Agricultural Air Quality:

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Air quality, and notably emissions to air from agricultural and natural landscapes across the United States, was *the* critical factor in the formation of the Soil Conservation Service (SCS) within the U.S. Department of Agriculture (USDA) in 1935. As the U.S. Congress debated legislation for the Soil Conservation Act in April 1935, a cloud of dust that originated from the Great Plains blew over Washington, DC. The dust cloud epitomized issues with land management and the drought that gripped much of the nation at that time. Wind erosion control, and thus particulate matter (PM), became core issues for the new SCS and USDA.

A new "tier 3" irrigation pump engine, with significantly lower emissions than older engines, installed and operational in San Joaquin Valley, CA, using the new NRCS Combustion System Improvement practice.

A USDA Perspective

While wind erosion and PM remain important issues for USDA, air quality considerations have broadened in more recent years because of (1) the increasing urban-rural interface; (2) greater understanding the impact of air quality on health, visibility, and safety, and the consequent regulation increases; and (3) increasing size and density of some farming operations. USDA has responded to these challenges by focusing on an array of agricultural air quality issues through research, education, and conservation programs.

USDA maintains in-house and extramural continuous, theme-based scientific programs that solve current problems, develop new science to prepare for future challenges, enable sustainable production, and ensure stewardship of air, land, and water resources. USDA air quality research programs focus on developing quantitative emissions data for agricultural production practices and improving information about the measurement, control, fate, and transport of odor, gases, and particulate matter. Emission categories targeted by USDA research and air resource conservation activities include direct PM emissions, ammonia, volatile organic compounds (VOCs), pesticides, oxides of nitrogen (NO_x), odorous sulfur compounds, and the three agriculturally-important greenhouse gases (GHGs): carbon dioxide, nitrous oxide, and methane.

Additionally, USDA air quality programs engage in extramural outreach activities that include transferring technologies and best practices to agricultural producers and the regulatory community to lessen the production and transport of air pollutants and GHGs. While USDA currently has modest research investments on the impacts of air quality on agricultural production, a significant amount of research has been focused on the effects of ozone on plant welfare and has been instrumental in informing the current U.S. Environmental Protection Agency (EPA) review of the ozone secondary standard.

Federal legislation in 1996 directed the Chief of the Natural Resources Conservation Service (NRCS, formerly the SCS) to establish the USDA Agricultural Air Quality Task Force (AAQTF) to address agricultural air quality issues. Since that time, the NRCS Chief has led the AAQTF, whose charter and members are renewed every two years. The AAQTF advises the USDA Secretary on agricultural air quality research needs, and provides expert opinion on a variety of federal agricultural air quality projects. The AAQTF consists of USDA employees, industry representatives, and other experts in the fields of agriculture and air quality. Recommendations from the AAQTF may also inform communications between federal and state agencies, including EPA.

The AAQTF has made recommendations to USDA for greater resource allocations for air quality research. These recommendations, coupled with growing awareness by the land-grant university community, resulted in greater resources for agricultural air quality research and extension. A significant increase came during 2003 when the USDA National Research Initiative (NRI), administered by the Cooperative State Research, Education, and Extension Service (CSREES, now NIFA) created a new $5 million-per-year air quality research and extension program. NIFA continues to provide research and extension extramural funding on air quality through its climate change challenge area that addresses emissions and mitigation of GHGs and nitrogenous gases from agroecosystems.

All USDA research is peer-reviewed with research priorities set via discussions with stakeholders and customers. Research results from USDA-funded research is targeted toward providing information and technologies that enable farmers, ranchers, land managers, and policy-makers to make sound, science-based decisions. Synthesis of agricultural GHG emissions data, for example, is used for regional and national accountings such as the U.S. Agriculture and Forestry Greenhouse Gas Inventory.[1]

USDA Research and Extension

Agricultural air quality research is primarily facilitated by two USDA agencies. The Agricultural Research Service (ARS) conducts long-term, theme-based in-house research for USDA. The National Institute of Food and Agriculture (NIFA) provides program leadership and federal assistance through grants to a wide variety of clients.

Outreach to agricultural producers is an integral part of USDA programs.

Figure 1. In a study to document plume characteristics with LiDAR measurements, ARS soil scientist John Prueger climbs a 30m tower positioned between swine production buildings to inspect air-sampling equipment.

Measurements and Instrumentation Development

There is considerable emphasis by ARS and NIFA-funded scientists to develop instrumentation and sound experimental protocols appropriate for various agricultural systems. Chemical, physical, and electro-optical measurement technologies are developed, modified, and enhanced, as needed. Wind tunnels, indoor and outdoor chambers, and laboratory facilities are utilized in research. A notable example is a laboratory-based apparatus developed by ARS that reduces the need for lengthy field measurements to understand some basic characteristics of pesticide emissions. Mobile measurement facilities are a goal when possible to enable collaborative field research by scientists from different laboratories (see Figure 1).

ARS is developing a data management system for air quality data that standardizes measurement protocols to enable data comparisons over time and geographic space such as the protocols used by scientists from 34 ARS laboratories across the United States contributing to the ARS Greenhouse gas Reductions through Agricultural Carbon Enhancement network (GRACEnet) project Another study, on herbicide losses following field application over 12 years by ARS researchers from Maryland, Iowa, and California, determined that soil moisture is a critically important factor affecting volatilization. The study showed that the addition of soil moisture to models describing these losses will for the first time provide a practical basis for decision support systems to reduce pesticide losses from agricultural fields.

Process-Based Model Development

ARS and NIFA air quality research pursues a comprehensive understanding of processes via development and enhancement of models describing and predicting emission, fate, transport, and deposition. The models are used as research tools and as the basis for decision support systems. The ARS Wind Erosion Prediction System (WEPS) was developed for the NRCS to assist landowners in developing soil management plans to reduce soil wind erosion. The WEPS model is being enhanced to incorporate nationwide NRCS databases available online, and improve the applicability of the model to more types of cropping systems. NIFA funding at Washington State University is coupling WEPS with a comprehensive regional air quality model (WRF and CMAQ) to better understand the impacts of windblown dust on regional air quality.

Emissions Management Technologies for Mitigation and Abatement

USDA air quality research develops best management practices for managing emissions. These practices take a variety of forms, including tillage and fertilizer practice recommendations, gas mitigation strategies such as biofilters, chemical amendments, modification to animal feed formulas, and recommendations on the orientation of new animal production facilities relative to prevailing winds. Decision support systems such as the ARS Integrated Farm System Model (IFSM) draw upon many separate models to provide a tool to simulate all major farm components on a process level. The IFSM provides a robust research and teaching tool for exploring the whole farm impact of changes of management technology on air quality.

Extension and Education

Outreach to agricultural producers is an integral part of USDA programs. An extensive network of state, regional, and county extension offices exist in every U.S. state and territory. Extension staff respond to public inquiries and conduct informal, noncredit workshops, and other educational events.

Extension programs are now electronically integrated across state boundaries through eXtension—an educational partnership of 74 U.S. universities. An example is the Air Quality in Animal Agriculture Web page.[2] The site contains information on controlling air emissions, complying with EPA Emergency Planning & Community Right-to-Know Act (EPCRA) reporting requirements for ammonia emissions, as well as many

educational webinars related to animal agriculture and air quality.

USDA Conservation Practices and Systems

The NRCS organizes conservation activity around the principle of resource concerns. The foundational concerns are soil, water, air, plants, animals, humans and, most recently, energy. The air resource is subdivided into four primary resource concerns: PM, precursor emissions to ozone, odors, and GHGs, the latter being the atmospheric change emphasis area.

Each of these air resource concerns are further subdivided into specific emission categories that can be evaluated in on-farm conservation planning. For instance, PM includes both direct PM emissions (e.g., dust, smoke, pesticides) and indirect or secondary PM formation (e.g., fine particulates like ammonium nitrate). NRCS conservation planners are able to assist landowners in identifying on-farm emissions and in developing mitigation strategies.

Until recently, most U.S. agricultural operations were not the focus of regulatory efforts. However, this regulatory focus is changing where air quality is poor and agriculture is a significant part of the emissions inventory. For instance, California's San Joaquin Valley, one of the world's most productive agricultural regions, faces significant regulatory challenges for both ozone and fine PM. For regions like this, the air resource can become the primary resource concern for NRCS.

More than 170 official conservation practices are used by NRCS. Most have been targeted at soil or water issues; however, during 2010, four new air quality-specific practices were released. These are air filtration and scrubbing, combustion system improvement, dust control on unpaved roads and surfaces, and dust control from animal activity on open lot surfaces (see Figure 2). Each of these practices target one or more key emissions and air resource concerns. Additionally, many of the other 170 practices now incorporate specific air quality purposes. For instance, recent changes to nutrient management, feed management, and prescribed burning practice standards include air-related goals.

The NRCS has provided more than $44 million in cost-share funding directly to California producers for combustion system improvements during 2009 and 2010. These funds were largely used to replace old tractors and other farm engines with new systems that have significantly lowered emissions (see photo of "tier 3" irrigation pump engine on page 8). More than 800 replacements were made in just two years, reducing NO_x emissions in the San Joaquin Valley region by nearly 1400 tons per year, and reducing VOC emissions by nearly 200 tons per year. For comparison, the NO_x emission reductions equate to approximately 408,000 vehicles removed from California highways.

More Information

ARS Air Quality programs:
www.ars.usda.gov/research/programs/programs.htm?NP_CODE=212

NIFA Air Quality and Climate programs:
http://nifa.usda.gov/airquality.cfm

NRCS Air Quality and Atmospheric Change:
www.airquality.nrcs.usda.gov

Integration of Research into NRCS Conservation Activities

The NRCS works closely with the research community to integrate new technology and information into air resource conservation. Agricultural air quality research by ARS and NIFA-funded academic institutions has greatly expanded in the past 10 years. NRCS air quality scientists serve as liaisons between the research community and agency field staff who work directly with landowners.

In 2004, the NRCS formed the national Air Quality and Atmospheric Change Technology Development

Figure 2. *Solid-set sprinklers and manure harvesting, such as shown here in Muleshoe, TX, are the primary activities for controlling particulate emissions from feedlots using a new NRCS conservation practice.*

Figure 3. *Gasification units, such as the one shown here on a poultry operation in West Virginia, can provide a source of renewable energy, improved manure management, and a source of biochar. This is an example of a project funded under the Conservation Innovation Grant program.*

Team specifically to better integrate new technology into the agency's conservation planning portfolio. This team has vigorously pursued the integration of air quality science into NRCS activities via the development of a comprehensive air quality training program for NRCS personnel nationwide, using both Web-based and in-class instructional methods.[3] Team personnel serve on numerous research committees and projects to ensure that research is relevant and meeting the needs of farmers and ranchers, and that new technology is implemented rapidly.

The NRCS also created a National Atmospheric Resource Specialist position in Washington, DC, to help direct air quality-related policy and technology efforts, and a new NRCS team in California to specifically address air quality, atmospheric change, and energy issues.

The Conservation Innovation Grant (CIG) program is a relatively new creation within NRCS conservation programs. CIG is a voluntary program to stimulate the development, demonstration, and adoption of innovative conservation approaches and technologies, while leveraging federal investment in environmental enhancement and protection, in conjunction with agricultural production. Under CIG, funds from the Environmental Quality Incentives Program (EQIP) are used to award competitive grants to non-federal governmental or non-governmental organizations, tribes, or individuals.

Since its inception in 2004, CIG has had an air quality category and has supported grants demonstrating and promoting promising air quality and atmospheric change-related technologies. CIG is not used for fundamental research, but for demonstrating the on-farm viability of research results by integrating findings into air-resource-benefiting practices on farms. Examples of air quality CIGs with broad applicability include the demonstration of gasification technology to reduce odors and other challenges associated with poultry operations while providing a means of renewable energy recovery and biochar production (see Figures 2 and 3), and the development of a National Air Quality Site Assessment Tool (NAQSAT) for assisting livestock producers when determining opportunities for managing air emissions.

Partnerships and the Future

Air quality and atmospheric change issues will likely increase in number and intensity for the foreseeable future. NRCS will continue to serve an important function as one of the primary federal agencies providing technical guidance to landowners and producers on conservation practices and systems that address these issues. Because of the paucity of emissions data from all types of agricultural systems, the demand for measurements will continue to be an emphasis of ARS and NIFA air quality research. Periodic synthesis of agricultural air quality research results and assessments of promising solutions will be conducted for policy-makers and to help determine research directions. Increased ties with stakeholders and customers will expand with an emphasis on providing sound data to policy-makers and management technologies for producers and land managers. Research on air quality by ARS and NIFA will be strengthened through partnerships and collaborations with scientists from other federal agencies, universities, industry, and non-government organizations, thus ensuring efficient, environmentally-friendly agricultural production practices. **em**

References

1. *U.S. Agriculture and Forestry Greenhouse Gas Inventory: 1990-2005;* Technical Bulletin No. 1921; Global Change Program Office, Office of the Chief Economist, U.S. Department of Agriculture, August 2008; available at www.usda.gov/oce/global_change/AFGGInventory1990_2005.htm.
2. Air Quality Education in Animal Agriculture (AQEAA) project Web site: www.extension.org/pages/15538/air-quality-in-animal-agriculture.
3. NRCS air, climate change, and energy online training resources: www.nedc.nrcs.usda.gov/TrainingResources/ACE_webbased.html.