Institutional barriers and opportunities for improving policy approaches to reducing excess reactive nitrogen from U.S. agriculture

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Abstract
Agriculture in the U.S. is the major source of anthropogenic reactive nitrogen. The control and management of this nitrogen is a major challenge. The challenge is magnified by the nature of the nitrogen cascade; the ability of nitrogen to change form and move between land, air and water. This is only one of the factors making excess reactive nitrogen a wicked problem. The U.S. Environmental protection Agency and the U.S. Department of Agriculture are major players in dealing with reactive nitrogen and have different institutional histories, responsibilities, and structures. Yet, in order to effectively manage and control reactive nitrogen these institutions and their activities are going to have to encompass and mirror the nitrogen cascade. Institutions that internally have barriers between segments of the cascade will have to overcome them. Parts of the cascade that involve other institutions will have to be coordinated with those institutions. To accomplish this there has to be the coordination of functions carried out by the two primary agencies. This is made all the more difficult by the fact that EPA plays a regulatory role in contrast to the Department of Agriculture's supportive sectoral role.

Key Words
reactive nitrogen, U.S. agriculture, non-point sources, policy approaches, institutional barriers, opportunities

Introduction

Agriculture in the United States is the major source of reactive nitrogen (Nr) introduced into the country's environment. The largest source is nitrogen fertilizer and the next largest is biological nitrogen fixation from cultivated crops. Together these account for more than half of the nitrogen introduced, approximately 53% of the 2002 total of 34.9 Tg of N/yr (SAB 2011). The bulk of the excess Nr entering the environment from U.S. agriculture is from non-point sources. In addition the nature of nitrogen as it interacts with and moves through the environment makes the management and/or control extremely challenging. This is best illustrated through the character of the nitrogen cascade (Galloway, et al., 2003). The ability of nitrogen to change forms and to move with relative ease between land, air, and water poses a major challenge to management and control.

The challenge is not just biophysical but is also institutional. Different institutions are created with different areas of responsibility which may differ across the institution. The U.S institutions concerned with excess Nr illustrate these divisions. USDA (United State Department of Agriculture) has responsibility for crop and animal agriculture, soils, forests (through the US Forest Service), and environmental effects of agricultural activities through the Natural Resources Conservation Service (formerly the Soil Conservation Service). The US Environmental Protection Agency (EPA) has a different set of responsibilities and zones of operation. The EPA is a technically based regulatory agency with specific responsibilities in air, water, and land. Its budget is primarily concentrated on regulation and the science that underpins that regulation. In contrast, the USDA budget supports food and nutrition programs, crop subsidy programs, conservation programs and rural development programs. If activities are to be undertaken to give incentives to farmers to change behavior or adopt different management, the USDA is the major player. Other agencies such as the National Oceanic and Atmospheric Administration (NOAA) and the U. S. Geological Survey (USGS) have critical technical, research and service roles, but are also budget and mission limited in ways that reduce ground level activities. Thus, the focus here is on the institutions and roles of USDA and EPA.

Government incentives or disincentives to achieve conservation or nutrient management goals on the agricultural landscape come primarily from USDA. It was the Soil Conservation and Domestic Allotment Act of 1936 that became the foundational instrument for providing incentives to farmers to voluntarily adopt conservation practices. This act set the pattern under which efforts are undertaken on the ground today for government encouragement of improved practices to ameliorate environmental externalities. The early

programs met the need to get conservation on the ground to hold soil or to take fragile farmland out of production and put it into conserving uses. It was also the primary means, through incentive payments, for getting badly needed cash into farmers' hands during the Great Depression (Benedict 1953). In 1937 $US 5.042 billion dollars were spent in conservation financial assistance to farmers in constant 2000 dollars. By 1999 the total conservation funding had declined to $US 2.742 billion. By this time, the major income transfer to farmers had become commodity program payments which were relatively small in 1937. While the cash incentive payments to farmers proved effective to accomplish the two goals they did set important precedents. There was no establishment of overall enforced farm stewardship standards as basic requirements for producers. Following from that was the precedent that the federal government would pay farmers through voluntary programs to rectify farmer caused environmental problems. This is in contrast to the situation in the European Union where farmers are required to meet basic environmental standards (Brouwer, et al., 2012). The questions of regulation and enforcement remain open for U.S. farmers for environmental concerns. In the European Union there are standards to be met even though they may vary by country or region. While the European Nitrate Directive is targeting restricting nitrogen applications exceeding agronomic recommendations, there are few similar government actions in the US beyond voluntary programs.

Even though USDA is a federal agency, state and local level administration, decision making, and control were built into USDA programs. It was recognized in 1935 that local organization would be required to deal directly with farmers and carry out conservation on the ground. The result was the establishment of soil conservation districts, often on a county basis, within the states. The federal government drafted a model state soil and water conservation district law. This was sent to state governors in 1937 and ultimately all states passed a law creating the local soil and water conservation districts based on the model law. These local districts became the recipients of state and federal money under state and federal umbrella organizations to respond to soil conservation and other environmental problems. They were operated by local governing boards made up of farmers who set priorities and managed budgets. These local institutions were not designed just for carrying out federal programs. Within USDA there was great concern in the 1930s about the fate of democracy, given what was occurring in Russia, Italy, Germany and other parts of the world. Local boards were established for a number of federal programs to encourage local democratic participation as part of the rationale for their creation (Eisenhower and Kimmel 1940).

If we combine the nature of the nitrogen cascade with the character of the two key institutions that could bring about better management and control of reactive nitrogen, we find a disconnect. EPA, created in the 1970s, is a science based regulatory agency with comparatively few local ties to farmers on the ground. USDA, by contrast, has a bottom up as well as a top down presence in the farming community based on institutions established 80 years ago. This combination of local, state and federal entities under the USDA umbrella has been functioning at various levels of effectiveness and dealing with problems similar to excess Nr over this period.

Method

We start with contrasting histories, institutional reach, missions, and on the ground involvement of USDA and the EPA for dealing with something like excess Nr. From here, we highlight these two institutions' approaches to the problem of excess reactive nitrogen within the context of the institutions and their activities. The notion of wicked and tame problems provides a template for relating a problem to the capacities of institutions and the approaches necessary for dealing with them. Controlling Nr coursing through the nitrogen cascade, is not a traditional linear tame problem. Nutrient management in agroecosystems is a wicked problem. Such problems are complex, dynamic and have many stakeholders that may be deeply involved making the issue socially and politically complex. Wicked problems cannot be solved by experts following the linear scientific method. A tame problem presents a clear definition of the problem that leads to a solution and the problem does not change over time. The problem is either solved or not – the stopping rule applies. For wicked problems there is no universal agreement on the nature of the problem. Attempts to solve the problem change the problem. The problem changes over time. The stopping rule does not apply – the problem can only be made better or worse. Continued efforts to deal with the problem depend upon stakeholders, resources available, and political forces. Wicked problems cannot successfully be tackled without the inclusion of stakeholders who may have different ideas about the problem and alternative solutions. As an example; climate change is a wicked problem while putting a man

on the moon (while complex) is tame. Environmental problems, such as managing Nr, fall into the wicked category (Kreuter et al 2004 and Batie 2008). Efforts to deal with them must reflect that.

Discussion

The USDA can be viewed as an institution that, because of its history, has stakeholders built into the system that are essential for attacking wicked problems. While priorities may be set at the federal and state level, as resources flow to Soil and Water Conservation Districts (SWCDs), these resources are partially directed at the local level with respect to how problems are defined, what alternative solutions might be considered, and what resources should be applied for technical assistance and financial incentives to undertake improved management. In contrast, the EPA, as an Agency set up with regulatory purpose and powers to enforce the several clean air and clean water acts, is in a very different position and less able to engage stakeholders.

One illustration of the involvement of EPA in attempting to deal with nutrient problems is the battle in the state of Florida over narrative and numeric standards to determine impaired waters. The controversy illustrates that wicked problems are not just technical challenges. They are also shaped and often ultimately governed by social and political concerns. Because of such things as its tourist industry, Florida has expended greater effort on improving water quality than many other states. However, the high levels of nutrient pollution in Lake Okeechobee and the Everglades have been of increasing concern. Florida has used narrative (broadly descriptive) standards to determine which waters would be classified as impaired and thus require attention. Environmentalists sued EPA under the Clean Water Act and EPA was forced to set numeric standards, i.e. a concentration thresholds for declaring waters impaired. This would likely result in more waters being declared impaired and targeted for remediation. Once waters are declared impaired then a process can take place where Total Maximum Daily Load requirements can be set for a watershed enforceable under the U.S. Clean Water Act. Load allocations are set for those with discharge permits and ultimately for non-point sources (NRC 2012).

One of the ironies of forcing a nutrient requirement on Florida was that only a limited budget was available for the state to mitigate nutrient problems. Increasing the length of the list of impaired water bodies accomplishes little unless more budget resources can be directed towards the problem. While EPA itself could do little on the ground, agricultural producers claimed they were doing their share through such activities as reducing sugar acreage or adopting improved grazing under incentive programs, so why should they be threatened with greater costs through increased imposition of Total Maximum Daily Loads. There is a clear institutional dichotomy here between EPA's regulatory responsibility and structure contrasted with the Federal. State, local USDA system that operates on the voluntary incentive based system. USDA can, however, wield a limited regulatory stick in conservation compliance. This requires minimal conservation on highly erodible land and offers some protection to wetlands and grasslands. If farmers do not comply, they lose their opportunity to receive USDA program benefits. However, there is continual controversy within the agricultural community about the level of this regulated resource protection and there are continued efforts to reduce it (Doering and Smith, 2012).

In 2007, The US EPA's Science Advisory Board (SAB) set up an Integrated Nitrogen Committee (INC), which delivered its report, "Reactive Nitrogen in the United States", in 2011. One of the objectives of that report was to evaluate the contribution an integrated nitrogen management strategy could make for environmental protection. In addition to a number of sector based technical and scientific concerns, the INC tackled some critical institutional questions. One of these was the structure of EPA organized in stand-alone divisions to reflect the separate water and air concerns of federal legislation. Thus, one of four major recommendation was that EPA should create a Nr task force within the agency's existing research and management capabilities in order to increase scientific understanding of Nr's impacts, to establish monitoring requirements, and determine the most efficient and cost effective means to decrease adverse impacts of Nr loads as they cascade through the environment (SAB 2011). A second one of the four recommendations was that successful management of Nr would require changes in the way EPA interacts with other agencies. This was seen as essential for the creation of coordinated federal programs to better address Nr concerns and ensure clear responsibilities for monitoring, modeling, researching and managing Nr in the environment. The recommendation included a list of federal agencies that needed to be involved in something like an interagency task force and referenced various National Research Council reports on

reducing nutrients in the Mississippi River that stressed institutional cooperation and change for the management and improvement of watersheds stretching across jurisdictional bounds.
There have been changes in EPA and USDA to improve their ability to deal with Nr. EPA has created an internal nitrogen entity that spans water, air, research, and other functions. EPA and USDA are beginning to communicate in areas where it is politically possible. A multi-day meeting was held in June 2014 with research staff attendance from EPA and USDA and USGS. On USDA's part, nutrient management is becoming more prominent in its incentive conservation programs and a major targeting effort has been made in the Nr rich Mississippi basin. However, the politics of Nr resist moving beyond current management efforts. The EPA's attempts at new regulations for waters of the US have created a firestorm. Nutrient regulation is an anathema to the non-point community that contributes much of the problem, and agricultural subsidy expenditure often takes precedence over incentive conservation payments that might bring better Nr management on the part of farmers. That said, the major financial resources for Nr management exist primarily in the budget for agriculture.

Conclusion
Successful management of reactive nitrogen is a truly wicked problem with no single problem definition, solution, or stopping point. The observation here is that any effort to try to bring non-point sources of Nr pollution under control has to be coordinated across institutions and stakeholders at different levels as well as be ongoing. The authors of the EPA, SAB INC report understood that to tackle the management of Nr successfully, institutions and approaches for science and management of Nr would have to align with the nitrogen cascade. However, the EPA and USDA have different institutional histories, missions and scope. These agencies will have to see increased coordination of their missions and coordination with other missions from agencies like USGS and NOAA to align with the nitrogen cascade. One of the major challenges with alignment is the functional difference, given that EPA is the primary regulatory power in this area, while USDA, with the sector ties and voluntary conservation programs, engages farmers and is perceived as friendly to agriculture.

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