The March–April 2015 issue of the Journal of Environmental Quality (JEQ) includes a special section on “Improving Nitrogen Use Efficiency in Crop and Livestock Production Systems.” CSA News recently asked one of the guest editors for this section, Eric A. Davidson, University of Maryland Center for Environmental Science, Appalachian Laboratory, Frostburg, MD, to provide some details about the special section below:

CSA News: How did this special section come about?

Davidson: We know a lot about how to improve nutrient management in agriculture, and we have some very powerful technologies at our disposal to do so, and yet, regrettably, nutrient pollution of groundwater, rivers and lakes, and coastal zones is still increasing downstream of many agricultural regions. Likewise, emissions of ammonia (NH₃) and nitrous oxide (N₂O) are also increasing in many regions. If we have the technology and know-how, then there must be some other impediments, such as socio-economic factors, that are standing in the way of progress. In August 2013, about 160 agronomists, scientists, extension agents, crop advisers, economists, farmers, representatives of regulatory agencies and non-governmental organizations, and other agricultural experts gathered at a conference in Kansas City, MO to discuss these issues.

CSA News: Why is this a timely or important topic?

Davidson: Humankind faces a vexing problem of nourishing about 9.5 billion people by 2050 while still maintaining the integrity of the soil and water resources and the global climate system that food production requires. The

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early 20th century invention of the Haber-Bosch process to synthetically convert inert atmospheric dinitrogen \( (N_2) \) gas to more reactive forms has transformed our modern agricultural system and has enabled the current human population to swell to more than 7 billion people. However, this transformation has come at considerable environmental cost, calling into question the future sustainability of this model. Averaged globally, about half of the fertilizer nitrogen \((N)\) applied to farms is typically removed with the crops while the other half either remains in the soils or is lost from the farmers’ fields. Losses occur mostly as nitrate \((NO_3^-)\) and dissolved organic nitrogen \((DON)\) leaching into groundwater and surface waters, or as NH\(_3\), nitric oxide \((NO)\), N\(_2\)O, and N\(_2\) gases emitted to the atmosphere. The \( NO_3^- \) and DON contribute to unwanted eutrophication and harmful algal blooms in downstream aquatic ecosystems, \( NO_3^- \) is a regulated pollutant in drinking water, NO is a precursor to tropospheric ozone pollution, \( NH_3 \) and NO are precursors to particulate matter air pollution and contribute to \( N\) deposition onto downwind ecosystems, and \( N_2\)O is both a potent greenhouse gas and a significant stratospheric ozone-depleting substance. Additional pathways for these soluble and gaseous \( N \) losses occur when crops are fed to livestock, which produces \( N \)-rich manure that must also be managed. As global mean per capita meat and dairy consumption rise at the same time that population also grows, the challenges of making our food production systems efficient with respect to \( N \) use will be compounded.

**CSA News:** What aspects of NUE are presented?

**Davidson:** While there are some papers on applications of developing technologies, such as controlled-release fertilizers, nitrification inhibitors, and cover crops, this collection also includes some very novel analyses of economic models and social science surveys that explore what influences farmers’ nutrient management decisions. For example, one study in a tile-drained corn growing region of Illinois showed that surveyed farmers expressed strong environmental and stewardship ethics, but fewer than 20% perceived \( NO_3^- \) as a water quality problem. Out-of-pocket expenses were quoted as being the greatest factor that limited farmers’ ability and willingness to implement water quality nutrient management, followed closely by lack of government funds for cost sharing and concerns about reduced yields. The surveys indicated that financial incentives and more readily available evidence to demonstrate effective local pollution reduction would have the greatest effect on adoption rates. A common theme emerging from sociological research is that most U.S. farmers now obtain the majority of their information about nutrient management from family members, retailers, and private-sector crop advisers. Hence, the most effective role of extension may now be to train the retailers and crop advisers so that these private-sector stakeholders may then become the trusted sources of up-to-date nutrient management information for the majority farmers.

**CSA News:** What major research gaps have you discovered from editing this special collection?

**Davidson:** The few partial success stories told in this special collection have a common theme of having tailored regulations, incentives, or outreach to local conditions, administered and enforced by local entities, and where local “buy-in” was obtained. Rather than targeting individual farmers with nationally administered programs, small groups of farmers, consultants, academics, and regulators, working together to solve common production or conservation issues, can be much more effective. However, we are just beginning to understand the socio-economic impediments to improving farm NUE. Hence, one of our recommendations is for state and federal governments to restore investments in research, education, and extension that integrate across agronomic, ecological, economic, and social sciences and provide the needed knowledge and human resources for advancing adoption of innovative crop and animal production systems.

**CSA News:** Anything else you’d like people to know?

**Davidson:** Other recommendations from the conference included: (i) develop partnerships and networks at local and regional levels among industry, universities, governments, non-governmental organizations, crop advisers, and farmers to demonstrate and quantify the most current, economically feasible, best management NUE practices for the local situation; (ii) improve continuing education to private-sector retailers and crop advisers on the most up-to-date nutrient management practices through professional certification programs by university and government extension and scientific societies; and (iii) tie nutrient management to performance-based indicators, including NUE indicators on the farm, with strong incentives for farmers to participate and report data.

The technological, economic, and social impediments to improve NUE are not insurmountable, but there is no silver bullet, nor silver plow, for solving the challenge of producing more food with low pollution. Fortunately, the “Mo Fo Lo Po” goal is easy to articulate and understand, and our knowledge base and technological know-how are already good. However, overcoming impediments to improving NUE in modern agriculture, while also meeting society’s food and energy security needs, will require significant new investments and cross-sectoral partnerships in knowledge-based agriculture.