CHAPTER SEVEN

Responses: Technologies and Practices

Appendix 7.5 Metrics for Nitrogen Management

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7.5 Metrics for Nitrogen Management

Our understanding of the current state and changes in the nitrogen (N) cascade relies on measurement of N in the environment. N measurements are typically expressed in terms of mass loading (e.g., kg NO_3 per ha) or concentration of a particular form of N (e.g., ppm NO_3). Data collected quantifying these metrics of N can then be translated into management strategies, policy recommendations, and regulations. Smart N metrics capable of documenting the conditions of California's N cascade (at an appropriate scale and reasonable cost) are therefore central to the development of response strategies.

What forms of N are measured and where they are measured can influence the interpretation of the impacts and the response options. For example, field-scale mass balance suggests groundwater recharge from only a few cropping systems in California leach a mass of N that would meet the maximum contaminate load standards of a concentration of 10 mg/L NO_3-N (approximately 35 kg N per ha at average recharge rates) that has been set to ensure safe drinking water (Harter et al., 2012). However, N in groundwater recharge may be attenuated through denitrification or diluted through increased irrigation or precipitation. Changes in N concentration during its transmission to groundwater suggest that where in the soil profile N is measured is important in understanding its actual impacts on drinking water.

Defining metrics and designing measurement and monitoring programs should be tied to impacts of N on the environment and the delivery of ecosystem services. The nature and magnitude of impacts are dependent upon the sources of N, the media (air, soil, or water), and the chemical forms of N. It is important to note that the relationships between sources and impacts are not straightforward. Only in some cases does the source of N largely determine its transmission in certain forms into certain media. In many cases, however, a single source contributes to multiple N concerns simultaneously–directly and indirectly. A balance must be struck between placing emphasis on measuring primary sources versus measuring subsequent cascading effects.

Historically, measurements have informed management and policy to help maintain N impacts below an acceptable threshold of risk. When a contaminant is found to have a direct correlation with environmental or health outcomes, control mechanisms can be put in place to limit the damage. Statewide ozone standards are one example of this approach. The California Air Resources Board (CARB) and air basins monitor air quality for ozone concentrations and suggest citizens take precautionary measures when concentrations exceed safe levels. A similar approach is used–though less frequently–as part of the water monitoring programs. Though effective, the concern is that addressing single impacts in isolation ignores the intertwined dynamics of the N cascade. For some cases and in some locations, a multi-impact management approach may be appropriate (e.g., Tulare Lake Basin with its poor groundwater quality, high ozone levels, and high N deposition).

Not all metrics address only a single N source or impact (e.g., NO_x concentrations). Collective metrics that aggregate across end points are available for some environmental impacts, with additional ones just coming into use. Perhaps the most well-known collective metric is applied global warming and greenhouse gas emissions. Methane, nitrous oxide, and carbon dioxide emissions can all be expressed in terms of their radiative forcing over a fixed time-frame (100 years) in a common unit, 'carbon dioxide equivalents.' Unifying the metric allows management practices that affect various impact pathways to be compared. Collective metrics are also used to define acidification (e.g., SO_x and NO_x as H^+ equivalents). Clearly it is possible and potentially advisable to present collective metrics when multiple factors affect a single impact.

Often, however, a single source affects multiple impacts in opposite directions, so that tradeoffs exist, for example, between food production and climate change. Here as well, collective metrics may be able to capture the relationships between the impacts. Recently, the global warming intensity of cropping systems (yield-scaled global warming potential) has gained traction in agronomic discussions because it scales the emissions by crop yield, acknowledging that some emissions are necessary in highly productive agricultural systems and food production is critical to survival. While the research community has begun to adopt this collective metric, it is yet to be integrated into policy or management approaches. The relatively slow adoption rate illustrates the speed at which a collective metric might come into use outside of research. Despite the slow transition, global warming intensity presents a good example of the type of innovation that will be needed to address multiple N impacts in a systematic way.

Metrics are fundamental to any N response strategy. California has the infrastructure needed to form the basis of a useful N monitoring program (see Appendix 7.6). However, coupling innovative metrics to the realities of the N cascade is still a challenge. Further, integrating information that can quickly and in near real-time feed back into the management and policy process is the next frontier in addressing N issues in California.

Reference

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