CHAPTER EIGHT

Responses: Policies and Institutions

Appendix 8.1 Experience with Nitrogen Policy Instruments in Practice: Case Studies

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8.1 Introduction: Experience with Nitrogen Policy Instruments in Practice

We consider a total of twelve case studies: five California programs, five nutrient-impaired waterbodies in other states, an overview of European nitrogen (N) policies, and a previously published review of state-level nutrient programs. The last of these is qualitatively different from the others and includes both program assessments as well as recommendations for the future. The case studies offer insights into and lessons learned from the more commonly used policy approaches as well as some information about other less commonly used policy instruments.

Contents:

8.2 Case studies

8.2.1 California's Nonpoint Source Program

California's Nonpoint Source (NPS) Program regulates many types of pollutants that originate from diffuse sources and that potentially impact surface and ground waters of the state. As has been documented extensively in this assessment, it is well established that agriculture is a major source (greater than 50%) of nonpoint source nitrogen (N) discharges to groundwater and a moderate source (between 25% and 50%) of N discharges to surface water, and thus it also follows that agriculture is a significant contributor to the associated N-related impacts on those resources (See Chapter 4).

The primary law that establishes authority for regulating agricultural nonpoint sources of N pollution in California is the Porter-Cologne Act. Under the Act, the SWRCB and the

RWQCBs are authorized to establish water quality control plans (called “basin plans” at the regional level) and to issue discharge permits (called Waste Discharge Requirements, or WDRs) and conditional waivers of those permits. Each source must comply with any discharge prohibitions specified in the relevant basin plan and/or the terms of a WDR or a conditional waiver. If a source is found to be in violation of any of these requirements, the state and regional boards are authorized to take enforcement actions including notices to comply, civil penalties and referrals for criminal penalties (SWRCB and CA EPA, 2004).

These three administrative tools—discharge prohibitions, WDRs and waivers of WDRs—provide the basis for regulating agricultural nonpoint sources of N pollution. While discharge prohibitions and WDRs may specify the conditions under which N discharges are allowed (if at all), they may not specify the means by which sources will achieve compliance. Thus these tools appear to be emission-based. However, discharge prohibitions and WDRs may be written such that the only practical means of compliance is to implement a prescribed set of best management practices (BMPs, or MPs in the California regulations). Furthermore, conditional waivers of WDRs may require that a particular set of MPs must be implemented. And moreover, assessment of the program focuses primarily on monitoring MP implementation and effectiveness. Thus, for practical purposes, the California NPS Program is largely technology based (SWRCB and CCC, 2000).

To reduce N pollution from agricultural sources, the NPS Program focuses on implementation of MPs that promote efficient use of nutrients and irrigation water. The program specifically promotes the adoption of comprehensive nutrient management plans by dischargers whose runoff impacts coastal waters or waters listed as impaired by nutrients, as well as more uniform application of irrigation water that is consistent with crop water requirements. In addition, the program provides education and outreach that is specifically aimed at reducing nutrient runoff and leaching (SWRCB and CCC, 2000), as well as technical assistance and financial incentives for MP implementation (SWRCB and CA EPA, 2004).

Although the authority for regulating agricultural nonpoint sources of N pollution in California has been in place for decades, historically these sources have received relatively little attention from regulators. This changed in 2004 when the SWRCB adopted the current NPS implementation and enforcement policy that places greater emphasis on controlling nonpoint sources (UC DANR, 2006). Since then, efforts to promote nutrient and irrigation related MPs through the administrative tools described above have increased. However, it appears that such efforts have focused primarily on discharges to nutrient impaired surface waters, despite the existence of the SWRCB’s anti-degradation policy for groundwater. As recently as 2012, there were no permitting requirements for agricultural nonpoint source discharges of N to groundwater (Canada et al., 2012). However the situation remains in flux. As of 2013, two SWRCB initiatives, the Long-Term Irrigated Lands Regulatory Program (ILRP) and the Central Valley Salinity Alternative for Long-Term Sustainability (CV-SALTS), both address discharges of N to groundwater.

The recent policy history and renewed regulatory focus on agricultural nonpoint sources of N pollution suggest that progress in this area has been limited. Despite persistent N pollution problems, the recent progress reports from the NPS Program primarily mention N pollution as an "upcoming [policy] priority" (CCC and SWRCB, 2012) or in the context of a recently approved Total Maximum Daily Load (SWRCB and CCC, 2009). The NPS Program has demonstrated success in reducing other types of NPS pollutants—including phosphorus, sediment and pesticides—in specific cases, which speaks to the potential effectiveness of the program's approach (SWRCB, 2010). However, there have been no state-wide assessments of the overall effectiveness of the program or of its cost-effectiveness. Moreover, transferring these successes to N problems could be complicated by the transformability of N species and the associated cross-media pollution potential.

Lessons learned from California's NPS Program include the following:

- *Proper implementation of MPs can bring about significant reductions in NPS pollution.* However, implementation and thus pollution reduction has not been widespread.
- *Granting broad authority for pollution control does not guarantee that particular problems will be addressed.* Regulatory resources are limited and thus specific prioritization of issues is needed to achieve progress.
- *While stakeholder involvement is important, relying on voluntary cooperation of dischargers is not conducive to progress.* Prior to adoption of the current implementation and enforcement policy in 2004, the program had been predicated on the voluntary cooperation of dischargers, with regulatory authority reserved for cases of persistent NPS pollution or discharger recalcitrance (SWRCB and CCC, 2000). The new policy places primary emphasis on regulatory authority while still incorporating stakeholder input to a great extent.
- *Agriculture is a key element of mitigating nonpoint source N pollution in California.* Given the significant N discharges by agricultural nonpoint sources and their strong spatial correlation with N impacted water resources, those sources must play a central role in efforts to mitigate N pollution.

8.2.2 California's Agricultural Water Quality Grants Program

The Agricultural Water Quality Grants Program was established in 2002 to address agricultural nonpoint source pollution and to assist growers with complying with new requirements for conditional waivers developed pursuant to Senate Bill 390 (Chapter 686, Statutes 1999). To help growers comply with the waivers, financial assistance programs were established to work in tandem with regulatory programs to provide outreach and education, coordination, technical assistance, and financial incentives to agricultural stakeholders to identify sources of pollutants and implement measures to address discharges from irrigated agriculture. Financial assistance has been made available to growers through the Agricultural Water Quality Grants Program, the NPS Grants Program, Agricultural Drainage Loan/Agricultural Drainage Management Loan Programs, and the State Water Board's Clean Water State Revolving Fund (CWSRF), a low interest loan program.

The initial focus of the Irrigated Lands Regulatory Program and the Agricultural Water Quality Grants Program was to reduce pollutants from agricultural operations into surface waters. Through the Agricultural Water Quality Grants Program and the CWA Section 319(h) Programs, grants are awarded to public agencies, and, in some cases, non-profit organizations or tribes through a competitive grant selection process. Grant amounts have ranged from $250,000 to $1 million with a required match ranging from 20% to 50%. Examples of eligible project types include projects that improve agricultural water quality through monitoring, demonstration projects, research, and construction of agricultural drainage improvements, as well as projects that reduce pollutants in agricultural drainage water through reuse, integrated management, or treatment. Funding has also been directed to high priority areas identified by the Regional Water Boards, and to farms along waterways where agricultural coalition water quality monitoring programs have identified problems associated with releases from irrigated agriculture. These grants pay 50% of the cost to install BMPs such as drip/micro-irrigation systems, retention ponds and recirculation systems on farms. Federal CWA Section 319(h) funding historically has been focused on agricultural projects; however, the focus in recent years has been on NPS projects in general.

Lessons learned from California's Agricultural Water Quality Grants Program include:

- *Cross-jurisdictional conflicts can severely limit participation and effectiveness.* The program requires disclosure of BMP locations and monitoring points, which producers view as both intrusive and a potential liability, and which conflicts with privacy provisions of the Farm Bill. This requirement has significantly limited program participation. Furthermore, the General Obligation Bond Law requires that projects be capital improvements with a useful life of at least 15 years; however, most BMPs have a much shorter useful life which can disqualify their eligibility for such funding.

- *Timely documentation of progress is problematic*. Cumulative impacts of water quality improvement projects, including compliance with water quality standards, generally take longer to realize than the time provided to implement a grant.
- *Evolving state finances can hinder projects already in progress.* The California "bond freeze" of 2008 impaired the ability of grantees and subcontractors to complete the work or receive payment for work completed, resulting in a number of stopped or delayed projects. Long-term successful grant programs are contingent upon a secure and stable source of funding.
- *Matching fund requirements can undermine BMP implementation.* Some applicants leverage funding from sources such as EQIP to fund the BMP implementation phase. However, because EQIP is a voluntary program, NRCS cannot force farmers to choose particular management practices and thus desired BMPs may not be installed. Furthermore, because EQIP has lesser reporting requirements than the Agricultural Water Quality Grants Program, the program has incomplete information on the types of management practices that are actually installed.
- *Grants can facilitate outreach, education and technical assistance, as well as learning about BMP effectiveness under varying practical conditions.*

8.2.3 California's Central Coast Agricultural Waiver Program

California's 1969 Porter-Cologne Act established the State Water Resources Control Board and gave broad authority to nine Regional Water Quality Control Boards, or "Regional Boards," to regulate water quality at a local level. Included in the Regional Board's jurisdiction is the right to waive the discharge permits required for any industry that releases pollutants into state waters. In an effort to encourage more robust water quality protection, the state legislature passed Senate Bill 390 (1999), which reasserted the onus on the Regional Boards to attach conditions to waivers and review them every five years. While all nine Regional Boards waive discharge requirements for all irrigated lands, each region takes a different approach to control agricultural runoff. Currently, four of the nine Regional Boards (Los Angeles, Central Coast, Central Valley and San Diego) have adopted a Conditional Agricultural Waiver.

In 2004, California's Central Coast Region (Region 3) was the first in the state to adopt a Conditional Agricultural Waiver. The conditions attached to the 2004 waiver required growers to enroll in the Agricultural Waiver program, complete 15 hours of water quality education, prepare a farm management plan, implement water quality improvement practices, and complete individual or cooperative water quality monitoring. When the 2004 Agricultural Waiver expired in July 2009, substantial data from the cooperative monitoring program and scientific studies demonstrated that water bodies in the region continued to be severely impaired from agricultural runoff. Because the Agricultural Waiver acts as the primary regulatory mechanism to achieve section 303(d) of the Clean Water Act for most Central Coast agricultural areas, the Regional Board was required to update the expired waiver and include provisions that would address pollutants known to cause water impairments. The Central Coast Regional Board did not have a quorum to adopt a new Agricultural Waiver in 2009, therefore the order was extended with minor modifications several times.

After nearly three years of negotiation, on March 15, 2012 the Central Coast Water Quality Control Board passed a new Conditional Agricultural Waiver (hereafter referred to as the "2012 Ag Waiver"). The updated and more comprehensive 2012 Ag Waiver places farms in one of three tiers, based on their risk to water quality (Tier 1 being the lowest risk and Tier 3 the highest), and imposes a different set of requirements for each tier. For Tier 1 and 2 farms, the requirements are similar to those in the 2004 order with two notable additions: groundwater monitoring (all tiers) and total N application reporting (for some Tier 2 and Tier 3 farms). Tier 3 farms, on the other hand, must comply with several new rigorous provisions, including individual discharge monitoring and reporting, developing and implementing an irrigation and nutrient management plan as well as nutrient balance targets. The most contentious of these additional requirements are individual surface water and groundwater monitoring. While more edge-of-field data are needed to determine contributions from individual nonpoint sources, growers are concerned about the privacy and value of individual discharge information as well as being regulated as point source dischargers. To get out of Tier 3 and avoid the more rigorous requirements, dozens of growers have partitioned their land and/or stopped using the two pesticides—diazinon and chlorpyrifos—that qualify a grower for a higher tier. Since 2012, the number of growers in Tier 3 has dropped from 111 to about 40.

Mounting scientific evidence (see Harter et al., 2012) of nitrate groundwater contamination as well as pressure from environmentalists and environmental justice groups elevated the nitrate issue to the top of the agenda during the 2012 Ag Waiver negotiation process. Consequently, a discharger's risk to nitrate pollution is weighed heavily in the tiering criteria and conditions. For example, growers with large farms and crops that have a high potential to discharge N to groundwater are automatically placed in a higher tier with more stringent requirements. As mentioned in Chapter 8, regulating nitrates is complicated by hydrogeological and biogeochemical processes that create time lags in water quality response. Even with additional data from Tier 3 farms, it may take decades for Agricultural Waiver controls to affect nitrate concentrations.

Time lags and other factors, such as limited nitrate substitutes, make certain policy tools previously used for other pollutants not applicable to nitrates. For example, the regulatory strategy employed in the 2012 Ag Waiver for diazinon and chlorpyrifos, both relatively dispensable pesticides with short half-lives, would not have the same effect on nitrates. Most growers decided to give up using diazinon and chlorpyrifos altogether (perhaps switching to other pesticides, which may have unintended consequences) rather than comply with Tier 3 requirements. This response would not be expected with nitrates for at least two reasons. First, reducing the use of or finding a substitute for the valuable fertilizer would be difficult, if not impossible. Second, the threat of individual monitoring requirements is greater for growers applying short half-life pesticides because they could be identified as a discharger in a short time frame. Contrast that with growers applying nitrates, who, with the same information requirements, would likely not be pinpointed as a polluter until well after their lease is up or they have retired.

Lessons learned from the Central Coast include:

- *Establish more comprehensive data collection and reporting.* Policy makers lack quality information to adequately enforce, evaluate, and use as the baseline for modeling efforts. More individual surface water and groundwater would help determine the impacts of nutrient and chemical applications. Additionally, data are needed on environmental impacts, financial costs, and stakeholder opinions of water pollution abatement tools.
- *Modest policy changes have fallen short of achieving agricultural water quality goals.* The updated 2012 Ag Waiver marginally expanded what was required of the vast majority of most growers (over 97% of growers are in Tier 1 and 2). However, widespread water quality improvements have not been realized. Many remain skeptical that the new provisions will amount to little more than the previous 2004 waiver in the usefulness of information.
- *Raise awareness of the water quality problem and actions will follow.* Both Agricultural Waivers have successfully brought attention to the severity of water pollution in the region. As a result, farmers and farm advisory agents are rethinking nutrient management and discharges from irrigated agriculture.
- *Scientific reports can have powerful implications for policy making.* Several scientific studies on both nitrates (e.g., Harter et al., 2012) and pesticides (see Granite Canyon Lab,

UC Davis) played a pivotal role in prioritizing pollutants of concern in the 2012 Ag Waiver.

8.2.4 California's Dairy Nitrogen Regulations

California's dairy industry is one component of its agricultural enterprise and a significant source of both ammonia and nitrate emissions, as documented in this assessment. Dairies are responsible for the majority of ammonia emissions to the atmosphere and approximately one third of nitrate emissions to groundwater. While crop-only operations emit the majority of nitrates to groundwater, dairies present unique problems. Foremost among these is that N is unavoidably generated as a waste by-product of milk production, rather than imported as needed for soil amendment. The economics of milk production are such that far more waste N is produced than can be utilized by surrounding cropland, resulting in nitrate leaching rates that can be ten times higher than at crop-only operations (Pang et al., 1997; Van der Schans, 2001). California's dairies tend to be large and thus qualify as Concentrated Animal Feeding Operations (CAFOs), which are regulated as point sources under federal law. This means dairies are subject to a different set of regulations than crop-only operations that are classified as nonpoint sources. Regardless, the physical and economic characterization of N emissions from dairies remains nonpoint, and thus these sources present the same pollution abatement challenges as crop-only operations.

The major federal environmental law currently affecting CAFOs is the Clean Water Act (CWA). Under the CWA, discharges of pollutants from point sources to waters of the United States are subject to the National Pollutant Discharge Elimination System (NPDES) permitting requirements. The CWA defines animal production facilities of certain CAFOs as point sources. The United States Environmental Protection Agency (EPA) began setting effluent limitations guidelines (ELGs) and NPDES permitting regulations for CAFOs in the mid-1970s.

Due to persistent pollution problems from animal feeding operations, the United States Department of Agriculture (USDA) and EPA released the Unified National Strategy for Animal Feeding Operations in 1999. The strategy established the goal that "all AFO owners and operators should develop and implement technically sound, economically feasible, and site specific comprehensive nutrient management plans (NMPs) to minimize impacts on water quality and public health." (USDA and EPA, 1999). The strategy involves a comprehensive suite of both voluntary and regulatory programs. Voluntary programs (locally led conservation, environmental education, and financial/technical assistance) cover the majority of AFOs while regulatory programs (NPDES permits) focus on high risk AFOs. To achieve the goals of the strategy, the EPA published the CAFO Final Rule in 2003. This rule can be seen as a part of the regulatory program proposed by the strategy: (1) CAFOs that actually discharge are required to apply for NPDES permits, and (2) a NMP for animal manure is required to be submitted as part of a CAFO's NPDES permit application. The EPA authorizes a majority of states to administer the NPDES permit program within a state permit program.

In California, Title 27 of the California Code of Regulations and the Porter-Cologne Water Quality Control Act (California Water Code Division 7) governs discharges from CAFOs. The State Water Resources Control Board and nine semi-autonomous Regional Water Quality Control Boards develop guidelines under both the federal and state regulations. In 2007, the Central Valley Water Board adopted the Waste Discharge Requirements General Order for Existing Milk Cow Dairies (General Order). The General Order is essentially a local permit program in the Central Valley Region, where over 80% of California's dairies are located (CDFA 2013). All dairies covered under the General Order are required to (1) submit a Waste Management Plan for the production area, (2) develop and implement a NMP for all land application areas, (3) monitor wastewater, soil, crops, manure, surface water discharges, and storm water discharges, (4) monitor surface water and groundwater, (5) keep records for the production and land application areas, and (6) submit annual monitoring reports. A key component of each NMP is a N budget which establishes N application rates for each crop in each land application area. The budget counts N in solid and liquid manure, irrigation water, and fertilizer. The types and frequencies of sampling, reporting, and record keeping are established by the Monitoring and Reporting Program (MRP) of the General Order. The MRP was modified in 2011 to require dairy dischargers to comply with groundwater monitoring requirements either by participating in a representative monitoring program or through individual groundwater monitoring. The Central Valley Water Board reissued the General Order in 2013 to set representative and individual groundwater monitoring programs as the primary tool to identify if manure management practices are protective of groundwater quality and include time schedules for dairy dischargers to implement improvements if monitoring data indicate that certain facilities or practices are not protective of groundwater quality.

Atmospheric pollutants from dairies are regulated under the federal Clean Air Act. Emissions of ammonia, nitrous oxide, volatile organic compounds (VOCs) and particulate matter under 10 microns (PM10) from CAFOs are primarily affected by the National Ambient Air Quality Standards (NAAQS) set by EPA under the Clean Air Act. The California Air Resources Board implements the NAAQS through a state implementation plan. Local air districts develop rules that are consistent with the requirements of California Senate Bill 700 to specify mitigation practices for CAFOs. In 2004, the South Coast Air Quality Management District adopted the nation's first air quality regulation (Rule 1127) to reduce ammonia, VOCs and PM10 from dairies, which includes best management practices and specific requirements regarding manure removal, handling, and composting. The San Joaquin Air Pollution Control District has regulated VOCs from dairies since 2005 but does not regulate N emissions.

The California Dairy Quality Assurance Program (CDQAP) plays an important role in helping dairies comply with these regulations. The CDQAP Environmental Stewardship Module is a voluntary partnership between dairy producers, government agencies and academia to protect the environment. It provides classroom teaching and independent third-party certification. Education courses help dairy producers understand environmental regulatory requirements, familiarize them with best management practice options, and supply record-keeping tools for both regulatory purposes and farm management. The certification program assists dairy producers in compliance with environmental regulations through a third-party, on-farm evaluation, which provides real-time feedback on management plan implementation.

Similar to California's nonpoint program, the recent changes to the dairy regulations suggest that past policies have not achieved desired emission reductions. An exception is the effect of NPDES permitting, which is believed to have significantly reduced discharges to surface waters (Kratzer and Shelton, 1998). A key contributing factor to this success is the relative ease of observing discharges to surface water from manure handling and storage facilities, which can be accomplished through aerial photography or visual inspections, combined with strong enforcement and significant penalties for noncompliance (Doug Patteson, SWRCB Region 5; personal communication, March 12, 2015). However, N emissions to groundwater and the atmosphere are more difficult to monitor and remain persistent problems. The effects of the more recent regulatory changes remain largely unknown. Although it has been six years since the adoption of the General Order, the representative and individual groundwater monitoring programs are still under construction, so there is very limited data on nitrate levels of groundwater around dairy operations. Furthermore, hydrogeological and biogeochemical processes create time lags in water quality response, so it can take years to decades for source control programs like the General Order to affect groundwater nitrate concentrations at monitoring wells.

The air quality in the South Coast Air Quality Management District has improved significantly over the past two decades, but the rate of improvement has slowed in the last several years. The effectiveness of the Rule 1127 is uncertain. The emissions from area sources (including dairies) are not monitored. Instead, they are calculated from activity information and emission factors.

The contribution of improved dairy operation management to better ambient air quality is largely unknown.

Lessons learned from California's dairy N regulations include the following:

- *Classification of CAFOs as point sources, and the associated regulatory effort, has mitigated N emissions to surface waters.* The remaining problems of CAFO emissions to groundwater and the atmosphere appear to be largely due to the more onerous monitoring problem and associated lack of prioritization by regulatory agencies.
- *CDQAP plays an important role in helping dairies comply with regulations.* This is an example of how a voluntary, largely information-based policy can be effectively used in a supporting role.

8.2.5 California's Regulation of Atmospheric Nitrogen Emissions

Farming and livestock operations are significant sources of N emissions in California, and bear some of the negative effects of N pollution as well. Agriculture-related N air pollution results from primary emissions from machinery and vehicles employed in production, chemical compounds used in production (e.g., pesticides), as well as emissions from the agricultural systems themselves. For example, agricultural livestock emit nitrogen compounds such as oxides of N (NOx) and ammonia. Vehicles used in agricultural production emit NOx (Canadian EPA, 2004). These emissions may lead to the formation of secondary air pollutants, such as ozone, that are deleterious to workers as well as crops (Winer et al., 1990).

California is divided into 35 air districts, each with its own set of laws and regulations regarding stationary sources. Among the many different laws and regulations governing each of the 35 air districts in California, policies that regulate N air emissions include: (1) an agricultural burning policy that regulates open outdoor fires used in disposal of waste generated from growing of crops, the raising of animals, and other agribusiness operations, or for purposes such as forest management, range improvement, irrigation system management (canal clearing), (2) a policy that imposes limits on NOx emissions, and (3) a policy on the disposal of animal carcasses ("reduction of animal matter") that requires that the gases, vapors and gas-entrained effluents from any article, machine equipment, or other contrivance used for this purpose be incinerated or processed.

Research on the effects of these local regulations on air quality has found that none of these three types of policies has had a significant effect on N air pollution, as measured by the number of exceedances of the NO_2 standard (Lin, 2013, 2011).

8.2.6 North Carolina's Neuse River Basin

From the 1960s through the 1990s, the estuary of North Carolina's 6000-square mile Neuse River Basin experienced an estimated 30% increase in N and phosphorus loadings due, in large part, to a region that experienced a doubling of its population, a five-fold increase in its number of business establishments, and a 50% increase in crop production (Schwabe, 2001, 2000). The abundance of nutrient loadings led to low dissolved oxygen levels, and extensive blue-green algal blooms during the summer months. In 1988, nutrient loadings reached such a level throughout the Neuse River as to warrant a basin-wide Nutrient Sensitive Waters classification. Then, during the summer of 1995, an unusually high level of precipitation, coupled with two major swine waste spills and an already nutrient-laden river basin resulted in conditions responsible for fish kills of over 11 million fish and huge algal blooms that rendered the Neuse River useless for recreation. In addition to the nearly anoxic conditions that caused plant and marine life to suffocate, considerable evidence has been accumulated indicating the presence of toxic dinoflagellates, organisms that can kill fish and have caused adverse respiratory health effects on humans under laboratory conditions (Burkholder, 1995).

In response to the deteriorating water quality conditions, the North Carolina Environmental Management Commission (EMC) adopted, in 1997, the state's first mandatory plan to control both point and nonpoint source pollution in the basin (EPA, 2013a). The plan targeted a reduction in N loadings by 30%, as measured at the mouth of the estuary, by 2003. While numerous sources were targeted for mandatory reductions, including point sources, urban sources, and rural sources, agricultural sources were required to participate in The Neuse Nutrient Strategy Agricultural Rule (NCDENR, 2013). Specifically, agricultural operators were required to participate in one of two options: (1) participate in the Local Nitrogen Strategy that would include specific plans for each farm that would, collectively, meet the 30% N reduction goal, or (2) implement Standard Best Management Practices (e.g., vegetative buffer strips, water control structures, and nutrient management plans). Option 1 was unique in that it allowed agricultural agencies and farmers to work in concert to find the most cost-effective and site-specific strategy for reducing N loadings. Alternatively, for those farmers who were not interested in participating in a joint effort, they could choose among one or more alterative BMPs to achieve the 30% reduction, with obvious flexibility. The Neuse Nutrient Strategy Agricultural Rule, along with the other components of the North Carolina EMC's point and nonpoint source management programs, was extremely successful. By the five year targeted adoption date of 2003, nutrient loadings were reduced by 42%, exceeding the 30% target. The development, implementation, and continued management of these policies required (and continues to require and encourage) tremendous input from the agricultural community as well as extensive coordination and communication between local and state agencies and the agricultural community.

Lessons learned from the Neuse River include:

- *Including nonpoint sources was critical in achieving an efficient and effective nutrient reduction outcome.* Nonpoint sources produced most of the pollution and had lower abatement costs.
- *Flexibility is crucial for cost-effectiveness.* Farmers were allowed to achieve the 30% reduction as a coordinated group, where the group would decide how to achieve the reductions through changes in cropping patterns, implementation of BMPs and/or nutrient management plans, or through individual farmers implementing one or more strategies. Furthermore, the authority for developing management plans was effectively devolved to individual counties, thus enabling local conditions to help determine the most effective local approaches.
- *Success hinged on concerted collaboration and communication among agencies, stakeholders, and the public.* The partnership included the North Carolina Division of Water Quality, North Carolina Division of Soil and Water Conservation, Soil and Water Conservation Districts, North Carolina Cooperative Extension Service, North Carolina Farm Bureau, Duke University, North Carolina State University, Neuse River Foundation, USDA/NRCS, and local agricultural, environmental, and scientific communities. Together, these partners committed more than $12 million to meet project goals from 1997 through 2002.

8.2.7 The Mississippi-Atchafalaya River Basin

The Mississippi-Atchafalaya River Basin contains about 40% of the contiguous United States (including parts of 31 states). Thirty year annual and spring trends (1980–2010) of nitrate concentrations from the watershed show increases of 17% and 25% respectively (Murphy et al., 2013). Sources of nutrients include point sources and nonpoint sources, with agricultural land being the largest single contributor. Much of this comes from the highly productive, rich soils of the central corn belt.

The river basin empties into the Gulf of Mexico which exhibits a seasonal hypoxic zone that is the second largest in the world. Since 1983, the annual variation in the zone size has been large, ranging from 40 km^2 to over 20,000 km^2 (Rabalais, n.d., accessed 28 January 2014). This variability is largely driven by weather as high water flows from the river basin deliver large amounts of N and phosphorus, the two key nutrients leading to the creation of hypoxia in the Gulf (EPA SAB, 2007). However, a five-year running average of the zone size remains large and shows no obvious downward trajectory (Rabalais, n.d.).

While the size of the zone has been well documented, the impacts to the ecosystem are less clearly understood. Nutrient loadings can actually increase fishery production prior to the development of seasonal hypoxia, but they may also increase the yield of less valuable species at the expense of more valuable ones (Turner, 2001). And short-run beneficial effects may be outweighed by long run effects on habitat and reproductive productivity. Hypoxia has not been shown to have effects on white shrimp yields in the Gulf, but it has been found to affect brown shrimp via alteration of habitat and post-larval migration patterns (Craig, 2012; O'Connor and Whitall, 2007; Zimmerman and Nance, 2001).

The primary policy response to the growing evidence of hypoxic conditions in the Gulf was the development of a Mississippi River/Gulf of Mexico Hypoxia Task Force in 1997 (EPA, 2014). This task force consists of five federal agencies and the primary states in the Mississippi-Atchafalaya River Basin. In 2001, the task force released its "Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico" where they set a target for reducing the 5-year average size of the hypoxic area to be less than 5,000 km^2 by 2015. The task force called for voluntary actions (in conjunction with incentives and education) to achieve these goals. A new action plan was formulated in 2008 which preserved the goal of 5,000 km^2 by 2015, though it was acknowledged that the goal was unlikely to be met. The EPA Science Advisory Board report in 2007 projected that reductions of N and phosphorus in the range of 40% - 50% would be needed to achieve this long term goal.

In addition to identifying a goal for the size of the zone, the state members of the task force committed to developing nutrient reduction strategies for their states. As of December 2013, nine of the twelve states have completed their strategies. While each differs, the focus of the state strategies remains on voluntary action, particularly from nonpoint agricultural sources. To date there has been a general lack of progress in meeting the goals developed by the action plan.

Lessons learned from the Gulf of Mexico include:

- *Participation in costly voluntary efforts tends to be low in the absence of private returns or compensation.* If financial incentives were provided that at least fully compensated farmers for their costs (including a small return to their effort), then reliance on voluntary measures may have been more successful. Furthermore, limited conservation budgets hinder the ability to provide such compensation.

- *Establishment of nutrient reduction plans can help clarify challenges and focus research efforts.* Scientists are exploring new ways to keep nutrients on the land via the development of new technologies such as bioreactors and saturated buffers. States are also beginning to fund conservation practices that are more directly related to the nutrient problem (particularly N), such as the new cover crop initiative in Iowa.

8.2.8 Maryland's Nutrient Management Program

The Chesapeake Bay Program was created in 1984 in response to concerns about nonpoint source nutrient pollution in the Chesapeake Bay. This program now includes all 5 states in the Chesapeake Bay Watershed (Virginia, Maryland, West Virginia, Delaware, Pennsylvania and New York), the District of Columbia and the US EPA. Each state sought methods to reduce nutrient loads to the Chesapeake Bay. In Maryland, the University of Maryland Cooperative Extension (UMD CE) created the Maryland Nutrient Management Program in 1988. This voluntary program teamed UMD CE personnel with growers to write and implement nutrient management plans. The initial focus of the program was on N application and use. Nutrient management plans were written to cover all bioavailable sources of N (i.e. commercial fertilizer, manure, compost, biosolids, and crop residue) during a 3-year period, including the effects of expected crop rotations and N mineralization. The plans used soil tests, manure tests, other nutrient credits (e.g., cover crops) to calculate bioavailable N, plant available phosphorus and potassium. UMD CE scientists created recommendations for nutrient application rates for approximately 20 major Maryland crops. The nutrient management plans matched the nutrient sources with the UMD CE crop recommendations to create nutrient application (management) plans.

The initial program concentrated on animal operations, though crop-only operations participated as well. The focus of these early efforts was on N applications. There existed imbalances between crop N, phosphorus and potassium demand, and manure N, phosphorus and potassium supplies. Thus, applying animal manures at N recommendations often led to over applications of phosphorus (and sometime potassium). Therefore, while the nutrient management planning program in Maryland was decreasing N use, the impact on phosphorus use remained unclear. The lack of sufficient watershed wide reductions in both N and phosphorus loads were implicated in the outbreak of *Pfiesteria piscicida* in the late summer of 1997 (Bosch et al., 2001). In response to this outbreak and the lack of progress on Chesapeake Bay clean-up, Maryland law makers passed the Maryland Water Quality Improvement Act (WQIA) of 1998. This act controls the use of N and phosphorus in agriculture, horticulture, turf grass, landscape, residential and golf course settings. It also sets additional restrictions on animal producers (i.e. feed formulation) and has incentives for agriculture to change from all animal manure sources of nutrients to commercial fertilizer (Simpson, 1998).

The WQIA requires all farmers with more than $2500 in revenue or eight animal units to obtain and follow a nutrient management plan. Recognizing the then limited capacity to write nutrient management plans, this requirement was phased in over a five year period. Expanding on the original approach, these nutrient management plans incorporate the Phosphorus Site Index (PSI) number for each field. The PSI was created by the University of Maryland as a tool to estimate the potential for environmental movement of phosphorus from the fields (University of Maryland, 2013). The PSI determines whether farmers can apply nutrients at the N recommendation, the phosphorus recommendation, or a hybrid of the two.

To create the needed capacity to write nutrient management plans for all farms in Maryland, the WQIA provided funding to UMD CE to hire additional nutrient management plan writers. It also set aside funding to allow UMD CE and the Maryland Department of Agriculture (MDA) to create and implement a training and certification program for private sector crop consultants, fertilizer dealers and farmers to write nutrient management plans (farmers could not be certified to write plans for their own farms unless additional training was undertaken).

Information in the plans was considered by farmers to be confidential business information. Lawsuits in the early 2000s ruled that the plans submitted to MDA were not confidential. To protect farmer confidentiality, Maryland changed the reporting requirements. Currently, growers have to send a short summary of their nutrient management plan to MDA while retaining the full nutrient management plan on the farm. The full nutrient management plan must be made available on-farm for MDA or Maryland Department of the Environment (MDE) inspection. This arrangement allows the full nutrient management plans to remain confidential under the Freedom of Information Act.

According to the Chesapeake Bay Program's models, implementation of the nutrient management plan requirements have and will continue to offer improvements to the Bay (Chesapeake Bay Program, 2013a). Though water quality was improving in the 1990s and 2000s, the Chesapeake Bay was not meeting water quality goals. In 2010, the US Environmental Protection Agency released a Total Maximum Daily Load (TMDL) for the entire Chesapeake Bay watershed (EPA, 2013b). Implementation of the TMDL is the responsibility of the states. The new TMDL set even lower nutrient targets than previous agreements. Thus, in 2012, Maryland modified its nutrient management requirements to include setbacks from streams for all nutrient applications, livestock in-stream restrictions, requirements for injection or incorporation of all organic nutrient applications, and restrictions on fall and winter nutrient applications. While modeling efforts predict that these changes in nutrient management will have a significant impact on water quality in the Chesapeake Bay (Chesapeake Bay Program, 2013b), it is still too early to fully assess their effectiveness.

Lessons learned from the Chesapeake Bay include:

- *A narrow focus on mitigating N pollution can create other nutrient pollution problems.* Consideration of relationships between N and other nutrients used in agricultural production is needed, particularly in the presence of organic wastes.
- *Issues of public disclosure of private information can be a significant obstacle.* However, careful crafting of policy requirements can overcome this.
- *Simulation models suggest nutrient management plans may have significant effects on water quality, but evidence to confirm efficacy in practice is pending.*

8.2.9 Florida's Everglades

The Everglades Agricultural Area (EAA) consists of a portion (2,833 km^2) of the original Florida Everglades and is farmed mainly to sugarcane, winter vegetables and sod. The EAA is situated north of the Everglades and south of Lake Okeechobee. The EAA basin is comprised of organic soils (Histosols) that were drained at the beginning of the century for agricultural and urban purposes. The Florida Everglades biotic integrity is endangered by urban and agricultural development, modifications to the hydrology and fire frequency, and nutrient-rich runoff from the EAA (Richardson, 2008; SFWMD, 1999). To farm successfully, growers in the EAA must actively drain their fields via an extensive array of canals, ditches and large volume pumps. Excess water is pumped off farms into South Florida Water Management District (SFWMD) canals and, historically, was sent to Lake Okeechobee or the Everglades Protection Area.

Concerns about the quality of drainage water leaving the EAA basin and entering the Everglades National Park and the greater Everglades Protection Area prompted the Florida legislature to adopt the Everglades Regulatory Program, part of the Everglades Forever Act (EFA). The main objective of the program is to reduce annual phosphorus loads from the EAA basin by 25% or more compared to a 10-year, pre-BMP baseline period (1978-1988) by implementing BMPs. The EFA mandates a nonpoint regulatory source control program to implement BMPs to control phosphorus at the source and a monitoring program to assess program effectiveness. Monitoring of this NPS pollution problem was possible due to the existence of the drainage system which collects and channels NPS emissions to points where they can be measured. The EFA further mandates the specific methodology for defining permissible total phosphorus loading levels for the basin based on historical data or baseline periods defined in the EFA (SFWMD, 2013). The program also includes the establishment of stormwater treatment areas (STAs) which are constructed wetlands for further treatment of the water before reaching the Everglades National Park. The EFA mandates an agricultural privilege tax (currently at $24.89 per acre) for the basin to be used towards the funding of Everglades restoration. Although the program does not fund BMP implementation up to the 25% reduction target, tax incentives are provided for reductions beyond the target (Kling, 2013).

The BMP program was implemented basin wide in 1995. The SFWMD requires a permit for a BMP plan for each farm basin within the EAA. The BMP plans are comprehensive, generally consisting of nutrient management, water management, and sediment control (Daroub et al., 2011). Each permit holder must select and implement a minimum of 25 "points" worth of BMPs from a suite of BMPs. Point values are assigned to BMPs based on the professional judgement of the district's Everglades Regulation Division staff (Whalen et al., 1998). By at least one important measure, the program has been a success: the EAA basin achieved a 71% total phosphorus (TP) load reduction for water year 2012 compared with the predicted load from the pre-BMP baseline period adjusted for rainfall. The total cumulative reduction in TP loads due to BMP implementation since water year 1996 is equivalent to a long-term average annual reduction of 55% (SFWMD, 2013).

In addition, because little information was available regarding the effectiveness of BMPs when the program was started in 1995, on-farm research and demonstration was provided through a collaborative effort between the University of Florida Institute of Food and Agriculture Science (UF/IFAS), SFWMD, Florida Department of Environmental Protection, and EAA growers. The original document for BMP design and plan implementation in the EAA was developed by the UF/IFAS researchers (Bottcher et al., 1997). EFA further requires EAA landowners to sponsor a program of BMP research, testing, and implementation that monitors the efficacy of established BMPs in improving water quality in the Everglades Protection Area. To fund these and related outreach efforts, EAA growers are taxed $3 to $5 per acre. These funds support ongoing research to improve the selection, design criteria, and implementation of BMPs by the UF/IFAS. Because important and practical findings of ongoing research incorporated into agricultural practices are essential to meet and maintain the performance goals and to optimize the regulatory program, updates to documentation for individual BMPs are made available online. The UF/IFAS also conducts biannual BMP training workshops to update and refresh all EAA growers with latest technology and effectiveness of BMPs.

Lessons learned from the Florida Everglades include:

- *A combination of mandatory BMP participation, grower-funded research and extension programs, and permit requirements has been very successful in reducing phosphorus runoff pollution.* The unique presence of the drainage system facilitated measuring environmental improvements.
- *Allowing selection of BMPs from a menu improves cost-effectiveness, though not as much as a tradable permit market.* However, a complete economic analysis is not available.

8.2.10 Pennsylvania's Conestoga River Watershed[1]

In the mid-1990s, the Conestoga Watershed in southeastern Pennsylvania was a Section 303(d) listed watershed due to phosphorus impairment. Agricultural sources were determined to be the primary contributor to the nutrient load. Rather than offering subsidies for voluntary BMP installation and maintenance, concerned environmental groups and their partners secured a USDA/NRCS Conservation Innovation grant to fund two reverse auctions for phosphorus abatement by producers.

The auctions allowed producers to submit bids for installing and maintaining one or more BMPs on their properties. In the first auction, producers submitted bids to install BMPs at the standard EQIP subsidy rates, while in the second auction producers also submitted bid prices. In both auctions, bidders worked with Lancaster County Conservation District technicians to use computer models to estimate their expected phosphorus reductions based on site-specific characteristics. In the second auction, these estimated reductions were used with the bid prices to determine a cost-per-pound of phosphorus abatement for each bid. Bids were then ranked by cost-effectiveness from lowest to highest cost-per-pound, and contracts were awarded in order of cost-effectiveness until the auction budget was exhausted.

The first auction produced an average bid price of $10.32 per pound of phosphorus, while the second auction produced an average price of $5.06. Together, the auctions mitigated an estimated 92,000 pounds of phosphorus. Using data on actual EQIP contracts in the Conestoga River Watershed, Selman et al. (2008) estimate that the reverse auction was more than seven times more cost-effective than the standard BMP subsidy approach—in other words, a reverse auction would produce more than seven times as much nutrient abatement as a standard EQIP subsidy program with the same budget.

Greenhalgh et al. (2007) identify several lessons learned from the Conestoga reverse auctions, including:

[1] This section is based on Greenhalgh et al. (2007) and Selman et al. (2008).

- *Carefully explain the purpose of the auction and the rules to all stakeholders.* The first Conestoga auction did not exhaust its budget, perhaps due to confusion and uncertainty among producers.
- *Simplify the auction process to promote increased participation.*
- *Utilize accurate and user-friendly methods for estimating load reductions and abatement costs.*

8.2.11 The European experience

The challenges of developing effective policies for addressing excess N in the environment are not unique to California or the United States. As such, there may also be important lessons to be learned from European efforts to develop integrated policies that mitigate the adverse effects of N pollution on environmental quality. The recently completed European Nitrogen Assessment, which was published in 2011, provides a comprehensive summary of the European Union's (EU) environmental policy directives that impact N management and discusses some of the successes (and failures) of these policies to achieve their intended water and air quality goals.

In the context of water quality, the EU's 1991 Nitrates Directive establishes criteria for classifying surface and ground water bodies as polluted when NO_3^- concentrations are greater than 50 mg of NO_3^- per liter (EC, 2010a). In addition, the Nitrates Directive requires member states to systematically (1) monitor water quality, (2) designate vulnerable zones or water bodies, and (3) establish codes for good agricultural practice (Oenema et al., 2011). In 2000, The EU also passed the Water Framework Directive which establishes water basin districts that are tasked with monitoring and improving the quality of ground, surface and coastal water bodies (EC, 2010b); Oenema et al., 2011). These water basin districts are also responsible for designating vulnerable zones and for providing regional implementation of the Nitrates Directive as well as the 1998 Drinking Water Directive (EC, 2010c) and the 2006 Groundwater Directive (EC, 2010d). The codes for good agricultural practice that are established by each member state outline a mandatory suite of practices for farmers related to manure storage, the seasonal time periods when manure and fertilizer application is prohibited, and the maximum amount of manure and/or fertilizer N that may be legally applied (e.g., a limit of 170 kg N ha^{-1} yr^{-1} as manure).

Beginning in 2003, "cross-compliance" has become a key policy mechanism used to implement various environmental directives within the EU's Common Agricultural Policy framework (Oenema et al., 2011). In this context, cross-compliance requires farmers to comply with relevant EU Directives in order to receive CAP payments for income support through the Single Farm Payment scheme. The Single Farm Payment also requires that farmers maintain land in “good agricultural and environmental condition” based on a pre-specified set of regional or national environmental standards. Many of these cross-compliance standards directly address agricultural N inputs and management through the good agricultural practice codes stipulated by the 1991 Nitrates Directive.

Data presented in the European Nitrogen Assessment and a related paper by van Grinsven et al. (2012) suggests that the Nitrate Directive has contributed to measurable improvements in water quality over the past two decades (Oenema et al., 2011). For instance, about 55% of rural surface water monitoring stations in EU-15 countries (EU members prior to 2004) showed decreasing concentrations of NO_3^- during the 1996–2003 period (EC, 2007). Most of the improvements were observed in the western European countries of Belgium, Denmark, Netherlands, Ireland and the United Kingdom (van Grinsven et al., 2012). However, some 31% of monitoring stations showed no change in NO_3^- concentrations over the same period and another 14% showed increasing NO_3^- trends (EC, 2007). By comparison, the impact of the Nitrate Directive on groundwater NO_3^- in shallow wells has been relatively modest and highly variable across regional monitoring stations due largely to the time lag required for changes in surface N loading to affect ground water in deep aquifers (EC, 2007; van Grinsven et al., 2012). Consequently, the impact of these policy directives has been uneven among surface and ground water resources and highly variable across regions. The 2006 Groundwater Directive is the EU’s most recent attempt to focus policy efforts in lagging areas and equip farmers and natural resource managers with the financial resources to carry out the long term task of improving and monitoring ground water quality. .

To address the air quality impacts of N and other pollutants, the 1996 Framework Directive on Ambient Air (revised in 2008) sets regional standards for ambient concentrations of NO_x, O_3 and $PM_{2.5}$, but not for NH_3 (EC, 2010e) for the EU member states. Likewise, member states must also comply with the 2001 National Emissions Ceilings Directive for precursors to ground level O_3 and acid precipitation (e.g., NO_x, NH_3, SO_2, and VOC) (EC, 2010f). The main mechanism to achieving these air quality standards is the 1996 Integrated Pollution Prevention Control Directive (EC, 2010g), which sets emission limits for various stationary and mobile combustion sources and requires implementation of pollution control measures using “best available techniques” and technologies (Oenema et al., 2011). Under these directives, agricultural producers are subject to the policies that regulate emissions from both agricultural machinery and intensive livestock operations.

These policy frameworks have also led to measurable improvements in air quality in recent decades. Between 1990 and 2006, gaseous emissions of NO_x and NH_3 from all EU-15 countries declined by 33% and 12% respectively, albeit with high variability among member states (Oenema et al., 2011). In the case of NO_x, the decline has been due to energy and pollution policies that require the use of improved emissions control technologies (e.g., flue gas treatment, catalytic converters), whereas for NH_3 emissions, the reduction is largely a function of external economic trends which have led to a contracting the European livestock herd and an overall decreased fertilizer use (neither of which is expected to happen in California in the near future).

Given the complexities of the N cycle and the social-ecological differences among EU countries, the mixed success of recent N policy initiatives appears to highlight some policy instruments that may have applications beyond the borders of Europe. In particular, the CAP's coupling of mandatory codes of good agricultural practice that set standards for when fertilizers and manure can be applied and caps on the total amount of N applied have parallels to the regulatory policies implemented in California and other parts of the United States. Likewise, the policies requiring cross-compliance across various environmental directives in order to receive CAP income support appears to provide a strong financial incentive to adopt improved N management practices. It is worth noting that a few regions in Europe have also experimented with taxing excess nutrients to help meet the EU Nitrate Directive requirements. For instance, in the Netherlands, the Mineral Accounting System was created to estimate excess N and phosphorus flows through agricultural systems. Excess flows were then taxed at the farm scale as an incentive to reduce nutrient loading. According to Mayzelle and Harter (2011), this approach was popular for its simplicity and had strong support from the Dutch government. Furthermore, Westhoek et al. (2004) estimate that it reduced the N surplus on Dutch dairy farms by approximately 50 kg/ha with a relatively low cost to the affected farms. However, the EU determined that the approach did not go far enough to satisfy the Nitrate Directive requirements, so it was ultimately replaced with nutrient application rate standards.

8.2.12 USEPA Review of Selected Nutrient Programs

In 2009, the USEPA convened a task group comprised of state and federal surface and drinking water managers who identified and framed key nutrient issues, questions, and options on how to improve and accelerate nutrient pollution prevention and reduction at the state and national level (EPA, 2009). The task group report summarizes the scope and major sources of nutrient impacts nationally, considers tools currently under existing federal authority and that are also being used by state authorities, and presents new tools or adjustments to existing tools to improve control of nutrient pollution. Next steps to better address nutrient pollution are identified as well. Here we present some of the main conclusions of the report that are most relevant for the policy challenges facing California.

The report stresses that current tools for mitigating nutrient pollution are underused and current policies are poorly coordinated. For instance, the report recommends that greater use of numeric water quality criteria and water quality assessments would result in additional TMDLs being developed for impaired waters. Both assessments and listings of impaired waters are viewed as incomplete, and there are significant opportunities for expanding NPS reduction if the authority at the federal and state levels for development, enforcement, and transparency were improved. With respect to CAFO regulations, it is felt that significant benefits in nutrient reduction could be achieved by extending regulation to smaller operations and through the regulation of off-site transport of waste. Water quality trading is thought to be underutilized, and should be encouraged and expanded to realize its full potential. With respect to CWA Section 319 grant money, its effectiveness relies on watershed plans as the primary tool for providing assistance and monitoring and thus depends on the comprehensiveness of the plan, the management of the grant funds, and how completely the plan is implemented. The farm bill includes a variety of conservation programs that provide financial and technical help to those eligible participants, yet it is dependent on the willingness of farmers to install and maintain controls that reduce nutrients as well as the state authorities to distribute the funds.

In essence, the report suggests that the CWA tools have not been implemented to the fullest extent to reduce nutrients. While the authors acknowledge that there are individual cases in which state nonpoint source programs have been highly successful in addressing individual sources of nutrients, their broader application and effectiveness has been undercut by the absence of a common multi-state framework of mandatory point and nonpoint source accountability within and across watersheds. The authors also stress that sound science, technical analysis, collaboration, and financial incentives will fail to adequately address nutrient impacts at a state-wide and national level without a common framework of responsibility and accountability for all point and nonpoint sources, with an emphasis that nonpoint sources present state and national governments with very effective and low-cost nutrient reduction opportunities.

The report makes two strong claims related to how policy can help reduce the impacts of N loadings. First, the report stresses that while agriculture contributes significantly to the problem, it has often been overlooked from a regulatory perspective; the report notes, row crop agriculture is exempt from regulation under the CWA generally and the NPDES program specifically. Consequently, there is a significant role for agriculture in future (and better coordinated and implemented) policies to reduce N pollution. Second, the report suggests that more rigorous regulation of nonpoint sources is one of the most promising tools for addressing nutrient pollution. Other promising policies that are relevant for California's N problem include greater use of numeric nutrient water quality criteria in discharge permitting, and green labeling. Labeling is thought to be promising due to the growth in organic farming that has occurred since national standards were introduced in 2002, and the associated reductions in nutrient pollution that are typical of organic farms. The report also identifies market-based nutrient reduction land-use incentives and the creation of a "nutrient releases inventory" as other potential incentive-based approaches to encourage and reward effective nutrient management practices on farms. The benefits of incentive-based non-regulatory tools are that they allow interested parties a reward for implementing measures that would otherwise be unaffordable and that might lead to savings in other areas. Additional tools that could be beneficial include agricultural waste composting and more fully utilizing existing grants programs to fund BMP implementation.

The report ends with discussions of specific cases in which agricultural N runoff has been addressed by states, including the following:

- *Connecticut's Nitrogen Credit Exchange Program*. A point source trading program covering all publically owned treatment works (POTWs), but potentially expandable to include nonpoint sources. Appears to be highly successful, both in terms of N load reduction and cost-effectiveness.
- *Delaware's Nutrient Management Program.* Requires nutrient management plans and provides training and certification for producers who generate or apply nutrients or use BMPs. Participation appears strong but reliance on education without regulation leaves questions about its environmental impact.
- *Iowa's Livestock Water Quality Facilities Program*. Provides flexible, low-interest loans to producers who volunteer to mitigate nonpoint source pollution. Highly successful in terms of participation but little information is available to evaluate its environmental impact.
- *Maryland's Policy for Nutrient Cap Management and Trading.* Voluntary point-nonpoint trading program. Initiated in 2008 but lacking information on its relative success to-date.
- *North Carolina's Agricultural Cost Share Program*. Provides cost-sharing funds, education, and technical assistance to producers who voluntarily install BMPs. Significant measurable impacts since its inception in 1984, but lacks information to evaluate its performance against objective criteria (e.g., environmental targets, cost-effectiveness).
- *Ohio's Agricultural Pollution Abatement Program*. Provides cost-sharing for voluntary BMPs. A well-established program but with little information available to evaluate its effectiveness.

- *Pennsylvania's Nutrient Trading Program.* Voluntary point-nonpoint source trading program. Little publicly available information on its performance, but Selman et al. (2009) report that only five trades occurred during the first four years of the program's implementation. However, water quality outcomes are not necessarily dependent on the number of trades.
- *Virginia's Agricultural Stewardship Act.* Relies on investigation of complaints against individual producers to identify polluting aspects of agricultural operations. Producers may be required to implement BMPs within a specified timeframe. Failure to do so invokes a fine. Despite relatively greater accountability compared to other state programs, there is again very little information to judge the environmental impact.
- *Wisconsin's Nonpoint Source Performance Standards and Prohibitions.* Requires compliance with and provides cost-sharing for initial installation of BMPs. Other agricultural policies utilize cross-compliance mechanisms to achieve implementation of the same BMPs. Lacks an evaluation component, so environmental impact is largely unknown.

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