WATER QUALITY BEST MANAGEMENT PRACTICES IN U.S. MIDWESTERN AGRICULTURAL LANDSCAPES: *WHAT CAN BE LEARNED FROM THE EXPERIENCE OF THE FOREST SECTOR*

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Kathryn Fernholz and Will Feeney

Harry Groot
Ed Pepke, Ph. D.
Chuck Henderson
Gloria Erickson

DOVETAIL PARTNERS, INC.

Water Quality Best Management Practices in U.S. Midwestern Agricultural Landscapes: What Can be Learned from the Experience of the Forest Sector

Executive Summary

Declining water quality is a pressing environmental challenge and a landscape scale issue, affecting public and private landowners and many aspects of society. The need to protect water resources has prompted both government and individual involvement in finding solutions. Agricultural crop and animal production significantly impact water quality (Table 1). Land cultivation activities can contribute to increased risks of soil erosion, and the application of fertilizers and pesticides contribute to contaminated water runoff. Land management practices, planting locations and methods, crop selection, soil types and many other factors affect the processes of erosion and runoff. The use of Best Management Practices (BMPs) and other strategies have been shown to mitigate water quality impacts from land use activities and can help to ensure healthy water systems. While there are many ways to address the risks of runoff and erosion, this report focuses on BMPs that can be implemented as part of land use practices within agricultural watersheds.

This report includes information and lessons learned from the forest sector, where BMPs for water quality protection are widely used on private and public lands and have been effective in reducing and mitigating impacts associated with forest management activities.

Table 1. Sources of water quality impairment for assessed U.S. rivers/streams and lakes/ponds/reservoirs.

Source of Impairment*	Rivers/Streams		Lakes/Ponds/Reservoirs	
	Miles	Percent of total assessed	Acres	Percent of total assessed
Physical changes	164,498	20.0	1,849,582	11.1
Crop production	114,849	14.0	1,988,175	12.0
Animal production	80,269	9.8	555,054	3.3
Forestry	23,727	2.9	316,071	1.9
Resource extraction	41,916	5.1	599,280	3.6
Municipal/industrial	205,673	25.0	6,048,322	36.4
Natural	40,743	5.0	1,354,245	8.2
Unspecified/unknown	125,308	15.2	4,551,991	27.4
Total assessed	822,340		16,610,248	
Total United States	3,589,765		42,003,669	

* **Sources of impairment:**

- Physical changes: hydromodification, flow regulation, dams and impoundments, water diversion, channelization, dredging, bank destabilization, habitat changes, loss of wetlands and riparian areas, erosion, and sedimentation.
- Crop production: all agricultural sources related to irrigated and nonirrigated crop production.
- Animal production: all agricultural sources related to animal production, including confined animal feeding operations and upland and riparian grazing.
- Forestry: all silvicultural and forest industry activities, forest roads, and fire.
- Resource extraction: mineral resource development, mining, oil, gas, and coal production.
- Municipal and Industrial: all municipal, urban, and industrial point and nonpoint sources, including runoff; construction and development; and waste disposal.
- Natural: mineral deposits and ecosystem nutrient cycling.
- Unspecified or unknown: all unidentified or unknown point and nonpoint sources.

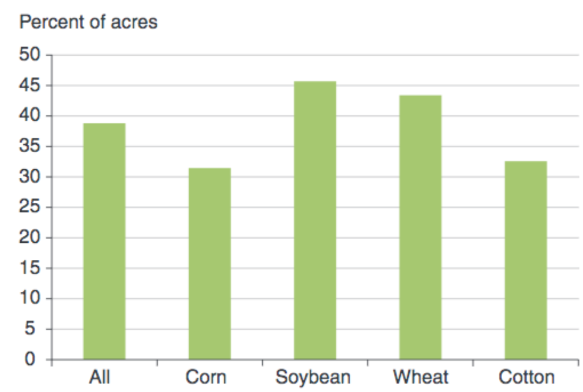
Source: U.S. Environmental Protection Agency 2006 National Assessment Database, as summarized in the National Report on Sustainable Forests, 2010. For more information: https://ofmpub.epa.gov/waters10/attains_nation_cy.control#causes

Background

Best Management Practices (BMPs) are established soil conservation practices that also provide water quality benefits.[1] In the United States. BMPs were developed as a requirement of the 1977 amendments to the federal Clean Water Act. Requirements for BMPs have been integrated into some of the largest natural resource industries in the U.S., including the forest sector. While the BMPs used in forestry are commonly referred to as "voluntary", their implementation is frequently made into a defacto requirement. For example, forestry BMPs to protect water quality are required on public lands (e.g., federal and state forestlands) and on many private lands when the owner or operator is a participant in a federal or state incentive program or where the purchaser of the timbersale includes BMPs as a requirement in the contract (e.g., due to certification or other licensing and registration requirements). Some states have made forestry BMPs regulatory or quasi-regulatory. Given these conditions, forestry BMPs are widely practiced and commonly enforced through forestry agencies, contract terms, and program performance requirements. In agriculture, however, while many state and federal programs promote BMPs there are few states that require BMPs be followed. While rates of implementation for forestry BMPs often exceed 90% of operations (see Table 2 on page 12); some studies indicate agricultural BMP use and adoption of various conservation practices range from 2% to 60%.[2] A fairly common agricultural practice is conservation tillage (e.g., no-till, reduce-till, strip-till) and recent studies have found that use of this practice averages over 35% for the major crops of corn, soybeans, wheat and cotton (Figure 1).[3]

To support more widespread use of BMPs in agriculture, the Environmental Quality Incentives Program (EQIP) was established by the U.S. Department of Agriculture in 1996.[4] Through EQIP, farmers are offered financial assistance to address natural resource concerns within their operations. With technical assistance and cost-share funds farmers can make improvements or implement BMPs that address the concerns. There is an established list of more than 150 conservation practice standards – ranging from access control and roads to conservation cover and windbreaks – that are eligbile for EQIP program funds.[5]

Figure 1. No-till or strip-till use on all acres of four major crops, 2010-11.



Source, ERS, 2015.

Water Quality Concerns in Agricultural Regions of the Midwest

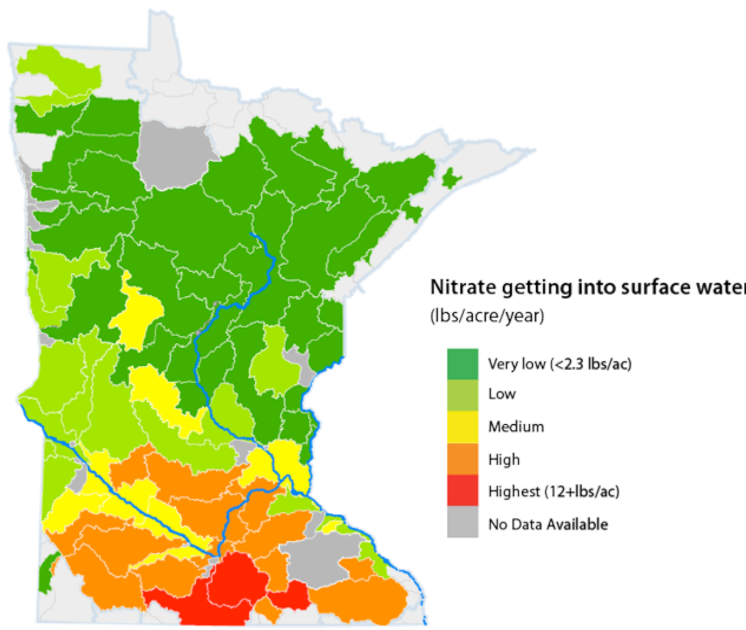
Many states in the Midwestern U.S. are experiencing water quality concerns. These challenges include surface waters and groundwater resources, as well as important municipal water supplies. There are diverse causes for water quality problems in the region; however, water runoff from agricultural fields contaminated with soil sediments, excess nutrients, and chemicals are a contributing factor.

1 Sustainable Agriculture: Definitions and Terms. Related Terms, https://www.nal.usda.gov/afsic/sustainable-agriculture-definitions-and-terms-related-terms#term3
2 ERS, 2015
3 ERS, 2015
4 https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/
5 https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/cp/ncps/?cid=nrcs143_026849

In 2014, a Minnesota Pollution Control Agency (MPCA) report found that while several common pollutants had decreased in abundance, two had increased.[6] One of those two was nitrate pollution, which is connected to fertilizer use and agricultural runoff. The MPCA reported that nitrates, a key component of fertilizers both organic and inorganic, pose a number of risks to water quality when present in high levels. Furthermore, in the southern third of Minnesota, a region dominated by agricultural land uses, nitrate levels in surface water were found to be far higher than in the rest of the state (Figure 2).[7]

The MPCA found that, "Cropland sources account for an estimated 89 to 95% of the nitrate load in the Minnesota, Missouri, and Cedar Rivers, and Lower Mississippi River basins".[8] Rising nitrate levels are a cause for concern for a number of reasons. Increased concentrations of nutrients like nitrate and phosphate lead to potentially harmful algal blooms in lakes and rivers, which in turn can reduce the dissolved oxygen content of the water. Soil erosion removes valuable topsoil, destabilizes river banks, and increases turbidity in streams, rivers, and lakes. Turbidity, in turn, damages fish habitat and can also increase the likelihood of algal blooms.[9]

Figure 2. Nitrates in Surface Waters in Minnesota (pounds/acre/year)



Source: MPCA, 2014

In addition to the challenges Minnesota has identified, there have also been recent water quality conflicts associated with impacts from agriculture in the Midwestern state of Iowa. In 2015, the Des Moines Water Works (responsible for providing drinking water to about 500,000 residents) filed a lawsuit asking that drainage districts be required to meet the water quality requirements of the Clean Water Act and reduce the pollution to the river where the city draws water.[10]

[6] Christopherson, David. "Water Quality Trends for Minnesota Streams and Rivers at Milestone Sites". Minnesota Pollution Control Agency. June 2014.
[7] "Report on Nitrogen in Surface Water". Minnesota Pollution Control Agency. N.d. https://www.pca.state.mn.us/featured/report-nitrogen-surface-water
[8] "Report on Nitrogen in Surface Water". Minnesota Pollution Control Agency. N.d. https://www.pca.state.mn.us/featured/report-nitrogen-surface-water
[9] "Describing Water Quality". Minnesota Department of Natural Resources. N.d. http://www.dnr.state.mn.us/whaf/about/5-component/wq_concepts.html
[10] https://www.desmoinesregister.com/story/money/agriculture/2015/05/14/water-works-nitrates-lawsuit/27331305/

In esssence, the lawsuit was asserting that the water discharged from agricultural drain tiles should be treated as "point source" pollution which is regulated under the Clean Water Act.[11] In 2017, the lawsuit was dismissed by a federal judge who directed the Iowa legislature to resolve the issue.[12]

The issues with water quality are not limited to the boundaries of individual states. Given the connectedness of watersheds and water systems, the concerns about water quality in Minnesota and Iowa can be linked to broader issues, including the "dead zone" in the Gulf of Mexico (Figure 3).

Figure 3. Major Midwest Watersheds

Source: MPCA, 2017
https://www.pca.state.mn.us/water/nutrient-reduction-strategy

The dead zone in the Gulf of Mexico is an area of water that has insufficient oxygen levels to adequately support fish and other marine life.[13] This condition is referred to as "hypoxia" and is linked to pollution, including runoff from agriculture and excess nutrients that enter the water.

The Louisiana Universities Marine Consortium has measured the condition and size of the dead zone for over 30 years. The size of the zone is influenced by many factors, including temperature and pollution levels as well as the amount of precipitation and other storm events that influence overall runoff rates and water levels. The average size over the last three decades is approximately 5,300 square miles. In 2017, the dead zone reached 8,776 square miles, approximately the size of New Jersey.

The Mississippi River/Gulf of Mexico Hypoxia Task Force has set a goal of reducing the dead zone to 1,950 square miles by 2035. This goal is estimated to require a nearly 60% reduction in the amount of nitrogen runoff that flows down the Mississippi River and into the Gulf of Mexico.[14]

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11 Point source pollution is associated with a single, identifiable source (e.g., pipe discharge). In contract, nonpoint sources of pollution are not attributable to a single source and may occur over a wide area.

12 https://www.desmoinesregister.com/story/money/agriculture/2017/03/17/judge-dismisses-water-works-nitrates-lawsuit/99327928/

13 https://news.nationalgeographic.com/2017/08/gulf-mexico-hypoxia-water-quality-dead-zone/

14 https://news.nationalgeographic.com/2017/08/gulf-mexico-hypoxia-water-quality-dead-zone/

Governmental and Non Governmental Efforts

The water supply is of critical importance to governments -- as such, many states and the federal government have enacted requirements to protect water quality from threats associated with a wide range of pollution sources. Many industries are regulated and their use and disposal of water is monitored to ensure conformance with water usage and discharge laws. These efforts have demonstrated the effectiveness of mandatory best management practices to ensure environmental quality. In recent years, some governments and other organizations are looking at how to expand requirements to address other land use activities that impact water quality. Three states that have chosen to enact recent legislation are Vermont, Minnesota and Ohio.

Vermont law mandates Required Agricultural Practices (RAPs), a set of practices tailored to different scales of agriculture, which are designed to mitigate soil erosion and agricultural runoff impacting water systems.[15] The RAPs were implemented in 2016 and apply to three different scales of farms, Large Farm Operations, Medium Farm Operations, and Certified Small Farm Operations. Standards include provisions such as not applying manure to certain fields between December 15th and April 1st, and that manure must not be applied within 200ft of public waters. The RAPs also address buffers, mandating ten foot buffers between fields and ditches, and twenty-five foot buffers between fields and waterways. Another key provision requires water quality testing every five years. Through the RAPs, the State of Vermont hopes to reduce threats to public waters (especially Lake Champlain) while also ensuring good water quality for the future.

Examples of Additional Public and Private Sector Efforts to Address Water Quality Concerns in Food Systems

There are numerous additional efforts within the public and private sector to address water quality concerns connected to food systems and agriculture, including:

- At least twelve states (Arkansas, Indiana, Illinois, Iowa, Kentucky, Louisiana, Minnesota, Mississippi, Missourti, Ohio, Tennessee, Wisconsin) have established **State-level Nutrient Reduction Strategies** that guide reducing excess nutrients in waters. https://www.epa.gov/ms-htf/hypoxia-task-force-nutrient-reduction-strategies
- The 2014 Farm Bill established the **Regional Conservation Partnership Program** (RCPP) to support innovative conservation opportunities and water quality initiatives. https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/farmbill/rcpp/
- **Sustainable Conservation** works with state and federal agencies in California to simplify the permitting process to enable more stream restoration. http://suscon.org/project/simplified-permitting/
- A new business unit called **Land O'Lakes SUSTAIN™** is helping farmers enhance sustainability practices from farm to fork and connects the State of Minnesota's Agricultural Water Quality Certification Program (MAWQCP) with Land O'Lakes' cooperative network. https://www.landolakesinc.com/Blog/February-2017/The-year-of-water-land-o-lakes-sustain
- The **Coca-Cola corporation** supports community water projects around the world, including efforts to address water resource impacts associated with agricultural systems. http://www.coca-colacompany.com/watermap
- The **Minnesota Corn Growers Association** supports on-farm research and practices to reduce nitrate loss and protect water quality. http://www.mncorn.org/research/innovation-grants/

[15] "A Summary of the Required Agricultural Practices". Vermont Agency of Agriculture, Food, and Markets. 2016. http://agriculture.vermont.gov/sites/ag/files/RAPsummaryPDF.pdf

In Minnesota, the state's Buffer and Soil Loss Statutes require that all public waters must be buffered with vegetated buffers of an average of 50 feet, and that public drainage systems must be buffered by a 16.5 foot minimum width buffer.[16] In March 2017, 74% of Minnesota counties were reported to be "60–100 percent compliant" with the water quality buffer initiative.[17]

In Ohio, the state has two new laws related to nutrient management in agriculture. One policy restricts the application of nutrients on frozen, snow-covered or saturated soil in twenty-four counties within the Western Lake Erie Basin. The other new policy was the first law in the nation to require farmers to complete a fertilizer applicator certification program prior to applying nutrients to their fields. Since its enactment in 2014, over 6,000 farmers have been certified.[18]

One of the challenges to managing water quality is to develop practices that can be applied appropriately at a broad scale to deliver measurable benefits. As has been shown in other sectors, this is the role of BMPs.

Best Management Practices For Reducing Erosion and Runoff

Common BMPs for reducing erosion and runoff in farming operations include such practices as conservation tillage, cover crops, and buffers.[19] These practices are described below and they are widely applicable and adaptable to a range of farming conditions which creates opportunities for watershed-scale protections and improvements in water quality. There are also BMPs that are specific to the use of fertilizers and pesticides that aim to reduce pollution while also improving efficiencies and effectiveness of applications, as well as BMPs for water conservation in irrigated agricultural operations.[20] Forestry BMPs are similar to recommended agricultural practices, including use of buffers and set-asides around waterbodies, modifications to equipment to reduce soil compaction, reducing soil disturbing activities during harvesting operations, and seeding of disturbed areas. Within forestry operations, there are also a number of BMPs addressing road design and maintenance, harvest planning, invasive species threats, and post-harvest conditions.[21]

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[16] "Buffer and Soil Loss Statutes, as amended in 2017 by Laws of Minnesota 2017, Chapter 93 (S.F. 844)". Minnesota Board of Water and Soil Resources. May 30, 2017. http://www.bwsr.state.mn.us/buffers/buffer_law_amendments_2017.pdf

[17] "Minnesota is Well On its Way to Full Compliance with Statewide, Bipartisan Water Quality Effort". Office of Governor Mark Dayton and Lt Governor Tina Smith. March 16, 2017. https://mn.gov/governor/newsroom/?id=1055-284342

[18] http://www.eesi.org/briefings/view/110215water

[19] A complete listing of National Conservation Practice Standards is available here: https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/cp/ncps/?cid=nrcs143_026849

[20] For examples of pesticide related BMPS, see. Minnesota Department of Agriculture, http://www.mda.state.mn.us/protecting/bmps/voluntarybmps.aspx ; For examples of fertilizer related BMPs, see: http://www.mda.state.mn.us/nitrogenbmps; For examples of water conservation BMPs, see: http://www.twdb.texas.gov/conservation/BMPs/Ag/doc/AgMiniGuide.pdf.

[21] For examples of forest road BMPs, see: http://www2.dnr.cornell.edu/ext/bmp/contents/during/dur_roads.htm; For examples of harvest planning BMPs, see: https://mylandplan.org/content/timber-harvesting ; For examples of invasive species BMPs, see: http://dnr.wi.gov/topic/invasives/bmp.html ; For examples of post-harvest BMPs, see: http://www2.dnr.cornell.edu/ext/bmp/contents/postharvest/post_intro.htm)

Conservation Tillage

In its most basic form, conservation tillage involves leaving plant material intact or partially intact on the field following harvest. Conservation tillage includes a broad range of soil tillage systems that leave residue cover on the soil surface, in an effort to reduce the risk of soil erosion from wind and water. After harvest, a farmer may not do any tillage, effectively leaving the remaining plant material and root systems in place. Alternatively a farmer may do partial or strip-tillage that disturbs only some portion of the field.

The National Crop Residue Management Survey (Conservation Technology Information Center (CTIC)) specifies that 30 percent or more of crop residue must be left after planting to qualify as a conservation tillage system. Some specific types of conservation tillage are Minimum Tillage**,** Zone Tillage**,** No-till**,** Ridge-till**,** Mulch-till**,** Reduced-till**,** Strip-till**,** Rotational Tillage and Crop Residue Management.[22,23] There are a number of benefits of conservation tillage practices, such as increased organic matter content in the soil, increased capacity to hold water, avoided soil compaction, and reduced erosion. Reductions in tilllage can minimize nutrient loss, influence insect and disease cycles, and change soil conditions. This practice also has the added potential economic benefit of requiring less labor and equipment operation than a more typical tillage system.[24] There are, however, potential downsides of conservation tillage depending on the soil profile of the farm, and what is being planted on it. For example, excess residue may impact the effective operation of planting equipment for the next crop or delay the start date of the planting season.

Conservation tillage is the first step of the U.S. Environmental Protection Agency's CORE 4 program, which seeks to reduce agricultural water pollution. The Environmental Protection Agency notes that conservation tillage "reduces runoff and soil erosion, conserves soil moisture, helps keep nutrients and pesticides on the field, and improves soil, water, and air quality".[25] The effectiveness of conservation tillage systems varies greatly depending on the extent to which it is implemented, the soil types, the general characteristics of the landscape, and the goals of the farmer.

Cover Crops

Cover crops are typically planted after the main harvest and grown until winter or the next planting season. Cover crops stabilize the soil with their root structure, increase nitrogen uptake, and prevent erosion.[26] Cover crops are hardy varieties capable of thriving under harsher conditions than during the normal growing season. According to the USDA, good varieties for Midwestern farms include plants like oats, wheat, rye, turnips, and radishes. The Midwest Cover Crops Council (MCCC) faciltiates widespread

[22] https://www.nal.usda.gov/afsic/sustainable-agriculture-definitions-and-terms-related-terms#term11

[23] DeJong Hughes, Jodi; Vetsch, Jeffrey. "On Farm Comparison of Conservation Tillage Systems for Corn Following Soybean". University of Minnesota Extension. 2007. http://www.extension.umn.edu/agriculture/soils/tillage/on-farm-comparison-of-conservation-tillage-systems-for-corn-following-soybeans/

[24] DeJong Hughes, Jodi; Vetsch, Jeffrey. "On Farm Comparison of Conservation Tillage Systems for Corn Following Soybean". University of Minnesota Extension. 2007. http://www.extension.umn.edu/agriculture/soils/tillage/on-farm-comparison-of-conservation-tillage-systems-for-corn-following-soybeans/

[25] "Agricultural Management Practices for Water Quality Protection". United States Environmental Protection Agency. 2017. https://cfpub.epa.gov/watertrain/moduleFrame.cfm?module_id=33&parent_object_id=1362&object_id=1362

[26] "Cover Crops: Minnesota Fact Sheet". USDA Natural Resources Conservation Service. N.d. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_021810.pdf

adoption of cover crops and identifies potential environmental benefits that include enhanced biodiversity, increased water infiltration into soils, wildlife habitat imrpovements, and opportunities to attract bees, other pollinators, and beneficial insects.[27] Implementing cover crops often involves purchasing new plantings or seeds, for which there are cost-share programs available.

Buffers

Conservation buffers are areas of land maintained in vegetation, designed to intercept pollutants and erosion. Placed around fields and along waterways, they can enhance wildlife habitat, improve water quality, and enrich aesthetics on farmlands. Various types of buffers include Contour Buffer Strips**,** Filter Strips**,** Riparian Forest Buffers**,** Field Borders**,** Windbreaks/Shelterbelts**,** Hedgerows**,** Grassed Waterways**,** and Alley Cropping**.**[28]

Buffers may include grasses as well as perennial plants, shrubs and trees. The vegetation in the buffer helps to reduce rates of runoff. Tree roots can help to stabilize soil and increase water infiltration. Buffers can be fairly narrow or quite wide; in general the wider a buffer, the more effective it will be in reducing runoff and erosion.[29] Buffers can be created by just letting vegetation grow undisturbed, or by planning out buffer development. Buffers have potential economic benefits as well: land managers can choose to plant trees that can later be harvested for timber or for fruit or nut production. An additional benefit of buffers is to increase the amount of shade on a waterway, which decreases water temperature and creates a more favorable environment for fish species such as trout. A common concern about buffers is that they will take up valuable farmland; however, with effective planning buffers can have minimal impacts on total farm operations.[30] The benefits of buffers include reducing excess amounts of sediment, organic material, nutrients and pesticides in surface runoff and reducing excess nutrients and other chemicals in shallow ground water flow.[31]

Grass waterways are strips of grass that run through farmland, which help to direct water flow, and slow and capture runoff. By placing grass waterways in areas of high surface flow, farmers and land managers can greatly mitigate erosion. Grass borders have a similar function along the borders of farmland. Grass borders and waterways have the benefit of requiring less effort in development than tree or shrub buffers, while still providing benefits. In recent years, there has been an increased interest in utilizing buffer strips to provide habitat for pollinators and to plant preferred species of plants for bees and other beneficial insects.

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[27] http://mccc.msu.edu/what-are-cover-crops/

[28] Buffer Strips: Common Sense Conservation (pamphlet) (Washington DC: Natural Resources Conservation Services/USDA, 1997). Available at NRCS Website: http://www.nrcs.usda.gov/FEATURE/buffers/ (8/23/07) https://www.nal.usda.gov/afsic/sustainable-agriculture-definitions-and-terms-related-terms#term10

[29] Bongard, Phyliss; Wyatt, Gary. "Design of Riparian Forest Buffers". University of Minnesota Extension. 2013. https://www.extension.umn.edu/environment/agroforestry/riparian-forest-buffers-series/design-of-riparian-forest-buffers/

[30] Rundquist, Soren; Mason, Patrick. "Iowa's Low Hanging Fruit". Environmental Working Group. 2015. http://www.ewg.org/research/iowas-low-hanging-fruit#.WaYwILJ97X7

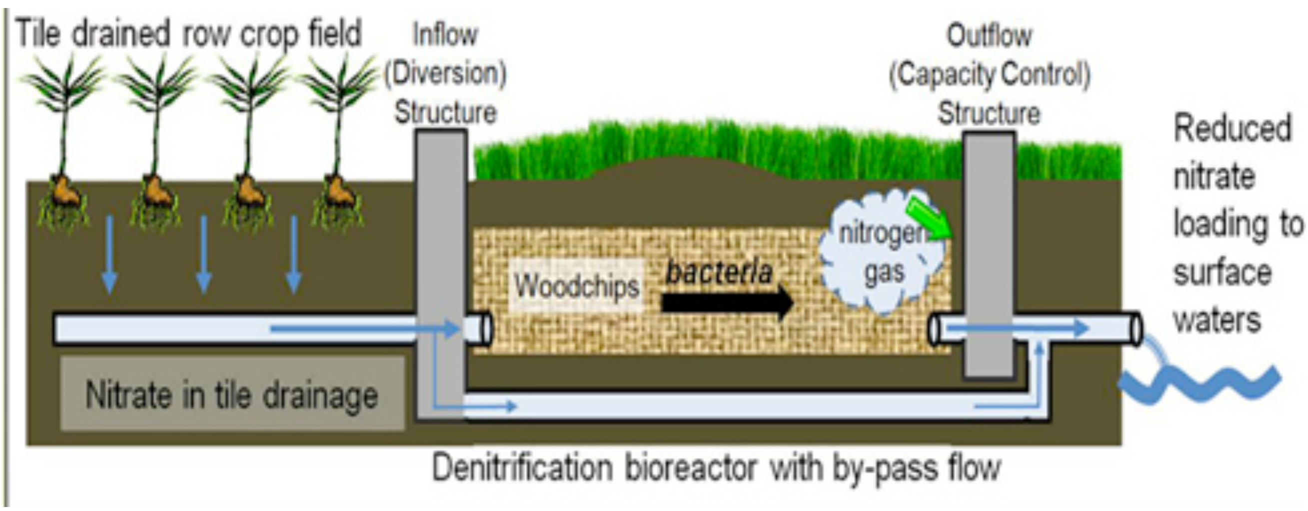
[31] "Conservation Practice Standard: Riparian Forest Buffer". Natural Resources Conservation Service. 2010. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_026098.pdf

As they trap sediment, grass waterways are additionally effective at preventing the delivery of fertilizers bound to particles of dirt, however they are relatively ineffective at preventing the delivery of fertilizer already dissolved in water. The Minnesota Department of Agriculture notes that for a waterway to be fully effective, upstream erosion must be prevented, or the waterway may become covered in sediment and not function properly.[32]

Denitrifying Bioreactors

There are also BMPs for agriculture that include a higher degree of structural improvements. These practices may offer some of the most significant opportunities to address water quality challenges because they are engineered to address specific challenges and conditions that occur within modern farming operations. An example is the *denitrifying bioreactor* (Figure 4).

Figure 4. Denitrifying Bioreactor



Source: Ottawa Soil and Water District, 2017

A denitrifying bioreactor *is a structure that uses a carbon source to reduce the concentration of nitrate nitrogen in subsurface agricultural drainage flow via enhanced denitrification*.[33] In practice, this means a carbon source (e.g., wood chips) is installed at the outlet of a drain tile or field edge and used to filter and remove nitrates from the discharging water before it enters a drainage system or other surface waters. The system works by microorganisms feeding on the woodchips and drawing oxygen from the nitrates in the water. As the organisms extract the oxygen from the nitrates, nitrogen gas is released into the atmosphere (Figure 4).[34] Research shows bioreactors may reduce nitrate levels by 35-50%. They are able to be retrofitted to existing tiling systems and have a useful lifespan of 15 to 20 years.

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[32] "Conservation Practices: Grass Waterway". Minnesota Department of Agriculture. N.d. http://www.mda.state.mn.us/protecting/conservation/practices/waterway.aspx

[33] https://www.nrcs.usda.gov/wps/PA_NRCSConsumption/download?cid=nrcseprd340747&ext=pdf

[34] http://globegazette.com/mcpress/news/local/iowa-soybean-association-assisting-with-bioreactors-and-saturated-buffers/article_8cb6af35-98b9-5c26-8b2e-5046054c4304.html

At the end of that period, the wood chips can be removed and replaced. Denitrifying bioreactors have been researched for more than a decade and as of 2015 they are eligible for EQIP funding to assist with the estimated $8-12,000 installation cost (e.g., to treat a 100 acre field).[35] The Iowa Soybean Association has been supporting the installation of bioreactors and it is estimated that there are about 40 installed in the state now (Figure 5).[36] One of the scenarios of the Iowa Nutrient Reduction Strategy calls for nearly 100,000 bioreactors in the state.

Figure 5. Installing a Denitrifying Woodchip Bioreactor

Source: Iowa Soybean Association, 2017

Lessons Learned from the Experience of the Forest Sector

The 1972 Federal Water Pollution Control Act (now referrred to as the Clean Water Act) laid the pathway for the development of BMPs in forestry. Amendments made in 1977 and 1987 initiated state programs for addressing nonpoint source (NPS) pollution.[37] The state programs were able to develop BMPs to control NPS risks, and states with significant forest management actvitivies established BMPs for these operations in order to achieve water quality goals.

The BMPs developed in each state involved participation from a variety of stakeholders, including forest industry, public agencies, researchers, landowners, environmental organizations and interested citizens. The BMPs were informed by water and soil research, and states established monitoring systems to evaluate compliance, effectiveness, and impacts. Numerous studies have been conducted to evaluate the impacts of forest management on water resources and the effectiveness of forestry BMPs.[38] These studies inform the use and design of the BMPs and efforts to monitor compliance. Similar research is being done in agriculture today, including work on bioreactors. The National Association of State Foresters has undertaken several efforts in recent years to aggregate information related to forestry BMPs and improve access to the monitoring reports and other analysis done within the state programs. Their recently launched "Timber Assurance" website provides access to many BMP related resources for each state, including information about the BMPs as well as access to state montioring reports.[39]

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[35] https://www.usda.gov/media/blog/2016/02/26/bioreactors-form-last-line-defense-against-nitrate-runoff

[36] https://www.agweb.com/article/first-ever-bioreactor-recharge-in-iowa/

[37] *"Nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, drainage, or hydrologic modification. Nonpoint source (NPS) pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and ground waters." EPA Definition,* https://www.epa.gov/nps/what-nonpoint-source

[38] NCASI, 2012

[39] See, https://stateforesters.org/current-issues/timber/state-programs-policies

In 2013, the NASF conducted a national survey of BMPs to evaluate effectiveness and found implementation rates averaged over 90% (Table 2). The report addressed BMPS related to harvest planning, skid trails, log landings, roads, wetland harvesting, prescribed fire, reforestation, stream crossings, and streamside management zones.

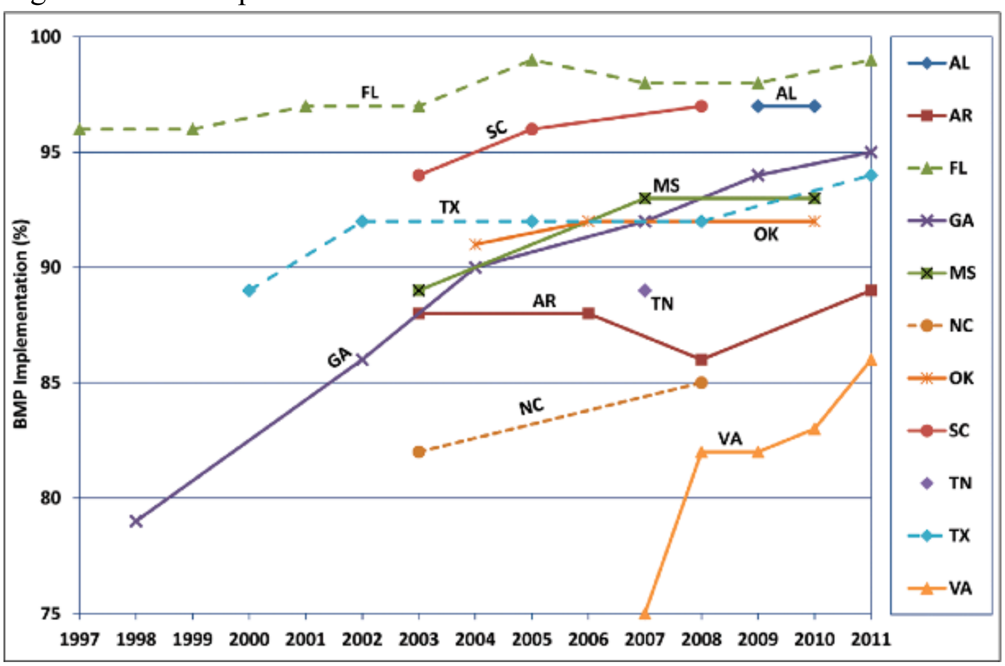
Table 2. U.S. Forestry BMP Implementation Rates (%)

State Average	Timber Harvest	Forest Roads	Skid Trails	Log Landings	Stream Crossings	Wetlands	Reforestation	Streamside Management Zones
91	93	92	89	94	87	91	97	91

Source: NASF, 2013

For the study, thirty-two states reported on BMP monitoring conducted between 2005 and 2013. Thirteen states reported implementation at 95 percent or better, eight states had rates that ranged from 90 percent to 94 percent, and the remaining 11 were at 80 percent and above. The survey examined states that utilize regulatory, non-regulatory, and quasi-regulatory approaches to BMPs in forestry and found similar rates of implementation across the different approaches.

Figure 6. BMP Implementation Trends for Southern States



Source: Olszewski, 2014.

Although forestry BMP implementation rates are now at a very high level, it took time to achieve this level of participation. For example, as shown in Figure 6, implementation rates were significantly lower in some states in the 1990s as compared to more recent monitoring results.

Various state and federal efforts have resulted in increased forestry BMP implementation, including training and education programs for landowners, loggers, and natural resource managers. Forest certification programs and other market and non-market incentives have also supported BMP adoption. Recent research by the University of Georgia examined the impact of the requirements of the Sustainable Forestry Initiative (SFI) certification program and sourcing standard on forestry BMP implementation rates. The preliminary results suggest that average BMP implementation rates are higher on harvested sites located within a 40-mile radius (i.e., sourcing area) of mills certified to the SFI Fiber Sourcing Standard.[40]

[40] http://www.sfiprogram.org/archives/conservation-community-partnerships-grant-program/active-grants1/university-of-georgia/

Regulatory Challenges

In recent court cases the effectiveness of forestry BMPs to protect water quality and prevent nonpoint source pollution has been tested and ultimately upheld. Lawsuits and EPA proposals have included the potential to consider forestry and forest roads as point sources of pollution requiring additional regulation under the Clean Water Act. In the EPA's determination not to designate stormwater discharge from forest roads for regulation under the Clean Water Act, the agency cited the effectiveness of existing BMP programs.

> *"EPA has determined not to designate stormwater discharges from forest roads for regulation….based on several interrelated factors. First, state, federal, regional, tribal government, and private sector programs already exist nationwide to address water quality problems caused by discharges from forest roads…Program implementation rates are generally high and have been shown to be effective in protecting water quality when properly implemented. These programs employ a variety of approaches, based in part on variations in regional topography and climate. While EPA recognizes that existing programs vary in their degree of rigor, the Agency has concluded that efforts to help strengthen existing programs would be more effective in further addressing forest road discharges than superimposing an additional federal regulatory layer over them."*
>
> Source: EPA, 2016.

Established farming, ranching, and silviculture (forestry) activities continue to be generally exempt from the permitting requirements of the Clean Water Act.[41] However, given the potential for additional legal actions to address water resources it behooves forestry and other land management sectors to ensure that existing programs and practices provide a defensible alternative to increased regulatory action. The recent controversies around the Environmental Protection Agency and U.S. Department of the Army 2015 Rule defining "waters of the United States" provides an example of challenges that may lay ahead.[42] The adoption of BMPs in forestry has been driven in part by requirements within forest certification programs and customers throughout the supply chain seeking to support responsible land use activities. Similar private sector programs and marketplace expectations also have the potential to significantly impact practices in food production systems.

Conclusions

Water quality concerns are increasingly pressing in modern agriculture. Common agricultural practices impact water quality and contribute to soil erosion and nitrate pollution. There are many methods of mitigating or preventing these impacts. Through adoption of Best Management Practices (BMPs) farmers and landowners can significantly reduce their impact on water systems. Protecting water quality is a landscape scale challenge – one that requires thinking and working across watersheds and the diverse land uses within them. The use of BMPs is one way to address the potential impacts of land disturbing activities. The use of BMPs has worked well in forestry and been upheld as a sufficient method for meeting the Clean

[41] Section 404 of the Clean Water Act, Exemptions to Permit Requirements https://www.epa.gov/cwa-404/exemptions-permit-requirements

[42] https://www.epa.gov/wotus-rule

Water Act and avoiding additional federal regulation. The water quality impacts of agriculture are of growing concern in many communities in the Midwest and other regions. To protect the farm economy, the quality of life of rural communities, and the water resources that everyone depends upon, it is important to support and apply effective best management practices.

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528 Hennepin Ave., Suite 703 Minneapolis, MN 55403 USA

info@dovetailinc.org | **Phone:** +1 612-333-0430 | **Fax:** +1 612-333-0432

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