CHAPTER SEVEN

Responses: Technologies and Practices

Appendix 7.4 Lifecycle Accounting and Pollution Trading: Next Generation Decision-Making

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This is an appendix to Chapter 7 of *The California Nitrogen Assessment: Challenges and Solutions for People, Agriculture, and the Environment*. Additional information about the California Nitrogen Assessment (CNA) and appendices for other chapters are available at the Agricultural Sustainability Institute website: asi.ucdavis.edu/nitrogen

Suggested citation:

TS Rosenstock, S Brodt, M Burger, H Leverenz, and D Meyer. "Appendix 7.4: Lifecycle Accounting and Pollution Trading: Next Generation Decision-Making." Online appendices for California Nitrogen Assessment: Challenges and Solutions for People, Agriculture, and the Environment. TP Tomich, SB Brodt, RA Dahlgren, and KM Scow, eds. Agricultural Sustainability Institute at UC Davis. (2016). asi.ucdavis.edu/nitrogen.

7.4 Lifecycle Accounting and Pollution Trading: Next Generation Decision-Making

Control technologies have historically been and, for the most part, are still evaluated based on their ability to impact or regulate specific nitrogen (N) species from a particular source. Emphasis on individual transfers of N, without systemic consideration of the entire N cascade, can result in exchanging one N pollutant for another (as discussed in Chapter 7, Section 7.2 of the *California Nitrogen Assessment*). Risks of pollution swapping extend throughout the supply chain and can even induce non-N pollutants. The wider environmental context needs to be considered to determine the value and appropriateness of a control technology. Unintended consequences may result when practice efficacy is defined too narrowly.

To begin with, the N cascade is inextricably linked with the carbon (C) cycle. As a result, fertilizer and food production, transportation and industrial combustion, soil processes, and waste processing and disposal affect both biogeochemical cycles simultaneously. The implication is that, in many cases, the perturbation of one cycle cannot be fully assessed without including effects on the other and implementation of risk reduction strategies can create tradeoffs among emissions of various elements.

A lot has been made of the interaction between C and N in terms of climate change and agriculture, with the value of practices that at first were thought critical to agriculture's response being heavily scrutinized; no-till or minimum tillage is one notable example. Cooling benefits of accumulation of soil C by minimum tillage has been called into question, with some evidence suggesting benefits are offset by increases in the much more potent N_2O; however, the effects are far from certain (Baker et al., 2007; Butterbach-Bahl et al., 2004; Six et al., 2004). Tillage presents an example of tradeoffs in direct field emissions, but tradeoffs among indirect emissions of greenhouse gases may also occur. Draining rice fields mid-season to control methane emissions has been cited as a possible mitigation option (Eagle et al., 2010). When soils dry out, oxygen diffuses into the soil allowing the soils to go from anaerobic to aerobic, reducing methane. But the transition of soil water content presumably would create conditions conducive to denitrification. Regardless if direct field emissions of N_2O increase, the added machine time necessary to manage the field—draining and reflooding, increased herbicide applications, etc.—would increase CO_2 emissions from fuel combustion. Consideration of the entire suite of emissions associated with changes in production is needed to support notions of mitigative technologies.

The agricultural examples illustrate the need to account for emissions of N and C across the entire life cycle of a production system to differentiate among practices. Much has been made of the value of such assessments, with diverse institutions from private companies (e.g., Tropicana Orange Juice) to international organizations such as the FAO (e.g., Livestock's Long Shadow and its follow-up) utilizing them. However, often the comparisons are rife with controversy. Disagreement stems from where the system boundaries are drawn and the underlying assumptions of the life cycle model. One of the most high profile examples is from the highly controversial report titled, "Livestock's Long Shadow" (Steinfeld et al., 2006). The report states that the radiative forcing of the global livestock industry is greater than the impact from transportation. The report, however, compared emissions from feed to fork for livestock but only the direct emissions from fuel combustion for transportation, and not all the indirect emissions associated with fuel extraction, processing, and distribution. Thus, concerns have been raised about the appropriateness of the appraisal (Mitloehner et al., 2009). In recent years, progress has been made toward standardizing methodologies, such as with the International Organization for Standardization's life cycle assessment and carbon footprint standards (www.iso.org), as well as Product Category Rules for creating Environmental Product Declarations (environdec.com), voluntary disclosures of environmental impacts of specific commercial products that are increasingly being used in the food industry. Nevertheless, for actual quantification of various N-related flows, such as N_2O emissions, that become part of such life cycle assessments, Kendall (personal communication) has found little consistency in the methods used. Therefore, we conclude that there is clear value and need to evaluate practices based on life cycle assessment. At the same time, evaluation and further refinement of the methods used to quantify impacts will add to their value.

Because of the need of full accounting of greenhouse gas emissions, it is important to note that direct field emissions account for only a fraction of total climate forcing from fertilizer use. So-called indirect emissions, those that don't occur from within the field of application boundaries, can be quite significant. Prior to the field application, production and transport of fertilizer generates a small amount of N_2O, but large amounts of carbon dioxide because of the energy demand for N fixation via the Haber Bosch process (See Box 5.4.2). After application, there are many pathways for N loss. When it moves beyond the field, it is still likely to produce N_2O emissions. In some cases, such as riparian environments, probability of emissions increases as conditions become more conducive (saturated soils). Crutzen et al. (2008) suggest that when up and downstream effects of agriculture are included in the accounting, 3 - 5% of applied fertilizer is given off as N_2O, more than double the amount of direct emissions.

References

Baker, J.M., Ochsner, T.E., Venterea, R.T., Griffis, T.J., 2007. Tillage and soil carbon sequestration—What do we really know? Agriculture, Ecosystems & Environment 118, 1–5. doi:10.1016/j.agee.2006.05.014

Butterbach-Bahl, K., Kesik, M., Miehle, P., Papen, H., Li, C., 2004. Quantifying the regional source strength of N-trace gases across agricultural and forest ecosystems with process based models. Plant and Soil 260, 311–329.

Crutzen, P.J., Mosier, A.R., Smith, K.A., Winiwarter, W., 2008. N2O release from agro-biofuel production negates global warming reduction by replacing fossil fuels. Atmospheric Chemistry and Physics 8, 389–395.

Eagle, J.E., Henry, L.R., Olander, L.P., Haugen-Kozyra, K., Millar, N., Robertson, G.P., 2010. Greenhouse gas mitigation potential of agricultural land management in the United States. A Synthesis of the Literature. Technical Working Group on Agricultural Greenhouse Gases (T-AGG) Report.

Mitloehner, F., Sun, H., Karlik, J., 2009. Direct measurements improve estimates of dairy greenhouse-gas emissions. California agriculture 63, 79–83.

Six, J., Ogle, S.M., Breidt, F.J., Conant, R.T., Mosier, A.R., Paustian, K., 2004. The potential to mitigate global warming with no-tillage management is only realized when practised in the long term. Global Change Biology 10, 155–160. doi:10.1111/j.1529-8817.2003.00730.x

Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M., De Haan, C., 2006. Livestock's long shadow. Food and Agriculture Organization of the United Nations, Rome.