**Measuring the Farmland Preservation Program’s Impact on Surface Water Quality**

In 2009, Wisconsin implemented the Farmland Preservation Program with two goals. First, they wanted to establish a plan for agricultural development county by county. Secondly, they sought to dramatically reduce nutrient loading in Wisconsin’s surface waters. To accomplish the first goal, Wisconsin created two new land development categories, Agriculture Enterprise Agreements (AEAs) and Farmland Preservation (FP) zoning. AEAs are a tool which private farmers can band together and apply to Wisconsin’s Department of Agriculture, Trade and Consumer Protection (DATCP) for a 15-year agreement to limit the lands use to Agriculture and FP zoning is an arbitrary process which takes place at either the county level or municipal level.

To accomplish the second goal of the program, they created a set of voluntary soil & water conservation standards. The incentive mechanism to entice farmers to implement the conservation standards are three levels of tax credits: $5, $7.50 & $10 per acre. To claim these tax credits a farmer must meet two conditions. First, the farmer must be in either a FP zone, AEA or both. If a farm is in an AEA, they qualify for a $5 per acre credit. If a farm is in a FP Zone, they qualify for a $7.5 per acre credit. If a farm is in both an FP zone and an AEA, they qualify for a $10 per acre credit. However, in all cases, to claim a tax credit they must implement a Nutrient Management Plan (NMP). NMPs are the condition that satisfies Wisconsin’s second goal, to reduce nutrient loading in the states surface waters (Department of Agriculture, Trade and Consumer Protection, 2023). The purpose of this paper is to analyze whether the FPP has improved surface water quality between 2009 and 2020.

***When Nutrient Management is Required in Wisconsin***

Wisconsin’s regulations for nutrient runoff management require NMP implementation for several reasons. First, under federal and state regulations, all Concentrated Animal Feeding Operations (CAFOs) require NMP implementation; this is governed under NR 243. Specifically, NR 243 requires that all CAFOs have a Wisconsin Pollution Discharge Elimination System (WPDES) permit, which in turn requires an NMP. Second, if a Wisconsin county offers cost-sharing to develop a plan a farm must either: accept and implement an NMP or decline and implement an NMP. Third, if the farm is governed under a local ordinance that requires them to implement an NMP. Fourth, an NMP is required if a farm is participating in the FPP. Finally, once a parcel of land has implemented an NMP, it must maintain that NMP indefinitely (Department of Agriculture, Trade and Consumer Protection, 2023).

**Non-Point Source Runoff Significance**

Reducing the levels of non-point source (NPS) pollution of phosphorus to under the environmental Protection Agencies goal of 0.1 mg/L in flowing waters is key to preventing agal bloom outbreaks (Litke, 1999). Phosphorus is the limiting nutrient for eutrophication and algal blooms in freshwater (Environmental Protection Agency, 2022). Algal blooms have a wide range of economic and environmental impacts; general estimates are upwards of $2 billion dollars’ worth of damages annually (Rabotyagov et al., 2014). Furthermore, there is the perncious effects of algal blooms on sea floor dwelling species (Baustian, Craig, & Rabalais, 2009), human use & ecology impacts (Dodds & Welch, 200), property valuation (Wolf & Klaiber, 2017) and other impacts. Due to the economic, ecological and recreational impacts, Wisconsin has taken an aggresive approach to curtailing phosporus nutrient loading. However, one of the key issues to reduction in Phosporus nutrient loading are the significant time lags associated with surface water recovery. These lagged impacts have been estimated to be measured in decades and as long as 70 years depending on size, location and depth of the sedimentary deposits (Rippey, Campbell et. al, 2021; Gren, 2009).

**Nutrient Management Best Practices**

To reduce eutrophication and hypoxic zones, phosphorus is the key nutrient to control. Schindler et. al., (2016) looked at research and experiments dating back to the 1970s and was able to identify phosphorus as the key nutrient to limiting algal blooms in lakes. Some of the studies they overviewed assessed several lakes by controlling the nutrients that were added in each one. They were able to cause algal blooms with excess phosphorus and found that nitrogen was not a limiting factor (Schindler, et al., 2016). Since P gets trapped in the soil, trapping practices e.g., cover crops, buffer strips, conservation tillage etc.… is key to reducing soil erosion. Liu, Wang & Zhang (2022) looked these conservation practices and found that by a one standard deviation increase in Environmental Quality Incentives Program (EQIP) payments, led to a 3.03% decrease in Biochemical Oxygen Demand. A decrease in BOD is noteworthy because it can indicate a reduction in the size of algal blooms (Liu, Wang, & Zhang, 2022). Additionally, two studies used an evolutionary algorithm to identify the best abatement combinations to reduce nutrient runoff. They specifically looked at tilling practices, contour stripping, land retirement and grassed waterways to model the least cost practices to reduce phosphorus and nitrogen runoff. They found that a combination of primarily no-till with cover crops maximized phosphorus and nitrogen runoff reduction while keeping cost per acre low. (Rabotyagov, et al., 2010; Kling, 2011).

Poor land management has also been a culprit for high rates of agriculture runoff. Parris (2011) found that practices such as ill-timed nutrient applications or tillage practices exacerbated poor water quality. He also found that large livestock operations can operate as a central hub for NPS pollution. He assessed the common strategies the Organization for Economic Cooperation and Development (OECD) countries take to combat these issues. Payments for ecosystem services/abatement practices and requiring large livestock operations to obtain a permit are the most common (Parris, 2011). Similarly, Meyer & Raff (2019) found that adding just one large scale livestock operation increased P level by 1.5% in comparison to the sample mean. The state of Wisconsin uses permits tied to soil & water conservation standards as their control method for nutrient runoff (Meyer & Raff, 2019). Unfortunately, Raff & Meyer were unable to parse out the effectiveness of the permitting/conservation standards program as there was a dramatic increase in the level of large-scale livestock operations during the studied period.

***Nutrient Management Requirements in Wisconsin***

NMPs in Wisconsin require several abatement practices to be implemented as part of their soil and water conservation standards; the following are a few of the key practices. First, farms must be a certain distance away from surface waters and not degrade stream bank integrity. Additionally, farms that grow crops or feed must meet Wisconsin’s definition of “tolerable” soil loss. Further, farmers are required to test soil once per five acres and update their test every four years. They must also include a nutrient application plan, which identifies areas that have fertilizer restrictions (e.g., near an open well). Finally, there is a list of practices of which farmers must implement two. This list includes abatement practices such as riparian buffers, no-till, contour stripping etcetera. (Department of Agriculture, Trade and Consumer Protection, 2023).

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