products until the environmental corrections become a necessity. That is, consumers prefer cheap livestock products and negative environmental impact as opposed to expensive products and little environmental impact, however, they prefer both of the latter to cheap products and excessive, visible environmental impact. We can then conclude that decreased environmental health can be compensated by less expensive commodities.

If price is a leading motivation for people to consume more environmentally unfriendly livestock products, then by eliminating feed subsidies a more level playing field can be achieved. This will raise the prices of many livestock products and decrease demand for these products. The negative effects from this economic action would include the loss of jobs and capital investment in the industry, and the government would be reluctant to decrease economic activity. But, consumer dollars will go elsewhere in the economy and the decrease in livestock production would decrease all of the negative environmental statistics. The increased price in corn would reduce domestic corn production and allow cheap imports for ethyl alcohol such as cane sugar to increase. Again the government would be reluctant to allow increased consumption of international products at the expense of domestic products, but the nature of free markets allows this and promotes it as natural capitalism.

In addition to subsidy elimination, direct government policy would be required to manage the pyrironmental externalities imposed by the livestock industry, for example, stricter waste management and rand management requirements. Short term efficiency increases are possible, for instance, the dairy cattle sector has been increasing production for years and simultaneously decreasing methane output (Ruminant Livestock) Government projects toward reversing some of the effects should also be employed like the revegetation of damaged ecosystems. Also, benefits should be provided to producers who benefit their local environment, such as tax breaks and partial compensation for positive environmental activities. This will come at a cost to the American taxpayer, although, with the elimination of farm subsidies, this should use less tax funding than originally required.

However, in a situation regarding the sustainability and management of resources, aggregate social references might carry less weight and a more paternalistic action should be employed. If the direct ethics of Aldo Leopold were used in government policy making, intensive livestock production would cease due to the effects on biodiversity and ecosystem degradation, but this action is unpractical considering the importance of livestock production to agriculture GDP (Livestock's Long Shadow, 270). The easy solution would be a major decrease in net livestock product consumption, although this too is unpractical. Society as a commitment to future generations involving the long-term sustainability of resources. Efficient practice in resource allocation must be a goal economically, politically and socially. Livestock operations efficiency in the short term must be substituted for fairness to society and future generations. The livestock industry shows great potential to reduce environmental impact through genetic modification technological improvements. Israel and Korea are making great advances in converting manure to energy (Bittman).

Still, the livestock sector's negative externality output cannot be ignored at the expense of the stability of earth's natural ecosystems; this is Leopold's main ethic, or limitation (Leopold). The short-term responses involve less livestock product consumption by society and livestock producers taking direct responsibility for a number of negative environmental externalities at their business' expense. Market trends indicate that US feed and livestock demand will continue to increase and provide opportunity for economic prosperity. And as a society maybe we need to learn that the power to conserve rather than consume can be of long-term economic benefit.

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