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Water Pollution from Agriculture

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Abstract

As part of a cooperative agreement with the United States Department of Agriculture (USDA), the George Washington University Regulatory Studies Center produced a five-chapter report on regulatory differences between the United States (U.S.) and the European Union (EU) and their effects on agricultural production and productivity. Those chapters are published here as a working paper series with five parts. This chapter reviews how the U.S. and EU regulate water pollution from agriculture, particularly nutrient contamination from fertilizer use on crops and from the management of manure from livestock. The chapter first reviews the core environmental problem—the process by which nutrient pollution occurs and the adverse environmental and human health consequences it causes. It also provides a broad overview of the institutions and policy frameworks that shape water quality polices relevant to agriculture in the two jurisdictions and proceeds by characterizing the specific policy instruments used in the U.S. and the EU to implement these broader policy frameworks. The chapter concludes by describing the on-the-ground implementation experience and the degree to which retrospective program evaluations are performed.

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Scope of the Environmental Problem

Water pollution from agriculture poses unique challenges for regulators. Agricultural runoff is largely a nonpoint source of pollution and traditional point-source pollution control policies may be unsuitable.Further, wide variations in agricultural practices and local environmental conditions can make it difficult for policymakers to set a single, jurisdiction-wide standard that meets varied needs. Another challenge, not addressed here, is that the agriculture sector, in both the U.S. and EU, has considerable influence in the political sphere.

Nutrient Use in Agriculture

More than anything else, a nutritious diet for humans and animals must include sufficient energy, typically measured in Calories, to support life. It also must include chemical compounds, such as vitamins or essential amino acids that cannot be manufactured metabolically. In contrast, plants derive their energy from sunlight, and they often have metabolic pathways that are capable of making any necessary chemical compounds. For these reasons, a list of plant nutrients generally will focus on the chemical elements that are critical to a plant's growth. They include non-mineral nutrients and mineral nutrients. Non-mineral nutrients are hydrogen (H), oxygen (O), and carbon (C), which plants obtain from the air[3] and water.

Mineral nutrients can be further divided into macronutrients and micronutrients. Macronutrients refer to nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S), which plants typically require in relatively large amounts, while micronutrients, such as iron (Fe), chloride (Cl), and manganese (Mn), are needed by plants in much smaller amounts. Among these nutrients, nitrogen, phosphorus, and potassium are most important for crop production, and supplementation in the form of intentional addition to the soil can substantially increase crop yield.

Animal wastes often are applied to croplands to provide needed nutrients. Poultry litter tends to be relatively high in phosphorous, and is highly valued where that nutrient tends to be scarce. Waste from hog farms tends to be higher in nitrogen, as does human waste. Treated human waste, called biosolids, may be applied to some crops.

In addition to animal and human waste streams, U.S. and EU agriculture uses synthetic fertilizer on a large scale. Atmospheric nitrogen can be "fixed" using a process invented by the German

[3] Nitrogen is also abundant in the air as N_2, but is generally not available to plants unless they are legumes. Throughout this chapter, any reference to nitrogen will mean "fixed" nitrogen—that is, nitrogen contained in a chemical compound, often a nitrate, which is metabolically available to plants.

chemist Fritz Haber. Today, the amount of nitrogen fixed by the Haber process, including a number of nonagricultural uses, has transformed the earth's natural nitrogen cycle.[4]

Nutrient Pollution from Agriculture

When nutrients are added to the soil in excess of the amount taken up by crops, the excess nutrients enter the surrounding environment, potentially causing harmful contamination of surface waters or groundwater. Potassium is often found in abundance in soils and is less often required in fertilization; as a consequence, nitrogen and phosphorus tend to be the two primary nutrient pollutants in water resulting in part from the use of fertilizers.

Waste from livestock operations, particularly animal manure, is another important source of nitrogen and phosphorus pollution in water. In some cases, such pollution results from point source[5] discharges from concentrated animal feeding operations (or CAFOs) while in other cases, livestock operations over larger land areas can lead to nonpoint runoff as animal wastes make their way to adjacent surface or groundwater.

Agricultural nutrient pollutants can reach water in a number of ways. In addition to point source discharges from CAFOs, nonpoint pollution can be caused by soil erosion, runoff to surface water, and leaching into groundwater. Soil erosion occurs when soil particles on the farmland containing nitrogen or phosphorus are moved by water or wind into the surrounding environment. Dissolved nitrogen or phosphorus on the surface of farmland can be washed into nearby waters by moving water such as rainfall, snowmelt, stormwater, and irrigation water. Last, dissolved nitrogen or phosphorus can also leach into groundwater or subsurface drains through the soil and then enter into surface waters. Phosphorus is mostly transported through soil erosion or runoff.[6]

Too much nitrogen or phosphorus in water can cause negative ecological and human health effects. The most significant problem is eutrophication—enrichment of a water body with nutrients—in surface waters including streams, rivers, lakes, bays, and coastal waters. High levels of nitrogen or phosphorous in surface waters cause excessive growth of algae, which can

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[4] Galloway, J. N., Townsend, A. R., Erisman, J., Bekunda, M., Cai, Z., Freney, J. R.,…Sutton, M. A. (2008). Transformation of the Nitrogen Cycle: Recent Trends, Questions, and Potential Solutions. *Science, 320*, 889-892. Retrieved from https://www.researchgate.net/profile/Jan_Willem_Erisman/publication/5363687_Transformation_of_the_Nitrogen_Cycle_Recent_Trends_Questions_and_Potential_Solutions/links/0fcfd5080f64094f9d000000.pdf

[5] Point sources refer to "any single identifiable source of pollution" such as industrial and sewage treatment plants, defined by EPA. In contrast, nonpoint sources refer to diffuse sources of pollution such as water runoff from land.

[6] Stubbs, M. (2015). *Nutrients in Agricultural Production: A Water Quality Overview.* Washington, DC: Congressional Research Service.

lead to algal blooms that deplete oxygen in the water. Algal blooms can kill fish and other aquatic life and elevate levels of toxins and bacteria in water. In addition, human health can be threatened if humans eat fish or drink water contaminated with toxins. Furthermore, nitrate pollution in groundwater used for drinking can itself be a human health concern.[7]

State of Agricultural Nutrient Pollution in the EU and the U.S.

This section summarizes the available assessments of water quality in the U.S. and the EU, and discusses the nutrient-related water contamination reflected by these assessments.

United States

There is little doubt that nutrient runoff from agricultural lands adversely affects water quality in rivers, streams, lakes, wetlands, and coastal areas. Quantifying such effects at a national scale in the United States is, however, subject to both methodological and data constraints. Causal attribution of environmental impacts can be difficult when there are multiple sources with the potential to pollute a particular water body. More importantly, when it comes to evidence about the magnitude of agriculture's impact on water, sufficient national data are unavailable to draw definitive conclusions.

Nonetheless, information from two EPA data sets allows some conclusions to be drawn. First, EPA's National Aquatic Resource Surveys (NARS) periodically study a probability-based random sample of sites within each of four types of water bodies.[8] These surveys are designed to permit inferences about national conditions in the lower 48 states. In the NARS program, water quality is assessed using several criteria, two of which—total nitrogen and total phosphorus concentrations—are linked to agricultural activities. Because of other non-agricultural sources of these two pollutants, however, NARS results cannot be used to definitively draw a causal connection between agriculture and water conditions in specific locations.

The second EPA dataset compiles information provided by the states as part of their implementation of the Clean Water Act (CWA).[9] The Act requires that states designate their

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[7] EPA. (2016f, December 5). *Nutrient Pollution: The Problem*. Retrieved from United States Environmental Protection Agency: https://www.epa.gov/nutrientpollution/problem

[8] The four types of water bodies are lakes, rivers and streams, wetlands, and coastal areas. EPA. (2009). *National Lakes Assessment: A Collaborative Survey of the Nation's Lakes.* Washington, DC: U.S. Environmental Protection Agency; EPA. (2015d). *National Coastal Condition Assessment 2010.* Washington, DC: U.S. Environmental Protection Agency; EPA. (2016d). *National Rivers and Streams Assessment 2008-2009: A Collaborative Survey*. Washington, DC: U.S. Environmental Protection Agency; EPA. (2016e). *National Wetland Condition Assessment 2011: A Collaborative Survey of the Nation's Wetlands.* Washington, DC: U.S. Environmental Protection Agency.

[9] EPA. (2017, January 26). *Water Quality Assessment and TMDL Information / National Summary of State Information*. Retrieved October 20, 2016, from https://iaspub.epa.gov/waters10/attains_nation_cy.control

waters for certain uses, such as fish and wildlife protection, recreation, fishing, drinking water, or industrial use. States must set these designations based on the highest valued use and no lower than any actual use of the water since November of 1975.[10] States then assess the degree to which water quality supports the designated use. Water bodies are characterized as impaired, threatened, or good with respect to the designated use.

Though subject to EPA oversight, states have different approaches to selecting waters for assessment, designating uses, or deciding which pollutants to sample. Only 32% of rivers and streams, 44% of lakes, and 1% of wetlands have been assessed by the states. For those water bodies that have been characterized as impaired, states typically report the type of impairment (e.g., pathogens, nutrients, mercury) and the probable source of impairment (e.g., agriculture, municipal sewage, industry, unknown). Because they do not represent a random, probability-based sample, nor follow a consistent methodology, these state reports cannot be aggregated to draw inferences about national conditions.

Highlights of the NARS findings—which do allow valid inferences about national conditions—are presented in Table 1. The results shown in the table were generated by the George Washington Regulatory Studies Center based on data provided directly by EPA. Just under a third of lakes and rivers and streams show total nitrogen in excess of 1.0 mg/l while roughly a quarter of these water bodies show total phosphorous over 0.1 mg/l. Given the nature of the NARS data set, however, it is not possible to identify the source of these nutrient concentrations.

Table 1: Results of EPA's National Aquatic Resource Surveys for 2016

	Total Nitrogen				Total Phosphorus			
	> 10 mg/l	1-10 mg/l	0.1-1 mg/l	<0.1 mg/l	> 1 mg/l	0.1-1 mg/l	0.01-0.1 mg/l	<0.01 mg/l
Lakes (number)	0.1%	29.5%	68.9%	1.5%	1.3%	22.2%	69.7%	6.7%
Rivers & Streams (miles)	2.0%	30.1%	58.6%	9.0%	1.9%	26.1%	61.9%	9.9%

Sources: GWRSC analysis of NARS data provided by EPA (2016d); EPA. (2016i). *National Lakes Assessment 2012: A Collaborative Survey of Lakes in the United States.* Washington, DC: U.S. Environmental Protection Agency.

As shown in Table 2, data reported by states under the CWA provide a somewhat clearer picture of the link between agriculture and water, albeit without the benefit of being a nationally representative sample. For example, about 55% of assessed rivers and streams and 71% of

[10] United States National Archives and Records Administration (1993). *Code of Federal Regulations*. Title 40, Part 131. Water Quality Standards.

assessed lakes are impaired for their designated uses. And, for those water bodies assessed as being impaired, 12% (or 141,161 miles) of rivers and streams, and 6% (or 1.1 million acres) of lakes, have agriculture as one of their probable sources of impairment.

While these are modest numbers, agriculture is the most prevalent source of impairment for rivers and streams, and the third-ranked source of impairment for lakes.[11] It is important to note also that for 20% of impaired lakes, and 12% of impaired rivers and streams, EPA reports the source of impairment as "unknown."

Table 2: EPA Summary of Water Quality Information Provided by States under the CWA

	Of Assessed Water Bodies				Of Impaired & Threatened Water Bodies		
	% of Water Bodies Assessed	Good	Threatened	Impaired	Threatened or Impaired by Nutrients	Probable Source of Impairment: Agriculture	Among Impairment Sources: Rank of Agriculture
Lakes	44%	29%	0%	71%	21%	6%	#3
Wetlands	1%	46%	0%	54%	5%	16%	#2
Rivers & Streams	32%	45%	0%	55%	10%	12%	#1

Source: (EPA, 2017)

European Union

In the EU, in order to set long-term objectives for water protection, the European Commission's Water Framework Directive (WFD, or Directive 2000/60/EC) requires member states to identify the status of waters in each river basin and to report on water quality in River Basin Management Plans (RBMPs). To support this process, in 2012, the European Environment Agency (EEA) published a synthesis report *European Waters – Assessment of Status and Pressures* based on the RBMPs and data reported by member states.[12] Among the 13,000 groundwater bodies and 127,000 surface water bodies included in the report, nonpoint source pollution from agriculture was identified as a "significant pressure" on more than 40% of rivers and coastal waters and on one third of lakes and estuaries; 25% of groundwater was classified as in "poor chemical status,"

[11] These results reflect the fact that, given EPA's methodology, individual water bodies may have more than one probable source of impairment. In addition, EPA applies a typology of approximately two dozen categories to characterize probable sources of impairement.

[12] The report covers RMBPs reported by 23 member states as of May 2012.

which was mostly caused by excessive levels of nitrates.[13] However, lack of monitoring data meant that information on the chemical status of waters was limited and inconsistent; more than 40% of the surface water bodies were reported as having unknown pollution status, and the water bodies with known status were not fully comparable because many of them were based on expert judgement in respective member states.[14]

In addition, the Nitrate Directive (Directive 91/676/EEC)—the main EU legislation that protects water quality against nitrates from agricultural sources—requires member states to monitor all water bodies with regard to nitrate concentration and trophic state[15] and report to the Commission every four years. Nitrate concentrations are monitored by a network of sampling stations covering groundwater, rivers, lakes and dams, and coastal and marine waters. According to the most current Commission report for the EU-27, between 2008 and 2011, there were about 33,000 groundwater monitoring stations, 29,000 fresh water monitoring stations, and 3,200 monitoring stations in saline waters.[16,17]

According to the report, between 2008 and 2011, 14.4% of groundwater monitoring stations in the EU-27 exceeded 50 mg/l nitrate (11.3 mg/l NO_3-N) and 5.9% were between 40-50 mg/l nitrate (9.0-11.3 mg/l NO_3-N) (Table 3).[18] In fresh surface waters, 2.4% of the reported stations showed annual average concentrations exceeding 50 mg/l nitrate and 2.4% were between 40-50 mg/l nitrate. Nitrate concentrations in saline waters were generally lower, with only 1.4% of the stations exceeding 25 mg/l nitrate (5.6 mg/l NO_3-N) and 72.5% of the stations below 2 mg/l nitrate (0.5 mg/l NO_3-N). Member states also reported the trophic status for fresh surface waters; however, the parameters and methodologies used in the assessment varied widely. Of all

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[13] EEA. (2012). *European waters — assessment of status and pressures.* Copenhagen: European Environment Agency.

[14] *Ibid*

[15] Trophic state has several categories: waters with high nutrient levels, high plant production rates, and an abundance of plant life are termed eutrophic, whereas waters that have low concentrations of nutrients, low rates of productivity and generally low biomass are termed oligotrophic; waters that fall in between are mesotrophic, and those on the extreme ends of the scale are termed hypereutrophic or ultra-oligotrophic. (EPA, 2009.) However, there are no consistent specifications across different types of waters or countries in determining the trophic state.

[16] "Saline waters" in the EU refers to transitional, coastal and marine waters. Transitional waters are defined by the WFD as "bodies of surface water in the vicinity of river mouths which are partially saline in character as a result of their proximity to coastal waters but which are substantially influenced by freshwater flows."

[17] EC. (2013a). *Report from the Commission on the implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources based on Member State reports for the period 2008-2011.* Brussels: European Commission. Retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52013DC0683

[18] The EU measures nitrogen concentrations as nitrate (NO_3) or nitrite (NO_2), while the U.S. uses nitrate-nitrogen (NO_3-N) or nitrite-nitrogen (NO_2-N). All units have been converted to NO_3-N or NO_2-N for consistency:
NO_3-N (mg/l) = 0.2259 * NO_3 (mg/l) NO_2-N (mg/l) = 0.3045 * NO_2 (mg/l)
NH_4-N (mg/l) = 0.7765 * NH_4 (mg/l)

reported river monitoring stations, 16.3% and 6.3% were eutrophic and hypertrophic respectively, and of all reported lake monitoring stations, 24.1% and 12.7% were eutrophic and hypertrophic respectively.[19] With regard to pollution sources, farming is responsible for over 50% of the total nitrogen discharge into surface water.[20]

Table 3: Nitrates Concentration at all monitoring stations in EU 27 for the period 2008-2011

	Annual Average Nitrate Concentration				
	> 50 mg/l	**40-50 mg/l**	**25-40 mg/l**	**2-25 mg/l**	**0-2 mg/l**
Groundwater	14.4%	5.9%	12.7%	67.0%	67.0%
Fresh surface waters	2.4%	2.4%	9.3%	64.5%	21.3%
Saline waters	1.4%	1.4%	1.4%	26.1%	72.5%

Source: (EC, 2013a)

In summary, it is not possible to directly compare the U.S. and the EU with respect to the observed water quality impacts of agriculture. Data are collected using different protocols in the two jurisdictions and, in addition, when it comes to readily accessible national data, the U.S. reports total nitrogen, while the EU reports nitrates (thereby excluding nitrogen in the form of nitrites and ammonia.)

Institutions, Policy Frameworks, and Objectives

Policy and Institutional Frameworks

The U.S. and EU share some similarities in their policy frameworks for addressing nutrient contamination of water from agricultural sources. Both rely on a cooperative approach with states (member states), whereby ambient water quality guidelines or standards are set at the broader jurisdiction level, but more detailed implementation decisions rest with the states. Both the U.S. and EU have binding (and nearly identical) jurisdiction-wide nitrogen standards for drinking water, and both use agricultural policy programs to incentivize (rather than require) farmers to take action to protect against nutrient pollution of water.

Controlling nonpoint sources of contamination poses challenges in each jurisdiction. While the U.S. sets regulatory standards for point sources of pollution (which affect CAFOs in the agricultural sector), it does not directly regulate nonpoint source pollution, including agricultural

[19] EC (2013a)

[20] EC. (2010b, January). *The EU Nitrates Directive.* Retrieved May 20, 2016, from European Commission: http://ec.europa.eu/environment/pubs/pdf/factsheets/nitrates.pdf

nutrient runoff, at the federal level. Instead, it relies on voluntary conservation programs implemented by states and USDA. As explained earlier, the EU Nitrates Directive does set compulsory requirements for farmers in member states, which are mostly transformed into cross-compliance requirements under the Common Agricultural Policy (CAP).

U.S. Legislation

EPA and USDA are the two main federal institutions responsible for the implementation of environmental and agricultural policy in the United States. Recognizing that solutions to water quality concerns vary with local conditions, the CWA adopts a cooperative federalism approach to protecting water quality, recognizing "the primary responsibilities and rights of States to prevent, reduce and eliminate pollution…".[21] Further, regulations affecting agriculture have always been controversial, so many national environmental policies specifically exempt agriculture from binding requirements. As a result, most efforts to control water pollution caused by agricultural activities in the U.S. take place at the state level and are often on a voluntary basis.

The CWA establishes the overarching framework for efforts to protect waters in the U.S. The CWA includes the Federal Water Pollution Control Act Amendments adopted in 1972 and a series of amendments since then. It authorizes EPA to guide states to establish surface water quality standards and set limits on effluent discharges from point sources. Generally, EPA issues guidelines containing mandatory effluent standards for various industry categories, while states are authorized to specify standards and grant permits to point source dischargers. Currently 46 states are authorized to implement the permitting program.[22] The CWA exempts nonpoint agricultural sources of contamination from these permitting requirements. This means that point source effluent discharges from animal feeding operations are the only farm activity covered by the permitting requirements.

EPA's Nonpoint Source Management, or Section 319, Program (established in 1987 amendments to the CWA) encourages states to address nonpoint source pollution including excess nutrients from agricultural runoff. Under the Section 319 program, states receive grants to support local nonpoint source control practices, such as best management practices for nutrient use, aimed at preventing excess nutrients from entering the surrounding environment.

The Coastal Zone Act Reauthorization Amendments of 1990 (CZARA) aims to reduce polluted runoff to coastal waters. It directs EPA and the National Oceanic and Atmospheric Administration (NOAA) to recommend a set of management measures for states to control

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[21] 33 U.S.C. § 1251(b) (2012) http://uscode.house.gov/view.xhtml?req=granuleid:USC-prelim-title33-section1251&num=0&edition=prelim

[22] EPA. (2016b, February 4). *About NPDES*. Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/npdes/about-npdes

polluted runoff from six main sources: agriculture, forestry, urban areas, marinas, hydromodification (e.g. shoreline and stream channel modification), wetlands, and riparian and vegetated treatment systems. States are required to develop coastal nonpoint programs based on the recommended management measures and are responsible for implementation.

Congress enacted the Safe Drinking Water Act (SDWA) in 1974 to set federal drinking water quality standards. Under the SDWA, regulated entities include any water systems that deliver drinking water to customers. EPA sets binding contaminant-specific "maximum contaminant levels" (MCLs) that drinking water systems must meet. These standards are referred to as the National Primary Drinking Water Regulations (NPDWRs). The NPDWRs also include standards for nitrate and nitrite levels in drinking water, a large part of which comes from agricultural runoff. These standards are achieved through a partnership between EPA, states, and water systems. States are required to adopt the NPDWRs but can set more stringent standards. Currently all states except Wyoming and the District of Columbia have received the authority from EPA to implement the SDWA.[23]

While the SDWA requires drinking water systems to meet MCLs at the point of distribution and focuses on treatment at that point, EPA is also authorized to address the quality of water at the source. The primary source water protection approach is source water assessments which were completed by states in 2012 for all public water systems. Using the information gathered through the assessments, local communities implement measures to prevent or reduce contamination of their drinking water supplies, which include prohibitions on land uses that might release pollutants into source waters and educational events that increase public awareness of the need to protect source waters.[24]

The Farm Bill, comprehensive legislation that Congress passes every five or so years, is a mechanism for setting and implementing U.S. agricultural policy. It typically includes an array of efforts to address water pollution from agriculture by authorizing a number of voluntary conservation programs. USDA agencies administer conservation programs to provide financial and technical support for farmers who adopt environmentally-friendly agricultural practices. In contrast with the EU, U.S. federal direct payments comprise a relatively small proportion of total farm income. During 2013-2015, the total federal government direct farm program payments accounted for 11% of net farm income, of which payments for conservation programs represented roughly 30%.[25] These conservation programs cover a wide range of environmental

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[23] EPA. (2015f, November 30). *Understanding the Safe Drinking Water Act.* Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/sdwa/overview-safe-drinking-water-act

[24] EPA. (2015c, November 17). *Conducting Source Water Assessments*. Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/sourcewaterprotection/conducting-source-water-assessments

[25] ERS. (2016, November 30). *Farm Income and Wealth Statistics*. Retrieved from United States of Department of Agriculture Economic Research Service: https://www.ers.usda.gov/data-products/farm-income-and-wealth-statistics.aspx

issues influenced by agricultural activities such as protection of soil quality, water quality, biodiversity and landscape. Those related to water pollution from nutrient runoff include land retirement programs and working land conservation programs, which are discussed below.

EU Legislation

In the EU, nutrient pollution from agriculture is primarily regulated through directives and the CAP. Directives establish objectives that all EU member states are required to achieve but gives member states the flexibility to devise the means to do so. For example, they set water quality standards for nutrient concentrations, as well as minimum measures member states must implement to control excess nutrients from agriculture. On the other hand, the CAP is binding on member states and applied uniformly across the EU.

The Water Framework Directive (WFD) is the primary EU-wide water legislation that entered into force in 2000. The WFD establishes a comprehensive, cross-border approach to water protection organized around river basin districts in the EU. The directive requires EU member states to monitor and assess water quality and to produce a River Basin Management Plan for each of the river basin districts within its territory. While not targeted specifically at nutrient pollution or agriculture, the WFD lists "substances which contribute to eutrophication (in particular, nitrates and phosphates)" in Annex VIII as "main pollutants" requiring control.

The WFD aimed to achieve "good status" for all European water bodies by 2015. For surface water, "good status" is defined as "good ecological and chemical status." Recognizing ecological variability, the WFD does not set absolute standards for "good ecological status" for surface water at the European level. Instead member states must ensure that a given body of surface water is "in conditions of minimal anthropogenic impact." In contrast, the WFD defines "good chemical status" for surface waters based on EU-wide quality standards.

The Groundwater Directive (GWD, or Directive 2006/118/EC), established in 2006 to achieve "good chemical and quantitative status" of groundwater, specifies EU-wide chemical quality standards for groundwater including nitrate concentrations. These standards serve as the minimum requirement for member states, but member states are allowed to set their own tighter limits taking into account their policy preference and hydrogeological conditions.

The Marine Strategy Framework Directive (MSFD, or Directive 2008/56/EC), adopted in 2008, aims to achieve good environmental status of Europe's marine waters by 2020. "Good environmental status" is assessed with eleven qualitative indicators, including minimized human-induced eutrophication. Member states are required to develop a strategy for their marine waters that includes a baseline assessment, tailored objectives and targets, monitoring plans, and management measures to achieve "good" environmental status.

In addition, the EU also sets standards for drinking water. The Drinking Water Directive (DWD, or Directive 98/83/EC) was established in 1998 to ensure the quality of water intended for human consumption. It sets EU-wide minimum quality standards for drinking water, covering a total of 48 indicator parameters including nitrogen concentrations. Member states can set additional requirements such as tighter limits on substances listed in the DWD or limits on additional substances not listed in the DWD.

The Industrial Emissions Directive (IED, or Directive 2010/75/EU) is the main EU legislation regulating industrial pollutant emissions to air, water and soil. It was adopted in 2010, integrating seven previously existing directives. In particular, it replaced the Integrated Pollution Prevention and Control (IPPC) Directive (Directive 96/61/EC) which had been in place since 1996. The IED mostly retains the scope regulated by the IPPC, including controlling pollution from "intensive rearing of poultry or pigs" which sets certain thresholds on numbers of poultry, pigs, and sows. It requires the regulated facilities to operate with a permit issued by member states. The permit contains a set of conditions including effluent limit values that can be achieved through the use of the Best Available Techniques (BAT). No EU-wide effluent limit value has been set for livestock rearing, which means that the IED allows member states to define BAT differently depending on their circumstances. In addition, regulated facilities are subject to environmental inspections—conducted by each member state—at least every 1 to 3 years under the IED.

Prior to the above directives, the EU established the Nitrates Directive in 1991 to prevent nitrate pollution from agricultural sources, especially from agricultural land runoff and leaching. It requires member states to identify and designate "Nitrate Vulnerable Zones" (NVZs) for fresh surface water or groundwater bodies with a concentration of nitrates exceeding 50 mg/l. Member states must establish Codes of Good Agricultural Practices to be implemented by farmers on a voluntary basis throughout its territory, which must include but are not limited to periods when fertilizer application is banned and minimum manure storage capacity, as specified by the Nitrates Directive. Within the designated NVZs, all measures included in the Codes of Good Agricultural Practices become mandatory. In addition, member states must establish "Action Programmes" to be implemented by farmers within NVZs on a compulsory basis. The Nitrates Directive specifies several measures that must be included in Action Programmes such as limitation of fertilizer and manure application, but member states can define specific numeric limits and set additional measures based on local conditions. Alternatively, member states can choose to apply both Codes of Good Agricultural Practices and Action Programmes on a compulsory basis to the whole territory, instead of designating NVZs. The Nitrates Directives also requires member states to continuously monitor nitrates concentrations in their waters and report to the Commission every four years.

While member states may decide on different measures when they translate these directives into their national legislation, a key mechanism for implementing these measures across the EU is the Common Agricultural Policy. Launched in 1962, the CAP is the most important agricultural

policy in the EU, containing various programs and standards concerning market support, income support and rural development that affect 22 million farmers and agricultural workers across the EU. CAP integrates environmental concerns into farming practices by establishing support schemes conditional on compliance with compulsory environmental requirements, and by providing additional financial incentives for voluntary good farming practices. With an annual budget of approximately €40 billion, CAP expenditure accounted for approximately 40% of total EU expenditure during 2010-2014.[26] All CAP subsidies represented 33% of total EU farm income, and its income support scheme—direct payments—was roughly 28% of farm income.[27]

Policy Objectives

To further illustrate the similarities and differences in EU and U.S. legislation and regulation, this section compares the water quality objectives, including both narrative and numeric standards, with regard to nutrient concentrations established in the above U.S. and EU policies. Policy objectives for control of nutrient pollution from agriculture vary between the U.S. and the EU, and across surface, ground, and drinking waters. In general, the U.S. does not set numeric nutrient limits for surface water quality. Numeric nitrogen criteria are only seen in select U.S. states, but EPA is encouraging states to issue more state-wide numeric criteria. While the EU does not set explicit nutrient standards for surface waters either, the Nitrates Directive specifies 50 mg/l of nitrates (or 11.3 nitrate-N) as the threshold value to identify NVZs, which means that member states must take measures to bring nitrate concentrations below this level.

Surface Water Quality

In the EU, the Nitrates Directive defines 50 mg/l of nitrates (equivalent to 11.3 nitrate-N) as the threshold value to designate Nitrate Vulnerable Zones for fresh surface waters across the EU, which serves as an implicit water quality objective.

In the U.S., pursuant to Section 303(c) of the CWA, states must designate uses of a water body such as agriculture, aquatic life, or recreation, and then decide on water quality criteria necessary to protect its designated uses, including nutrient criteria. These state-specific standards must be approved by EPA. In the case that no state-specific water quality standards have been developed or approved, water quality standards promulgated by EPA are applied.

Most of the state-specific standards related to nutrients are narrative criteria, which are expressed qualitatively, but EPA has been encouraging states and territories to promulgate statewide

[26] EC. (2016, July 06). *CAP post-2013: Graphs and figures*. Retrieved from European Commission: http://ec.europa.eu/agriculture/cap-post-2013/graphs/index_en.htm

[27] *Ibid*

numeric nutrient criteria. As of May 2016, EPA classified 28 out of 56 states and territories[28] as level 2 or above, meaning that they had set numeric total nitrogen and/or total phosphorus criteria for at least "some waters."[29] Among the 50 states, Wisconsin, New Jersey, Minnesota, and Florida are identified with "2 or more watertypes with N and/or P criteria" (level 4), but no states currently have developed a "complete set of N and P criteria for all watertypes" (level 5).[30]

Table 4 illustrates how some different states have addressed nutrient limits in surface waters. Colorado has set numeric standards for nitrate, nitrite, and combined nitrogen concentrations (the sum of nitrate and nitrite measured as nitrogen) in surface waters by designated uses.[31] North Carolina has only numeric nitrate standards for fresh surface waters that are protected as water supplies in watersheds, but not for fresh surface water for recreation such as fishing or swimming.[32] New York currently uses narrative standards for nutrients in water, which limit the amount of phosphorus and nitrogen to a level that will not result in harmful growth of algae, weeds and slimes but plans to adopt numeric nutrient criteria by 2017.[33] It is worth noting that these examples are meant to be illustrative of different state approaches for addressing nutrient limits in surface water and not representative of nutrient limits, broadly.

Table 4: Examples of U.S. State-Specific Surface Water Quality Standards

Parameter	Colorado	North Carolina	New York
Nitrate-N (NO_3-N)	a. 100 mg/l for waters designated for agriculture; b. 10 mg/l for waters designated for domestic water supply.	10 mg/l for fresh surface waters that are protected as water supplies in watersheds	Narrative standards for phosphorus and nitrogen in fresh and saline surface waters – "none in amounts that will result in
Nitrite-N (NO_2-N)	a. Case-by-case calculation based on species present for waters designated for aquatic life; b. 10 mg/l for waters designated for agriculture;	No criteria	

[28] Including 50 U.S. states, the District of Columbia, and five major territories (American Samoa, Commonwealth of Northern Marianas, Guam, Puerto Rico, and the US Virgin Islands).

[29] EPA. (2016g, May 24). *State Development of Numeric Criteria for Nitrogen and Phosphorus Pollution*. Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/nutrient-policy-data/state-development-numeric-criteria-nitrogen-and-phosphorus-pollution

[30] *Ibid*

[31] Colorado. (2005, August 08). *The Basic Standards and Methodologies for Surface Water.* Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/sites/production/files/2014-12/documents/cowqs-no31-2005.pdf

[32] North Carolina. (2003, April 01). *Surface Waters and Wetlands Standards.* Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/sites/production/files/2014-12/documents/nc-classifications-wqs.pdf

[33] New York. (2008, June 12). *Water Quality Regulation.* Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/sites/production/files/2014-12/documents/nywqs-section1.pdf

	c. 1 mg/l for waters designated for domestic water supply.		growths of algae, weeds and slimes that will impair the waters for their best usages."
Nitrate-N + Nitrite-N	a. 100 mg/l for waters designated for agriculture; b. 10mg/l at the point of intake to the domestic water supply.	No criteria	

Sources: (Colorado, 2005); (North Carolina, 2003); (New York, 2008)

Groundwater Quality

In the EU, the "good status" for groundwater bodies specified in the WFD refers to chemical and quantitative status. Groundwater quantitative status refers to the degree to which a body of groundwater is affected by abstractions.[34] Assessments of groundwater chemical status is further specified in the GWD, which sets minimum groundwater quality standards at the European level, including a nitrate criterion. The criterion—50 mg/l of nitrates—is also consistent with the threshold value specified in the Nitrates Directive, which applies to groundwater bodies as well. Some member states (Austria, Ireland, UK, Hungary, and Latvia) have set tighter threshold values (Table 5).[35]

As with surface waters, there is no national groundwater quality standard in the U.S. Since groundwater serves as a drinking water source in many regions, state-specific groundwater standards are mostly linked with drinking water standards. As Table 5 shows, the standards are similar in the EU and U.S.

Table 5: EU and U.S. Groundwater Quality Standards

Examples of EU Groundwater Quality Standards		
Parameter	**EU-wide minimum standard**	**EU member states threshold values**
Nitrate-N	11.3 mg/l	Austria: 10.2 mg/l Ireland: 8.5 mg/l UK: 4.1-9.5 mg/l * Hungary: 5.6-11.3 mg/l * Latvia: 11 mg/l

[34] Groundwater abstraction is the process of taking water from a ground source, either temporarily or permanently. Most water is used for irrigation or treatment to produce drinking water. Depending on the environmental legislation in the relevant country, controls may be placed on abstraction to limit the amount of water that can be removed. (http://www.eea.europa.eu/themes/water/wise-help-centre/glossary-definitions/groundwater-abstraction)

[35] EC. (2010a). *Report from the Commission in accordance with Article 3.7 of the Groundwater Directive 2006/118/EC on the establishment of groundwater threshold values.* Brussels: European Commission. Retrieved from http://ec.europa.eu/environment/water/water-framework/groundwater/reports.htm

Examples of U.S. Groundwater Quality Standards			
Parameter	**New Jersey**	**Washington**	**Utah**
Nitrate-N	10 mg/l	10 mg/l	10 mg/l
Nitrite-N	1 mg/l	-	1 mg/l
Nitrate-N + Nitrite-N	10 mg/l	-	10 mg/l

** A range of threshold values indicates different threshold values for different regions with in the country.*

Sources: (EC, 2010a); New Jersey. (2010, July 22). *Ground Water Quality Standards.* Retrieved from New Jersey Government: http://www.nj.gov/dep/rules/rules/njac7_9c.pdf; Utah. (2016). *Utah Ground Water Quality Protection Program.* Retrieved from Utah Department of Environmental Quality: http://www.deq.utah.gov/ProgramsServices/programs/water/groundwater/standards.htm; Washington. (1990, October 31). *Water Quality Standards for Groundwaters of the State of Washington*. Retrieved from Washington State Legislation: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-200.

Drinking Water Quality

As discussed above, both the EU and the U.S. set territory-wide drinking water standards. These standards have specific references to nitrogen concentrations (Table 6).

Table 6: EU and U.S. Drinking Water Quality Standards

Parameter	EU Standards	U.S. Standards
Nitrate-N	11.3 mg/l (50 mg/l NO_3)	10 mg/l
Nitrite-N	0.15 mg/l (0.50 mg/l NO_2)	1 mg/l
Nitrate + Nitrite	$[NO_3]/50 + [NO_2]/3 \leq 1$	-

Sources: EU Council. (1998). Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption. *Official Journal of the European Communities*, 32-54; EPA. (2016h, May 3). *Table of Regulated Drinking Water Contaminants*. Retrieved May 24, 2016, from https://www.epa.gov/ground-water-and-drinking-water/table-regulated-drinking-water-contaminants#one

Policy Instruments

Authorized by the above-described legislation and seeking to achieve similar though not identical policy objectives, the EU and the U.S. have adopted a combination of different policy tools to protect water from agricultural nutrient pollution.

EU Policy Instruments

The WFD is the central policy instrument for all types of water pollution in the EU. It requires member states to develop a River Basin Management Plan (RBMP) for each individual river basin district. RBMPs are expected to include water quality monitoring reports and management

measures that member states will undertake to achieve "good status." However, across the EU, very few RBMPs contain a detailed description of how nutrient targets are to be reached.[36] Accordingly, the primary mandatory control of nutrient pollution is achieved through the IED for point sources and the Nitrates Directive for nonpoint sources.

Livestock operations are the largest identifiable point source in the agricultural sector, and the EU regulates pollutant emissions from intensive livestock operations. The IED covers farms operating intensive rearing of poultry or pigs, which is defined as operations: (i) with more than 40,000 poultry, (ii) with more than 2,000 pigs (over 30 kg), or (iii) with more than 750 sows. Approximately 20% of the total number of pigs and 60% of the total number of poultry in the EU are over these thresholds.[37]

Farms covered by the IED are required to operate with a permit issued by member states. The permit must include all measures necessary for controlling pollution, including effluent limits for polluting substances set on the basis of the Best Available Techniques (BAT). The polluting substances specified in the IED cover a wide range of air and water pollutants, including "substances which contribute to eutrophication (in particular, nitrates and phosphates)." For livestock operations, the IED does not set EU-wide effluent limits, but allows member states to set their own values based on BAT. Furthermore, the IED also specifies that when the BAT-based limits are considered insufficient in achieving existing environmental quality standards (e.g. water quality standards), additional quality-based measures must be included in the permit.

The Nitrates Directive is the primary instrument for controlling agricultural nonpoint sources of nutrient pollution. It is specifically targeted towards nitrate losses from leaching and runoff, and requires member states to establish Action Programmes that apply within NVZs on a compulsory basis, and Codes of Good Agricultural Practices to be implemented throughout their territory on a voluntary basis. The voluntary, territory-wide, Codes of Good Agricultural Practice include measures: (i) limiting the time periods when nitrogen fertilizers can be applied on land; (ii) limiting the conditions for fertilizer application (on steeply sloping ground, frozen or snow covered ground, near water courses, etc.); (iii) requiring a minimum storage capacity for livestock manure; and (iv) implementing crop rotations, soil winter cover, and catch crops.[38]

The Action Programmes, which are mandatory within NVZs, include all measures included in Codes of Good Agricultural Practice and other measures such as the limitation of fertilizer

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[36] Boyle, S. (2014). The Case for Regulation of Agricultural Water Pollution. *Environmental Law Review, 16*(1), 4-20. doi:10.1350/enlr.2014.16.1.200

[37] EC. (2013b). *Report from the Commission on the reviews undertaken under Article 30(9) and Article 73 of Directive 2010/75/EU on industrial emissions addressing emissions from intensive livestock rearing and combustion plants.* Brussels: European Commission.

[38] EU Council. (1991). Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources . *Official Journal L 375*, 1-8.

application, including maximum amount of livestock manure to be applied (170 kg nitrogen per hectare per year).[39]

Beyond setting maximum amounts of manure application, the Commission has not set numeric values for the required measures, leaving member states a great degree of freedom to design operational requirements at the farm level. Member states are also responsible for enforcing these measures, although the cross-compliance requirement provides some assurance that codes are being met.

In general terms, cross-compliance requires a basic level of environmental compliance by farmers as a condition of eligibility for other important government programs. It shares characteristics with both regulatory standards and economic incentives. Introduced in the 2003 CAP reform, all farmers receiving direct payments have been subject to compulsory cross-compliance since 2005. It makes direct payments contingent upon farm compliance with specified environmental requirements, including: (i) Statutory Management Requirements (SMRs) concerning the environment, food safety, animal and plant health and animal welfare; and (ii) good agricultural and environmental condition (GAEC) covering additional standards related to soil protection, habitat protection, and water management. Hence, SMRs and GAEC constitute the two key components of cross-compliance.

Under current EU regulation, the Nitrates Directive is referred to as SMR 1, and is the only SMR that addresses the issue of water. SMR1 requires that farmers comply with the standards established in Action Programmes and/or Codes of Good Agricultural Practice. There are three compulsory GAECs, specified in Council Regulation (1306/2013), that address water quality. These include 1) buffer strips along water bodies, 2) approval by local authorities for irrigation water, and 3) prevention of direct and indirect agricultural discharge of ammonia and nitrates into groundwater.[40] GAECs are mostly narrative requirements at EU level, and member states are responsible for establishing operational requirements that farmers can implement.

Failure to comply with the SMR or GAEC requirements results in reduction or elimination of CAP payments. Non-compliance due to negligence can lead to a 5% reduction in CAP payments for first occurrence and 15% for reoccurrence. For intentional non-compliance, the penalty is a payment reduction of no less than 20%. The significant size of direct CAP payments creates powerful incentives for cross-compliance by farmers. Direct payments represent about 70% of CAP expenditure[41] in the EU-27 in 2009-2014, amounting to over €40 billion annually.[42] Direct

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[39] *Ibid*

[40] EU Council. (2013). Regulation (EU) No 1306/2013 of the European Parliament and of the Council of 17 December 2013. *Official Journal of the European Union L 347*, 549-607

[41] EC. (2016, July 06). *CAP post-2013: Graphs and figures*. Retrieved from European Commission: http://ec.europa.eu/agriculture/cap-post-2013/graphs/index_en.htm; The remaining 30% of CAP expenditure was spent on export subsidies, rural development, and other market support.

payments also represent an important share of EU farmers' income. In 2010-2014, the average share of direct payments agricultural income was 28%, ranging from 15% to 40% in individual member states.[43] Because of farmers' high dependence on direct payments, cross-compliance requirements are considered much more coercive instruments than voluntary incentive-based instruments.

Another critical component of CAP—agri-environment measures—is a voluntary incentive-based instrument that integrates environmental concerns into farming practices. Agri-environment measures were first introduced in the late 1980s as optional measures to be applied by member states, and have become compulsory for member states in the framework of their rural development plans since the 1992 CAP reform, but remain optional for farmers. Farmers get payments in return for environmental services to meet requirements above or beyond mandatory requirements as defined by SMRs and GAEC. Member states have a high degree of freedom in the design and implementation of agri-environmental measures. Examples include environmentally favorable intensification of farming, integrated farm management and organic agriculture, and conservation of high-value habitats and their associated biodiversity. According to Lankoski & Ollikainen,[44] most member states focus more on biodiversity and landscapes, but Denmark, Finland, and Sweden have developed ambitious voluntary policies addressing nonpoint source pollution.

The amount of funding for agri-environment measures is much less significant than cross-compliance. For the EU-27, the total spending on agri-environmental measures from 2007 to 2009 was about €6 billion annually, around 7% of total agricultural support. Agri-environmental programs covered 22% of the utilized agricultural area of the EU-27 in 2009, equivalent to approximately 38.3 million hectares (or 94.7 million acres).

U.S. Policy Instruments

The U.S. employs several policy instruments to address nutrient pollution in water from agriculture. Many of the key instruments are established by the CWA.

The Total Maximum Daily Load (TMDL) Program, established by Section 303(d) of the CWA, is a planning tool used by states to support restoration and protection activities for impaired waters (i.e., water bodies that do not meet applicable water quality standards for their designated uses).[45] States must develop a TMDL for each impaired body of water based on a calculation of

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[42] *Ibid*

[43] *Ibid*

[44] Lankoski, J., & Ollikainen, M. (2013, 3rd Quarter). Innovations in Nonpoint Source Pollution Policy - European Perspectives. *CHOICES, 28*(3).

[45] It is worth noting that federal requirements may reduce the level of flexibility for states to designate waters for lower valued uses. For example, statutory and regulatory provisions such as anti-backsliding requirements

the maximum allowable amount of specific pollutants that may be discharged ("loaded") into the water from all sources in order to attain the relevant water quality standards. Pollutant load reduction levels are then allocated to point and nonpoint sources according to their actual pollutant load. As a means of achieving the load reduction targets, states may adjust point source discharge limits and/or encourage nonpoint source management practices. Accordingly, the TMDL process itself does not establish binding discharge limits and is not self-implementing, but it provides a pollution "budget" for effective pollution control. Since October 1995, there have been nearly 70,000 TMDLs submitted by states and approved by EPA, among which 6,200 TMDLs establish "budgets" for nutrient pollutants.[46]

In the U.S., point source discharge limits are implemented though the National Pollutant Discharge Elimination System (NPDES) permit program, established by section 402 of the CWA. Similar to the EU IED permit, permits issued under the NPDES program contains two levels of control: technology-based effluent limitations established by EPA on an industry-by-industry basis,[47] and water quality-based effluent limitations if technology-based limits are not sufficient to achieve water quality standards. While almost all agricultural nonpoint source discharges (e.g. stormwater discharge and irrigation return flows) are exempt from the NPDES program, CAFOs are regulated through the NPDES point source permitting requirements.

EPA regulation requires CAFOs to obtain NPDES permits to discharge manure, litter, and process wastewater pollutants. Compared to the EU IED, the NPDES covers a larger scope of animal operations in terms of animal species and sizes of operations. First, a CAFO refers to an operation rearing a wide range of animal species including cattle, pigs, poultry, horses, or sheep. Second, almost all sizes of CAFOs are subject to NPDES permits if they are found to be a significant contributor of pollutants, although EPA has defined size thresholds to distinguish large, medium, and small CAFOs that are subject to different effluent limitations.[48] The CAFO Effluent Guidelines published by EPA have specified national technology-based effluent limits that are applicable only to large CAFOs. Generally, discharge from most types of large CAFOs is prohibited. For example, the Guidelines regulate "no discharge of manure, litter, or process wastewater pollutants" for CAFOs with "more than 700 mature dairy cows or 1,000 cattle other

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prevent states from setting standards at a level that is less stringent relative to those previously established. See EPA (2016b).

[46] EPA. (2015b, September 30). *Assessment and Total Maximum Daily Load Tracking and Implementation System (ATTAINS)*. Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/waterdata/assessment-and-total-maximum-daily-load-tracking-and-implementation-system-attains

[47] EPA identifies the best available technology that is economically achievable for that industry and sets regulatory requirements based on the performance of that technology. (https://www.epa.gov/eg/learn-about-effluent-guidelines#levels)

[48] EPA. (2015e, November 16). *Regulatory Definitions of Large CAFOs, Medium CAFO, and Small CAFOs.* Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/sites/production/files/2015-08/documents/sector_table.pdf

than mature dairy cows or veal calves."[49] With regard to medium and small CAFOs, states are authorized to determine effluent limits on a case-by-case basis. Anybody who discharges a pollutant from a point source CAFO into U.S. waters without an NPDES permit is in violation of the regulation and subject to a penalty.

Another important policy instrument in the U.S. is the Section 319 Nonpoint Source Management Program, established by the 1987 amendments to the CWA. Through the program, states receive grant money to support a wide variety of activities including technical assistance, financial assistance, education, training, and technology transfer for implementation of specific nonpoint source projects.[50] These projects are not targeted only at agricultural nonpoint sources, but also to pollution from urban runoff and atmospheric deposition. However, over 40% of the Section 319 grants (worth about $65 million per year) have been used to control nonpoint source pollution from farms.[51]

In addition to the Section 319 program, all coastal and Great Lakes states are required to participate in the Coastal Nonpoint Pollution Control Program established in 1990 by the CZARA. Under the program, EPA and NOAA have developed a set of recommended management measures to be implemented by states. Among the management measures applicable to agricultural sources are location-specific nutrient management plans, which comprise several core components, including: (i) realistic yield expectations for the crops to be grown; (ii) a summary of the nutrient resources available to farmers; (iii) an evaluation of field limitations such as soils with high leaching potential and highly erodible soils; and (iv) identification of timing and application methods for nutrients.[52] Many of the management measures for agricultural nonpoint sources are commonly practiced and recommended by USDA as components of other programs; therefore, many farms subject to CZARA may already be in compliance with the measures.[53]

The coastal nonpoint programs are implemented through changes to states' Section 319 programs and other coastal zone management programs. At the farm level, states can provide voluntary incentives for farmers to adopt nonpoint source pollution management practices, but must enforce adoption if voluntary approaches fail.

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[49] EPA. (2012, July 30). *Complied CAFO Final Rule.* Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/sites/production/files/2015-08/documents/cafo_final_rule2008_comp.pdf

[50] EPA. (2016a, February 2). *319 Grant Program for States and Territories.* Retrieved May 20, 2016, from https://www.epa.gov/polluted-runoff-nonpoint-source-pollution/319-grant-program-states-and-territories

[51] *Ibid*

[52] EPA. (1993, January). *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters.* Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/polluted-runoff-nonpoint-source-pollution/guidance-specifying-management-measures-sources-nonpoint

[53] *Ibid*

Compared to the EU, the U.S. relies much less on cross-compliance mechanisms under which major reductions are made to farmers' agricultural support payments as a consequence of unsound environmental practices. A few compliance mechanisms in the U.S. are designed to protect highly erodible soils and wetlands, however, there is no requirement for compliance with nutrient-related standards. Instead, good farming practices are encouraged through voluntary programs.

Farm Bill conservation programs are voluntary programs designed to ensure good environmental practices and outcomes in agricultural production. The 2014 Farm Bill provided an estimated $28 billion in funding for conservation programs for 2014-2018.[54] Unlike the other programs implemented by states, conservation programs are administered by USDA agencies such as the National Resources Conservation Service (NRCS) and the Farm Service Agency (FSA). Eligible program participants receive financial and/or technical assistance to implement various conservation practices. While none of the conservation programs is targeted only towards water pollution or nutrient runoff, most of them aim to address multiple environmental problems caused by agricultural activity and thus are relevant here. The conservation programs that cover water quality issues include: (i) land retirement programs, such as the Conservation Reserve Program (CRP) and Conservation Reserve Enhancement Program (CREP), which suspend agricultural activities on designated lands; (ii) working land conservation programs, such as the Environmental Quality Incentives Program (EQIP) and Conservation Stewardship Program (CSP), which allow agricultural practices to continue but with added environmental protections; and (iii) other programs such as the Source Water Protection Program (SWPP). Details on each conservation program are described in Chapter 3 of this report.[55] For the sake of completeness, a brief summary of each program is provided below while Table 7 compares key features of these programs.

CRP is the largest land retirement program in the U.S. It pays farmers a yearly rental payment for removing environmentally sensitive land from agricultural production. CREP is an offshoot of CRP, which is a state-federal partnership program that targets high-priority conservation issues. Only land in states with approved CREP agreements—currently 33 states—can be enrolled in CREP. The 2014 Farm Bill reauthorized CRP with an annual enrollment cap of 24 million acres, declining from 32 million acres from the 2008 Farm Bill.[56] The 2016 budget for CRP is $1.8 billion.[57]

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[54] USDA. (2016). *FY2016 Budget Summary and Annual Performance Plan.* Washington, DC: U.S. Department of Agriculture.

[55] Susan E. Dudley, Lydia Holmes, Daniel R. Pérez, Aryamala Prasad & Zhoudan Xie. "Policy Transatlantic Agriculture & Regulation Working Paper Series, No. 3: Transatlantic Approaches to Agriculture Policy." The George Washington University Regulatory Studies Center. October 3, 2017. https://regulatorystudies.columbian.gwu.edu/transatlantic-approaches-agriculture-policy-transatlantic-agriculture-regulation-working-paper

[56] *Ibid*

EQIP is a key agricultural conservation program that complements EPA's efforts to control nonpoint source pollution from agriculture.[58] It provides financial and technical assistance to farmers who implement conservation practices that improve soil, water, plant, animal, air, and natural resources. The 2016 budget for EQIP is $1.35 billion.[59] There is no acreage cap established for EQIP, but the EQIP statute specifies a $450,000 payment limitation for individuals and legal entities.[60] In 2014, approximately 19.5 million acres of land in the U.S. were treated with one or more EQIP practices.[61] Of them, 8.3 million acres of land received EQIP practices related to water quality, 10.36% of which were for nutrient management.[62]

CSP is another working land conservation program that supports farmers who meet stewardship requirements on working agricultural and forest lands. Farmers can get annual payments for installing new conservation activities and maintaining existing practices, and supplemental payments for adopting a resource-conserving crop rotation.[63] The payment that farmers receive is determined by the actual environmental performance they achieve; the higher the performance, the higher the payment. The 2014 Farm Bill reauthorized CSP with an annual enrollment cap of 10 million acres.[64]

SWPP is a joint program with FSA and the nonprofit National Rural Water Association (NRWA) to promote clean source water primarily used for drinking water. NRWA implements the program with oversight and assistance by FSA, and provides education and technical assistance to local communities and farmers. There are 44 states participating in the program.

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[57] *Ibid*

[58] GAO. (2012). *Greater Oversight and Additional Data Needed for Key EPA Water Program.* Washington, DC: U.S. Government Accountability Office.

[59] USDA (2016)

[60] NRCS and CCC. (2016). Environmental Quality Incentives Program (EQIP). *Federal Register*, *81*(92), 29471 - 29483.

[61] NRCS. (2015, July 15). *NRCS Conservation Programs: Environmental Quality Incentives Program (EQIP).* Retrieved from Natural Resources Conservation Service: http://www.nrcs.usda.gov/Internet/NRCS_RCA/reports/fb08_cp_eqip.html

[62] *Ibid*

[63] NRCS. (2016). *Conservation Stewardship Program.* Retrieved from Natural Resources Conservation Service, USDA: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp/#

[64] USDA (2016)

Table 7: Overview of U.S. Conservation Programs Related to Water Quality

	Conservation Reserve Program (CRP)	Conservation Reserve Enhancement Program (CREP)	Environmental Quality Incentives Program (EQIP)	Conservation Stewardship Program (CSP)	Source Water Protection Program (SWPP)
Initial Establishment	1985 Farm Bill	1996 Farm Bill	1996 Farm Bill	2008 Farm Bill	2002 Farm Bill
Administration Agency	FSA	FSA	NRCS	NRCS	FSA & NRWA
2016 Budget (million $)	$1,834		$1,350	$1,457	Not specified
2014 Enrollment Cap (million acres)	24		N/A	10	N/A

Source: USDA (2016)

Given the shared objective of controlling nonpoint source (NPS) pollution from agriculture, the CWA Section 319 NPS program and the Farm Bill conservation programs have a close linkage. In its national evaluation of the 319 program, EPA highlighted this linkage and the coordination between state NPS agencies and USDA agencies.[65] In 26 states, NPS program goals and priorities are supported by EQIP or other conservation program funding, although many states indicated that this support was not "broad-based" or "recurring."[66] Many states also fund NPS program/NRCS liaison positions to increase cross-program coordination and funding. Furthermore, in at least 16 states, the state may provide additional financial assistance to farmers for the cost of participating in a USDA conservation program.[67] This provides additional incentive for farmers to participate. The most recent NPS Program and Grants Guidelines for States and Territories further emphasized "coordination with USDA Farm Bill programs as a way to leverage water quality investments."[68]

[65] EPA. (2011). *A National Evaluation of the Clean Water Act Section 319 Program*. Washington, DC: U.S. Environmental Protection Agency.

[66] *Ibid*

[67] *Ibid*

[68] EPA. (2013b). *Nonpoint Source Program and Grants Guidelines for States and Territories*. Washington, DC: U.S. Environmental Protection Agency.

Comparison of EU & U.S. Policy Instruments

The EU and U.S. policy instruments for addressing water pollution from agriculture have several similarities but also present a great degree of variation. While both the EU and the U.S. have mandatory limits on point sources of effluent from animal operations, the U.S. NPDES covers a larger scope than the EU IED in terms of animal species and sizes of operations. When it comes to agricultural nonpoint sources, the EU's Nitrates Directive has established territory-wide requirements on nutrient pollution, whereas in the U.S., states have more authority to control nonpoint sources and there is more reliance on voluntary measures. Both the EU and the U.S. have programs that link agricultural subsidy payments to farmers' environmental practices, but the EU's programs create far more powerful incentives for compliance than do the suite of U.S. programs. Participation in U.S. agricultural subsidy programs are on a voluntary basis, with famers able to choose whether to opt-in to the programs. On the other hand, CAP payments comprise a large share of EU farm income, so making full payments contingent upon compliance with the Nitrates Directive creates a strong motivation to participate. Beyond CAP, however, the EU's voluntary agri-environmental program to promote environmentally friendly farming practices are similar to the suite of U.S. subsidy programs.

Policy Implementation

The ultimate impact of policies to protect water from agricultural nutrient pollution depends not only on the specific content of those policies but also on the practical realities of their on-the-ground implementation and the degree to which they are operationalized through ongoing enforcement and compliance.

Specific Implementation of Broad Policy

U.S. Implementation

The implementation of the national policy also varies across U.S. states. For example, CWA section 303(d) requires only the development of a TMDL but not its implementation, and states have demonstrated varied levels of progress toward implementation. A 2007 EPA survey suggests that only 37% of TMDLs submitted often or always have detailed implementation plans, while 46% never or seldom have them.[69]

When it comes to TMDL implementation, there is also variation in the choice of policy instrument. One example is the Chesapeake Bay nutrient trading programs, jointly developed by several states in the Bay watershed including Maryland, Pennsylvania, and Virginia in the early

[69] EPA. (2007b, January). *Developing Effective Nonpoint Source TMDLs: An Evaluation of the TMDL Development Process.* Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/sites/production/files/2015-09/documents/developing-effective-nonpoint-source-tmdls.pdf

2000s.[70] The Chesapeake Bay TMDL allocates needed reductions of nutrients (primarily nitrogen and phosphorus) to all the seven jurisdictions located in the Chesapeake Bay watershed.[71] Furthermore, the Chesapeake Bay TMDL includes a multistate trading platform, by which nutrient credits can be traded between participants from different states in the Chesapeake Bay watershed. Through this program, point sources may purchase nutrient credits from other point sources or agricultural nonpoint sources within the state to meet their annual load limits. Nutrient credits are generated from reductions of nutrient discharges to impaired water bodies. Compared to the conventional "command-and-control" instruments, nutrient trading is expected to achieve the TMDL load allocations in a more cost-effective way through the market mechanism inherent in the program.

In addition, states have demonstrated varied NPDES permit coverage status for CAFOs.[72] As of December 2014, five states (Maine, Pennsylvania, Wisconsin, Kansas, and Oregon) have accomplished 100% permit coverage, while most of the other states have lower coverage rates. Of the total 456 CAFOs in Delaware, for example, only one CAFO has been issued a NPDES permit. In North Carolina, 14 out of 1,222 CAFOs were reported to have NPDES permits.

The implementation of nonpoint source management programs presents even more variation than point source programs in the U.S, since the main efforts to control nonpoint source pollution are left to the states on a voluntary basis. For example, Section 319 grants have been used to address different categories of pollution, among which 40% have been targeted at agricultural nonpoint source pollution from fiscal year 2004 through 2010.[73] In these Section 319 projects, states have adopted different approaches to prevent water pollution from agriculture, including direct approaches such as agricultural conservation practices, as well as indirect approaches such as education and outreach.[74]

EU Implementation

When translating EU-wide requirements into specific national legislation, member states have considerable freedom to choose policies based on the characteristics of their agricultural sector and the condition of their natural environment. This has resulted in diverse approaches in

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[70] WRI. (2011). *Comparison Tables of State Nutrient Trading Programs in the Chesapeake Bay Watershed.* Washington, DC: World Resources Institute.

[71] Copeland, C. (2012). *Clean Water Act and Polluant Total Maximum Daily Loads (TMDLs).* Washington, DC: Congressional Research Service.

[72] EPA. (2014, December 31). *NPDES CAFO Permitting Status Report -- National Summary, Endyear 2014.* Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/sites/production/files/2015-08/documents/npdes_cafo_permitting_status_report_-_national_summary_endyear_2014.pdf

[73] GAO (2012)

[74] GAO (2012)

implementation across the EU. Two prominent examples are the implementation of the Nitrates Directive and of the CAP Cross-Compliance Program.

EU countries have taken several approaches to the implementation of the Nitrates Directive. First, designation of NVZs reflects national management philosophies. Austria, Denmark, Finland, Germany, Ireland, Lithuania, Luxembourg, Malta, the Netherlands, Slovenia, the Region of Flanders and Northern Ireland have chosen to designate their entire territory as an NVZ, while other member states such as Bulgaria, Portugal, and Scotland have only designated waters that contain more than 50 mg/l of nitrates as NVZs.[75] On the other hand, some member states have not completed designation of NVZs for a number of waters exceeding the nitrate threshold (e.g. France, Greece, Poland, and Slovakia), although the Directive has been in force for over 20 years since 1991.[76]

Second, while the Nitrates Directive specifies minimum measures to be included in national Action Programmes, there is variation in the operational requirements established by member states to implement these measures. For example, with regard to limitation of fertilizer application, some member states set limits on total nitrogen (Netherlands, Ireland, Northern Ireland, and Flanders also have limitations on phosphorus) for all crops, while others have chosen to apply more complex systems.[77] For example, Denmark sets yearly farm-specific "nitrogen standard quotas," calculated by factoring in climatic conditions, soil types, crop composition and distribution, precipitation and irrigation.[78]

Further, EU member states have attempted to adopt different policy instruments to achieve particular objectives. For example, to control manure pollution, compulsory regulatory requirements for manure storage capacity and periodic bans on land application of manure as fertilizer are common in most EU countries. The Netherlands had to abandon its effort to apply a Mineral Accounting System (MINAS) that combined farm-level nutrient accounting with a tax on nutrient surplus, when the European Commission challenged the policy in the European Court of Justice on the grounds that it was in conflict with the maximum manure application rate specified in the Nitrates Directive.[79] More recently, a pilot project for voluntary nutrient trading was initiated in the Baltic Sea area in 2015, providing more cost-effective measures to achieve

[75] EC (2013a)

[76] EC (2013a)

[77] EC (2013a)

[78] The Danish EPA. (2012, September 7). *Nitrate Action Programme 2008-2015.* Retrieved from Environmental Protection Agency, Ministry of Environment and Food of Denmark: http://eng.mst.dk/topics/agriculture/nitrates-directive/nitrate-action-programme-2008-2015/

[79] Schröder, J., & Neeteson, J. (2008). Nutrient management regulations in The Netherlands. *Geoderma, 144*, pp. 418-425.

nutrient reductions in the area.[80] The pilot project hoped to provide lessons for a national or inter-governmental nutrient trading system.[81]

Third, under certain conditions, member states are allowed to delay or relax some directive mandates if they can demonstrate that other measures can meet the directive's objectives (called "derogation" in the EU).[82] For example, Ireland was granted a derogation under the Nitrates Directive in 2014 that increases the manure application limit of 170 kg N/ha to 250 kg N/ha per year for farms with at least 80% grassland.[83] As of the end of 2012, seven member states (Denmark, Netherlands, Germany, United Kingdom, Ireland, Belgium, and Italy) had been granted derogations under the Nitrates Directive.[84]

With regard to the implementation of CAP Cross-Compliance Program, a series of SMRs and GAEC are required, but most are general in nature. Member states are responsible for developing specific operational obligations with which farmers must comply. Obligations for farmers in compliance with SMRs are mostly based on pre-existing national legislation, such as the national Action Programmes established respectively by member states. There is an even wider variation in the approach taken by member states to define farmers' obligations for GAECs.[85] For example, many member states (e.g. Austria, Cyprus, Finland, and France) have defined farmers' obligations for all three issues identified by the Commission, while some member states (e.g. Estonia, Denmark, Hungary, and Latvia) have developed obligations for only two or less issues.[86]

Enforcement and Compliance

The degree of enforcement and compliance activity can have a substantial influence on the degree to which various policy measures affect on-the-ground conditions. For both the EU and the U.S., data on enforcement and compliance are incomplete, and often less than fully transparent due to technical and administrative constraints.

In the EU, farmers are subject to sampling inspections for compliance with the SMRs and GAEC under the Cross-Compliance Program. In 2005, in the 23 member states that reported to the

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[80] NutriTrade. (2016). *Background & Objectives*. Retrieved from NutriTrade: http://nutritradebaltic.eu/project-nutritrade/

[81] *Ibid*

[82] EC (2010b)

[83] The European Commission. (2014, January 3). Commission Implementation Decision of 27 February 2014. *Official Journal of the European Union*, pp. 7-10.

[84] EC (2013a)

[85] Alliance Environment. (2007, July 26). *Evaluation of the Application of Cross Compliance as Forseen under Regulation 1782/2003*. Retrieved from European Commission: http://ec.europa.eu/agriculture/eval/reports/cross_compliance/index_en.htm

[86] *Ibid*

Commission, inspections were carried out at about 5% of farms subject to the Program. Payment reductions were applied to 11.9% of inspected farmers, totaling about €9.8 million.[87] Some observers have, however, argued that compliance with the SMRs and GEACs is not always accurately recorded. First, the inspections were not always conducted as required. For instance, it was reported that more than 30 requirements from SMRs were not checked in Finland, including several standards pursuant to the Nitrates Directive.[88] In addition, regular inspections are undertaken only once for a sample of farms, and the timing of visit is not necessarily the best time in a year to verify a number of farming and environmental conditions.[89]

In the U.S., data on enforcement and compliance for the CWA are reported by states and integrated into EPA's Enforcement and Compliance History Online (ECHO) system. Of the 5,626 CAFOs regulated under the NPDES program recorded in ECHO, 362 facilities (6%) have a current violation, and 564 (10%) have had violations in the last three years. However, EPA also noted that many violations are not identified in public databases, because some states do not have the resources to record data for all permitted facilities, especially for small individually permitted ones.[90] NPDES compliance represents a small proportion of the U.S. efforts to control nonpoint source pollution, since most of the policy instruments are implemented on a voluntary basis, such as through Section 319 projects and conservation programs.

In the EU, payment reductions for noncompliance under cross-compliance are a function of the aid received and not of the cost of compliance, which can encourage noncompliance when the cost of meeting certain requirements is significantly higher than the expected payment reduction.[91] A sanction of 1% to 3% of total payments is usual. This is particularly prominent in the case of small farms: for example, a small farm in Slovenia that breached requirements from three regulations only received a 3% reduction, equivalent to €15.26.[92]

The U.S. CWA specifies higher penalties. Under the NPDES program, a person who discharges a pollutant from a point source into a water body without a permit or in violation of a permit would face penalties of 1-2 years in jail and/or $2,500 -$50,000 per day for negligent violations, and 3-6 years in jail and/or $5,000 - $100,000 per day for knowing violations.[93]

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87 *Ibid*

88 ECA. (2008). *Is Cross Compliance an Effective Policy?* Luxembourg: European Court of Auditors.

89 *Ibid*

90 EPA. (2015a). *A Summary of Reviews, Violations, and Enforcement Response at Individually-Permitted Nonmajor Dischargers under the National Pollution Discharge Elimination System (NPDES) Program.* Washington, DC: U.S. Environmental Protection Agency.

91 ECA (2008).

92 ECA (2008).

93 EPA. (2016c, March 16). *Criminal Provisions of the Clean Water Act*. Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/enforcement/criminal-provisions-clean-water-act#directdischarge

According to an internal evaluation undertaken by EPA, the primary reason for significant noncompliance with NPDES permits is inconsistent and ineffective oversight from EPA.[94] The report pointed out that EPA failed to provide clear guidance for taking suitable, timely, formal enforcement actions to major NPDES facilities, resulting in long-term significant noncompliance.[95] Such findings were echoed by a later GAO report, indicating that inconsistent oversight also caused considerable challenges faced by states' Section 319 nonpoint source management projects.[96]

Program Evaluation

Considerable limitations of data availability, with regard to both water quality and program implementation, have limited retrospective program evaluation for the regulations and programs implemented to control nutrient pollution from agriculture. Hence, the effectiveness of many of these policies in improving water quality has not been definitively established.

The European Commission has published four implementation reports for the Nitrates Directive since 1996. The most recent report assessed progress on implementation of the Directive by 27 member states for the period 2008-2011.[97] It summarized nitrate monitoring results in waters, as well as Action Programmes developed by member states. It found that water quality had improved since the previous 2004-2007 reporting period, with 42.1% of all freshwater monitoring stations showing a decreasing nitrates concentration trend.[98] However, it was unable to separate how much of that was attributable to implementation of the Nitrates Directive, since there are other EU Directives addressing nitrogen pollution such as the Urban Waste Water Directive.

The difficulty in attributing environmental improvements to a single Directive is also recognized in the 2012 Fitness Check of EU Freshwater Policy.[99] The Fitness Check was carried out to review EU freshwater policy, as a part of the Commission's approach to a new regulation agenda in the area of environment. Specifically, it analyzed relevance, effectiveness, efficiency, and coherence for eight Directives, including the WFD and the Nitrates Directive. It found that the Nitrates Directive had significantly reduced nitrogen and phosphorus inputs from agriculture to surface waters, but the progress is far slower than initially expected.[100]

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94 EPA. (2007a). *Better Enforcement Oversight Needed for Major Facilities with Water Discharge Permits in Long-Term Significant Noncompliance.* Washington, DC: Office of Inspector General, U.S. Enironmental Protection Agency.

95 *Ibid*

96 *Ibid*

97 EC (2013a)

98 EC (2013a)

99 EC. (2012). *The Fitness Check of EU Freshwater Policy.* Brussels: European Commission.

100 *Ibid*

In the U.S., while the CWA requires states to develop TMDLs assessing water quality and defining water quality objectives, the implementation of TMDLs as well as their effectiveness on water quality improvement is unclear. In 2000, GAO found that EPA did not have complete and consistent data on water quality, particularly data for nonpoint sources, to implement and measure CWA programs.[101] In its 2002 report, GAO further pointed out that states used varied approaches to identify impaired waters, which lacked scientific basis and led to inconsistencies in the listing of impaired waters nationwide.[102] In response to these two reports, EPA published additional guidance on states' water monitoring and reporting since 2003.[103]

In 2007, EPA's Office of Inspector General conducted an internal assessment of TMDL implementation, recognizing that EPA did not have sufficient information on TMDL implementation activities and outcomes.[104] It recommended that EPA should improve data tracking on TMDL implementation and clarify TMDL performance measures. EPA officials responded that the CWA limited its ability to measure TMDL results.[105]

A 2013 GAO report showed that EPA still had limited information on the extent to which the TMDLs had achieved their policy objectives.[106] In its national database (i.e. ATTAINS), EPA tracks only development of TMDLs but not implementation activities. While information on discharge permits and program grants is recorded, albeit incompletely, in other databases, there are technical data constraints that limit EPA's ability to link that information to data on water quality.[107] State representatives surveyed by GAO stated that few impaired water bodies had attained water quality standards, primarily because a large proportion of TMDLs had not achieved their targets for nonpoint source pollution.[108] Another impediment to developing a more complete understanding of program effectiveness is that data on many USDA-funded conservation programs are not available to EPA because of the privacy provisions in the Farm Bill, according to GAO. While USDA has collected data for its projects, the data are highly aggregated so as to make assessments of project impacts impossible.[109]

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[101] GAO. (2000). *Key EPA and State Decisions Limited by Inconsistent and Incomplete Data*. Washington, DC: U.S. Government Accountability Office.

[102] GAO. (2002). *Inconsistent State Approaches Complicate Nation's Efforts to Identify Its Most Polluted Waters.* Washington, DC: U.S. Government Accountability Office.

[103] EPA. (2013a, September 12). *Monitoring, Assessment and Reporting Guidelines*. Retrieved from U.S. Environmental Protection Agency: https://archive.epa.gov/water/archive/web/html/repguid.html#int_rpt

[104] EPA. (2007c). *Total Maximum Daily Load Program Needs Better Data and Measures to Demonstrate Environmental Results.* Washington, DC: Office of Inspector General, U.S. Environmental Protection Agency.

[105] *Ibid*

[106] GAO. (2013). *Changes Needed If Key EPA Program Is to Help Fulfill the Nation's Water Quality Goals.* Washington, DC: U.S. Government Accountability Office.

[107] *Ibid*

[108] *Ibid*

[109] GAO (2012); GAO (2013)

Conclusion

Nutrient runoff from agricultural lands can contaminate surface and ground waters and pose particular challenges for governments seeking to protect environmental quality. One challenge is that, with the exception of large animal feeding operations, agricultural pollution comes largely from nonpoint sources, so traditional regulatory approaches that target effluent at the source are impractical. Another challenge for centralized governments is that environmental conditions vary regionally, so top-down policies may not be as effective as those based on local knowledge.

To address the nonpoint source nature of agricultural runoff, both jurisdictions use a combination of incentives and penalties to make farmers consider environmental externalities and apply sound environmental management practices. They do so, however, to different degrees. A large fraction of EU farm income (33%) comes from CAP subsidies. Since receipt of the full subsidy is contingent upon complying with the Nitrate Directive (among other requirements), farmers might be highly motivated to comply. However, research suggests that insufficient monitoring of compliance combined with rather limited penalties might reduce those incentives. In the U.S., farmers can voluntarily opt into programs that offer subsidies in exchange for certain practices, but the amount of payment tends to be much less than in Europe.

To address the localized nature of runoff, both the EU and the U.S. have approached the challenge of regulating agricultural nutrient pollution by establish general jurisdiction-wide guidelines, while largely leaving to states and member states the responsibility for developing specific numeric limits and ensuring compliance. This dispersed responsibility has advantages in that it allows jurisdictions closest to the problems to manage them. It also has drawbacks in that no comprehensive data are available to measure activities and outcomes in either jurisdiction.