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TRENDS
Risk Science & Application

Fall 2008

The Impacts of Mass Agriculture: Livestock

By Cindy Langlois, M.S.

The growth in mass-scale agriculture necessitates the use of environmental controls once limited to industry.

Agricultural livestock operations have changed dramatically in the last 20 years. Traditional crop-livestock farms were integrated, using livestock manure as fertilizer for crops that were used to feed those livestock. Typically, farmers raised the quantity of livestock their croplands could support. Now industrialized livestock production is much larger in scale and does not depend on local croplands. These large facilities produce a high-quality product at a low purchase price for consumers by using economies of scale. However, they require the use of feed, which often is transported long distances. At the same time, animal manure is treated and stored in a small area, potentially resulting in soil accumulation and runoff of various pollutants (Thorne, 2007). The success of large livestock production depends on proper management, which acknowledges its place in the local and global ecosystem.

Often, proper management and the use of appropriate technologies can have benefits beyond conventional pollution prevention.

In the U.S., concentrated animal feeding operations (CAFOs) produce more than 50% of the animals for human consumption (Gurian-Sherman, 2008). In these large operations, animals are confined in indoor stalls throughout their lives until they are transported to processing plants for slaughter (Burkholder *et al.*, 2007). According to the U.S. EPA, a large CAFO contains: 1,000 or more cattle; 700 or more mature dairy cows; between 2,500 and 10,000 swine, depending on their size; 10,000 or more sheep; 55,000 or more turkeys; or 30,000 or more laying hens or broilers.

CAFOs can be an efficient means of raising livestock. Keeping animals indoors

continued on pg. 2

I N S I D E

Letter to our Readers

September 2008

Dear Colleague,

As summer winds down, we are all enjoying the abundant summer vegetables that we grow in our gardens and find at our local farmers' markets. But this is the first summer that we have thought about them in terms of their greenhouse gas emitting potential! Environmentally conscious and sustainable farming are goals for which U.S. farmers strive. In many ways, the environmental issues faced by large-scale farming operations are the same as those faced by their industrial counterparts, and environmental scientists can apply the same approaches and tools for finding solutions.

Contributors to this issue include Ms. Cindy Langlois, a Gradient toxicologist, and Mr. David Merrill, a Gradient Principal, and Dr. Chris Long, who together have been involved in several air modeling projects involving farm emissions. Joining them in our guest editorial is Ms. Ruth Ann Hendrix, who shares her thoughts on the competing demands facing today's farmers. Ms. Hendrix's family owns and operates Rose Acre Farms, which is the second largest egg farming operation in the U.S.

We hope this issue of *Trends* will provide you with new "food for thought."

Yours truly,

Neil Shifrin, Ph.D.
President

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The Impacts of Mass Agriculture: Livestock

continued from pg. 1

protects them from predators and disease and allows for much greater control of feed and waste. However, improperly managed and operated CAFOs can have significant environmental impacts. These impacts stem largely from issues with waste handling, storage, and treatment.

Specifically, CAFOs produce about 300 million tons of manure per year. This manure is generally treated in waste lagoons, where it decomposes and is stored for eventual land use as fertilizer. However, these lagoons can be a source of air emissions, odors, and pathogens (Gurian-Sherman, 2008). Furthermore, because animal manure from livestock contains nutrients (nitrogen, phosphorus), heavy metals (copper, zinc), pathogens (parasites, viruses, and bacteria), veterinary pharmaceuticals, naturally excreted hormones, *etc*., seepage and overflow of the lagoons can lead to soil, surface, and groundwater contamination. This contamination can lead to eutrophication of surface waters, resulting in excess algal growth and decay, which can cause fish kills.

Other aspects of livestock production in CAFOs, such as the effects on public health, are being considered by scientists and farmers. Because of the close proximity of animals in CAFOs, livestock are given antibiotics for the prevention and treatment of disease, as well as to promote growth. These drugs can aid in the development of antibiotic-resistant pathogens, which can cause illnesses in humans.

Methods are available to avoid and mitigate the environmental impacts of large-scale farming operations. A full accounting of all the system components that could effect pollution (*e.g.*, feed ingredients and medicines, manure storage and treatment, precipitation and weather patterns, surface and groundwater sources, and soil nutrients to name a few) is necessary to provide site-specific solutions. For example, to reduce the potential contamination from waste lagoons, they need to be appropriately sited – sufficiently far away from water sources and residents and above the floodplain – to minimize the effect of overflow, odors, and air emissions. Watertight liners can reduce the amount of contaminant seepage. Permanent strips of vegetation between fields, lagoons, and waterways can reduce the effects of runoff. Technology can also play a role. Agitation of lagoons can reduce the build-up of nutrients and settled solids. Finally, covers for waste lagoons can reduce odors by reducing air emissions.

Often, proper management and the use of appropriate technologies can have benefits beyond conventional pollution prevention. For example, cattle and sheep account for 20% of methane emissions resulting from human activity. Methane gas is produced by ruminating animals as part of their normal digestive process, but it is also a potent greenhouse gas. One method of reducing methane production is to supplement the animals' diet with substances that improve digestion and thereby decrease fermentation. Methane emissions per unit of forage have been reduced 25% to 75% by this method. Furthermore, improved digestion increases productivity (increased milk production, *etc*.).

Ways to mitigate the environmental and public health impacts related to large-scale animal production exist and take into account the entire CAFO system and its place in the local and global ecosystem.

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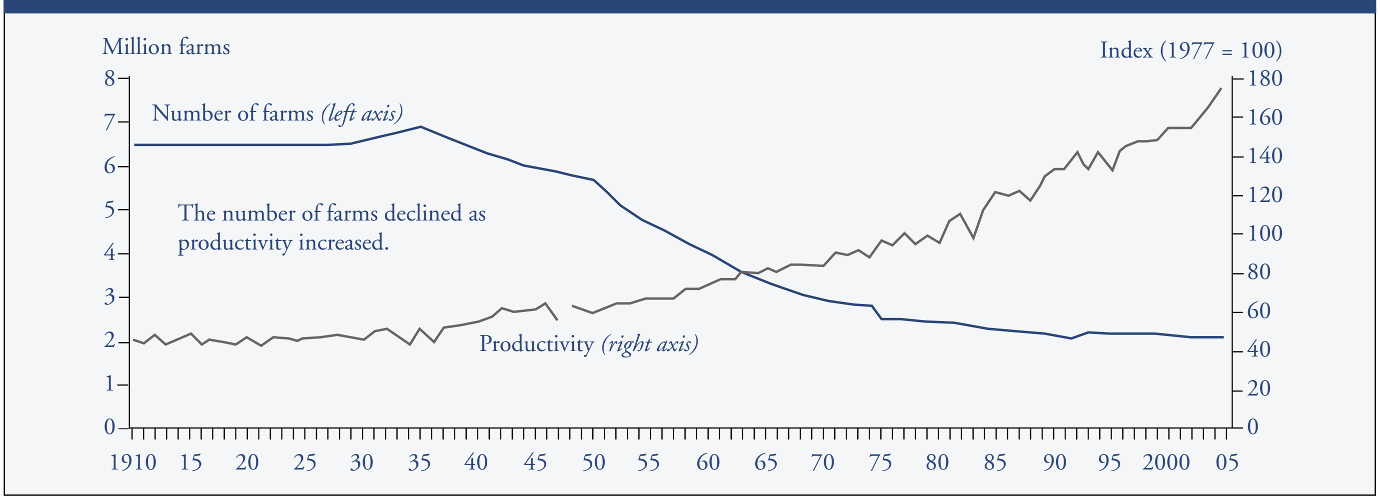
continued on pg. 4

FARM PRODUCTIVITY AND NUMBER OF FARMS, 1910 TO 2005



Source: USDA, Economic Research Service, compiled from National Agricultural Statistics Service annual estimates of the number of farms from the June Agricultural Survey and the ERS estimates of farm productivity. ERS productivity indices prior to 1948 came from Johnson, C.D. 1990. A Historical Look at Farm Income. U.S. Dept. of Agriculture, Economic Research Service. ERSSB807. 32p.

Industrial Farming *vs.* Local Foods

By David Merrill, M.S.

Would a "food odometer" or carbon footprint label on our food affect our buying choices?

The term "locavore" – coined by members of the Berkeley Farmers Market and named the "2007 Word of the Year" by the Oxford American Dictionary – has become the hip mantra of consumers who want to eat only locally grown food. Like the catchphrases "think globally, act locally" and "you are what you eat," the locavore concept has taken off for a variety of reasons: eating fresher foods, supporting local farmers, knowing where food is sourced, reducing one's carbon footprint, and fostering sustainable agriculture.

The notion that buying locally can reduce the carbon footprint associated with food production is intuitive: reducing the distance our food travels from farm to table reduces the associated transportation energy required. Food transportation in the U.S. is estimated to account for 14% of the energy use within the food system (ATTRA, 2008). In the mid-1990s, "food miles" were introduced as a means of quantifying the transportation impact for food sources in a typical consumer's food basket. A recent Australian study estimated that a typical food basket traveled a total distance of over 70,000 kilometers to reach Australian consumers (Gaballa and Abraham, 2007). Similar studies indicate food consumed in the midwestern U.S. travels a weighted average source distance of 1,500 miles (ATTRA, 2008).

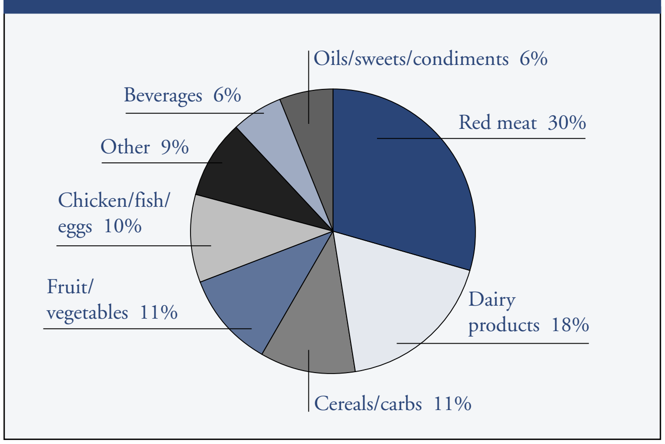
While food miles provide one objective measure of the external impacts/costs of food production, they are only one component of a more comprehensive lifecycle analysis. For example, local transportation systems may not operate as efficiently as long-haul transportation methods, rendering food miles alone an imprecise metric. Moreover, the high energy requirements to produce food in areas where agricultural productivity is low or growth conditions unfavorable may offset transportation energy requirements. For example, a Swedish study found that tomatoes produced in Spain and shipped to Sweden required less overall energy than tomatoes raised in Sweden, due to the high energy requirements of the greenhouse-grown Swedish tomatoes. Another study found that lamb raised in New Zealand, based on year-round grass-fed production, required less overall energy to produce and ship to Britain than locally raised lamb, which had much higher energy requirements associated with housing and feeding (ATTRA, 2008).

A recent Australian study estimated that a typical food basket traveled a total distance of over 70,000 kilometers to reach Australian consumers.

Weber and Matthews (2008), from Carnegie Mellon University, evaluated the lifecycle greenhouse gas (GHG) emissions attributed to production, transportation, and distribution of food consumed by American households. The authors found that the final transportation from farm to retail, which they suggest are the food miles relevant to consumer buying choices, accounted for only 4% of the lifecycle GHG emissions (additional transportation is required during production). Interest-

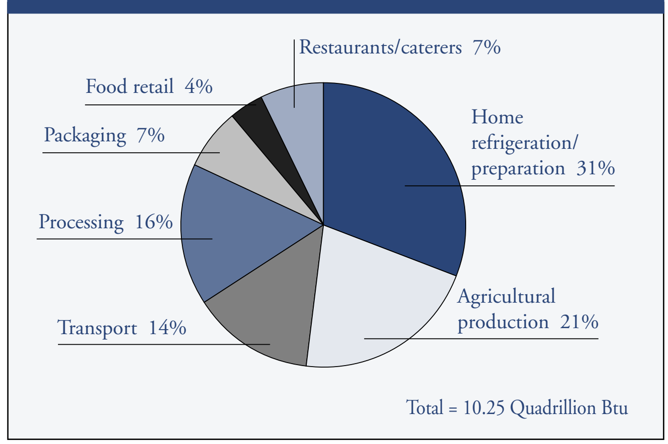
continued on pg. 5

Greenhouse Gases from Food



Source: Engelhaupt. 2008. Do Food Miles Matter? *Environ. Sci. Technol.* April 16, accessed at http://pubs.acs.org/subscribe/journals/esthag-w/2008/apr/science/ee_foodmiles.html.

United States Food System Energy Use



Source: Heller and Keolian. 2000. Life Cycle-Based Sustainability Indicators for Assessment of the U.S. Food System, accessed at http://css.snre.umich.edu/css_doc/CSOO-04.pdf.

Regulating CAFOs

By Christopher M. Long, Sc.D.

The regulatory requirements for CAFOs consist of a patchwork of traditional and emerging federal, state, and local programs.

In January 2003, the United States General Accounting Office (GAO, 2003) issued a report addressing the state of the U.S. EPA regulation of concentrated animal feeding operations (CAFOs) that concluded that an estimated 60% of CAFOs remained unregulated across the country. This report identified deficiencies in the state implementation of federal regulatory programs, as well as a lack of federal oversight, as key impediments to effective CAFO regulation. As recently summarized by the EPA (U.S. EPA, 2007), there are a number of major federal regulatory programs affecting CAFOs that, together with a variety of state regulations, contribute to the patchwork nature of existing CAFO regulation. This article highlights some of the recent developments in federal regulatory programs, as well as some of the remaining questions regarding the overall effectiveness of current federal and state CAFO regulation.

> ***…many communities and individuals will likely continue to seek relief from CAFO discharges or emissions through local ordinances or litigation.***

Until 2002, there were few major changes specifically relating to CAFOs to the basic infrastructure of applicable federal environmental regulations that include the Clean Water Act, Clean Air Act (CAA), and notification provisions of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), and the Emergency Planning and Community Right-to-Know Act (EPCRA). However, to fulfill a court-ordered decree stemming from litigation alleging its failure to comply with the Clean Water Act, the EPA issued in December 2002 revised effluent limitation guidelines and National Pollutant Discharge Elimination System (NPDES) permit regulations for CAFOs. While changing the definitions of CAFOs and requiring that all large CAFOs apply for a NPDES permit, these regulations eliminated loopholes that allowed many large CAFOs to avoid regulation. Requirements were also added for the implementation of best-practice nutrient management plans.

Recognizing the difficulty in bringing CAFOs into compliance with air emissions requirements using the traditional, case-by-case enforcement model, the EPA also recently initiated the start of the "first-ever nationwide study" of air emissions from poultry, dairy, and swine animal feeding operations. While requiring that the thousands of participating CAFOs meet all applicable air emissions at the end of the study, the two-year, industry-funded study began in July 2007. It will involve the measurement of air emissions of particulate matter, hydrogen sulfide, ammonia, and volatile organic compounds at 24 CAFO sites in nine states. The EPA plans to use these data to better identify the nature and extent of any CAA violations and to identify best practices for controlling industry-wide emissions.

Coinciding with the progress being made on the federal level, some states have continued to move forward with their own laws. In particular, in 2007, North Carolina enacted performance standards for animal waste management systems designed to "substantially eliminate" ammonia and odor emissions at newly permitted or expanded swine farms. Overall, the strength of regulation remains highly variable from state to state, with most states having setback requirements, some having regulations for hydrogen sulfide emissions (*e.g.*, Minnesota, Iowa), and a few having threshold-based odor regulations (*e.g.*, Missouri, Colorado).

With the EPA having recently proposed the elimination of reporting requirements for hydrogen sulfide and ammonia emissions from animal waste, more changes to the regulatory landscape may be imminent. Given the confusing and still-developing matrix of state and federal regulations, many communities and individuals will likely continue to seek relief from CAFO discharges or emissions through local ordinances or litigation.

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The Impacts of Mass Agriculture: Livestock

continued from pg. 2

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Burkholder, J., B. Libra, P. Weyer, S. Heathcote, D. Kolpin, P. Thorne, and M. Weichman. 2007. Impacts of waste from concentrated animal feeding operations on water quality. *Environ. Health. Perspect.* 115:308-312.

Gurian-Sherman, D. 2008. CAFOs Uncovered. The Untold Costs of Confined Animal Feeding Operations. Union of Concerned Scientists. April, accessed at http://www.ucsusa.org/food_and_environment/sustainable_food/cafos-uncovered.html.

Thorne, P. 2007. Environmental health impacts of concentrated animal feeding operations: Anticipating hazards – searching for solutions. *Environ. Health. Perspect.* 115:296-297.

What's New at Gradient

Recent Awards and Appointments

Barbara D. Beck has been appointed President-Elect of the Academy of Toxicological Sciences. She has also been reappointed as an Instructor in the Department of Environmental Health at the Harvard School of Public Health.

Peter Valberg has been elected a Fellow of the Academy of Toxicological Sciences.

Recent Articles

Aylward, L., G. Charnley, **J.E. Goodman,** and **L.R. Rhomberg.** 2008. Comment on Chronic disease and early exposure to air-borne mixtures. 2. Exposure assessment, by James Argo. *Environ. Sci. Technol.* 42(6):2201.

Goodman, J.E., D. Gaylor, **L.A. Beyer, L.R. Rhomberg,** and **B.D. Beck.** 2008. Effects of MTBE on the reported incidence of Leydig cell tumors in Sprague-Dawley rats: Range of possible Poly-3 results. *Regul. Toxicol. Pharmacol.* 50:273–284.

Mechanic, L.E., B.T. Luke, **J.E. Goodman,** S.J. Chanock, and C.C. Harris. 2008. Polymorphism Interaction Analysis (PIA): A method for investigating complex gene-gene interactions. *BMC Bioinformatics* 9(1):146.

Ponizovsky, A.A., **S. Thakali,** H.E. Allen, D.M. Di Toro, A.J. Ackerman, and D.M. Metzler. 2008. Effect of soil properties on nickel partitioning in soil solutions at low moisture content. *Geoderma* 145:69-76.

Rhomberg, L.R. and **J.E. Goodman.** 2008. CERHR conclusions would have been strengthened by a more explicit weight-of-evidence analysis. *Birth Def. Res. Part B: Dev. Repro. Toxicol.* 83(3):155-156.

Upcoming Presentations

Tucson, AZ. September 14-16, 2008. Julie Goodman, Lisa Bailey, and **Barbara Beck.** Annual Meeting of the American College of Epidemiology. "Recent Occupational Studies of Manganese and Their Bearing on the Reference Concentration."

Washington, D.C. September 15-16, 2008. Catherine Petito Boyce. Battery Council Health, Safety and Environmental Protection Conference. "Toxicology of Lead 101."

Amherst, MA. October 20-23, 2008. The 24th Annual Conference on Soils, Sediments, and Water:

- **Andy Bittner and Kurt Herman.** "DNAPL Source Zone Definition: A Blended Approach to Reduce Uncertainty for Remedial Decision-Making."
- **Manu Sharma.** "Pharmaceuticals in the Environment: Environmental Risk Assessment."
- **Tim Verslycke.** "Are APIs EDCs?"

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Industrial Farming *vs.* Local Foods

continued from pg. 3

ingly, Weber and Matthews note that while air transportation is by far the largest emitter of GHG on a unit basis (*e.g.*, ton CO_2/ton-km transported), it accounts for less than 1% of the food basket transportation requirements for food shipped to U.S. consumers. The authors found that red meat and dairy products had the highest GHG emissions, whereas chicken, fish, fruits, vegetables, and cereal products had the lowest (see chart). Their lifecycle analysis indicated that a ~20% shift in dietary habits away from red meat to chicken, fish, or a vegetarian diet would achieve approximately the same GHG emission reduction as would switching 100% of the diet to local food sources.

Of course, the energy requirements and GHG emissions associated with food production do not provide a complete answer to how to define sustainable practices. Considerations relating to the use of synthetic fertilizers and pesticides *vs.* organic farming, the importance of maintaining genetic diversity, land conservation practices, *etc.* and our ability to meet the ever increasing food demands must be included.

With the globalization of our food production system, which makes fresh foods available around the globe in any season, the lifecycle costs of food production may play a role not only in individual buying choices, but also may shape the direction of future sustainable practices.

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ATTRA. 2008. Food Mile: Background and Marketing. National Sustainable Agriculture Information Service. Available at: www.attra.ncat.org/pdf/foodmiles.pdf.

Gaballa, S. and A.B. Abraham. 2007. Food Miles in Australia: A preliminary study of Melbourne, Victoria. Center for Education and Research in Environmental Strategies. Available at: sustainability.ceres.org.au/pdfs/sei/CERES_Food_Miles.pdf.

Weber, C.L. and H.S. Matthews. 2008. Food-miles and the relative climate impacts of food choices in the United States. *Environ. Sci. Technol.* 42(10): 3508-3513.

Guest Editorial: Feeding the World

By Ruth Ann Hendrix, MPH

The more some aspects of farming have changed over the generations, the more some other elements have remained the same.

There are three major issues that American farmers must balance daily: labor, technology, and regulations. Agriculture is labor-intensive; people are necessary to do much of the work and it is physically demanding. While technology has increased production, the chemicals and nutrients used are often not time-tested. Increasingly, federal and state regulations are enforced at one level for animals, then at another level for humans. Competing interest groups provide conflicting information to the general public on commercial agriculture. Even with all the pressures and demands, American farmers provide food for much of our domestic consumption and agricultural exports.

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People are needed to produce food. Even in the most automated food production plants, people are needed to keep the robots running. Some steps in the food production chain are still manual. Whether they source their labor from unionized, non-unionized, or immigrant workers, farmers face the constant challenge of finding cost-effective labor. These labor pressures make it likely that agriculture will continue its path of increased automation.

Farmers have a love-hate relationship with technology in our country. Some want to embrace technology without proper tests. Others want nothing to do with modern techniques, instead supporting the organic movement. The laboratory is the only place where all the variables can be controlled. The real test of a new technology is done over time in the field and with animals in normal commercial applications. While laboratory results can be identified with confidence, real-world outcomes can be quite different. We have learned much about pesticides and insecticides in the last 50 years. The farm chemicals have changed dramatically in half-lives over the past decades. We need new technologies to improve grain yields, prevent human and animal disease, decrease pesticide use, and decrease water consumption in production to reduce our overall environmental impact. We know that future generations will be appalled at some of our current finest technology, but hopefully our advances will be positive.

At the end of the day, farmers just want to produce food. We want to use the best technology and information available to keep our food supply as fresh, convenient, nutritious, and wholesome as possible. We want to use science-based regulations for the good of all people living in this place. We want to be good neighbors and to leave the earth in the best possible shape for future generations.

The author is a member of the family that owns and operates Rose Acre Farms in Seymour, Indiana.

By The Way...

...[T]he biofuels rush has tipped the fuel value of corn in the U.S. above the food value of this staple; 16% of the U.S. corn crop was diverted to ethanol production in 2007, and a full third is expected to go to producing ethanol in 2008.

Source: Mira Kamdar, "Climate Change Challenge for the Poor Part II," Yale Center for the Study of Globalization, 2007 (http://yaleglobal.yale.edu/display.article?id=9734).

In the next issue:

Pharmaceuticals in the Environment

Regulating Environmental Assessment of Pharmaceuticals

Are Pharmaceuticals Endocrine Disruptors?

Guest Editorial: Do Pharmaceuticals in Water Pose a Risk to Human Health?

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