Boone River Watershed Current Conditions Report:

Nutrients

Boone River Watershed Management Authority

November 2020

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Boone River

Watershed Management Authority

Current Conditions Report:

Nutrients

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Prepared as part of the Boone River Watershed Management Plan

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INTRODUCTION AND BACKGROUND

REPORT OVERVIEW

The Boone River Watershed Management Authority (WMA) has identified eight primary resource concerns for the Boone River Watershed; Shorelines and Riparian Areas, Plant and Animal Communities, Sediment, Nutrients, Stormwater, Public Access, Flood Resiliency, and Hazard Mitigation. This report focuses on Nutrients, and is one of eight reports developed for each of these concerns. Information contained in this report will facilitate the identification of resource and implementation priorities that will be used in the development of the Boone River Watershed Management Plan. Additionally, data gaps that are limiting such prioritization have been identified for future consideration.

INTRODUCTION TO RESOURCE

Nutrients are a part of the natural system and are essential in maintaining life. However, excess quantities of nutrients can negatively impact water resources, biota, and human health. Two nutrients that are generally associated with water quality issues are phosphorus and nitrogen. Excess quantities of these two nutrients can accelerate eutrophication in lakes and streams resulting in high algal productivity and low dissolved oxygen. Moreover, surpluses of nitrate-nitrogen in the environment can threaten drinking water supplies. Waterbodies can receive nitrogen and phosphorus naturally (e.g., rainfall) and directly or indirectly from discharge pipes (i.e., point sources) and surface runoff or leaching (nonpoint sources).

Concerns with excess nutrients in the Boone River Watershed mirror those found across the state. Ongoing nutrient management efforts in the watershed have not only been focused on reducing impacts to local resources but also downstream resources. In 2009, the USDA launched the Mississippi River Basin Healthy Watersheds Initiative. As part of this initiative, Iowa, along with other States in the Mississippi River Basin, developed nutrient reduction strategies to minimize the contributions of nitrogen and phosphorus to surface waters within the basin, and ultimately to the Gulf of Mexico.

The Boone River is a tributary of the Des Moines River. The Des Moines and Raccoon Rivers provide drinking water for more than 500,000 people in Des Moines and all or parts of many surrounding communities (DMWW, 2020). Given the use of the Des Moines River for drinking water and a multitude of recreational activities, its protection is not only important locally, but also to the state.

The watershed has been characterized as an area of significant freshwater biodiversity that is vulnerable but somewhat undegraded compared to many other Iowa streams (Jones, Schilling, & Gilles, 2018). However, in 2016 it had the highest nitrate yield (load per watershed area) of 35 Iowa watersheds studied (Jones et al., 2018). Excess phosphorus and nitrogen pose a threat to local surface and groundwater resources and their beneficial

uses. Nutrient management efforts in the Boone River Watershed support source water protection, water quality, conservation, and flood control goals established by federal, state, and local authorities.

EXISTING DATA

Several entities have conducted research in the watershed or are currently collecting data/information used to assess and/or manage nutrients. Water quality management plans have been developed for four sub-watersheds; Eagle Creek, Eagle Grove, Prairie Creek, and Lyons Creek. Plans developed for these areas include an extensive amount of local resource data, including nutrient concentrations, loads, and reduction targets.

Several entities have been involved in ambient water quality monitoring in the watershed including; The Nature Conservancy (TNC), Iowa Soybean Association (ISA), and Iowa Department of Natural Resources (IDNR). The U.S. Geological Survey and IIHR-Hydroscience and Engineering (University of Iowa) are collecting “real-time” water quality data on the Boone River near Goldfield and Webster City. While not utilized for this report, the ISA also collects data on individual farms to evaluate the effectiveness of specific management practices.

The U.S. Environmental Protection Agency (USEPA) requires all States to submit Water Quality Assessment Reports every two years. These reports include physical, chemical, and biological information for monitored streams, rivers, and lakes in addition to an analysis of the extent to which waters are meeting water quality standards. Data and results from completed assessments are provided to the public via the IDNR website. This also includes data and information related to fish kills. Table 1 contains a compilation of data sources that provide a compilation of information on nutrients and nutrient sources in the watershed. The list is not exhaustive but serves as a starting point for this subject.

Table 1: Fundamental Source of Data for Nutrients

Entity	Document/Information
IIHR – Hydroscience and Engineering Nature Conservancy	Boone River Watershed Stream Nitrate, 2007-2017 Report
Iowa Department of Natural Resources (IDNR)	TMDL for the Des Moines River
Iowa Department of Natural Resources (IDNR)	Ambient Water Quality Data
Iowa Department of Natural Resources (IDNR)	Fish, Macroinvertebrate, and Habitat Monitoring
Iowa Department of Natural Resources (IDNR)	Groundwater Vulnerability Regions of Iowa
Ellet Hoke	Research - Identification of freshwater mussels in the Boone River.
USDA-Natural Resources Conservation Service	Boone River Watershed 8-Digit Hydrologic Unit Profile
Iowa Soybean Association (ISA)	Eagle Creek Watershed Plan
Iowa Soybean Association (ISA)	Eagle Grove Watershed Plan
Iowa Soybean Association (ISA)	Prairie Creek Watershed Plan
Iowa Department of Natural Resources (IDNR)	Lyons Creek Watershed Plan

STATE OF THE RESOURCE

CURRENT CONDITIONS

Eutrophication, or excess nitrogen and phosphorus, is a common impairment to streams, rivers, and lakes across the country. Approximately 17 percent of the nation's streams and rivers and 28 percent of the nation's lakes are impaired from excessive nutrients (USEPA, 2020a).

Water quality impairment from a specific pollutant is generally identified by evaluating the extent to which the water quality standard is being achieved. Since Iowa has not adopted nutrient standards for streams, rivers, and lakes, impairment is determined from surrogate parameters such as dissolved oxygen, primary productivity, and biota health. A drinking water quality standard for nitrate-nitrogen does exist for waterbodies that are used for drinking water – this standard is 10 mg/L. This is also referred to as a maximum contaminant level (MCL). While it does not apply to the Boone River directly, it does apply to the Des Moines River.

While managing nitrogen and phosphorus are equally important, the focus of nutrient management in the watershed is on nitrogen to protect downstream drinking water supplies. The characterization of current conditions in the Boone River Watershed in respect to nutrients includes a cross section of related and available data and information. Groundwater data for the watershed was not assessed for this report.

NUTRIENT RELATED IMPAIRMENTS

Boone River and Tributaries

The lack of numerical criteria can reduce the number of waterbodies identified as being impaired from a specific pollutant such as nitrogen and phosphorus. The USEPA reports that only 2% of the streams in Iowa are impaired due to nutrient related issues (USEPA, 2020).

While the Boone River is not listed as being "impaired" from nutrients, results of nutrient monitoring and modeling suggest nutrient concerns exist (Jones et al., 2018). The Boone River is a tributary to the Des Moines River. Surface water from the Des Moines River is used by the City of Des Moines as a drinking water supply. In 2009, the IDNR developed a Total Maximum Daily Load (TMDL) for nitrates in the Des Moines River (Schilling, KE, & Wolter, CF, 2009). The Boone River Watershed was identified as having one of the highest nitrate yields in the Des Moines River Basin (Schilling et al., 2009).

Excess phosphorus and nitrogen can influence the biological integrity of a stream or river. There has been a decline in the diversity and abundance of freshwater mussels in the Boone River, as documented by Hoke (2004). In 2015 a more recent IDNR freshwater

mussel survey, found a significant increase in populations in the Boone River over previous surveys, which would seem to indicate that conservation activities that have been ongoing in the Boone River Watershed are having a positive impact on the freshwater mussel populations and the river itself (Kurth, 2018).While this decline has not been directly linked to nutrients it may be reflective of increased loading.

No tributaries to the Boone River are impaired specifically from phosphorus or nitrogen. However, there have been multiple incidents in the watershed that have resulted in fish kills and impairment listings. Fish kills related to fertilizer spills have been documented in Lyons Creek, Drainage Ditch 97, Eagle Creek, and Little Eagle Creek (IDNR, 2020a; and ISA, 2012). Accidental spills and releases can have short- and long-term impacts to waterbodies.

On a larger scale, impacts from excessive nutrient loading have been documented in the Gulf of Mexico. Hypoxia, which refers to a reduced level of oxygen in the water, has been tied to nutrient loading from the Mississippi River Basin giving rise to the Mississippi River Mississippi River Basin Healthy Watersheds Initiative (USDA, 2020a).

Public Lakes

The State of Iowa has not adopted numerical nutrient criteria for lakes. The lack of numerical criteria can reduce the number of waterbodies identified as being impaired from a specific pollutant such as nitrogen and phosphorus. The USEPA reports that only 16% of the lakes in Iowa are impaired due to nutrient related issues (USEPA, 2020).

Ambient nutrient concentrations have been directly linked to only one impaired waterbody in the watershed, Briggs Woods Lake (IDNR, 2020a). While the IDNR identified agriculture as a source for nutrients to this lake, some conditions such as periods of low dissolved oxygen have been related to natural nutrient cycling.

Although nutrient impacts to natural lakes in the watershed have been less studied, a review of historical water quality conditions of natural lakes in Iowa was completed in 2012 (Heathcote A., Filstrup C, & Downing J., 2012). Conclusions from this review was that 88 percent of Iowa's natural lakes showed a pattern towards increasing nutrients and nutrient enrichment had led to diagnostic shifts in the algal communities. Lake Cornelia was one of 30 lakes included in that review. While Lake Cornelia is not currently listed as being impaired from nutrients, it is impaired due to high turbidity (IDNR, 2020a). Excessive nutrients can contribute to high turbidity by increasing algae production and amounts of detritus or dead organic matter suspended in the water column.

NUTRIENT SOURCES

In 2004, the IDNR developed a nitrogen and phosphorus budget for the State of Iowa (Libra, R., & Wolter, C. 2004). A wealth of data was used to quantify nutrient contributions for the primary sources. Results of this study indicate that 38% of the nitrogen in the state's

watersheds stem from fertilizer and manure (Figure 1). The contribution of phosphorus increases to 99% for these two sources (Figure 2). Human and industrial inputs are relatively small, accounting for one percent or less of the total inputs for both nitrogen and phosphorus. This coincides with data and modeling results from several sub-watersheds. Point source contributions of nitrogen were estimated to be 0.1% in the Eagle Creek drainage, 0.2% in the Prairie Creek drainage, and 0.4% in the Lyons Creek drainage.

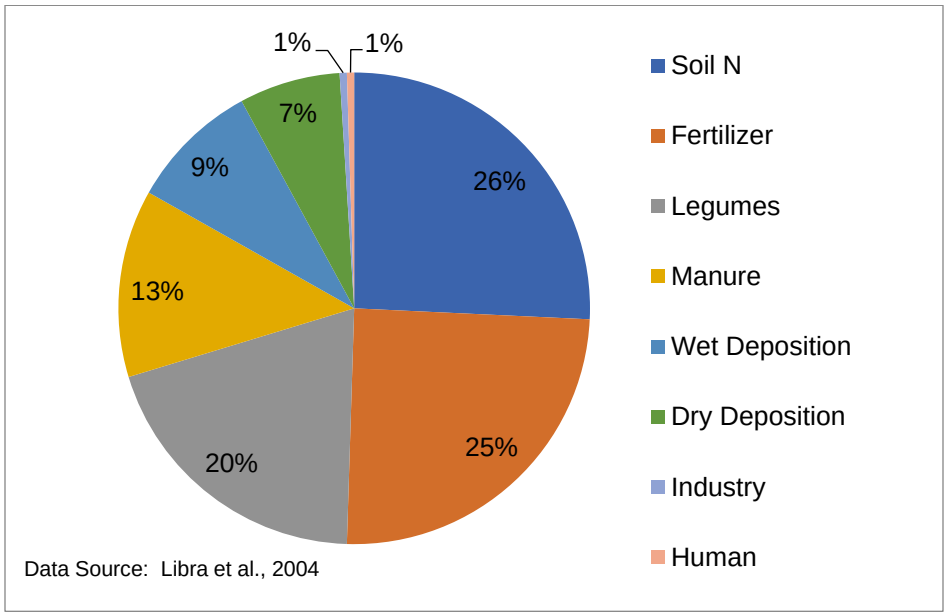

Figure 1: Contribution of nitrogen from primary sources in Iowa

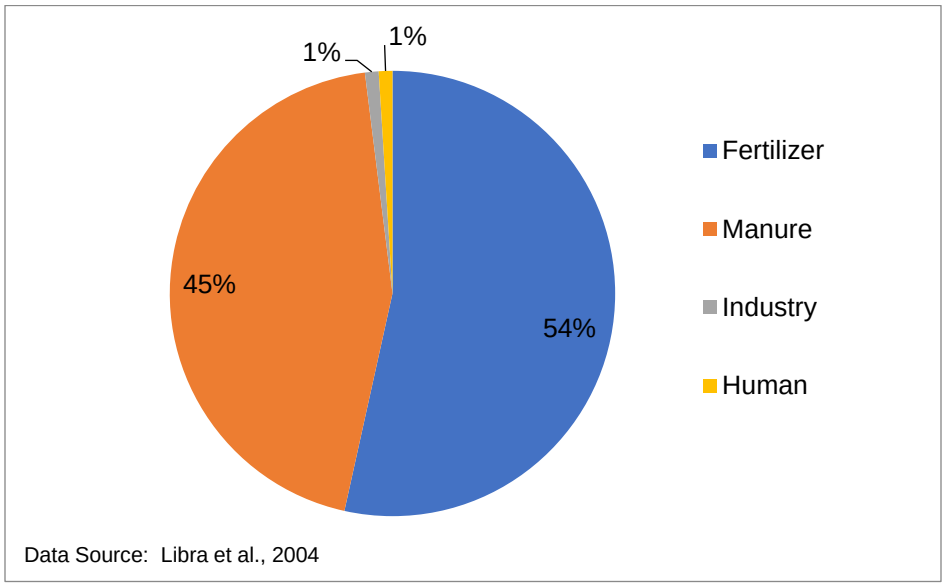

Figure 2: Contribution of phosphorus from primary sources in Iowa

It is assumed, given the amount of land used for crop production in the watershed, that commercial fertilizer and manure are primary sources of nutrients to the Boone River and its tributaries. In 2019 approximately 86% of the Boone River Watershed was used for crop production with nearly all of this all being used to grow corn and soybeans (USDA, 2020b). Manure is commonly used across the country as crop fertilizer. As of 2007, there are approximately 110 animal feeding operations (AFO) in the Boone River Watershed (USDA-NRCS, 2008). Since then AFO's have nearly doubled. In 2019, there were 204 AFOs; 11 of which are open feedlots - the rest are confinements. Of the 204, 29 are considered Inactive. 5 of those 29 are open feedlots. These AFOs included approximately 450,000 animal units total: 58% swine, 41% chickens, with the remaining 1% consisting of cattle and turkey (IDNR, 2019).

High bacteria concentrations in surface water, such as documented by the IDNR in the Boone River, Buttermilk Creek, Lyons Creek, and Briggs Woods Lake can indicate influences from livestock or human waste (IDNR, 2020a). While the potential nutrient and bacteria contribution from failing onsite wastewater systems (OWTS) has not been estimated, there are several small communities with aging septic systems or drain tile networks that discharge sewage directly into surface waters (USDA-NRCS, 2008). In Kossuth County there are 184 homes without septic systems. The other counties do not have information available (USDA-NRCS, 2008). The other counties do not have information available. Additionally, stormwater contributions of nutrients to the Boone River and its tributaries have not been quantified or are not available.

While Briggs Woods Lake lies below approximately 5,700 acres of mainly agricultural land, the design of the lake minimizes sediment and nutrient loading from its watershed. Being located off the main channel reduces the impact many reservoirs see from high flow events. Nutrient load estimates for the lake have not been determined or were not available. Volume loss rates and maintenance estimates for the settling basin were not available. Since a majority of the drainage above the lake is used for crop production, commercial fertilizer and manure are likely the primary nutrient sources. The status of on-site waste systems in the drainage is unknown.

Lake Cornelia is a natural lake that had a historic maximum depth of "perhaps six feet" (Heathcote et al., 2012). The lake has undergone one major dredging project which occurred from 1942 to 1947 and removed approximately 800,000 cubic yards of sediment from the lake (Heathcote et al., 2012). Researchers "assume that the sediment disturbance and re-suspension had some impact on the integrity of the chronology, specifically through the redistribution of older sediments above more recent deposits" (Heathcote et al., 2012). While specific nutrient sources for the lake have not been studied, developed areas around the lake shoreline provide opportunities for nutrient inputs to the lake. These could be from OWTSs, if present, or from fertilizer applications.

NUTRIENT DELIVERY

Nutrients can be delivered to a watercourse via several avenues including; subsurface flow, overland runoff, tile drains and outlets, pipes (permitted and illicit), and through direct inputs from such activities as dumping trash or discarded items. The primary nutrient delivery mechanisms in the Boone River Watershed are overland runoff and subsurface drainage systems, including drainage ditches.

Runoff

The load of nutrients transported through overland runoff is dictated by two factors; pollutant concentration and runoff volume. Crop tillage practices can influence both these factors. Practices that increase field residue can result in lower fertilizer needs (e.g., increased organic matter), lower concentrations of nutrients in runoff, and less quantity of runoff. Reduced tillage practices, when combined with avoidance practices such as those associated with nutrient management, and filtration practices such as buffers, can significantly reduce the amount of nutrients transported to surface water from runoff.

Urban areas generally have higher runoff rates due to impervious surfaces. In addition to transporting a host of pollutants including nutrients, bacteria, and heavy metals, urban runoff contributes to flooding. The load of nutrients (and other pollutants) from urban areas to waterbodies in the watershed have not been quantified.

As mentioned above, Briggs Woods Lake lies below approximately 5,700 acres of mainly agricultural land. Nutrient delivery from the contributing watershed has been partially controlled by lake design. Being located off the main channel reduces the impact many reservoirs see from high flow events.

Subsurface Drains

Approximately 54% of the Boone River Watershed has poorly drained soils (USDA-NRCS, 2008). Like other watersheds lying within the recently glaciated Des Moines Lobe landform, the Boone River Watershed is underlain with an extensive network of porous drainage pipes which effectively lower the water table so as to maximize crop yields (Jones et al., 2018). It's long been known that these pipes (tiles) are the primary delivery mechanism for nitrogen from farmed fields to streams (Jones et al., 2018). Individual farmers and landowners install and manage the field tile networks whereas the larger downstream infrastructure is managed at the county government level by drainage districts (Figure 3). While the current extent and locations of tile drain are unknown it has been estimated that approximately 60% of the watershed has the potential for subsurface drainage (USDA-NRCS, 2008). This was based on the amount of land that had poor or very poor drainage and less than 2% slope.

Drainage Ditches

Agricultural drainage ditches are created by excavating or by modifying existing drainage networks. There are five primary drainage ditches in the Boone River Watershed (Figure 3) that have a combined length of 24 miles; #2, #3, #4, #94, and #105 (USDA, 2020b). Studies conducted on these ditches outside the watershed have shown that they can provide valuable wet vegetated non-cropped habitats to both aquatic and terrestrial taxa, supply food resources lacking in otherwise dry and intensively managed cropland, and perform connectivity functions within a wider landscape (Herzon I., & Helenius, J., 2008). There is also a concern that these ditches provide a direct route for nutrients and other chemicals to reach a stream.

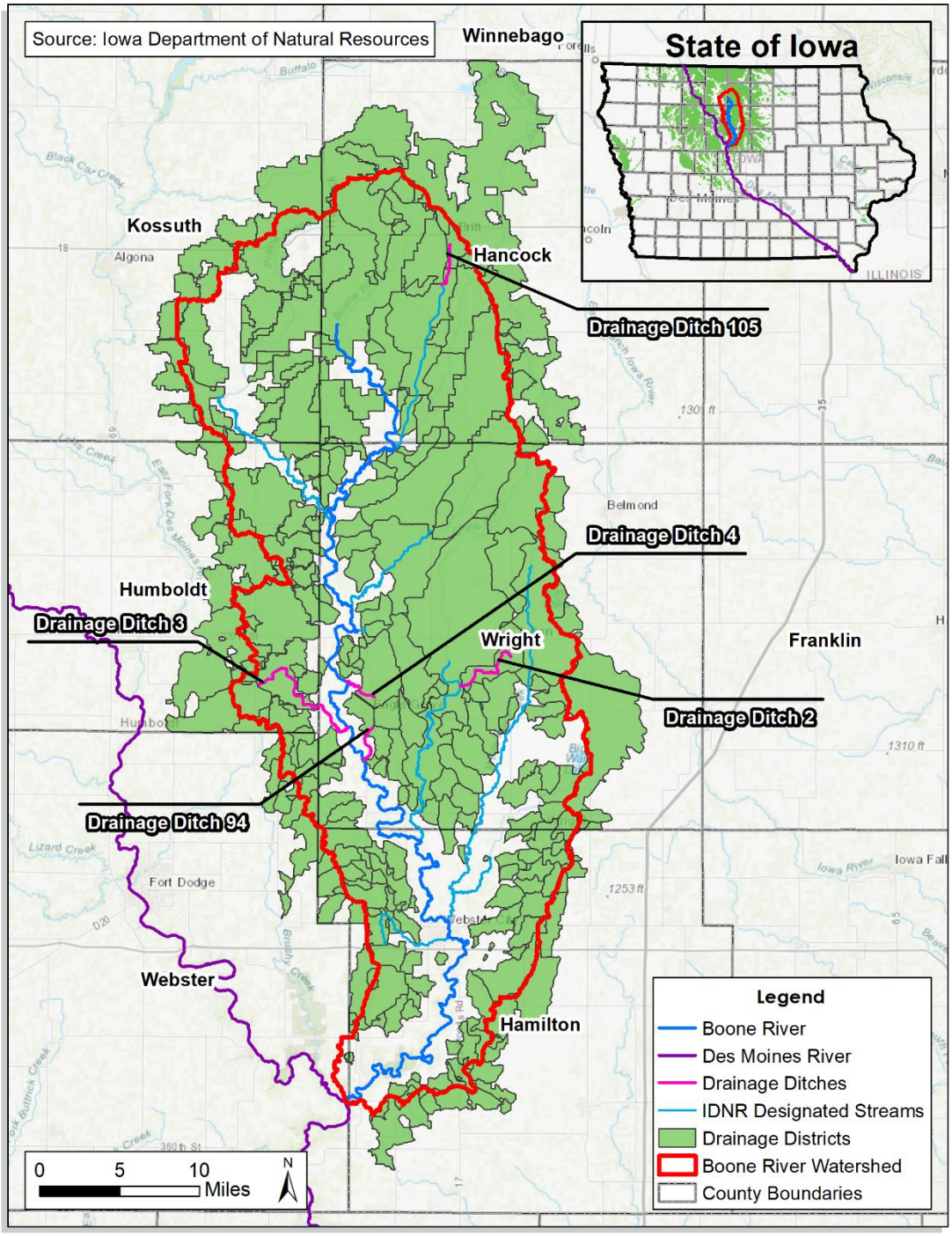

Figure 3: Drainage Districts and Ditches within the Watershed

CONCENTRATIONS AND LOADS

Boone River and Tributaries

Yields of nitrate nitrogen from the Boone River Watershed are some of the highest in the state (Jones et al., 2018). These yields were identified as being reflective of three things: 1) large percentage of land in row crop (corn and soybean) production; 2) dense networks of constructed drainage underlying nearly all fields; 3) high-organic matter soils which can store large amounts of nitrogen in its various inorganic and organic forms. As a result, farmed fields in the watershed are highly vulnerable for nitrate loss. Approximately 41 percent of the nitrate samples collected from the Boone River from 1999 to 2006 exceeded 10 mg/L (Schilling et al., 2009). The IDNR has collected 124 monthly samples from the Boone River near Stratford since 2010 (IDNR, 2020b). Forty of the 124 samples collected during this period or 32 percent had nitrate concentrations equal to or above 10 mg/L, which is the maximum contaminant level for nitrate in drinking water. Average annual nitrate nitrogen concentrations in the Boone River from 2010 to 2018 ranged from 2.53 mg/L in 2012 to 12.83 mg/L in 2015 (Figure 4).

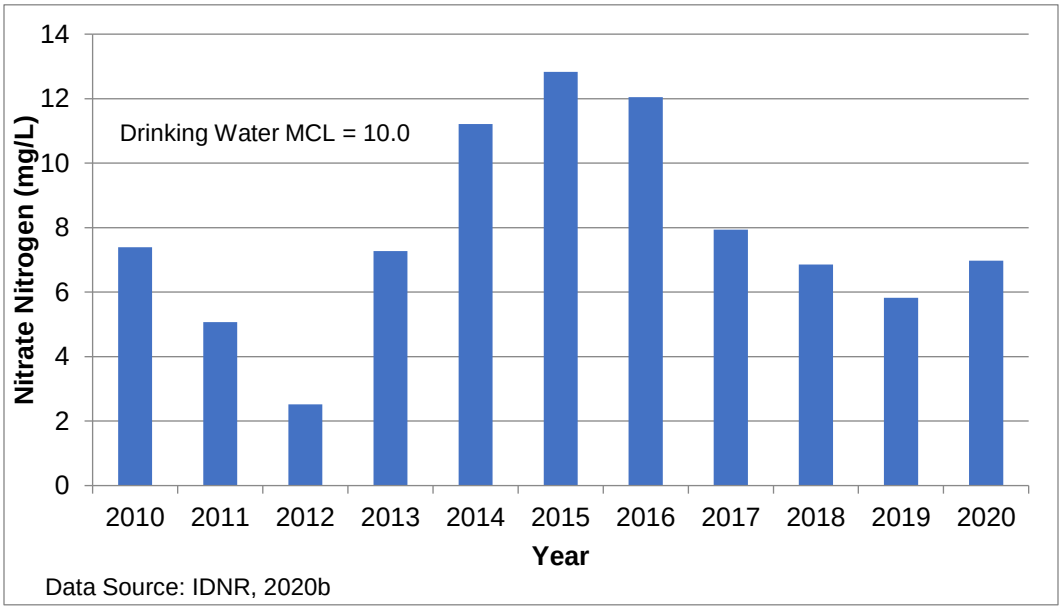

Figure 4: Annual Average Nitrate Nitrogen Concentrations in the Boone River

Tributaries to the Boone River also exhibit high nitrogen concentrations and loads. Monitoring conducted for the Lyons Creek Watershed Plan revealed high nitrate-nitrogen concentrations at all monitoring sites throughout the watershed (ISA, 2012). Additionally, the TMDL for the Des Moines River has identified Lyons Creek as having the fifth highest nitrate-N load of the 173 subwatersheds modeled (ISA, 2012). A map illustrating the nitrogen load from nonpoint sources by subwatersheds in the Boone River in relation to the

rest of the Des Moines River Subwatersheds is shown in Figure 5. Many of the Boone River subwatersheds exhibit nitrogen losses greater than 18 lb/ac (ISA, 2018).

Water quality monitoring within Lyons Creek was conducted in hopes of identifying priority areas; however, Lyons Creek exhibited fairly consistent nitrate concentrations at all monitoring locations (ISA, 2012). This is consistent with monitoring results from other subwatersheds, whose monitoring results can be viewed online at https://www.acwa-rrws.org/water-monitoring/annual-data/.

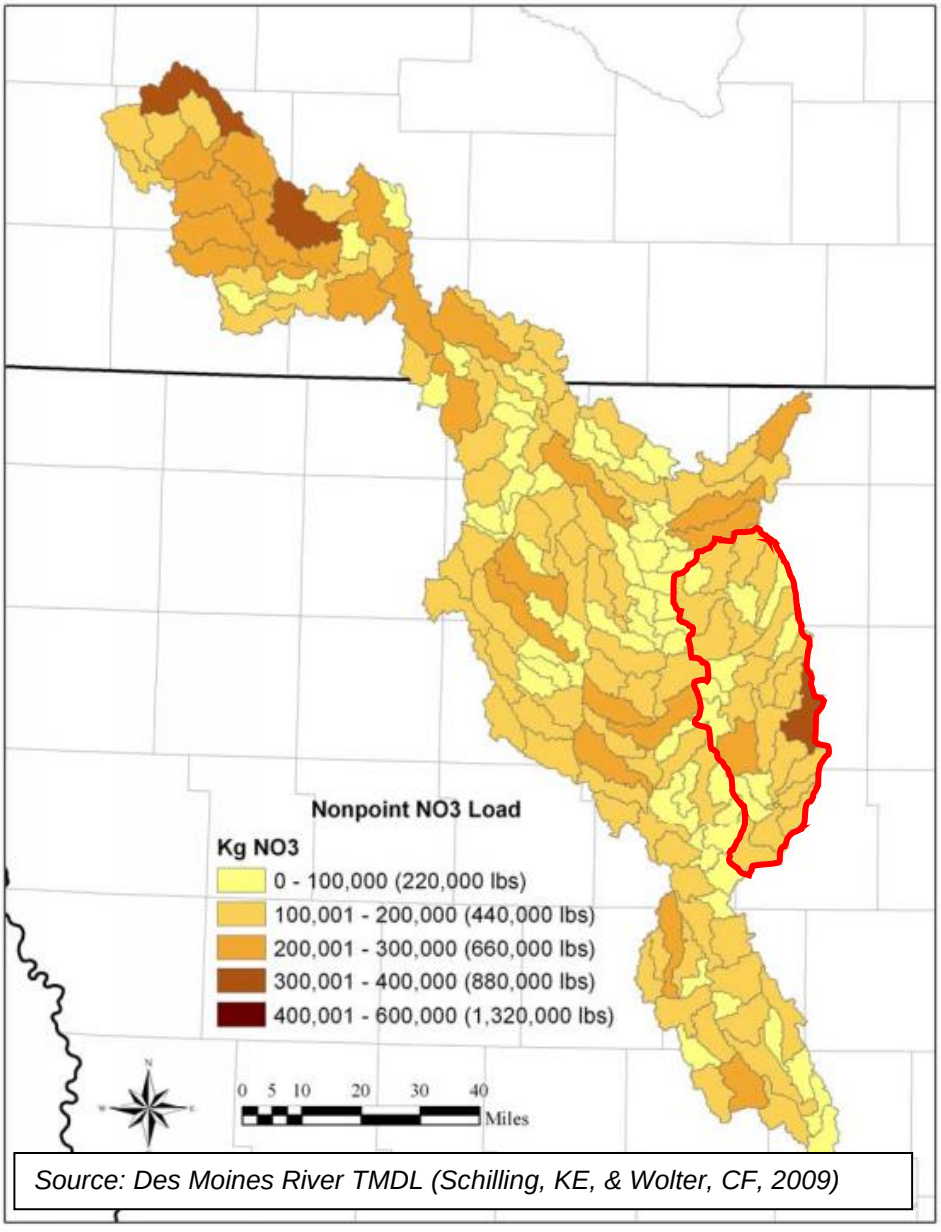

Figure 5: Nonpoint Nitrogen Concentrations by HUC 12 Subwatershed

Public Lakes

The IDNR conducts ambient monitoring on three public lakes in the watershed; Big Wall, Briggs Woods, and Cornelia (IDNR, 2020b). Data collected in 2018 and 2019 were compiled to calculate mean concentrations (Table 2). Big Wall Lake exhibits the highest mean total phosphorus concentration with more than half being in the dissolved form. Briggs Woods Lake has the highest kjeldahl and inorganic nitrogen concentrations and the lowest orthophosphate concentration.

High ratios of Total Nitrogen:Total Phosphorus (TN:TP) in lakes can indicate; limiting nutrients, the level of eutrophication, and potential influences from human induced sources (Quiro, 2002). Additionally, lower TN:TP ratios have been linked to higher concentrations cyanobacteria (Harris T., Wilhelm F., Graham J., & Loftin K, 2014). The current TN:TP ratio for Big Wall Lake indicates a nitrogen limited system. While ratios for Briggs Woods Lake and Lake Cornelia are higher, they both fall between 20 and 50 suggesting pollutant concentration is driving productivity rather than the nutrient ratio (Table 2). The trapping of particulate phosphorus in the sediment basin above Briggs Woods Lake is most likely increasing the TN:TP ratio.

Table 2: Current Nutrient Concentrations for Selected lakes in the Boone River Watershed.

	Mean Concentrations 2018-2019 (sample size denoted in parenthesis)		
Parameter/Lake	Briggs Woods Lake	Big Wall Lake	Lake Cornelia
Ammonia-nitrogen (mg/L)	0.01 (12)	0.07 (15)	0.03 (12)
Inorganic nitrogen (nitrate and nitrite) (mg/L)	0.29 (6)	0.06 (15)	0.05 (6)
Kjeldahl nitrogen (mg/L)	1.66 (6)	1.24 (15)	1.34 (6)
Orthophosphate (mg/L)	0.01 (5)	0.13 (15)	0.01 (6)
Phosphate-phosphorus (mg/L)	0.07 (6)	0.25 (15)	0.05 (6)
Total Nitrogen:Total Phosphorus	27	5	29

Data Source: IDNR, 2020b

HISTORICAL CHANGES

The landscape in the Boone River Watershed has changed dramatically the past 150 years. These changes have resulted in higher nitrogen inputs to the land surface, the loss of natural buffers and filtration, and increased pollutant delivery from the installation of drainage networks.

Historical changes in total phosphorus concentrations in Lake Cornelia were quantified in 2012 (Heathcote et al., 2012). The estimated lake phosphorus concentration in 1755,

based on diatom analysis, was 22 µg/L while the modern observed phosphorus concentration was 74 µg/L (Heathcote et al., 2012). This accompanied a diatom shift towards more eutrophic species (Heathcote et al., 2012).

CURRENT PROJECTS AND PROGRAMS

There are a vast number of local, state, and federal entities that administer programs and projects related to nutrient management. The primary federal agencies listed below are those that are currently involved in watershed projects or those that may be applicable to the watershed. While projects and programs that encompass monitoring, research, and education are also important, they are not included in this section.

PRIMARY FEDERAL AGENCIES AND PROGRAMS

USDA – Natural Resources Conservation Service

In 2009 the USDA-NRCS initiated the Mississippi River Basin Healthy Watersheds Initiative (MRBI) that spans across 13 states. This initiative uses several Farm Bill programs, including the Environmental Quality Incentives Program (EQIP) and the Agricultural Conservation Easement Program (ACEP), to help landowners sustain America's natural resources through voluntary conservation. The overall goals of MRBI are to improve water quality, restore wetlands and enhance wildlife habitat while ensuring economic viability of agricultural lands (USDA, 2020a). The initiative is currently involved in watershed projects in the Prairie Creek and Eagle Creek drainages. These projects involve a multitude of partners consisting of landowners, producers, government agencies, conservation based organizations, and organizations representing agricultural producers.

U.S. Environmental Protection Agency

Nonpoint source (NPS) pollution has been identified as being the most significant source of pollution in the Boone River Watershed. In 1987, Congress added Section 319 to the Clean Water Act and created a federal grant program that provides money to states, tribes, and territories for developing and implementing NPS management programs (USEPA, 2020b). Funding provided through Section 319 can be a significant source of funding to implement nutrient management activities in the watershed. The IDNR is responsible for implementing the Section 319 program in Iowa.

PRIMARY STATE PROGRAMS & INITIATIVES

Iowa Nutrient Reduction Strategy / Water Quality Initiative

The Iowa Nutrient Reduction Strategy is a science and technology-based framework to assess and reduce nutrients to Iowa waters and the Gulf of Mexico. It is designed to direct efforts to reduce nutrients in surface water from both point and nonpoint sources in a scientific, reasonable and cost-effective manner (IDNR, 2020c). The Iowa strategy outlines

a pragmatic approach for reducing nutrient loads discharged from the state's largest wastewater treatment plants, in combination with targeted practices designed to reduce loads from nonpoint sources such as farm fields (IDNR, 2020c).

The Iowa Water Quality Initiative (WQI) is the funding and implementation efforts for the Iowa Nutrient Reduction Strategy, and is managed through the Iowa Department of Agriculture and Land Stewardship (IDALS). The WQI improves water quality through a collaborative, research-based approach that is evaluated and reported by a team of independent researchers from multiple institutions. This comprehensive approach includes implementation of practices in both urban and agricultural areas, allowing cities and farmers alike to adopt conservation practices that fit their unique needs, lands, and budgets.

Iowa Department of Natural Resources

The Iowa Department of Natural Resources (IDNR) administers several regulatory and non-regulatory programs that involve nutrient management including: Public Drinking Water Program, National Pollutant Discharge Elimination System (NPDES), Lake and River Restoration, and Nonpoint Source Management (Section 319 Program). The NPDES program regulates a wide array of activities including industrial and municipal discharges, construction site runoff, and stormwater management.

Iowa Stormwater Education Partnership

The Iowa Stormwater Education Partnership (ISWEP) is a nonprofit organization that provides support for local stormwater management programs including statewide education and outreach. The ISWEP provides support to MS4 and non-MS4 communities.

LOCAL AND NONPROFIT IMPLEMENTATION EFFORTS

The Nature Conservancy

The Nature Conservancy assists with projects designed to protect land and water. They are currently a partner on the Boone River Watershed Nutrient Management initiative. To date, they have completed 31 oxbow restoration projects within the watershed. Oxbows improve riparian area functions including creating fish and wildlife habit; capturing nutrients and sediments; and provide floodwater storage.

Local Watershed Management Plans

Watershed Management Plans have been developed for four sub-watersheds in the Boone River drainage; Eagle Creek, Eagle Grove, Prairie Creek, and Lyons Creek (Table 3, Figure 6). These plans are currently being implemented in all the sub-watersheds except for Lyons Creek. The area covered by current plans is 185,313 acres or approximately 32%

of the Boone River Watershed. Multiple practices targeted in these plans address nutrient management.

Table 3: Completed watershed management plans in the Boone River Watershed

Watershed	Planning Area (ac)	% of the Boone River Watershed
Prairie Creek	90,000	15%
Eagle Creek	70,000	12%
Eagle Grove	14,240	3%
Lyons Creek	11,073	2%
Total Planning Area	**185,313**	**32%**

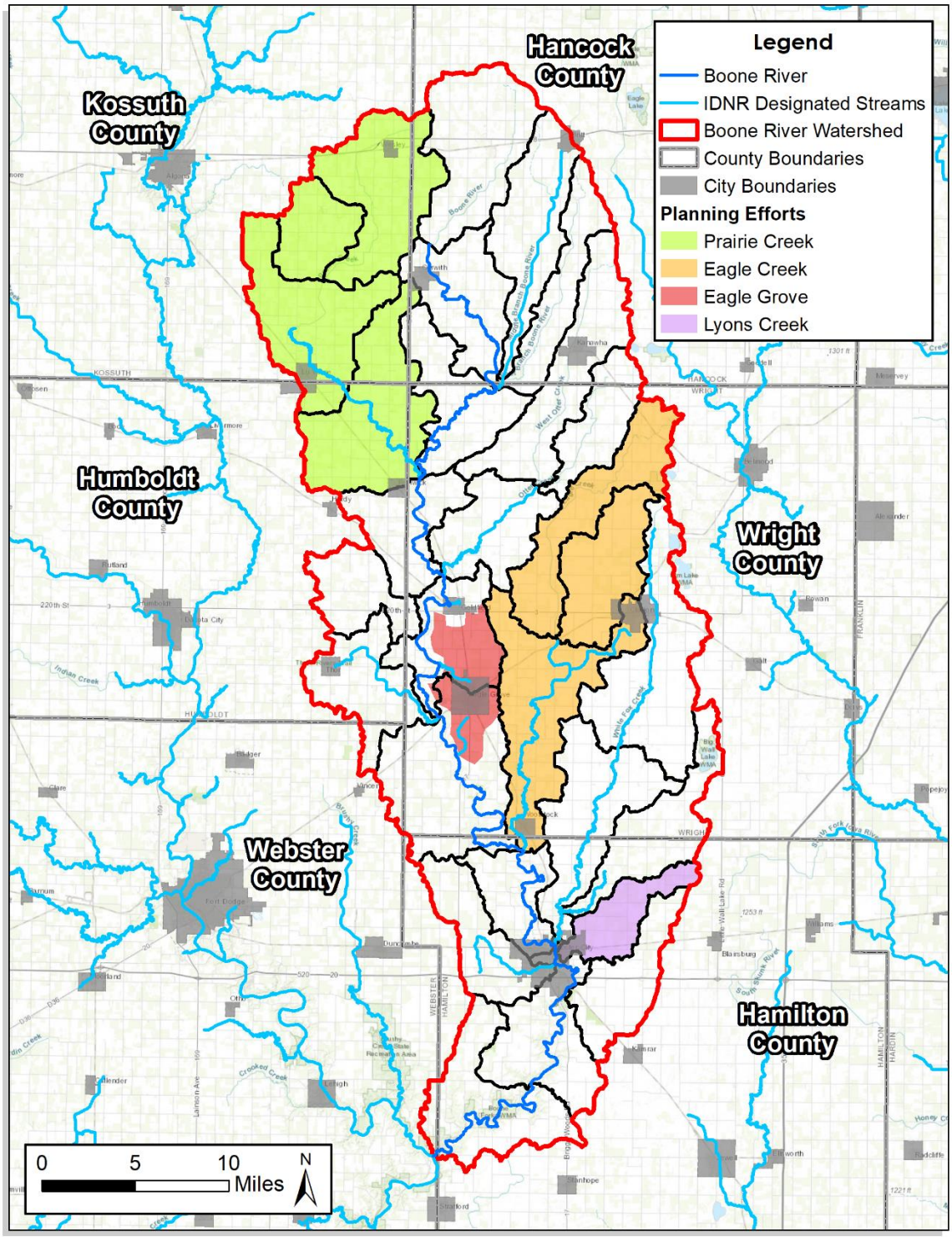

Figure 6: Areas in the Boone River Watershed Addressed by Current Watershed Management Plans

FUTURE TRENDS

A study of recent nitrate trends (2007-2017) was conducted for 30 sites in the watershed (Jones et al., 2018). Results of this study indicate increasing nitrate trends at all 30 monitoring sites. Increases are significant at the $p<0.01$ level at 12 sites and $p<0.05$ at four sites with annual increases ranging from 0.16 to 1.49 mg/L (Jones et al., 2018). It's very doubtful that increased crop acres in this watershed are driving these increases in nitrate levels, as most of the farmable land has been farmed for many years. However, there is anecdotal evidence that the drainage infrastructure is being expanded and improved throughout Iowa (Helmers, 2013).

A continuation of increasing nitrate trends in the Boone River and its tributaries will increase the challenges in protecting source water and the natural environment. Additionally, phosphorus and nitrogen loading to streams, rivers, and lakes will increase eutrophication resulting in higher algae biomass, an increase in cyanobacteria, increased turbidity, higher pH, and less dissolved oxygen.

RECOMMENDATIONS

The following goals have been developed for initial discussion with the WMA regarding nutrient resource concerns. It is anticipated that these goals may be modified for inclusion in the final Boone River Watershed Management Plan.

WATERSHED GOALS

To ensure watershed goals align with and support state priorities, assistance and coordination should be sought from respective professionals at the IDNR, IDALS, and WMA partners. Nutrient management goals for the Boone River Watershed should be developed to:

- Protect source water in the watershed from nitrate contamination,
- Protect downstream source water from nitrate contamination,
- Protect recreation uses of the Boone River and its tributaries,
- Maintain and enhance the physical, chemical, and biological integrity of streams, rivers, and lakes in the watershed, and
- Maintain agricultural profitability and sustainability.

General goals for the watershed include:

1. Inform and engage landowners, recreational users, and the general public in the development resource protection strategies.
2. As applicable, utilize current regulatory programs to control and monitor nutrient loading from point source discharges, permitted facilities, spills and releases, construction sites, and urban stormwater.
3. Utilize non-regulatory programs to reduce nutrient loading from agricultural and urban nonpoint sources in the watershed.
4. Continue to support and promote USDA programs and conservation practices throughout the watershed.
5. Along with partners, continue to initiate targeted projects in priority subwatersheds that address water quality, soil health, habitat, wildlife, and public access.
6. Support monitoring activities that help define the physical, chemical, and biological integrity of the Boone River and its tributaries.
7. Develop a water quality model to help quantify existing nutrient loads and predict future loads under various land use scenarios

RESOURCE GOALS

State and regional goals have been developed for nitrogen and phosphorus. These goals were developed to protect downstream drinking water supplies from nitrate contamination (i.e., Des Moines River) and reduce hypoxia in the Gulf of Mexico. Additional nutrient goals

have been established for several subwatersheds. Additional nutrient related goals for Briggs Woods Lake have been developed as it is the only lake in the watershed identified as impaired due to nutrients.

BOONE RIVER AND TRIBUTARIES

- In accordance with the TMDL for the Des Moines River, reduce maximum nitrate nitrogen concentrations in the Boone River by 34.4 percent to achieve a concentration of 9.5 mg/L or less.
- In order to meet the Iowa Nutrient Reduction Strategy goals, reduce nonpoint source loads of nitrogen by 41 percent and phosphorus loads by 29 percent.
- By 2038, reduce nonpoint source loads of nitrogen by 41 percent and phosphorus loads by 29 percent in the Eagle Grove subwatershed.
- By 2032, reduce nonpoint source loads of nitrogen by 41 percent and phosphorus loads by 44 percent in the Eagle Creek subwatershed.
- Within 20 years of project start date reduce nitrate-N loads leaving the Lyons Creek watershed by 34% per year while maintaining agricultural productivity.
- By 2035, reduce nonpoint source loads of nitrogen by 41 percent and phosphorus loads by 74 percent in the Prairie Creek subwatershed.
- Document the nature, extent, and magnitude of the nutrient problem in unmonitored sub-watersheds.
- On a voluntary basis, develop and implement stormwater management plans for communities that may be contributing nutrients to the Boone River or its tributaries.

BRIGGS WOODS LAKE

- Develop and implement a nutrient management plan for Briggs Woods Lake.

IMPLEMENTATION

STRATEGIES

The overall framework for protecting water quality and beneficial uses from being degraded by nutrients includes both regulatory and non-regulatory efforts. The primary regulatory mechanism to address nutrient loading from industry, wastewater facilities, urban stormwater, and larger livestock operations is the National Pollutant Discharge Elimination System (NPDES). The NPDES program for Iowa is administered by the IDNR. While the development of stormwater plans is required for MS4 communities there are none of these communities in the watershed. Therefore, stormwater planning and implementation in the watershed will be voluntary.

Non-regulatory efforts to reduce and control nutrients leaving private lands involve the voluntary adoption of management practices. A majority of the management practices

promoted through USDA programs are beneficial to the environment by improving soil health, reducing erosion, and reducing bacteria, nutrient, and chemical runoff.

The voluntary adoption of management practices can be achieved on a targeted or non-targeted basis. Non-targeted implementation of management practices across the Boone River Watershed can be accomplished through existing programs such as EQIP or WQI. These programs provide all landowners, both in and outside of priority areas, access to technical and financial assistance.

Targeted implementation of management practices can be accomplished through “projects” focused in a priority area, which is generally a smaller drainage. This would be a continuation of projects that are currently being implemented in Eagle Creek, Eagle Grove, and Prairie Creek drainages. Targeted projects can bring additional cost-share and more implementation flexibility. In most cases, the decision by a landowner or producer to implement or adopt a “practice” is financially based.

Lake drainages can be considered for targeted projects. Based on the information reviewed, it appears the sediment basin above Briggs Woods Lake is providing benefits to lake water quality. The current status of this basin should be evaluated for potential maintenance needs. Landowner adoption of conservation measures upstream of the lake will also extend the life of the sediment basin and slow the rate of eutrophication in the lake.

ACTION STEPS

Several action steps have been identified that should be taken on a subwatershed scale to achieve overall goals for the watershed. These actions will facilitate planning and the development of implementation strategies for subwatersheds that do not have completed management plans. Additional actions have been developed to facilitate nutrient management planning and implementation on Briggs Woods Lake.

Boone River Subwatersheds

- Estimate annual phosphorus and nitrogen loads to the Boone River
- Identifying and quantify loads from major nutrient sources
- Evaluate the current condition and function of nutrient delivery mechanisms including tile outlets, drainage ditches, and stormwater outfalls
- Evaluate in a quantifiable manner, the current condition of riparian areas along the Boone River and its tributaries

Briggs Woods Lake

- Identify major nutrient sources in the lake watershed
- Quantify annual nutrient yield from the lake watershed
- Quantify annual nutrient loading to the lake

PROJECT OPPORTUNITIES

Watershed management plans have been completed in four sub-watersheds; Eagle Creek, Eagle Grove, Prairie Creek, and Lyons Creek. These four sub-watersheds total 185,313 acres or 31% of the Boone River Watershed. Projected needs for management measures in the four sub-watersheds mentioned above were used to estimate future needs in the remaining portion of the drainage or approximately 395,873 acres (Table 4). It should be noted that costs associated with reduced tillage were “negative” in all the watershed plans. Additionally, costs associated with nutrient management were “negative” in three of the four plans. Additional practices and updated cost estimates could be provided in the Boone River Watershed Management Plan, if necessary.

Table 4: Estimated need for management practices in the Boone River Watershed.

Practice	Units	Estimated Watershed Practice Needs	Expected Cost
Cover crops	Acres	239,120	$18,812,766
No-till/Strip-till	Acres	213,500	-$2,135,000
Nutrient management	Acres	80,169	$60,127
Prairie strips	Acres	3,544	$1,049,054
Drainage Water Management	Acres	2,135	$2,135,000
Buffers & Filter Strips	Acres	854	$1,131,550
Conversion of Cropland	Acres	427	$128,100
Pasture Management	Acres	320	$94,154
Bioreactors	Structures	265	$2,614,308
Saturated Buffers	Structures	203	$608,475
Wetlands	Sites	53	$20,794,006
Oxbow restorations	Sites	90	$717,360
Total Cost	**-**	**-**	**$46,009,899**

EDUCATION STRATEGIES

It is imperative that all resource managers, decision makers, and general public understand the value of plant and animal communities, related issues, management tools, and costs associated with the protection and restoration resources. This can only be achieved through continuous communication, education, information transfer, and monitoring and assessment. Specific education strategies should be considered within the context of the overall goals and recommendations in the Boone River Watershed Management Plan. Therefore, the development of education strategies should be completed after watershed goals have been finalized.

Targeted projects in sub-watershed should be developed with input from landowners, producers, and residents along with resource professionals. The process of developing targeted plans can serve as an opportunity to educate the public. Education strategies developed for current projects should be used as a starting point for new projects. Some topics to consider include:

- How conservation practices can affect the bottom line of a farm
- The availability of cost-share programs and how to access them
- Specific guidance and demonstrations on implementing each type of conservation practice
- How nutrients affect environmental, community, and human health

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