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Emerging National Research Needs for Agricultural Air Quality

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Over the next 50 years, the Earth's human population is predicted to increase from the current 6.1 billion to more than 9 billion, creating a parallel increase in demand for agricultural commodities.

Satisfying the demand for food is already driving changes in crop and livestock production methods that may have profound environmental effects. Increased consumption of animal protein in developed and developing countries, for example, has resulted in concentrated production of poultry and livestock, which has led to concentrated emissions of pollutants from these production facilities and has created regulatory concerns for agriculture. Development of land for nonagricultural uses has placed more pressure on marginal agricultural lands and has caused environmental degradation including the emission of trace gases (e.g., carbon, sulfur, and nitrogen species) into the atmosphere.

Efforts to maximize benefits and reduce detrimental effects of agricultural production must transcend disciplinary, geographic, and political boundaries, and involve natural and social scientists, economists, engineers, business leaders, and decision makers.

Agricultural Pollutant Emissions and Fate

In the past 60 years, nitrogen fertilizers have had a beneficial effect on agriculture globally by increasing crop yields. However, the high loading of reactive nitrogen has led to deleterious effects on the environment, such as decreased visibility from increased aerosol production and elevated nitrogen concentrations in ground and surface waters [*Aneja et al.,* 2001]. Nitrogen compounds released into the atmosphere from anthropogenic or natural sources interact in atmospheric reactions (e.g., gas-to-particle conversion), are transported by winds, return to the surface by wet and dry deposition processes, and may have adverse effects on human health and the environment (Figure 1).

Emissions from animal and crop agriculture have now become a significant problem, both politically and environmentally, owing to increased food production and ever-growing pressures to develop agricultural land. These agricultural byproducts include odor emissions (e.g., organic acids), reactive nitrogen [e.g., ammonia (NH_3) and nitrogen oxides (NO_x)], particulate matter (e.g., particulates from tillage and burning), and gaseous sulfur compounds [e.g., hydrogen sulfide (H_2S)].

Globally, domestic animals are the largest source [32×10^{12} grams NH_3-N (ammonia-nitrogen) per year] of atmospheric NH_3, comprising approximately 40 percent of natural and anthropogenic emissions combined. Synthetic fertilizers and agricultural crops together contribute an additional 9×10^{12} grams NH_3-N per year (12 percent of total emissions) [*Schlesinger and Hartley,* 1992]. Thus, humans have more than doubled the flux of ammonia to the Earth's atmosphere and greatly increased the deposition of reactive nitrogen in regions downwind of agriculture.

Emissions of sulfur gases, volatile organic compounds, greenhouse gases, and particulate matter from agricultural sources are less quantified. Gaseous deposition, from both crop and animal operations, contributes to eutrophication and acidification of some downwind ecosystems [*Krupa,* 2003]. Greater removal of crop residues and efforts to incorporate crop remains into soil organic matter, coupled with legislation, have substantially decreased agricultural burning in the United States, but burning still represents a tremendous challenge in developing countries that do not have access to these technologies.

Public concerns about the potential environmental and health effects of air emissions from confined animal feeding operations (CAFOs) expand the impacts of food production beyond those associated with traditional agricultural practices. The increasing size and geographic concentration of CAFOs, and growing concerns about emissions from them, have led regulators and policy makers to focus on mitigating the harmful effects of CAFO emissions.

The geographic concentration of agricultural operations has brought with it related contamination of air, water, and soil that demands immediate attention. In addition, these concerns are compounded by the potential negative economic impacts of proposed regulations to curtail air pollution from agriculture: on agricultural economies and livelihoods and on the domestic and export markets for agricultural goods from the United States.

The cattle, hog, and poultry CAFOs and related dairy operations, for example, are a significant industry, with revenues that exceeded $120 billion for the United States in 2004 (http://www.ers.usda.gov/publications/Agoutlook/AOTables/). By comparison, revenues for crop production were ~$116 billion in 2004.

To mitigate air pollution from agriculture, scientists and policy makers must consider

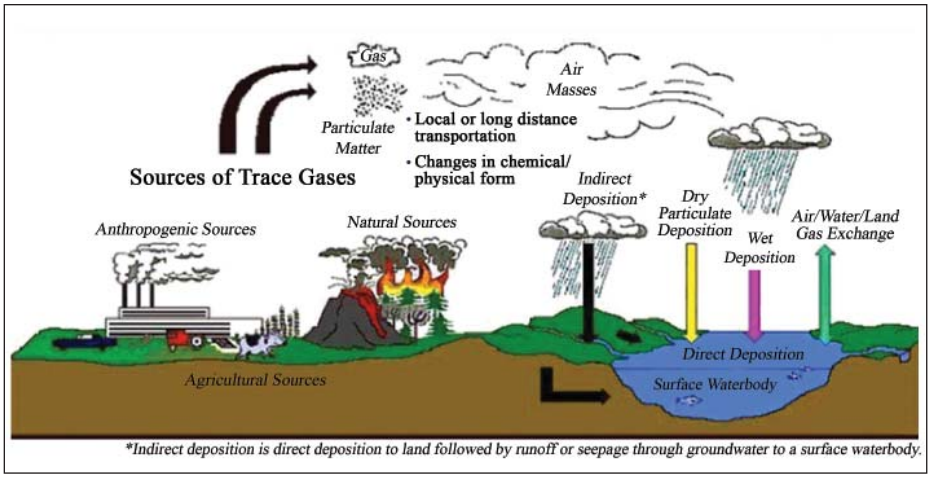

Fig. 1. Atmospheric emissions, transport, transformation, and deposition of trace gases.

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