Iowa Nutrient Reduction Strategy

2018-19 Annual Progress Report

PREPARED BY
Iowa Department of Agriculture and Land Stewardship
Iowa Department of Natural Resources
Iowa State University

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SELECTED HIGHLIGHTS OF THE

2018-19 Iowa Nutrient Reduction Strategy ANNUAL PROGRESS REPORT

What are the goals of the Iowa Nutrient Reduction Strategy?

The Iowa Nutrient Reduction Strategy (NRS) directs efforts to reduce nutrients in surface water in a scientific, reasonable, and cost-effective manner. The NRS was prompted to reduce nutrient loads that are transported to the Gulf of Mexico. The plan established a goal of a 45% reduction of annual nitrogen (N) and phosphorus (P) loads. Both point sources, like wastewater treatment and industrial facilities, and nonpoint sources, like agricultural fields, are highlighted by the NRS as areas in which nutrient reduction should occur.

How do we measure progress toward NRS goals?

The NRS Annual Progress Report tracks measurable indicators within four dimensions of the NRS Logic Model – Inputs, Human, Land, and Water. To affect change in water quality, there is a need for increased inputs, measured as funding, staff, and other resources. Inputs increase outreach efforts and affect change in human attitudes and behavior; increasing conservation-oriented attitudes among farmers, landowners, point source facility operators, and other stakeholders. Changes in human attitudes and behavior influence conservation practice adoption and wastewater treatment facility upgrades, indicated in the Land category. Finally, physical changes on the land affect change in water quality, measured through both water quality monitoring and modeled estimates of nutrient loads in Iowa surface water. The measurable indicators that correspond to each category provide quantified parameters to track year-to-year changes and continual trends.

What are some of the findings and updates featured in the 2018-19 NRS Annual Report draft?

INPUTS

The total funding for NRS-related efforts in the 2018-19 reporting period – including education and outreach, research, practice implementation, and water monitoring – was an estimated $560 million. This is an increase from $512 million in the 2018 reporting period and $438 million in the 2017 reporting period. (Page 10)

In the 2018-19 reporting period, 95% of the funding directed at NRS-related efforts was appropriated through public funds, with the Conservation Reserve Program (CRP) rental payments accounting for more than half of this public funding. Five percent of total reported funding in 2019 was from private sources including landowner contributions to cost-share and non-governmental organizations. (Page 11)

HUMAN

- In the 2019 reporting period, 540 outreach events were conducted in 98 counties by partner organizations (public, private, and NGO), with a total attendance of 50,800 attendees. Total events increased from 511 in 2018, and total attendance increased from 46,000. (Page 11)
- The NRS Farmer Survey tracks farmer knowledge, attitudes, and behavior related to water quality and nutrient reduction. In the Iowa hydrologic unit code (HUC) 6 watershed, the percentage of farmers responding as knowledgeable or very knowledgeable about the NRS increased from 27 to 34% between 2015 and 2018. In that time, there has been minimal change in attitudes toward the NRS and related issues. For instance, across the surveyed watersheds, 81-84% of farmers agreed or strongly agreed that, "I am concerned about agriculture's impacts on Iowa's water quality," with no significant change in subsequent responses. Analysis of this survey is ongoing. (Page 13)

LAND – NONPOINT SOURCE EFFORTS

- Cover crops planted in Iowa increased from 379,000 acres in fall 2011 to 973,000 in fall 2016, according to the newly available 2017 United States Department of Agriculture (USDA) Census of Agriculture. Data sources for tracking cover crops since the 2017 Census are being evaluated and processed. (Page 18)
- Based on the USDA Census of Agriculture, annual corn and soybean planted acres have remained relatively consistent, averaging 22.1 million acres since the 1980s. Preliminary analyses of the USDA Cropland Data Layer suggest that perennial agricultural acres – including estimates of total net acres in pasture, hay, and acres enrolled in the Conservation Reserve Program – have decreased since 2010, with approximately 4.3 million acres in 2018. (Page 16)
- No-till acreage increased from 6.9 million acres in 2012 to 8.2 million in 2017, according to the Census of Agriculture. (Page 21)
- By the end of the 2018 calendar year, there were an estimated 27 bioreactors and 13 saturated buffers installed through cost-share programs, treating an estimated 2,000 acres or more. (Page 21)
- Iowa has 86 nitrate-removal (i.e., Conservation Reserve Enhancement Program (CREP)) wetlands that treat 107,000 acres. An additional 30 wetlands are currently under development for completion in the coming years (Page 21). Additional efforts to scale up wetland implementation include a $1.15 million grant from the Environmental Protection Agency (EPA) – Gulf of Mexico Program provided to the Iowa Department of Agriculture and Land Stewardship (IDALS) in 2019. The project will install up to six wetlands in targeted locations to improve water quality and habitat in the Middle Cedar River watershed.
- Since 2011, approximately 22.5 million feet of terraces have been constructed using state cost-share funds. These terraces treated 174,000 acres of land and reduced P losses by 40 tons in 2018. (Page 22)

LAND – POINT SOURCE EFFORTS

- One hundred and thirty-two (87%) of the 152 wastewater and industrial facilities that are a part of the NRS now have permits that require submission of a feasibility study. (Page 25)
- The NRS establishes a target of reducing total nitrogen (TN) and total phosphorus (TP) from point sources by 66% and 75%, respectively. In 2018, 20 municipalities and 22 industries met one or both of these targets. (Page 28)

WATER– MONITORING SURFACE WATER and ESTIMATING LOAD CHANGES

- Surface water monitoring is conducted statewide on an ongoing basis. (Page 34).The annual nitrate load fluctuates and is driven primarily by streamflow (Page 36). Work is ongoing to detect trends over time. Similar annual estimates for P loads from water monitoring sites are being developed.
- Between the baseline period (1980-96) and the 2006-10 period, modeled N loads increased by an estimated 5% and P loads decreased by an estimated 18%. (Pages 9)
- Since the 2006-10 period, newly implemented agricultural conservation practices have affected nutrient loads. Modeled estimates are presented on page 38. For instance, cover crops reduced N loss by 4,200 tons in 2018 and P loss by 330 tons.

To promote the goals of the NRS, what are some of the strategic and capacity-building efforts that have occurred recently?

- In 2018, the Iowa Legislature passed, and Governor Kim Reynolds signed into law, new legislation that provides more than $270 million for water quality efforts in Iowa over 12 years. (Page 40)

- Since 2013, the Iowa Nutrient Research Center (INRC) has received approximately $8.7 million in state appropriations and funded 76 water quality projects led by scientists at Iowa's three Regents Universities, with 13 of these projects awarded in 2018 and 16 in 2019. Projects address research questions identified in the NRS Nonpoint Source Science Assessment. (Page 43)

- The Iowa Water Quality Initiative (WQI) provides targeted funding and support for 15 ongoing projects, three of which began in 2015. These projects are working to address critical gaps and opportunities to scale-up adoption of a subset of conservation practices (Page 47). IDALS hired six technical support resource personnel stationed in priority watersheds and one statewide edge-of-field coordinator to help farmers, landowners, and communities add conservation practices that reduce P and N losses.

- The Clean Water State Revolving Fund (SRF) Water Resource Restoration Sponsored Projects program leverages investments made by municipalities to upgrade wastewater facilities, allowing communities and their partners to create innovative approaches to watershed protection and urban-rural partnerships. Through June 2019, the program has awarded 99 sponsored projects in 81 communities and one state park for a total commitment of $66.5 million. In the 2019 fiscal year, the program funded $1.8 million in projects for soil and sediment erosion control and $5.3 million in manure management, among various other projects dedicated to municipal and agricultural water quality management. (Page 40)

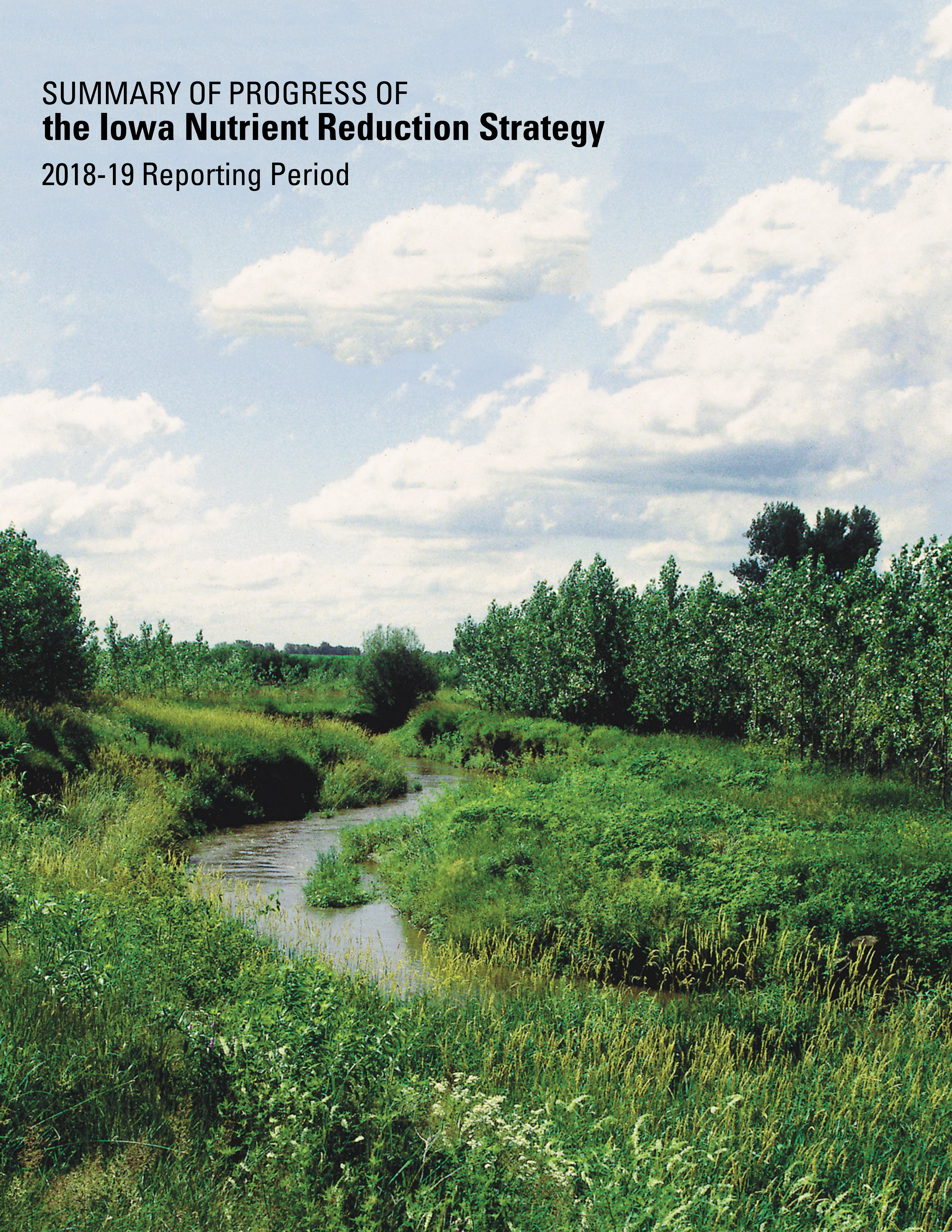
- The Conservation Infrastructure initiative was started in 2016 to help identify potential economic development opportunities associated with addressing barriers to implementing conservation practices and advancing the NRS. The expected outcomes for the Conservation Infrastructure initiative include: reduction or elimination of identified barriers of implementing the NRS, increased private sector engagement and role in delivering conservation, and increased private sector economic activity that is driven by conservation. (Page 46, Appendix A)

- The NRS measurement process continues to evolve as new data sources for tracking conservation implementation become available. In 2019, the Iowa Nutrient Research and Education Council (INREC) Survey of Agricultural Retailers provided insight into the use of various in-field practices, while the statewide BMP Mapping Project provided geospatial and temporal data on structural practices (e.g., terraces, farm ponds). The 2019 Annual Report draft highlights results from these projects and researchers are working to evaluate and integrate these data into progress-tracking efforts. (Pages 48, 50)

SUMMARY OF PROGRESS OF

the Iowa Nutrient Reduction Strategy

2018-19 Reporting Period



PART ONE:
Measured Progress of the Iowa Nutrient Reduction Strategy

INTRODUCTION

The Iowa Nutrient Reduction Strategy (NRS) is a science- and technology-based approach to assess and reduce nutrients delivered to Iowa waterways and the Gulf of Mexico. The strategy outlines opportunities for reducing nutrients in surface water from both point sources, such as municipal wastewater treatment plants and industrial facilities, and nonpoint sources, including agricultural operations and urban areas, in a scientific, reasonable, and cost-effective manner.

The NRS was developed in response to recommendations provided by the United States Environmental Protection Agency (EPA) in its March 16, 2011, memo, "Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reduction." Ongoing action for nutrient load reductions is further supported by the recent EPA recommendations, "Renewed Call to Action to Reduce Nutrient Pollution and Support for Incremental Actions to Protect Water Quality and Public Health," released September 22, 2016.

This Annual Progress Report, revised and published each year, provides updates on point source and nonpoint source efforts related to specific action items identified in the NRS. The Annual Progress Report also provides updates on statewide efforts and activities that aim to achieve reductions in nitrogen and phosphorus loads. The NRS documents, including each year's Annual Progress Report, can be accessed at www.nutrientstrategy.iastate.edu.

Partners

The NRS and the Annual Progress Report are a collaboration of representatives of the Iowa State University College of Agriculture and Life Sciences, Iowa Department of Natural Resources (DNR), and Iowa Department of Agriculture and Land Stewardship (IDALS). The Water Resources Coordinating Council (WRCC), a body of governmental agencies that coordinate water-related issues in Iowa, is presented with the Annual Progress Report each year.

Additional partners comprise the Watershed Planning Advisory Council (WPAC), which includes private and non-governmental organizations. These partners, and others outside WRCC and WPAC, voluntarily contributed valuable data that provides the basis for analysis of NRS funding, staff, outreach, practices, and water monitoring to track efforts conducted during the 2019 reporting period (June 1, 2018, to May 31, 2019).

Navigating this report

The Annual Progress Report is a compilation and evaluation of the work that partner organizations conduct toward the NRS's goal of 45% reduction of Iowa's annual nitrogen (N) and phosphorus (P) loads.

Part One presents the metrics associated with tracking progress of nutrient reduction from nonpoint and point sources, following a Logic Model approach (Figure 1). The 2015 NRS Annual Progress Report introduced a logic model framework as the basis of considerations set forth by the WRCC Measures Subcommittee. The NRS Logic Model is guided by measurable indicators of desirable change that can be quantified. It represents a progression toward goals for achieving a 45% reduction in annual N and P loads. This measurement framework assists the annual reporting process, which was recommended by the aforementioned EPA memos.

Each section of Part One explores a dimension of the NRS Logic Model – Inputs, Human, Land, and Water. A significant reduction in nutrient loads is the ultimate goal of the NRS and is represented by the right-most category of Figure 1. To affect change in water quality, there is a need for increased inputs, measured as funding, staff, and other resources. Inputs increase outreach efforts and affect change in human attitudes and behavior. This shift toward more conservation-oriented attitudes among farmers, landowners, point source facility operators, and other stakeholders is a desired change in the human dimension of water quality efforts. With changes in human attitudes and behavior, changes on the land should occur, measured as conservation practice adoption and wastewater treatment facility upgrades. Finally, these physical changes on the land should affect change in water quality, which ultimately can be measured through both empirical water quality monitoring and modeled estimates of nutrient loads in Iowa surface water. The measurable indicators that correspond to each category, outlined in Figure 1, provide quantified parameters to track year-to-year changes and continual trends.

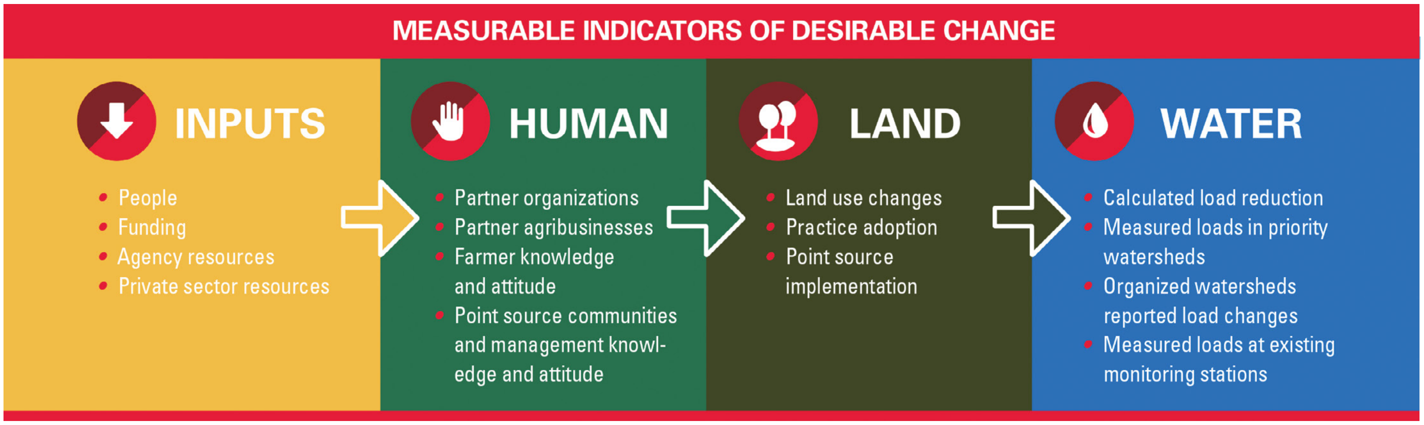


Figure 1. The Logic Model of the Iowa Nutrient Reduction Strategy, guided by measurable indicators of desirable change. (Iowa Nutrient Reduction Strategy Measure of Success Committee, Water Resource Coordinating Council)

In measuring progress of the NRS, the Logic Model serves as a comprehensive reporting tool to inform data collection, indicator development, and assessment of the successes and challenges associated with reducing nutrient loads from point and nonpoint sources. The Logic Model guides the assessment of a progression of changes and informs improvements in each of the four primary categories.

While Part One describes the indicators of nonpoint and point source nutrient reduction progress, Part Two – "Capacity Building and Strategic Work" – explains a variety of ongoing projects and programs that aim to build the capacity of partner organizations' nutrient reduction efforts in Iowa. Included in Part Two are updates on strategic work that was specifically identified in the original NRS documents.

Challenges associated with measuring change

Measuring NRS progress is a complex undertaking that is accompanied by a variety of challenges, a few of which are outlined here. First, measurable indicators that direct change toward the end-goal must be identified and refined. In the case of the NRS, measurement efforts assess a wide variety of factors that are impacted by many stakeholders. In an effort to develop indicators that represent meaningful change in each logic model category, each indicator was evaluated based on:

- Data availability
- Trends or year-to-year changes that can be used to evaluate progress
- Whether the indicator can inform decision-making and program delivery if progress is not made.

Data availability to accurately assess progress in each category of the logic model is a primary hurdle. For example, past analyses relied on governmental conservation program (i.e., cost-share) data to evaluate conservation practice adoption on agricultural land. Due to the recent availability and future availability of various data sources that are not cost share-specific, there is a growing understanding of the extent to which farmers employ conservation beyond the use of public financial assistance. This growing understanding is driven by data collection efforts that began in 2015 to evaluate the extent of conservation practice use that occurs outside government assistance programs. For instance, the development of a survey of agricultural retailers and co-ops was completed in 2018 and initial results – representing the 2017 and 2018 crop years – have informed analysis of in-field practices for this report. In addition, data collection for the BMP Mapping Project, which quantifies the existence of structural agricultural practices, was completed in 2019, and analysis of the data is in progress. The NRS measurement process involves continual evaluation of new and emerging data sources to assess their utility, validate their results, and integrate them with existing data sources to better understand progress toward NRS goals. The evaluation of data sources relies on consultation with researchers and experts at public agencies and universities in Iowa. Efforts to process new data sources and integrate them with previously used datasets were conducted in 2019. Integrating disparate data sources comes with its own challenges. The variety of data sources employed by the NRS Measurement Project exhibit different characteristics in terms of spatial and temporal scale. Some sources are collected to reflect field-level conservation use (e.g., the United States Department of Agriculture (USDA) Cropland Data Layer), while others reflect large watershed or statewide scale parameters (e.g., the Iowa Nutrient Research and Educational Council (INREC) In-Field Practice Survey). Similarly, some data sources are made available every five years (e.g., the USDA Census of Agriculture), while others reflect annual change (e.g., the NRS Farmer Survey).

A sufficient period of record also is needed to evaluate progress. In complex, natural systems, it can be difficult to distinguish trends over a short period of time. As an example related to the "Water" dimension of the NRS Logic Model, in a high-precipitation year, nutrients in surface water are elevated due to exceptionally high streamflow. Conversely, in a drought year, nutrients may appear to be well controlled due to low streamflow. It will take a multi-year or multi-decade period of record to get an accurate handle on progress by detecting an overall trend in what can be highly variable data.

Indicators of each Logic Model dimension and their related data sources are continually under evaluation and may be subject to change in the future.

Baseline and benchmark nutrient loads for assessing progress

Progress of the NRS is measured against the average annual total N and P loads that occurred during the 1980-96 time period (Figure 2). This baseline period is consistent with the goals set forth by the Gulf of Mexico Hypoxia Task Force, which stated in its 2008 Gulf of Mexico Action Plan that reductions "measured against the average load over the 1980-1996 time period, may be necessary."

Table 1 provides estimates of annual total N and P loads from Iowa over this baseline period by summarizing the results detailed in the two studies: "Assessment of the Estimated Non-Point Source Nitrogen and Phosphorus Loading from Agricultural Sources from Iowa During the 1980-96 Hypoxia Task Force Baseline Period," and "Nitrogen and Phosphorus Load Estimates from Iowa Point Sources During the 1980-96 Hypoxia Task Force Baseline Period." Both studies are available at www.nutrientstrategy.iastate.edu/documents. A brief summary of the studies' methods and results is also available at the same web page.

Table 1. Baseline (1980-96) and benchmark (2006-10) average annual loads from nonpoint sources (NPS) and point sources (PS).

		1980-96 Baseline Load (tons)	2006-10 Benchmark Load (tons)	Change, 1980-96 to 2006-10	
Nitrogen	NPS	278,852*	293,395	5.2%	INCREASE
	PS	13.170	14,054	6.7%	INCREASE
	Total	292,022	307,449	5.3%	INCREASE
Phosphorus	NPS	21,436	16,800	21.6%	DECREASE
	PS	2,386	2,623	9.9%	INCREASE
	Total	23,822	19,423	18.5%	DECREASE

*The method used to derive the total nitrogen estimate of 292,022 tons indirectly reflected the point source contributions.

Informally, progress also is measured against the annual total N and P loads that occurred during the 2006-10 time period, which serves as a benchmark time period just prior to the development of the NRS. This time period was utilized during development of the NRS Nonpoint Source Science Assessment and the Point Source Technology assessment, due to the availability of data at the time.

INPUTS

Inputs are an early indicator of change in Iowa's efforts to reduce nutrient loading within the state and further downstream. Increases in inputs, particularly funding, are necessary to expand Iowa's capacity for encouraging and realizing changes in human behavior, and for promoting and paying for conservation and water quality improvement. Targeted inputs toward specific facets of NRS work may be required to have an effect on the goals set forth by the NRS. For instance, focusing funding in specific watersheds or communities, and prioritizing nutrient reduction practices that are highly effective or that require additional incentives, are targeting strategies that occur within various programs. Due to data availability, though, this report aims to provide an overview of statewide funding and staff resources that are dedicated to NRS implementation.

Figure 2. Conceptual timeline of the 1980-96 baseline, the 2006-10 benchmark, and selected subsequent events in the history of the Iowa Nutrient Reduction Strategy (NRS).

Funding

The total funding for NRS-related efforts in the 2019 reporting period – including education and outreach, research, practice implementation, and water monitoring – was an estimated $560 million. This is an increase from $512 million in 2018 and $438 million in 2017 (Figure 3). These estimates encompass both public and private funding and were estimated from the voluntarily submitted reports of WRCC and WPAC member organizations and by other partner organizations that conduct work contributing to NRS implementation. The majority of public programs described in this report are considered base programs and have, in general, been in existence for decades. In addition, these estimates include the farmer and landowner contribution to the implementation of cover crops, terraces, water and sediment control basins (WASCOBs), and grade stabilization structures that received cost-share funding; other practices were not included due to insufficient financial cost-share data. This is due to the relative assurance of quantifying investments for the subset of practices based on currently available datasets. Finally, these annual estimates do not account for the investments made by private entities, farmers, or landowners for practices financed entirely outside of cost-share programs.

MEASURING PARTNER EFFORTS

Beginning in the 2015 reporting period, organizations affiliated with the Water Resources Coordinating Council (WRCC) and the Watershed Planning Advisory Council (WPAC) reported their NRS-related funding and efforts to be included in the annual report.

This data collection method was continued, but adapted, in the 2016 reporting period. Since 2016, funding, staff, outreach efforts, and monitoring efforts have been collected annually through this adapted, standardized data entry process. This method reduced duplication of reported inputs and efforts that are performed collaboratively. For example, a grant that was disbursed by one organization and awarded to another may be reported by both organizations, but double-reporting was minimized by obtaining specific information about different funding sources. Similarly, data on outreach events that were held by two or more partner organizations were evaluated to prevent double-counting of one event.

Distilled information from these partner reports is used for measuring progress of inputs and outreach in this annual report. Additionally, the full partner reports, including each organization's overview of its NRS efforts, are provided in Part Three of this report.

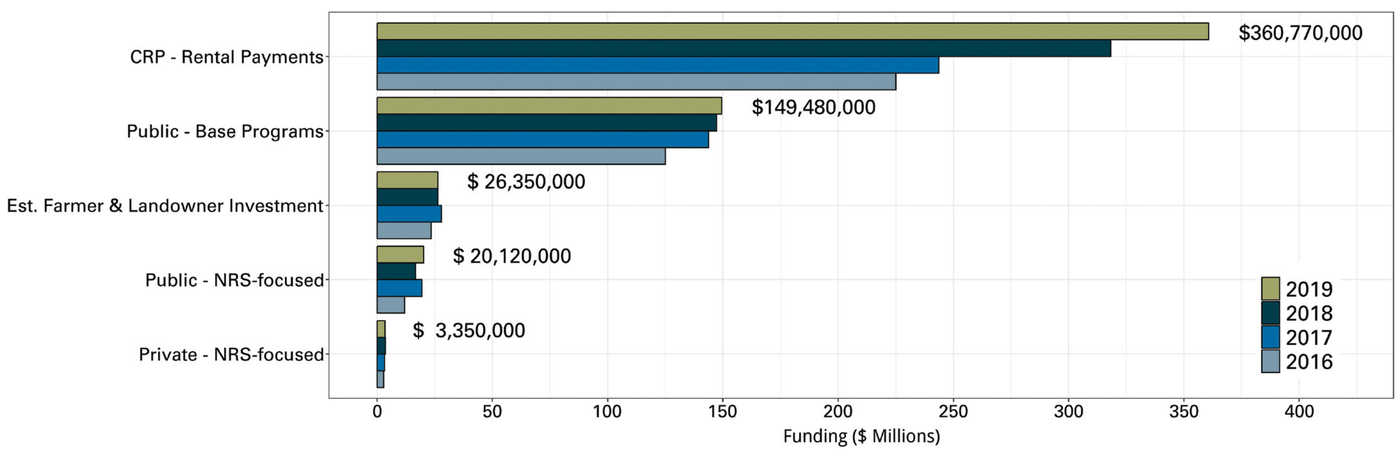


Figure 3. Funding obligated for NRS efforts by partner organizations in the 2016 through 2019 reporting periods. The dollar figures that are inset within the chart indicate the funding obligated by each funding source during the 2019 reporting period. The "public base programs" category captures public conservation programs that were in place prior to the start of the Iowa Nutrient Reduction Strategy. Farmer and landowner investment accounts only for investment in cover crops, terraces, water and sediment control basins (WASCOBs), and grade stabilization structures that received cost-share funding. Efforts to expand this analysis of farmer investment are underway, so these estimates likely will change in future reports. The "Public - NRS-focused" category captures public programs initiated in response to the Iowa Nutrient Reduction Strategy or similarly timed efforts. The "Private - NRS-focused" category captures funding obligated by private organizations in response to the Iowa Nutrient Reduction Strategy.

Funding contributed by public agencies and private organizations

Of the total reported funding for the 2019 reporting period, 95% was appropriated through public funds. Conservation Reserve Program (CRP) rental payments accounted for more than half of this public funding, at about 64% of total funding. This proportion was about the same in 2018, at 62%. This suggests the increase in total NRS funding was driven by the increase in CRP rental payments. Five percent of total reported funding in 2019 was private – landowner contribution to cost-share or funding reported by private and non-governmental organizations – though the landowner contribution to conservation practice implementation is underestimated.

It is vital to note most public funding comes from sources that could be considered "base" programs. These programs were in place for many years before the NRS was initiated. Efforts to optimize manure management, reduce soil loss, monitor streams, and maintain many other long-term conservation activities have occurred in Iowa for decades; these programs were established to address single or multiple resource concerns and should not be solely evaluated on how these address or measure nutrient loss. It may be necessary for additional resources to be made available from a variety of sources – public and private – that target and launch innovative NRS efforts in order to advance towards meeting NRS goals. Public programs that are NRS-focused (i.e., implement newly established NRS efforts or were developed in response to the NRS or similar natural resources needs) increased from 2016 to 2017 by about $7.5 million, decreased by approximately $2.7 million from 2017 to 2018, and increased again by $3.4 million in 2019.

While the level of public funding for NRS implementation in the 2018 reporting period accounts for the vast majority of total funding, non-governmental partners reported approximately $3.4 million of private funding for NRS efforts during this past reporting period, a slight decrease from $3.7 million in the 2018 reporting period. Much of this funding was sourced from commodity check-offs and organizations' membership dues.

There are various sources of funding that are anticipated to be available in the next few years. Descriptions of these anticipated funding sources are provided on page 40.

HUMAN

Inputs are applied to affect change in nutrient loads, which will require widespread adoption of conservation practices to reduce nutrient loss from nonpoint sources. In order to implement nutrient reduction practices and cut N and P loss by 45%, attitudes of people must first shift to affect a change in behavior related to water quality.

A variety of factors have been analyzed to measure the progress of human attitudes related to the NRS and conservation in general. First, the annual extent of education and outreach by partner organizations is discussed, which was quantified as the number of events conducted during the reporting period. Second, farmer awareness, attitudes, and perspectives on the NRS are discussed as a metric for the potential for conservation adoption.

Changes in public education and outreach

Outreach and education events

Outreach and education events that partner organizations held during the 2019 reporting period reflect the collective efforts to spread awareness and educate the public about nutrient reduction options for water quality improvement.

In the 2019 reporting period, 540 outreach events were conducted by partner organizations, with a total attendance of 50,800 (Table 2). Total events increased from 511 in 2018, and total attendance increased from 46,000. Figure 4 indicates that, across most of the

Table 2. A summary of the education and outreach events held by partner organizations during the 2019 reporting period, which is defined as June 1, 2018, to May 31, 2019.

	Number of Events	Average Attendance	Total Reported Attendance
Conference	9	98	882
Community Outreach	130	95	12,070
Field Day	154	53	7,938
Workshop	51	34	1,693
Youth and School Visit	196	144	28,221
Supplemental Workshop Topic	653	23	14,883
TOTAL	540		50.804

categories of events, outreach has increased since the 2016 reporting period, when events were first tracked; however, the increase over time has fluctuated. The extent of total outreach across all categories has increased annually.

These events, which provide information to make informed decisions about conservation practices and educate attendees about water quality issues, were self-reported by WRCC and WPAC member organizations, and include five general categories:

- Conferences, which facilitate knowledge-sharing, networking, and partnering.
- General community outreach, including fairs, tours, and other community events.
- Field days, which often serve to educate farmers, landowners, and agribusiness representatives.
- Workshops, which entail training in a particular skill or topic area related to nutrients and water quality.
- Youth education, which focuses on spreading understanding about natural resource and watershed issues through K-12 educational programming.
- Supplemental workshop topics – an additional category of events quantified for this report – include training sessions that were focused on issues other than nutrient loss but contained intentional curriculum related to nutrients and water quality. For instance, a large number of pesticide applicator training sessions in 2018 and 2019 included training for saturated buffers and perennial establishment.

These results suggest that, overall, the outreach that focuses on NRS topics increased slightly during the last reporting period, based on the self-reported data partner organizations submitted. Certain areas of the state, particularly central Iowa, receive more outreach than other areas (Figure 5). There was a similar geographic distribution of outreach events in the 2017 and 2018 reporting periods. Efforts are underway to identify geographic areas of the state that, over time, received the most attention in these efforts, and which areas still require increased attention. In addition, as annual data are collected, there is opportunity

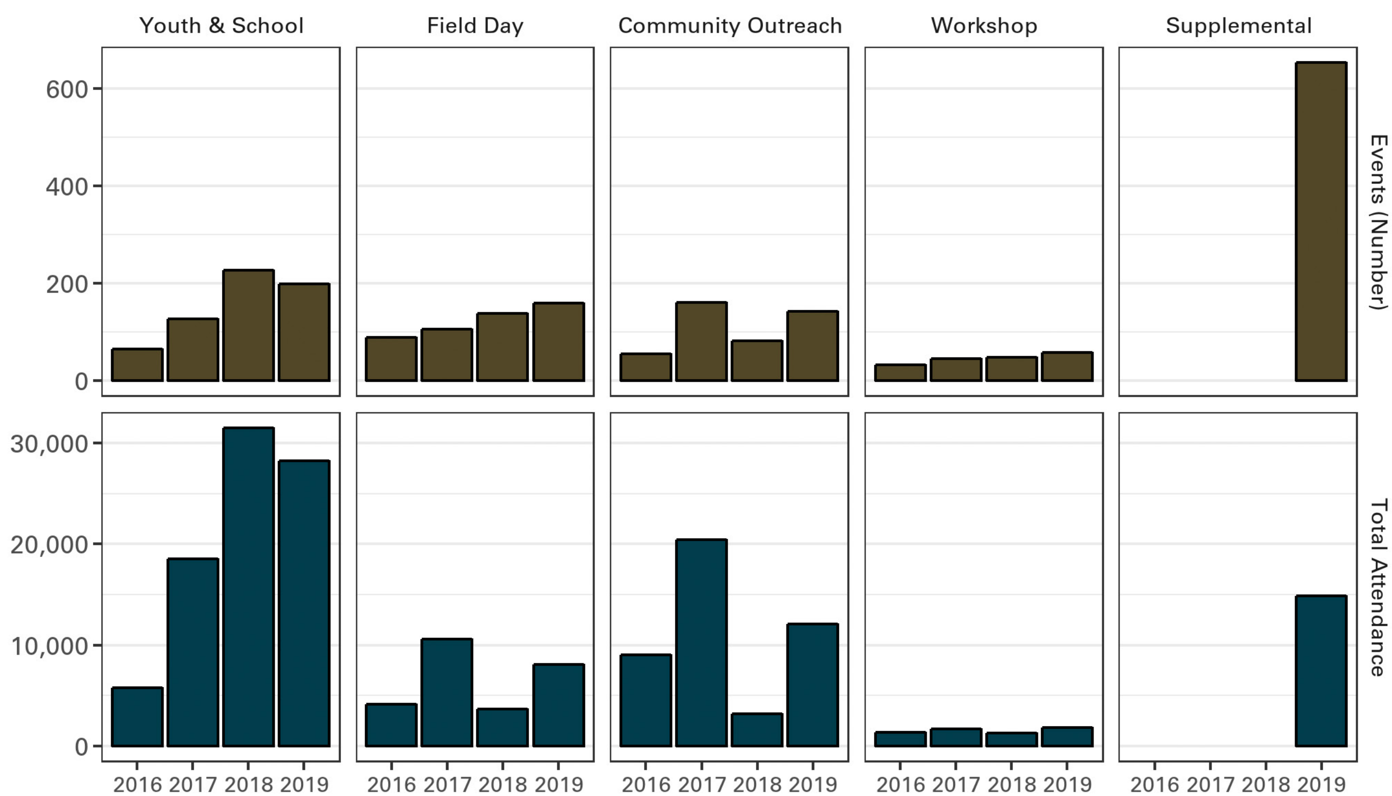


Figure 4. The annual events and total attendance within each category of outreach events reported by partner organizations. The "Supplemental" category represents a set of recent workshops that were focused on broader subject areas but contained some specific training on nutrient-related topics, as an attempt to expand outreach and education.

for greater understanding of the outcomes of increased outreach in local areas. NRS measurement efforts have begun to compile the data that are necessary to conduct preliminary analyses of these research questions.

Farmer knowledge and attitudes concerning nutrient reduction

The NRS Farmer Survey – an ongoing, five-year (2015-19) project – aims to understand Iowa farmers' awareness of and attitudes toward the NRS, and their conservation behavior related to nutrient loss. The project is implemented through an annual semi-longitudinal survey that covers six hydrologic unit code-6 (HUC6) watersheds. Each of these HUC6 watersheds contains one or more HUC8 watersheds that have been identified as NRS "priority watersheds" (Figure 6). Random samples of farmers were drawn at the watershed level from the population of farmers who operate at least 150 acres of row crops (i.e., corn or soybean).

Tracking changes in knowledge and attitudes

In the Iowa HUC6 watershed, where farmers are surveyed every year and for which four years have been analyzed, farmers showed an increase in knowledge about the NRS. The percentage of farmers who responded they are knowledgeable or very knowledgeable increased from 27% to 34% (Table 3). Those who responded they have little or no knowledge decreased from 31% to 26%.

In the other watersheds for which analysis has been conducted – the Missouri-Little Sioux and the Upper Mississippi-Maquoketa-Plum – there was no measurable change in knowledge across two years (Table 3). These results suggest annual change is incremental and additional years of surveys may be necessary to detect the rate of knowledge change.

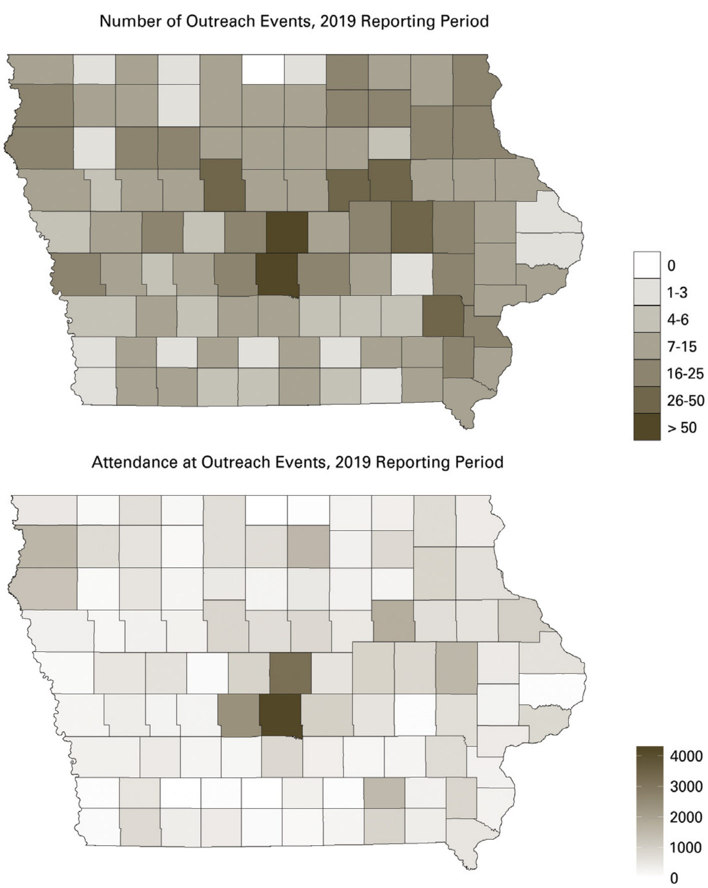


Figure 5. The distribution of outreach events and attendance at those events conducted by partner organizations during the 2019 reporting period.

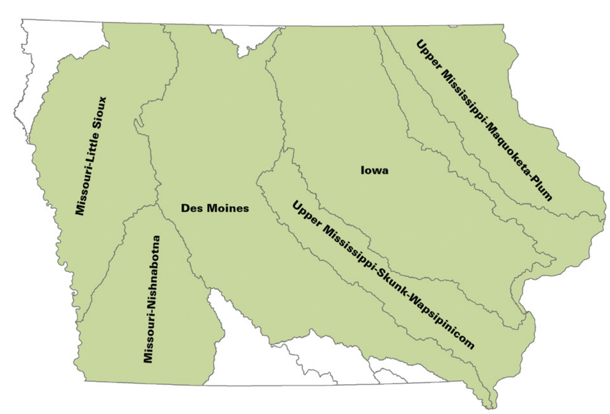


Figure 6. Map displaying the sampled watershed areas of the Iowa Nutrient Reduction Strategy Farmer Survey.

Table 3. Selected results from the Iowa Nutrient Reduction Strategy Farmer Survey, conducted in various HUC6 watersheds from 2015 to 2019. The NRS Farmer Survey tracks farmers' knowledge, attitudes, and behavior related to nutrient reduction.

HUC6 Watershed	Years Sampled	Change in Knowledge	Change in Attitudes
Iowa	2015 to 2019	From 2015 to 2018, the percent of farmers indicating they were knowledgeable or very knowledgeable rose from 27% to 34%. Those indicating they were not at all knowledgeable or slightly knowledgeable fell from 31% to 26%. Analysis of 2019 data is in progress.	There was minimal change in farmers' attitudes toward the Iowa Nutrient Reduction Strategy and related issues. As an example, 82% agreed or strongly agreed that "I am concerned about agriculture's impacts on Iowa's water quality".†
Missouri-Little Sioux	2015 and 2016	From 2015 to 2016, there was no significant change in knowledge, with 30% indicating they were knowledgeable or very knowledgeable, 29% indicating they were not at all knowledgeable or slightly knowledgeable, and 31% indicating they were somewhat knowledgeable.	There was no change in farmers' attitudes toward the Iowa Nutrient Reduction Strategy and related issues. As an example, 84% agreed or strongly agreed that "I am concerned about agriculture's impacts on Iowa's water quality".†
Upper Mississippi-Maquoketa-Plum	2016 and 2017	From 2016 to 2017, there was no significant change in knowledge, with 27% indicating they were knowledgeable or very knowledgeable, 29% indicating they were not at all knowledgeable or slightly knowledgeable, and 43% indicating they were somewhat knowledgeable.	There was minimal change in farmers' attitudes towards the Iowa Nutrient Reduction Strategy and related issues. As an example, 81% agreed or strongly agreed that "I am concerned about agriculture's impacts on Iowa's water quality".†
Des Moines	2017 and 2018	Analysis in progress	Analysis in progress
Missouri-Nishnabotna	2018 and 2019	Analysis in progress	Analysis in progress
Upper Mississippi-Skunk-Wapsipinicon	2019	Analysis in progress	Analysis in progress

†For additional results related to attitudes about the NRS and nutrient reduction issues, see the individual watershed reports at www.nutrientstrategy.iastate.edu/documents.

Similarly, there was relatively little change in attitudes across all watersheds.

Factors that affect cover crop adoption and experiences

Cover crops are a nutrient reduction practice that is heavily promoted through public water quality programs. For this reason, and because cover crops can feasibly be applied in any region or topography of Iowa's farmland, some studies on farmers' conservation attitudes have centered on cover crop adoption.

Data from the NRS Farmer Survey (described in the preceding subsection) was used to explore the causal factors that increase or decrease the likelihood farmers will adopt cover crops. The study found participation in watershed activities and the receipt of cost-share or technical assistance had strong positive effects on cover crops use. Information and influence from public sector entities had moderately positive indirect effects on cover crop use, by affecting farmers' knowledge and attitudes of nutrient reduction issues. These results shed light on the factors that affect Iowa farmers' likelihood of adopting cover crops, and are consistent with the broader research literature on agricultural conservation adoption. Examination of this survey's data continues, and will inform existing outreach programs and incentive approaches.

Land: Implementation of Nonpoint Source Nutrient Reduction Efforts

This section describes the extent of practices implemented for the reduction of N and P loss from nonpoint sources. This portion of NRS progress measurement is a tool for examining voluntary participation by the Iowa agricultural sector in nutrient reduction efforts[1].

Effectiveness of conservation practices for reducing nutrient loads

There are a variety of nonpoint source practices that address nutrient loss. These comprise general categories: land use change, in-field management, and edge-of-field and erosion control. Land use change from annual row crops to extended rotations, perennial cropping systems, or agricultural land retirement are, generally speaking, a highly effective method for reducing the loss of nutrients from agricultural land. Land use change can occur in a variety of ways. First, broadly speaking, alternative crops or agricultural products may be produced, which require an economic market for those products. Second, land may be retired from row crops to non-agricultural perennials, such as prairie, which takes cropland out of production. Third, targeted areas within agricultural fields may be converted to non-row crop purposes as a means of maximizing profitability while addressing nutrient loss concerns. For instance, a less productive portion of a corn-soybean field may be converted to a perennial crop or pasture, potentially providing both economic and environmental benefits by reducing inputs and optimizing outputs.

Opportunities for nutrient loss reduction also exist in edge-of-field treatments and in-field management practices (Figure 7). These practices mitigate nutrient loss while keeping agricultural land in production. In-field practices for nutrient reduction comprise management techniques that are implemented on an annual basis for row crop production, such as cover crops, tillage reduction, and in-field nutrient (i.e., fertilizer) management. In-field nutrient management practices, such as reduced N application rates, tend to demonstrate a more modest nutrient reduction potential than do cover crops, tillage reduction, land use change, and edge-of-field practices, but are typically implemented with lower up-front financial investment. In-field practices must be conducted annually on an ongoing basis to achieve sustained nutrient loss reductions; with the exception of equipment investments, the costs for inputs, seed, and labor must be invested each year. Thus, management practices are assessed for annual change over time, not accumulated acres across several years.

Finally, edge-of-field and erosion control practices show high effectiveness in reducing nutrient loss. These practices are structural installations (e.g., terraces, bioreactors, wetlands) and exhibit a lifespan of a decade or more. As a result, while these practices reduce impacts substantially from continued row crop production, these require high up-front financial investment and support from engineers, construction professionals, and landowners. This investment, though, provides nutrient reduction benefits for the lifespan of the practice, as long as the practice is properly maintained and managed. Ultimately, a specialized suite of practices – land use change, in-field management, and edge-of-field – that addresses the variety of local resource concerns is necessary for any operation or watershed.

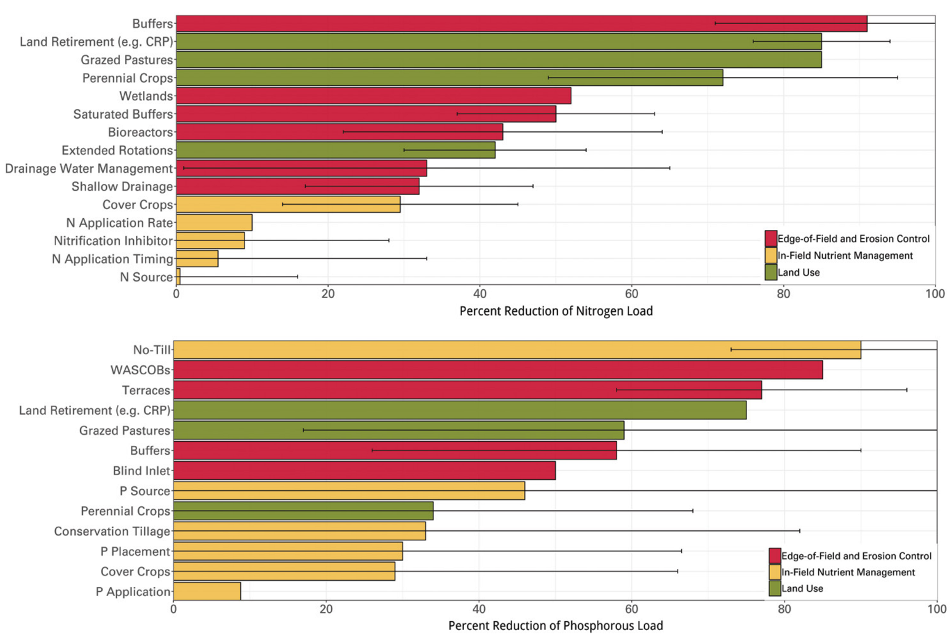


Figure 7. The effectiveness, presented as mean percent reduction of nitrogen and phosphorus loads, of conservation practices that have been approved for the Iowa Nutrient Reduction Strategy. Error bars represent one standard deviation above and below the mean. For some practices, scientific literature suggests a standard deviation larger than the mean reduction, representing high variability in measured effectiveness; review of recent literature is ongoing.

[1]There is a role for participation by urban residents and sectors as well (see pages 40-41), although urban practices for nutrient reduction are pending evaluation for inclusion in the NRS Science Assessment, so are not tracked in this report.

Land use change

Iowa's land use in 2018 and historically

Iowa's total land area is 35.7 million acres[2]. The state's land is dedicated primarily to agriculture; total agricultural land – as reported by the USDA Census of Agriculture – has averaged 33 million acres since 1920, with a range of 30.6 million acres in 2012 to 34.5 million acres in 1945 (Figure 8). Thus, over 90% of Iowa's total land area is dedicated for agricultural purposes. The land area dedicated to field crops – corn, soybean, and other annual and perennial crops – has remained relatively steady since 1920, averaging 26.6 million acres. During that time, statewide pasture acres have decreased from a high of 11 million acres in 1935 to a low of 2.5 million acres in 2012.

With a decline in pasture came a redistribution of cropland use. In 1935, pasture acres briefly exceeded corn acres. An abrupt reversal occurred in 1940; corn, and then soybean acres, climbed, while pasture, oat, and hay acres declined. Wheat and other small grains have experienced little production in Iowa over the last 50 years (Figure 8). Shifts away from these grains in the mid-20th century occurred as animal-powered production became obsolete.

There are some key implications of this land use history as it pertains to nutrient loss. First, the increase in corn and soybean production coincided with the declining production of extended rotations and pasture. Second, annual field crops like corn and soybean rotations leave farm fields vulnerable to N and P loss, particularly in the spring during the pre-plant period and just after planting, and in the fall after harvest, due to the lack of growing roots and surface cover to protect the soil surface. Third, while fluctuations in total corn and soybean acres occur from year to year, these two crops have dominated Iowa's landscape for the last 50 years or more.

Agricultural land use change, 1980 to 2018

Over the last few decades, increasing acres of corn-soybean and corn-corn systems has occurred alongside an overall loss of extended rotations, small grains, and pasture and hay. Between the 1980-96 baseline period and the 2006-10 benchmark period (Table 1), an increase in corn and soybean acres caused a 5% increase in statewide N loads. This increase in row crop acres also impacted P loss, but those impacts were mitigated by extensive soil conservation efforts, resulting in a 19% decrease in annual P loads. Since the 2006-10 benchmark period, the upward trend of annual row crop acres has continued. Table 4 provides a summary of information collected to quantify changes in land use.

Table 4 and Figure 9 display the acres of corn, soybean, and their respective crop rotations that are drawn from three separate data sources: the USDA National Agricultural Statistics Service (NASS), the USDA Farm

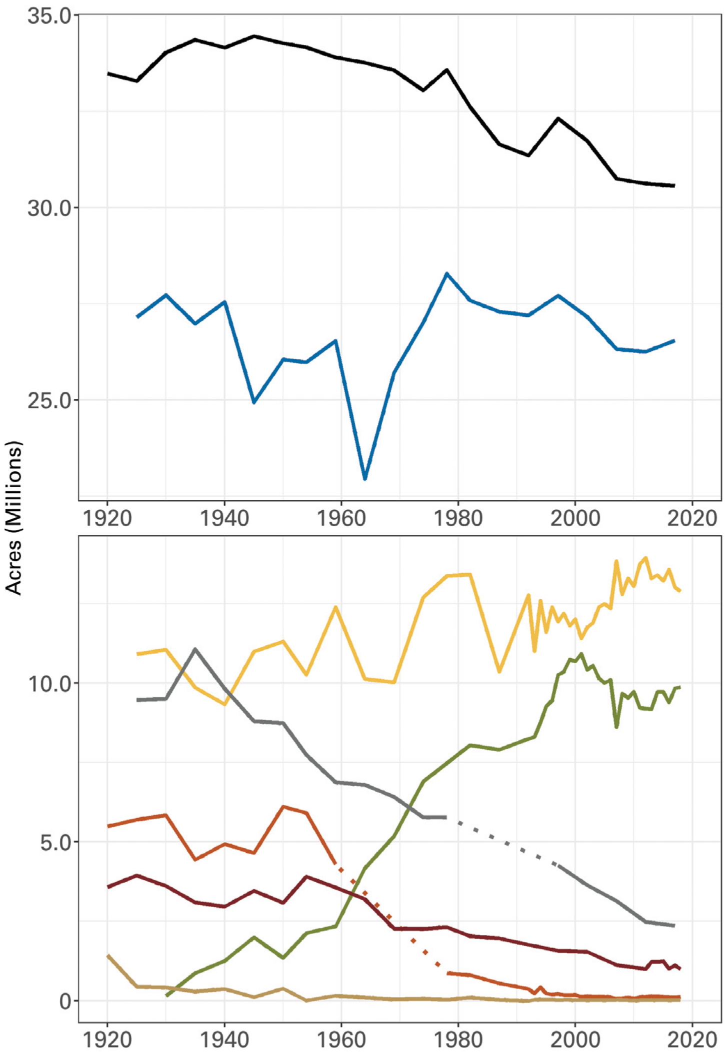


Figure 8. Iowa agricultural land use and major crop acreages from 1920 to 2018, as reported by the USDA Census of Agriculture and by the Farm Service Agency. Dotted lines represent periods of insufficient data. The post-1992 fluctuations in corn and soybean acres are attributed to the availability of annual data; prior to 1992, census data at intervals of approximately five years were used.

[2]www.census.gov/quickfacts/table/PST045216/19

Service Agency (FSA), and the USDA Cropland Data Layer (CDL). These data sources utilize different methodologies for determining annual land use. NASS operates surveys on land use and land management, and adjusts and validates its results using other data sources, including the FSA database. The FSA utilizes farmer-reported data for individual fields, centered around farmer and landowner participation in USDA programs. The CDL is geospatial data derived from satellite imagery to estimate land use. Each source provides valuable and distinct information, but each has limitations. For example, NASS and FSA data are based on annual, aggregate information, which isn't conducive to changes by field which would allow for rotation or other analyses. Efforts to evaluate, compare, and adequately employ these data sources for tracking indicators of land-use change and its impacts on nutrient loads will continue. Due to some discrepancies in total aggregated crop acreages across data sources, analysis is currently being conducted to determine and evaluate a process for reliably tracking land use change and its impacts on nutrient loads.

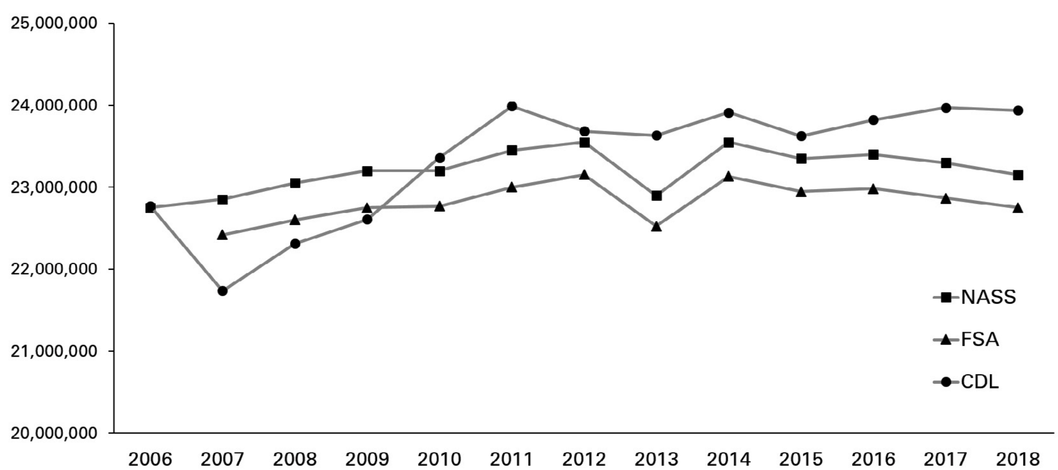
With the availability of geospatial data provided through the CDL, the use of specific crop rotations can be assessed. For the NRS Nonpoint Source Science Assessment, USDA researchers examined the five-year period from 2006-10 and classified 30-meter pixels of Iowa's agricultural land as corn-soybean, continuous corn, extended rotations, or pasture and hay, determined by the progression of crops during the five-year period. In 2019, this analysis was refined and included an assessment of the crop rotation within each agricultural field boundary (instead of individual pixels) during the 2006-10 period and, for comparison, the 2014-18 period.

Since the 2006-10 benchmark period, corn-soybean rotations have increased from 16.4 million acres to 18.6 million acres, and continuous corn operations have

Table 4. The corn and soybean acreages reported by three data sources maintained by the United States Department of Agriculture: the National Agricultural Statistics Service (NASS), the Farm Service Agency (FSA), and the Cropland Data Layer (CDL). CDL acreages are processed as the dominant crop within field boundaries, which is described on pages 17-18.

	1982	1987	1992	1997	2002	2007	2012	2017
Corn								
NASS	13,750,000	10,400,000	13,200,000	12,200,000	12,200,000	14,200,000	14,200,000	13,300,000
FSA	-	-	-	-	-	13,946,009	13,949,340	13,024,474
CDL	-	-	-	-	-	13,585,205	14,014,457	13,788,944
Soybean								
NASS	8,470,000	7,950,000	8,200,000	10,500,000	10,450,000	8,650,000	9,350,000	10,000,000
FSA	-	-	-	-	-	8,474,500	9,202,421	9,841,356
CDL	-	-	-	-	-	8,151,430	9,157,857	10,180,211
Corn-Soybean Rotation								
CDL	-	-	-	-	-	-	16,590,438	18,248,250
Continuous Corn Rotation								
CDL	-	-	-	-	-	-	4,295,658	4,490,112

Figure 9. Annual sums of planted corn and soybean acres based on three data sources: the USDA National Agricultural Statistics Service (NASS), the USDA Farm Service Agency (FSA), and the USDA Cropland Data Layer (CDL). The CDL estimates are processed as the acres of fields with corn or soybean as the dominant crop; for more information on this procedure, see page 17.



increased from 4 million acres to 4.3 million acres (Figure 10). During the same period, extended rotations have decreased from 2 million acres to 940,000 acres, and pasture, CRP, and hay have decreased from 5.4 million acres to 4.3 million acres. The use of geospatial data provides the capacity to estimate, on a field scale, the quantity of acres that shifted from one rotation to another. Between the 2006-10 and 2014-18 periods, this analysis shows a net shift of 244,000 acres of continuous corn, 917,000 acres of extended rotations, and 636,000 acres of pasture and hay toward corn-soybean rotations. A net shift of 212,000 acres of extended rotations and 152,000 acres of pasture has gone toward continuous corn. Finally, 97,000 acres of pasture and hay have shifted toward extended rotations.

This analysis provides important context for understanding changes in the use of various agricultural rotations in Iowa; however, it fails to account for sub-field land use change and shows some discrepancies with overall land use data from FSA and NASS. This field-level assessment does not always capture the incorporation of grassed waterways, buffers, and turn-rows, or the conversion of other areas within a field. Thus, the quantification of sub-field land use changes is a data gap that will be explored further in future research.

This analysis was conducted in each period using the same geospatial framework of agricultural field boundaries, so the increases in rotations of corn-soybean and continuous corn were not driven by a change in total agricultural land (e.g., shifts from non-agricultural uses to agricultural uses). Thus, the sum of all agricultural fields within this analysis is constant.

These changes in land use have not occurred uniformly across the state. Figure 11 displays the percent change of these crop rotations in each HUC8 watershed, while Figure 12 shows the absolute change in acres. The loss of extended rotations, pasture, and hay has occurred primarily in the southern and northeastern areas of the state. As a result, increases in corn-soybean and continuous corn rotations have occurred in the same areas.

In-field practices for reducing nutrient loss

Cover crops

The NRS Nonpoint Source Science Assessment found that cover crops reduce N loads by 28-31% and P loads by 29%. The extent of this practice's implementation has experienced growth in recent years. USDA estimated that 973,000 acres were planted in fall 2016, an increase from the 379,000 acres the USDA Census of Agriculture measured in fall 2011.

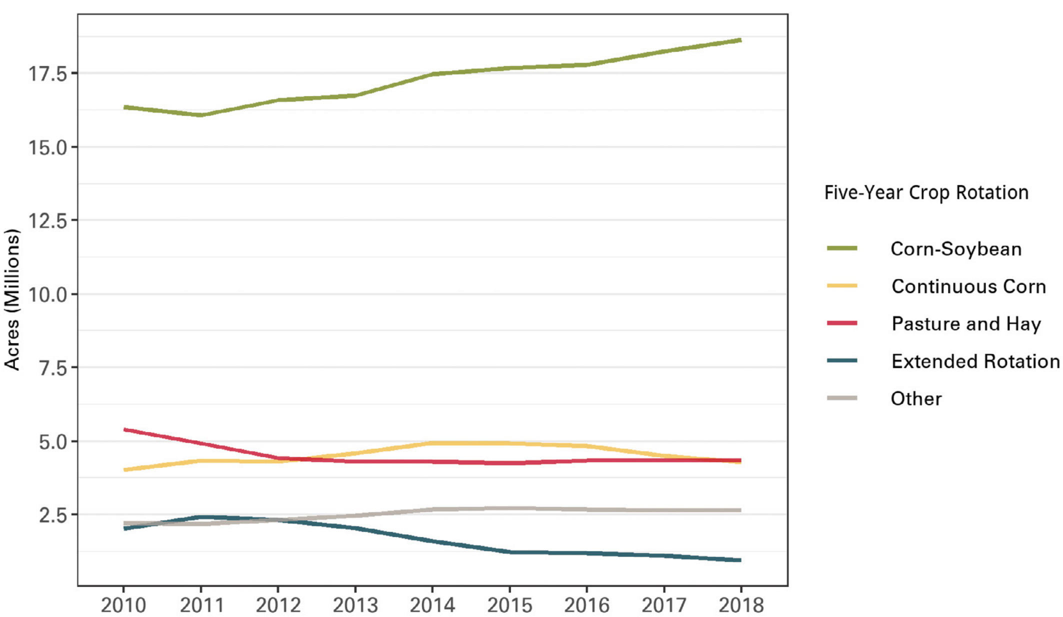


Figure 10. Annual acres of crop rotations in Iowa agricultural fields, as a rolling five-year period. The x-axis labels the final year of each five-year period. For instance, "2010" represents the 2006-10 time period, while "2018" represents the 2014-18 time period. Data source: United States Department of Agriculture Cropland Data Layer.

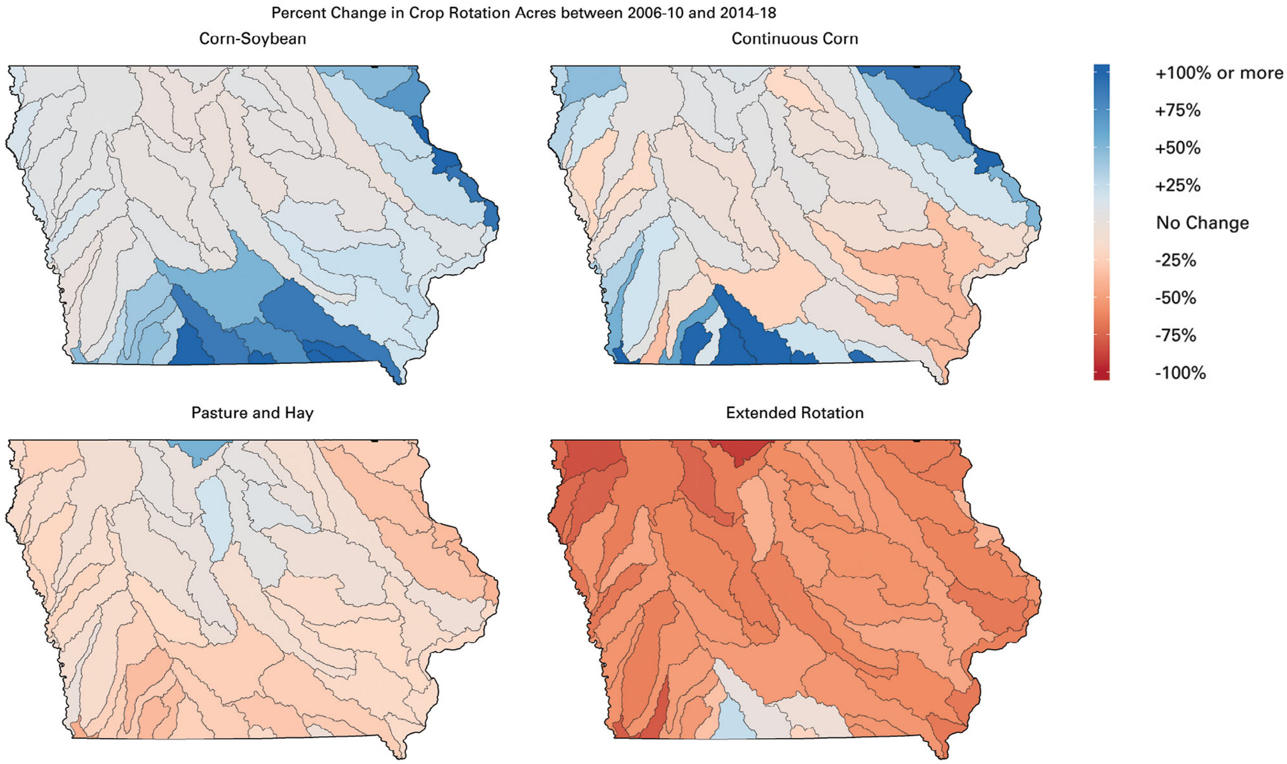


Figure 11. Heat maps displaying the percent change in acres of four crop rotations: corn-soybean, continuous corn, pasture and hay, and extended rotations. The percent change for each type of crop rotation compares the 2014-18 time period to the 2006-10 time period, with the latter representing the benchmark time period for the Iowa Nutrient Reduction Strategy, established during the development of the INRS Nonpoint Source Science Assessment. The pasture and hay category includes Conservation Reserve Program acres.

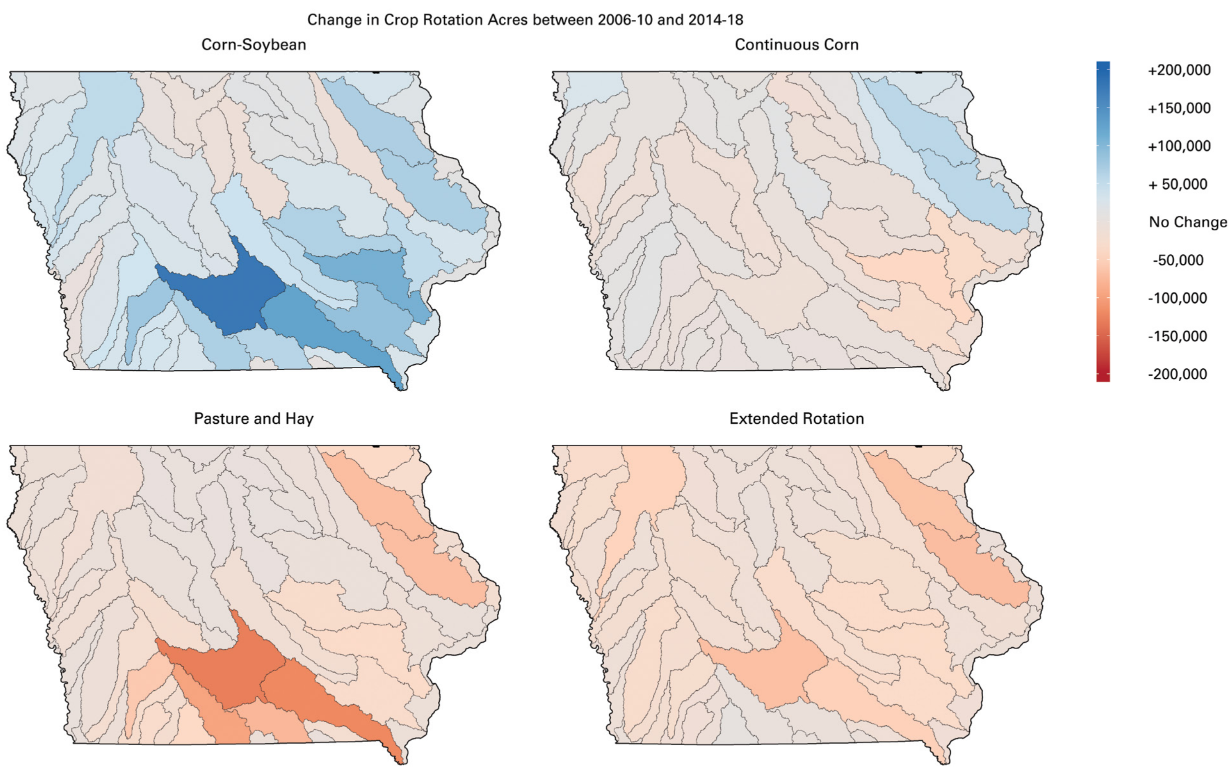


Figure 12. Heat maps displaying the absolute change in acres of four crop rotations: corn-soybean, continuous corn, pasture and hay, and extended rotations. The acreage change for each type of crop rotation compares the 2014-18 time period to the 2006-10 time period, with the latter representing the benchmark time period for the Iowa Nutrient Reduction Strategy, established during the development of the INRS Nonpoint Source Science Assessment. The pasture and hay category includes Conservation Reserve Program acres.

Figure 13 displays the density of cover crop use in Iowa's HUC8 watersheds. These densities reflect only the spatial distribution of government conservation program contracts (i.e., cost-share acres). Based on the cost-share database, cover crop use is concentrated in the southeast portion of the state, and secondarily in the eastern and northeastern regions.

In addition to the USDA Census of Agriculture, additional measures of cover crop acres are currently being reviewed and assessed. First, the INREC Survey of Agricultural Retailers, described and reported on page 48, provides an annual estimate of cover crop acres for the 2017 and 2018 crop years. Other emerging data sources have examined cover crop use in Iowa with remote sensing and imagery databases. The methodologies associated with these studies are currently under review by university and public agency researchers to assess how they will be included in future versions of the NRS Annual Report.

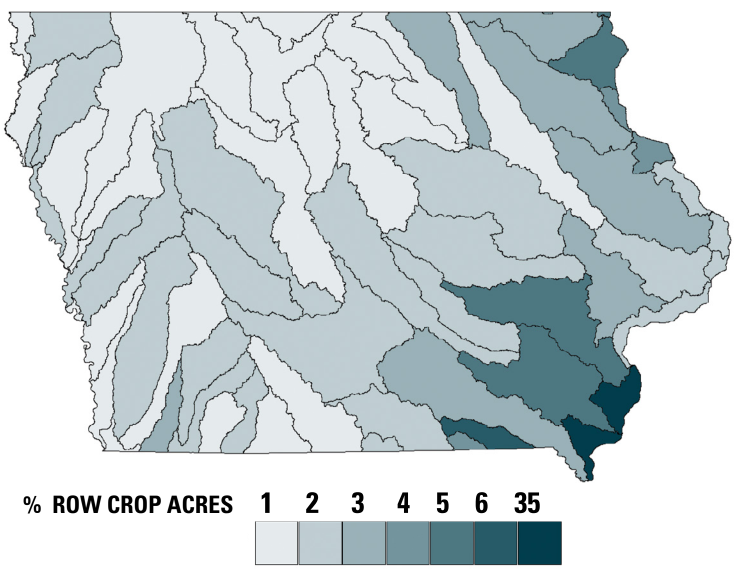


Figure 13. The relative densities of cover crops implemented with state and federal cost-share funding in 2017. In each HUC8 watershed, cover crop acres are indicated as a percent of the watershed's row crop acres, ranging from approximately 1% to 35%. This image does not account for cover crops that were implemented without government funding.

[3]"Assessment of the Estimated Non-Point Source Nitrogen and Phosphorus Loading from Agricultural Sources from Iowa During the 1980-96 Hypoxia Task Force Baseline Period," found at www.nutrientstrategy.iastate.edu/documents.

Nutrient management – commercial nitrogen fertilizer

The NRS Nonpoint Source Science Assessment lists a variety of in-field nutrient management practices that exhibit the potential for reducing N and P loss to surface water. These management practices include applying fertilizer at efficient rates (including commercial fertilizers and manure), applying nitrification inhibitor in tandem with fall anhydrous fertilizer, and shifting fertilizer application timing closer to or after crop planting. During the 1980-96 baseline period, researchers estimated the average rate of commercial fertilizer applied to corn in corn-soybean rotations was 150 pounds of N per acre. This rate of commercial fertilizer application was approximately the same during the 2006-10 benchmark period. These estimates were calculated using annual reports of fertilizer sales in Iowa and county-based crop acreages from both NASS and the CDL. There are ongoing efforts to evaluate current use of commercial N fertilizer through two approaches: by replicating the analysis of the fertilizer sales data to reflect more recent crop years and by analyzing the findings reported by the INREC Survey of Agricultural Retailers (see page 48).

Nitrapyrin is a commercial nitrification inhibitor that is recommended for use with fall-applied anhydrous to reduce N loads by approximately 9%. Based on the NRS Nonpoint Source Science Assessment, researchers estimated that during the 2006-10 benchmark period, fall anhydrous was applied annually to 5.7 million acres of corn-soybean and continuous corn acres. Of these acres, nitrification inhibitor was applied to 3.5 million acres to mitigate the potential for nitrification. As a comparison to the 1980-96 baseline period, researchers associated with the NRS Nonpoint Source Science Assessment suggest, based on professional knowledge, that nitrification inhibitor was used on a negligible number of acres during that time period due to the recent development of the technology.

Nutrient management – animal manure as fertilizer

To estimate the total plant-available N from manure during the 1980-96 baseline period and the 2006-10 benchmark period, researchers evaluated livestock animal units in conjunction with published manure nutrient availability. These studies are available in the NRS Nonpoint Source Science Assessment and in a report on baseline period nonpoint source loads[3]. Efforts to track the sources of manure and plant available N from this manure since the 2006-10 period are ongoing. University and public agency researchers are compiling and processing data associated with the USDA Census of Agriculture and the Iowa Animal Feeding Operation database to evaluate temporal trends in manure nitrogen. This study is expected to be completed in 2020.

Tillage

Tillage practices have shifted over the last few decades. There were effectively no acres of no-till in Iowa prior to 1987[3]. According to the USDA Census of Agriculture, there were 6.9 million acres of no-till in 2012 and 8.2 million acres in 2017, accounting for an increase of more than 1.2 million acres. Additionally, there were 8.8 million acres of conservation tillage in 2012 and 10.1 million acres in 2017, accounting for an increase of nearly 1.4 million acres. Conventional tillage decreased in prevalence from 7.9 million acres to 5 million acres from 2012 to 2017. As a result, the shift to no-till in the last few decades has served as a main driver in Iowa's efforts to reduce soil loss, thereby reducing P loss.

Edge-of-field and erosion control practices

Bioreactors and saturated buffers

Bioreactors and saturated buffers are edge-of-field practices that treat tile flow to remove nitrate before the water enters an adjacent stream, ditch, or tile main. At 43% and 53% reduction, respectively, these practices are highly effective at reducing annual nitrate loads to streams. By the end of the 2018 calendar year, there were 27 known bioreactors and 13 saturated buffers that had been installed through cost-share programs in Iowa; using a conservative assumption that these practices each treat 50 acres of drained cropland, at least 2,000 acres are currently treated (Figure 14). Having been developed in the last decade or so, these practices are relatively new, so adoption may continue to rise as programs and partners focus inputs and outreach toward implementation.

In 2016, the FSA began to allow and incentivize the installation of bioreactors and saturated buffers in CRP contract areas through the Clean Lakes, Estuaries, and Rivers (CLEAR) Initiative. Outreach to promote and facilitate adoption is ongoing. In addition, the recent establishment of the Water Quality Agriculture Infrastructure Program (Senate File 512) will provide increases in funding and resources dedicated to the installation of bioreactors, saturated buffers, and nitrate removal wetlands.

Wetlands

Wetlands that capture agricultural subsurface drainage have an effectiveness of 52% N export reduction and are primarily constructed through the Conservation Reserve Enhancement Program (CREP). IDALS and FSA have partnered to construct these wetlands by entering into an easement agreement with landowners for a minimum of 30 years. This practice requires high financial investment, but has longevity of multiple decades or more. Wetlands that are similarly sited and constructed have been completed historically by other programs and individuals, but data currently are not available to assess the extent of this implementation.

Currently, Iowa has 86 CREP wetlands that treat 107,000 acres (Figure 15). The program experienced its highest rate of installations in 2007, with nine new wetlands treating nearly 15,000 previously untreated acres. Implementation of the program continues, with 30 wetlands currently in the planning and construction phases. Wetlands constructed since 2011 (i.e., since the 2006-10 benchmark period) treat 48,700 acres.

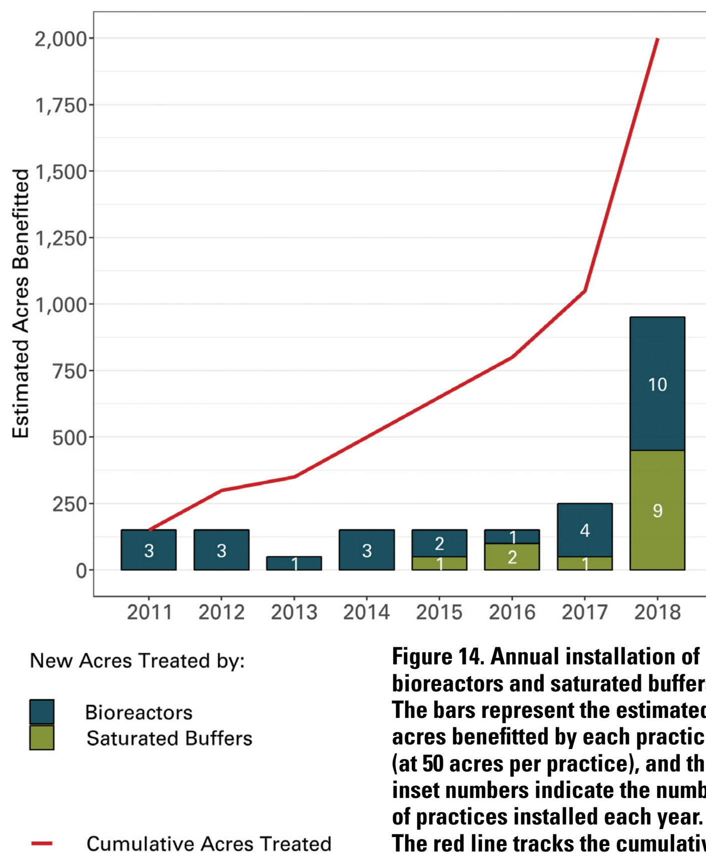


Figure 14. Annual installation of bioreactors and saturated buffers. The bars represent the estimated acres benefitted by each practice (at 50 acres per practice), and the inset numbers indicate the number of practices installed each year. The red line tracks the cumulative acres treated by all bioreactors and saturated buffers since 2011.

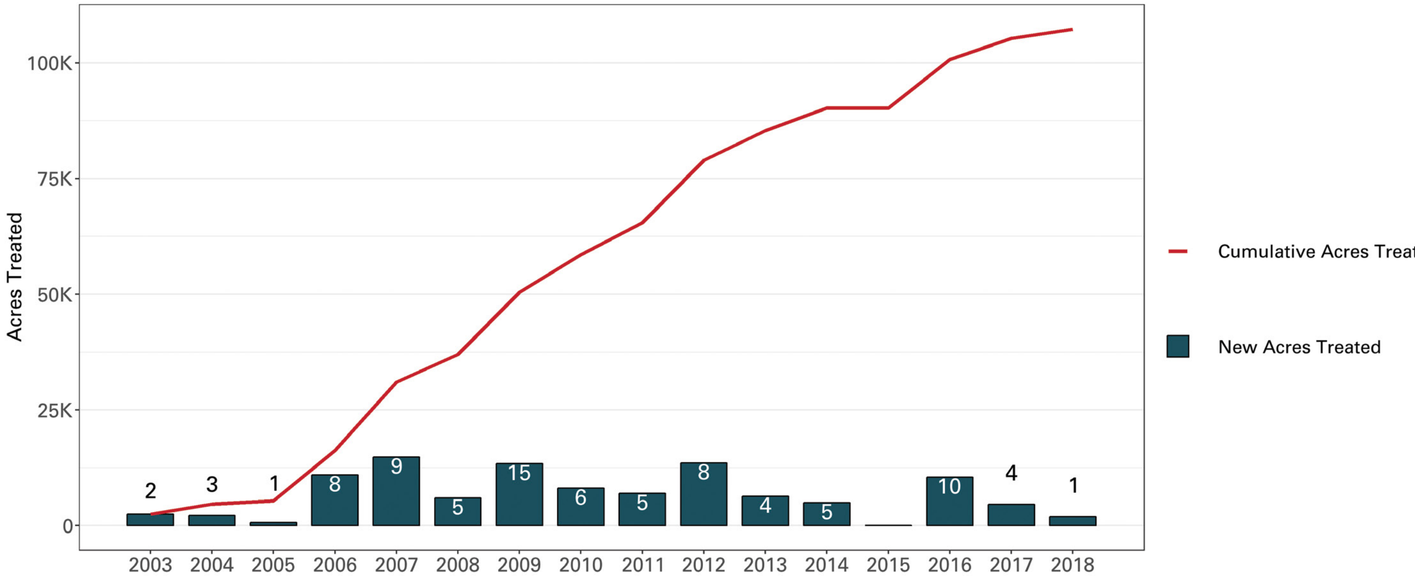


Figure 15. Annual installation of nitrate removal wetlands under the Conservation Reserve Enhancement Program (CREP). The bars represent the estimated acres benefitted by new wetlands constructed in the corresponding year, and the inset numbers indicate the number of wetlands installed. The red line tracks the cumulative acres treated by all CREP wetlands since the start of the program.

Terraces

Terraces reduce P loss by an average of 77% and represent an established practice that has seen significant levels of adoption over the last few decades. Terraces reduce P loss by reducing soil erosion on cropped slopes. This practice requires a relatively high financial investment and, along with other soil erosion prevention practices, has been a historical focus of public sector programs. Currently, it is assumed a significant number of terraces are constructed through the financial assistance of government cost-share programs and this report presents data from those sources. The Land Improvement Contractors of America Iowa Chapter conducted a survey of their members that indicated approximately 50% of their work on these practices is installed with no assistance from public conservation programs. This information was key in developing the ongoing BMP Mapping effort to better

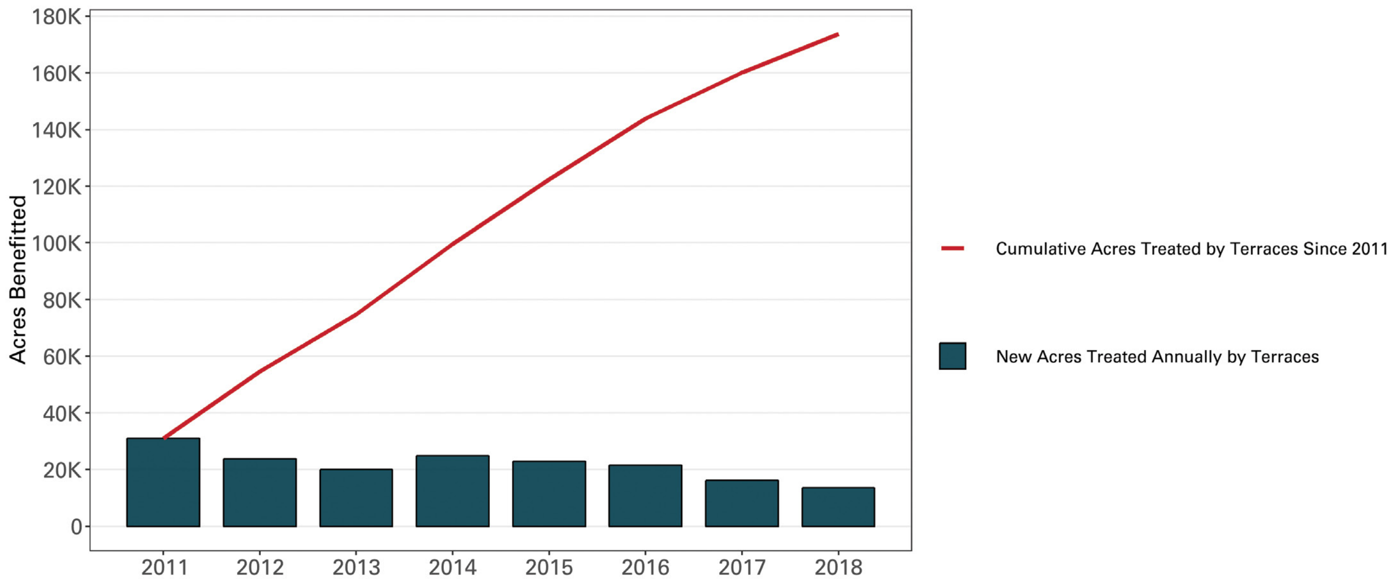


Figure 16. Terrace construction in government assistance programs since 2011. With 22.5 million new feet of terraces constructed through cost-share programs since 2011, an estimated 174,000 acres are treated by those newly constructed terraces.

understand these additional practices and corresponding load reductions. The BMP Mapping project also will provide the ability to track these practices over time due to their visibility on the landscape. For more information on this effort, see page 50.

While progress continues in the implementation of many in-field, edge-of-field, and land use practices, early NRS efforts have laid the groundwork for continuing programmatic, financial, and personnel investments to address the scale necessary to meet nonpoint source nutrient reduction goals. Nonpoint source efforts have, to date, built a foundation for delivering conservation services and conducting outreach among farmers and landowners, particularly within prioritized local areas.

LAND: Implementation of Point Source Nutrient Reduction Efforts

Progress of point source facility permits

Steady progress has been made in issuing permits requiring the submittal of a nutrient reduction feasibility study to point sources listed in the strategy – the first step in advancing nutrient reductions by point sources. Progress also has been made in issuing such permits to point sources in priority watersheds; 82% of these permits now have been issued.

One important adjustment made to tracking point source progress is shifting to calendar year reporting. This allows reporting to be consistent with many other calendar year reporting aspects of the annual report, is consistent with other federal reporting processes, and also allows additional time to process the large amount of facility data that's now available through implementation of the INRS.

There was a significant increase in the number of feasibility studies submitted during the past year, as facilities whose permits were issued in 2016 completed the required two years of raw waste and final effluent monitoring and evaluated alternatives for nutrient reduction technologies. As these feasibility studies are reviewed and approved by the DNR, the schedules these contain for installing nutrient reduction technologies are added to the facilities' National Pollutant Discharge Elimination System (NPDES) permits by amendment. Once the construction outlined by the schedules is complete and treatment processes are optimized, facilities will sample total nitrogen (TN) and total phosphorus (TP) for 12 months. Effluent limits based on those results then will be added to the permit and become enforceable. Tables 5 and 6 summarize the permitting progress to date.

This year, six months of additional data (June to December 2018) was available to further bolster the comparison of actual treatment plant loadings and reductions with the assumptions made during the development of the NRS. This continues to be one of the most complete sets of nutrient data available in the country for point sources, and the amount of data will continue to increase as more permits are issued. Using this data, it has been possible to determine what reductions in loadings of TN and TP are occurring today, even before nutrient reduction technologies are installed.

Table 5. Issued permits, feasibility studies, and construction amendment counts.

	TIME PERIOD (June 1 to May 31, except for 2018)							
METRIC	2013-14	2014-15	2015-16	2016-17	2017-18	2018	TOTAL	STRATEGY GOAL
Permits issued with NRS requirements	20	32	29	24	19	15	132	152
Permits issued with NRS requirements in targeted watersheds	8	7	9	3	3	2	32	40
Feasibility studies submitted	0	0	20	30	27	31	95	-
NRS permits amended to include construction schedules	0	0	2	13	14	19	39	-

*The Totals reflect the entire period the nutrient reduction strategy has been in place. The Totals are cumulative, but because this report switched from reporting year (June 1 to May 31) to calendar year (January 1 to December 31) in 2018, the Totals are not an exact sum of the values in each row.

Table 6. Limits, percent reduction, and monitoring counts.

	TIME PERIOD (June 1 to May 31, except for 2018)					
METRIC	2013-14	2014-15	2015-16	2016-17	2017-18	2018
Count of Nutrient Strategy permits with TN and/or TP limits	0	0	1	38	46	49
- Nitrogen limits only	-	-	1	38	44	47
- Phosphorus limits only	-	-	1	5	8	8
Count of facilities meeting % reduction targets - Nitrogen	9	9	14	19	24	29
Count of facilities meeting % reduction targets - Phosphorus	2	2	6	9	11	13
Total permits with nutrient monitoring (including those not in nutrient strategy)	201	201	224	344	399	388

Additional facts and information on each of these measures as well as a preliminary analysis of data collected by point sources since the inception of the NRS is presented in this report.

How many NPDES permits have been issued that require feasibility studies?

Of the 152 facilities affected by the strategy, 132 (88%) now have permits that require submittal of a feasibility study. The DNR committed to issue or reissue NPDES permits to at least 20 of the total point sources listed in the strategy each year. These permits include a requirement to complete and submit a nutrient reduction feasibility study (feasibility study) that evaluates the feasibility and reasonableness of reducing the amounts of TN and TP discharged by larger publicly-owned treatment works (POTWs) and industries. Figure 17 shows a total of 132 permits have been issued requiring feasibility studies as of December 31, 2018: 21 permits in the 2014 reporting period, 32 during the 2015 reporting period, 29 in the 2016 reporting period, 24 in the 2017 reporting period, and 14 in calendar year 2018. The goal of 20 permits per year has been exceeded in each year the strategy has been in place except for calendar year 2018. The goal of 20 permits was not met in 2018 because there are impediments to the reissuances of the remaining permits; for instance, many of the remaining permits have been delayed by the requirement to perform a use attainability analysis of the receiving stream.

The total number of facilities addressed by the NRS and therefore the number of permits that will require completion of a feasibility study changes slightly from year to year for several reasons:

- New industries begin operating. For example, Iowa Fertilizer Company and Iowa Premium Beef are new major industries that began operating facilities in Iowa after the NRS was released in 2013.
- Industries previously discharging to POTWs begin operating separately from the city. DairiConcepts is an existing minor industry that constructed and began operating a biological wastewater treatment facility after having discharged its wastewater to a city treatment facility for many years.
- An industry may cease operations or dispose of its wastewater by means other than discharging to a river or stream. For example, Sioux-Preme Packing Co. began land applying all of its wastewater beginning in May 2015.
- City wastewater treatment facilities are replaced with new facilities or are expanded to treat larger volumes. If the new or upgraded facility is designed to treat 1.0 million gallons or more per day it becomes a major facility and is subject to the NRS. The cities of Wapello and Hampton expanded their treatment plants to treat a larger volume in 2016-17.
- A city may downsize its treatment plant capacity as industries leave the city. If this downsize results in the design flow dropping below 1.0 million gallons per day, the facility is no longer classified as a "major" facility and is therefore not subject to the NRS. For example, in 2013 the City of Garner replaced its treatment facility that had a design flow of 1.05 million gallons per day with a new facility that has a design flow of 0.873 million gallons per day.
- A city may eliminate its discharge by connecting to another facility that provides treatment for its wastewater. The City of Ankeny began sending its wastewater to the Des Moines Water Reclamation Facility in January 2014. The City of Waukee is scheduled to do the same by January 2019.

How many NPDES permits have been issued to facilities in priority watersheds?

In 2013, shortly after the NRS became effective, the WRCC designated nine watersheds throughout the state as priority watersheds. These priority watersheds are intended to serve as areas in which to focus targeted conservation and water quality efforts through nonpoint source demonstration projects, implementation activities by nonpoint sources, and implementation of nutrient reduction technologies by point sources. Thirty-nine of the point sources listed in the strategy discharge in one of these nine priority watersheds. Permits have been issued to 32 of these facilities, or 82%, as of December 31, 2018, up from 30 facilities in the last reporting cycle. All of the facilities in the Boone, East Nishnabotna, Turkey and West Nishnabotna watersheds have permits that require the submittal of a feasibility study. Figure 17 shows the progress to date in issuing permits to point sources in the priority watersheds.

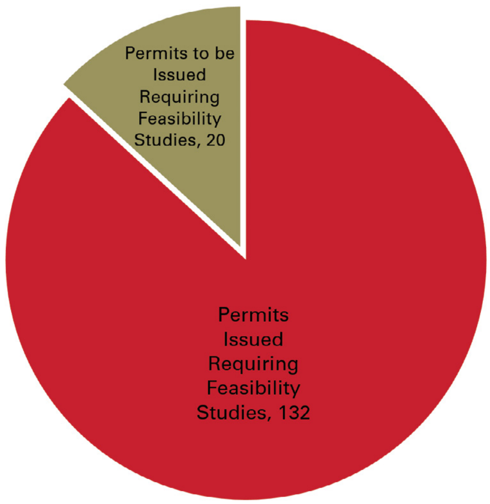


Figure 17. Of the 152 that are required by the NRS, 132 permits requiring feasibility studies have been issued.

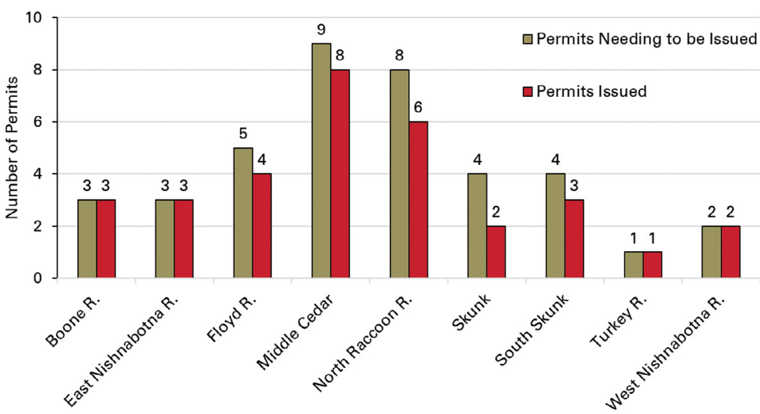


Figure 18. Point source progress in priority watersheds.

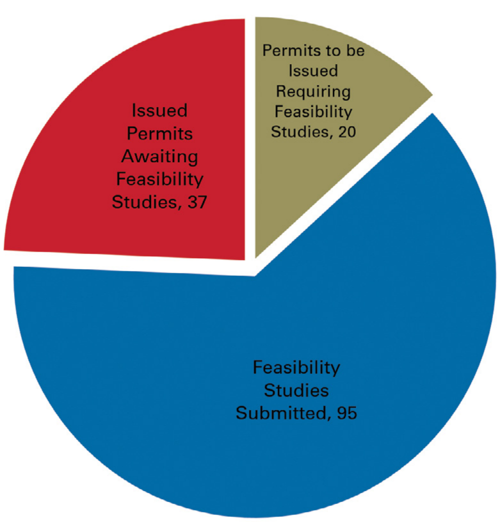


Figure 19. The progress of issued permits and submitted feasibility studies among the total NRS facilities.

Commitments and schedules for construction and facility upgrades

How many nutrient reduction feasibility studies have been submitted?

Point sources listed in the strategy are required to monitor raw waste and final effluent for TN and TP during a two-year period following the issuance of the first NPDES permit requiring completion of a feasibility study. However, some industries (e.g., power plants) that do not have a treatment plant are required to monitor only the final effluent. A facility uses the data collected during this two-year period to evaluate the feasibility and reasonableness of reducing the amounts of nutrients discharged into surface water. The NRS establishes a target of reducing TN and TP from point sources by 66% and 75%, respectively. The feasibility study must include an evaluation of facility operational changes that could be implemented to reduce the amounts of TN and TP discharged. If the implementation of operational changes alone cannot achieve the targets, the facility must evaluate new or additional treatment technologies that could achieve reductions in the nutrient amounts discharged. Ninety-five feasibility studies have been submitted as of December 31, 2018, and another 37 are required to be submitted (Figure 19).

How many NPDES permits have been amended to include schedules for constructing nutrient removal technologies?

The feasibility study must include a proposed schedule for implementing the operational changes or installing new or additional treatment technologies found to be feasible and reasonable. Upon approval of the proposed schedule by the DNR, the NPDES permit is amended to include the schedule for construction or implementation of changes. Currently, 39 permits have been amended to include construction schedules, up from 12 permits in the last reporting cycle (Table 7).

Table 7. Municipal and industrial permits that have been amended with construction schedules. How many permits have been amended to include nutrient limits?

Municipal permits that have been amended with construction schedules to meet strategy goals (as of 7/1/2019)	
Count of Facilities	29
Earliest Completion Date	8/1/2018
Latest Completion Date	10/1/2027
Average Length of Schedule (Years)	4.5
Industrial permits that have been amended with construction schedules to meet strategy goals(as of 6/14/2019)	
Count of Facilities	10
Earliest Completion Date	1/1/2018
Latest Completion Date	5/1/2023
Average Length of Schedule (Years)	3.4

Four permits were amended in 2018 to include effluent limits for TN or TP. The cities of Mt. Vernon, Cherokee, and Washington, along with Archer Daniels Midland Corn Processing made operational changes or upgrades at their wastewater treatment facilities and determined they were meeting one or more of the targets established in the NRS.

There are 181 permits that have been issued to facilities that are not affected by the NRS that specify limits for one or more N compounds (excluding ammonia nitrogen). There are two permits that have been issued to facilities that are not affected by the NRS that specify limits for one or more P compounds. Limits in these permits are either required by federal effluent standards in the case of certain industries (e.g., meat processing, fertilizer manufacturing) or are based on a total maximum daily load (TMDL) developed by the Iowa DNR to address an identified water quality impairment. In many cases these limits do not require a reduction in the amount of N or P discharged, but the limits also do not allow for an increase in the amount discharged.

How many nutrient reduction facilities are in place or under construction?

Several POTWs and industries have constructed or are presently constructing biological or chemical nutrient reduction facilities. Many others are planning to construct facilities in the coming years. Improved metrics are being evaluated to better capture whether a treatment plant was upgraded to remove nutrients, if the treatment plant was optimized to meet these goals, and what facilities are currently under construction. Currently the data allows the reporting of facilities that met the NRS point source goals of 66% removal of total N and 75% removal of total P.

The cities and industries displayed in Table 8 met the percent reduction goals for TN, TP, or both in 2018 by either treatment plant improvement or optimization.

Nutrient monitoring by point sources

When permits are issued to facilities listed in the NRS, these require those facilities to monitor effluent TN and TP once per week. There are currently 133 facilities, up from 125 facilities last reporting cycle, listed in the NRS that are required to monitor their effluent for TN and TP. In addition to these facilities, all cities and industries that treat the volume of wastewater generated by the equivalent of 3,001 or more people are required by rule to monitor final effluent (but not raw waste) TN and TP.

Table 8. Cities and industries that met the percent-reduction goals for TN, TP, or both during the 2018 reporting period.

Calendar Year 2018		
	Facility	%
Municipal		
Nitrogen	ATLANTIC CITY OF STP	80.6%
	CASCADE CITY OF STP	76.0%
	CLEAR LAKE SD	78.0%
	CLINTON CITY OF STP	68.9%
	ELDRIDGE SOUTH SLOPE	71.0%
	GRUNDY CENTER CITY OF STP	66.8%
	IOWA CITY (SOUTH)	77.4%
	MOUNT PLEASANT (MAIN)	80.7%
	OELWEIN CITY OF STP	76.3%
	SIOUX CITY CITY OF STP	74.4%
	WAPELLO CITY OF STP	86.5%
	WASHINGTON CITY OF STP	68.1%
	WEST BURLINGTON	73.4%
	WEST LIBERTY CITY OF STP	89.7%
Phosphorus	CARROLL, CITY OF STP	83.3%
	CORALVILLE CITY OF STP	83.6%
	DAVENPORT CITY OF STP	75.4%
	IOWA CITY (SOUTH)	81.0%
	SIOUX CITY CITY OF STP	83.1%
	WEST LIBERTY CITY OF STP	89.1%
Industrial		
Nitrogen	OSI INDUSTRIES (OAKLAND FDS)	93.3%
	AGROPUR INC.	91.5%
	MICHAEL FOODS, INC.	91.0%
	AG PROCESSING INC a COOPERATIVE	88.3%
	GRAIN PROCESSING CORP.	86.9%
	LIME SPRINGS BEEF, LLC	86.5%
	ASSOCIATED MILK PRODS ARLINGTON	83.7%
	REMBRANDT ENTERPRISES, INC.	80.3%
	CAMBREX CHARLES CITY, INC.	75.7%
	JBS PORK (CARGILL MEAT)	75.6%
	MONSANTO COMPANY	75.5%
	JOHN DEERE DUBUQUE WORKS	74.9%
	DAIRICONCEPTS	71.1%
	CARGILL, INC.	69.1%
	PRAIRIE FARMS DAIRY (SWISS VALLEY)	67.7%
Phosphorus	GELITA USA, INC.	96.9%
	JOHN DEERE DUBUQUE WORKS	94.7%
	MANILDRA MILLING CORP.	80.5%
	DAIRICONCEPTS	77.2%
	ASSOCIATED MILK PRODS ARLINGTON	77.2%
	LIME SPRINGS BEEF, LLC	75.9%
	AGROPUR INC.	74.8%

There are currently 388 facilities monitoring for TN, TP, or both and this number will continue to increase as more permits are reissued.

Treatment facility performance

At the time the NRS was developed, little monitoring data was available for the amounts of TN or TP discharged by point sources in Iowa. Assumptions were made based on respected engineering literature that Iowa POTWs treat raw wastewater that contains approximately 25 mg/L TN and 4 mg/L TP. These values were used together with a percentage of the wastewater treatment plant design flow to estimate the loads being discharged by each of the point sources listed in the strategy, and assuming facilities at that time were not removing any TN or TP. Estimates also were made of the amounts that would be discharged if target concentrations of 10 mg/L TN (66% removal) and 1 mg/L TP (75% removal) were achieved.

Results of weekly monitoring are available for all of the facilities whose permits have been issued since the strategy was released. Data in Table 9 reflect actual results and estimated values. The table includes the actual results from 81 POTWs for which at least 10 months of weekly sample results are available for both raw waste and final effluent, and 37 industries with at least 10 months of data for raw waste, final effluent, or both. Not all industries operate wastewater treatment plants and therefore not all have raw waste data. In addition, final effluent TN and TP values have been estimated for 22 POTW facilities, using actual effluent flows and Total Pollutant Concentrations (TPCs) established during the derivation of the 1992 Iowa point source annual baseline (discussed in a later section of this document).

Seventeen of the 86 POTWs had an average annual effluent concentration for TN equal to or less than 10 mg/L while three had an average TP concentration equal to or less than 1.0 mg/L.

Fourteen POTWs met or exceeded the target percent removal for TN (66%) and six met or exceeded the target for TP (75%).

By subtracting the yearly average final effluent mass (pounds per day) discharged by each POTW from the yearly average raw waste mass, then multiplying the resulting value by 365, the total pounds of TN and TP removed by the 81 POTWs with 10 or more months of data during calendar year 2018 was determined. For the 22 POTWs that did not have 10 or more months of data, the average effluent flows for each facility were multiplied by the TPCs from the baseline report to determine a yearly final effluent mass. That final effluent mass then was divided by the average percent removal for the facility's treatment type to determine an estimated yearly raw

Table 9. Performance by all facilities with 10 or more months of data.

	Estimate (target)	POTWs (with estimates)	Industry
TOTAL NITROGEN (AVERAGE)			
NUMBER OF FACILITIES		103	21
Raw waste (mg/L)	25	31.1 (range 14.5 – 111.3)	107.8 (range 2.0 - 359.1)
Final effluent (mg/L)	10	16.0 (range 3.3 – 55.7)	24.7 (range 0.7 - 127.7)
% removal (lbs)	66%	43.8% (range -0.9% - 89.7%)	71.6% (range -11.3% - 93.3%)
TOTAL PHOSPHORUS (AVERAGE)			
NUMBER OF FACILITIES		103	27
Raw waste (mg/L)	4	5.2 (range 1.5 – 26.0)	31.9 (range 0.6 - 146.8)
Final effluent (mg/L)	1	3.0 (range 0.4 – 20.5)	12.8 (range 0.2 - 75.3)
% removal	75%	39.5% (range -2.2% - 89.1%)	34.0% (range -348.6% - 96.9%)
ANNUAL LOAD REDUCTION (CALENDAR YEAR			
Total nitrogen (tons)	-	10,089	2,495

mass. An estimate of the average percent removal for each treatment type was determined using actual 2018 data for each facility type (Table 10). By subtracting the estimate of the yearly average final effluent mass for each POTW from the estimated yearly average raw waste mass, then multiplying the resulting value by 365, a reasonable approximation of the total pounds of TN and TP removed by the 22 POTWs during calendar year 2018 was estimated. Adding the calculated and estimated values for all of these individual facilities shows that POTWs removed approximately 10,089 tons of TN and 1,958 tons of TP in a 12-month period.

By subtracting the average pounds per day in the effluent discharged by each industry from the average pounds per day in the raw waste, then multiplying the resulting value by 365, the total pounds of TN removed by 21 industries and the total pounds of TP removed by 27 industries during calendar year 2018 were determined. No estimates were performed for the industries that did not have 10 months or more of TN or TP data because TPCs cannot be accurately calculated for industries, due to the variability in their treatment processes and in their wastewater. Industries removed approximately 2,495 tons of TN and 859 tons of TP in a 12-month period. These removal numbers are higher than last year simply due to more data being available from the additional permitted facilities.

Treatment performance by type of treatment

Table 10 provides a summary of raw waste, final effluent, and percentage removal data for both TN and TP for the same 81 POTWs and 27 industries used to develop Table 9, but breaks down the data by the type of treatment system in use today. As a note, Table 10 does not include estimated values for POTWs.

As it was in previous reporting years, it is difficult to draw firm conclusions from this data because few facilities are represented for most of the treatment types. For example, while the third highest TP removal percentages for POTWs were for aerated lagoons, the data is from five facilities which may not be representative of all aerated lagoon systems. Sequencing batch reactors had the highest TN percentage removals with the average removal for TN very close to the target removal of 66%. It is even more difficult to draw general conclusions with respect to industries because there are so few facilities represented by the data.

Estimates vs actual data

The available data show that the actual raw waste concentrations of TN and TP for POTWs are only slightly higher on average than the estimates used in preparing the NRS, but that those for industries are significantly higher. In the case of POTWs, considerable literature

Table 10. Performance by treatment type for facilities with 10 months or more of data.

Treatment type	number	Total nitrogen			Total phosphorus		
		Raw (mg/L)	Final (mg/L)	%R (lbs/d)	Raw (mg/l)	Final (mg/L)	%R (lbs/d)
POTW	81						
Activated sludge	33	35.8	17.7	47.6%	6.2	3.1	49.6%
Aerated lagoon	5	26.0	9.8	56.6%	3.8	2.2	36.1%
Oxidation ditch	1	27.2	21.5	20.3%	3.8	2.8	25.3%
Rotating biological contactor	6	19.3	11.8	32.5%	3.2	2.4	19.3%
Sequencing batch reactor	11	30.3	12.6	63.3%	5.0	2.4	52.8%
Trickling filter	25	29.3	17.8	33.6%	4.7	3.4	25.3%
INDUSTRY	TN-21, TP-27						
Activated sludge	TN-14, TP-20	75.2	18.4	68.3%	23.9	10.1	36.2%
Aerated lagoon	4	174.6	45.4	72.1%	50.0	5.5	24.3%
Oxidation ditch	1	239.5	58.3	75.6%	35.8	30.6	14.3%
Rotating biological contactor	0	-	-	-	-	-	-
Sequencing batch reactor	2	137.1	10.7	92.4%	73.5	45.5	41.4%
Trickling filter	0	-	-	-	-	-	-

was available that described the characteristics of normal domestic sewage that could be used as a starting point for preparing estimates. That was not the case for industries where the NRS acknowledged that "data on the amounts of nitrogen and phosphorus discharged by industries is not readily available but likely varies significantly based on the type of industry."

Several factors can affect the nutrient content of industrial waste including the following:

- Type of industry
- Production processes and flow rates
- Whether process wastewater is treated by the industry itself or discharged to a POTW for treatment
- Types and amounts of chemicals used
- Government regulations

For example, phosphoric acid is the most common chemical used by food processing establishments for cleaning in order to meet USDA regulations for cleanliness. The amount of cleaning required and the type of equipment cleaned using phosphoric acid likely has a bearing on the amounts of TP in both the raw waste and final effluent. A meat processing facility will have higher amounts of both N and P than a power plant, due to the nature of wastewater produced. An industry that sends its process wastewater to a municipal system for treatment and discharges only cooling water and other utility waste streams will discharge lesser amounts of nutrients than the same type of industry that treats its own process wastewater.

In Table 10, the greatest departure from initial estimates is the removal percentages being achieved by some treatment facilities. It is noteworthy that significant reductions in the amounts of TN and TP occur even before most facilities have installed or implemented specific nutrient reduction measures. It was assumed at the time the strategy was developed that treatment facilities removed little, if any, TN or TP unless these were specifically designed and constructed for biological or chemical nutrient removal. However, the data show POTWs on average remove about 40% of the TN and TP entering the treatment plant despite not having been specifically designed to do so. Industries appear to be achieving even higher rates of removal than POTWs although the data for industries represents only a small number of facilities and caution should be exercised in drawing conclusions based on this limited data.

Updating information for point source contributions in the NRS

With data now available to calculate annual raw waste and final effluent concentrations and percent removal rates for TN and TP for approximately 80% of the POTWs listed in the strategy, it is an appropriate time to reassess the estimates made of the total contribution of TN and TP from major point sources, and the reductions that can be expected as treatment facilities are upgraded or replaced to include nutrient removal processes.

The NRS states that "Discharges from wastewater treatment plants contribute approximately eight percent of the total nitrogen (TN) and 20% of the total phosphorus (TP) entering Iowa's streams and rivers annually." The NRS also projected that if the 147 wastewater treatment plants listed in the strategy were to meet the goals by reducing TN loads by two-thirds and TP by three-fourths, that would reduce the amount of nitrogen discharged by 11,000 tons per year and the amount of phosphorus by 2,170 tons per year. These figures represented a 4% reduction in N and 16% reduction in P in the total estimated statewide amounts entering Iowa's rivers and streams from both point sources and nonpoint sources.

These estimates of point source load contributions were derived by multiplying raw waste concentrations of 25 mg/L TN and 4 mg/L TP by two-thirds of the average wet weather design flow for each treatment facility and assuming no removal of TN or TP by treatment plants. The concentrations were values for typical domestic sewage taken from a respected engineering text. No removal was assumed because no treatment plants at the time were known to have been constructed with nutrient removal capabilities. While it was recognized that a number of plants were designed to treat ammonia nitrogen, that process simply converts ammonia to nitrate but does not remove TN from the wastewater. Since each facilities' annual average (long-term average day) flow was unknown at the time an approximation was derived using a peaking factor table in the EPA Nitrogen Control Manual.

As displayed in Table 11, the actual raw waste concentrations for POTWs for both TN and TP are quite similar to the original estimates. Those for industries differ significantly. What the original estimates did not take into account was the significant amounts of nutrients already being removed even though most facilities have not yet installed nutrient reduction treatment technologies.

Table 11. Comparison of estimated versus actual nutrient levels.

ESTIMATED OR ACTUAL	TOTAL NITROGEN (TONS/YEAR)	TOTAL PHOSPHORUS (TONS/YEAR)
Estimated potential point source load reductions	11,000	2,170
Actual load reduction in calendar year 2018 for 81 POTWs (TN and TP), 21 industries (TN) and 27 industries (TP)	12,584	2,817
Estimated % removals with BNR	66%	75%
Actual % removals by POTWs today (pounds)	43.8%	39.5%
Actual % removals by industries today (pounds)	71.6%	34.0%
Estimated raw waste concentrations	25 mg/L	4.0 mg/L
Actual raw waste concentrations - POTWs	31.1 mg/L	5.2 mg/L
Actual raw waste concentrations - industries	107.8 mg/L	31.9 mg/L

Table 12. Iowa point source 1992 annual baseline TN and TP load estimates.

DISCHARGE TYPE	TOTAL NITROGEN (TONS)	TOTAL PHOSPHORUS (TONS)
Major POTWs	10,311	1,380
Minor domestic wastewater dischargers	1,597	324
Industrial (major and minor with BTP)	1,262	683
SUM	13,170	2,386

Iowa point source baseline and integration into progress tracking

The Hypoxia Task Force (HTF) 2015 goal framework includes an interim target to reduce N and P loading 20% by 2025 while continuing efforts to achieve the 45% reduction target by 2035. These targets are to be measured relative to the average Mississippi/Atchafalaya River Basin (MARB) nutrient loading to the Gulf of Mexico during the 1980-96 baseline period. Given this and efforts to implement the NRS, it will be important to have the ability to track point source progress in reducing nutrient loads from those loads present during the 1980-96 baseline period.

In 2016, DNR began coordinating with the US Geological Survey (USGS) in an effort to better understand historical nutrient loads from point sources in Iowa. The USGS shared a draft data set that contained annual TN and annual TP load estimates for Iowa point sources for the years 1992, 1997, and 2002. DNR evaluated the 1992 annual nutrient loads and concluded the shared data set could be used, with modification, to estimate baseline nutrient loads for Iowa point sources. Annual TN and TP loads in 1992 were estimated for Iowa's major POTWs, minor domestic wastewater dischargers (including POTWs and semipublic facilities), and industrial dischargers that provide biological treatment of process wastewater (BTP). These loads then were summed to provide the point source baseline TN and TP load estimates shown in Table 12. The full report titled "Nitrogen and Phosphorus Load Estimates from Iowa Point Sources During the 1980-96 Hypoxia Task Force Baseline Period" can be found at www.nutrientstrategy.iastate.edu/documents.

This work was presented at the NRS Five-Year Point Source Implementation Review and Planning Meeting on April 30, 2018. Based on feedback received at the meeting, stakeholders were interested in integrating these baseline estimates into NRS progress tracking efforts. More specifically, stakeholders wanted a clearer understanding of how current point source loads compare to the 1980-96 baseline, the loads at the time of the NRS development, and the estimated loads if all facilities covered by the NRS were to meet the NRS goals.

This required three main areas of work. First, the original point source loads estimated at the time of the NRS development were recalibrated using the newer, more accurate methodology employed to estimate the 1980-96 baseline. This entailed using 2013 monthly average effluent flow data and either Iowa-specific typical pollutant concentrations for TN and TP (for major POTWs and minor domestic wastewater dischargers) or long-term average effluent concentrations (for industrial dischargers with BTP). Second, loads for the 2018 reporting period were calculated using actual facility-specific TN and TP load data when available and modeled estimates using the aforementioned new methodology. Third, TN and TP effluent concentrations of 10 mg/L and 1 mg/L, respectively, were used to estimate loads if all facilities covered by the NRS were to meet the NRS goals (assumes flows equal to 2013 levels). Figure 20 summarizes the outcomes of this effort by providing point source load values for the 1980-96 baseline, the 2013 recalibrated loads, and the calendar year 2017 loads. The dashed lines in Figure 20 provide the estimated loads in the case that all facilities covered by the NRS meet the NRS goals.

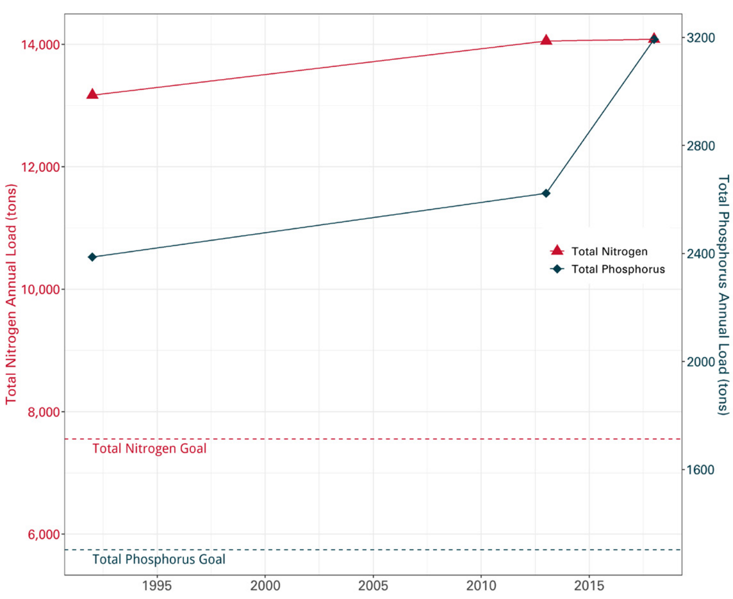


Figure 20. Iowa point source annual nutrient loads from major publicly owned treatment works, minor domestic, and industrial facilities with biological treatment of process wastewater.

Looking ahead

- The list of affected facilities in Section 3.3 of the NRS will continue to be reviewed and updated annually as new facilities become subject to the strategy and facilities are dropped from the list because they no longer meet the criteria established for inclusion.

- Permits will continue to be issued to facilities listed in the NRS. The permits will specify requirements to complete and submit nutrient reduction feasibility studies.

- The Iowa DNR will review nutrient feasibility studies as these are submitted, and amend NPDES permits to include construction schedules for installing nutrient reduction treatment technologies. Where a feasibility study concludes it is not feasible or reasonable to meet the targets identified in Section 3 of the NRS, the facility's permit will be amended to require submittal of another feasibility study five years from the Iowa DNR's approval of the first study.

- The Iowa DNR will continue to analyze raw waste and final effluent data for nutrients as data from more facilities becomes available to evaluate performance of treatment facilities both before and after operational changes are made or additional treatment is installed.

The Iowa DNR will continue to correct and explain anomalies in the data submitted by treatment facilities. Such anomalies can include, but are not limited to, the reporting of negative values, single high or low concentrations or loads that are inconsistent with other reported data, days with zeros for one or more concentration or mass values, and apparent data entry errors.

WATER

The goal of the NRS is to reduce Iowa's N and P load export by 45%; the strategy outlines a process for achieving this goal through increased efforts by both point sources and nonpoint sources to manage the nutrient losses driven by human activities. As displayed in the NRS logic model (Figure 1), nutrient reduction will result from effective changes in human behavior, land use, and point source nutrient removal processes.

This section addresses the following questions. First, how are water quality changes and nutrient export tracked in Iowa? Second, what are the challenges associated with measuring change in Iowa's nutrient export? Third, what are the current efforts to track nutrient export? Finally, what are the recent findings from these efforts?

How are water quality and nutrient export tracked in Iowa?

Two complementary approaches are used to assess progress of the NRS. First, Iowa's annual N export is estimated from the measured nitrate and nitrite concentrations in surface water. Similar methods for estimating P export are being implemented. Second, the conservation practices implemented throughout the state, as quantified for the "Land" section of this report, feed into calculations of nutrient reductions. These values are modeled based on the current understanding of these practices' effectiveness in reducing the loss of N and P in Iowa agricultural landscapes. These efforts are complementary because by tracking both, there is a better understanding of what is happening on the landscape in terms of practices, while also monitoring nutrients in water. This process has been done historically and is the basis of the practices assessed in the NRS Science Assessment. The monitored performance of individual practices, at the appropriate implementation scale, indicates the ability to reduce nutrients when scaled up. Either approach looked at independently will not accomplish or inform progress of the NRS effectively.

One of the key elements of the NRS is to develop new efforts and maintain existing programs to measure water quality changes that occur over time as nutrient reduction practices are implemented by both point and nonpoint sources.

The 2015 NRS Annual Progress Report states that "efforts are underway to improve understanding of the multiple nutrient monitoring efforts that may be available and can be compared to the nutrient water quality monitoring framework to identify opportunities and potential data gaps to better coordinate and prioritize future nutrient monitoring efforts." This description still applies; the current understanding of the extent and utility of the monitoring network is discussed next, though this is a distilled, not exhaustive, discussion of Iowa's water monitoring.

What are the current challenges associated with measuring change in Iowa's nutrient export?

In September 2016, the DNR coordinated and published a collaborative report, titled "Stream Water-Quality Monitoring Conducted in Support of the Iowa Nutrient Reduction Strategy," that describes the current network of surface water monitoring in Iowa, while detailing the challenges and data gaps associated with water quality monitoring, and suggesting ways to improve and

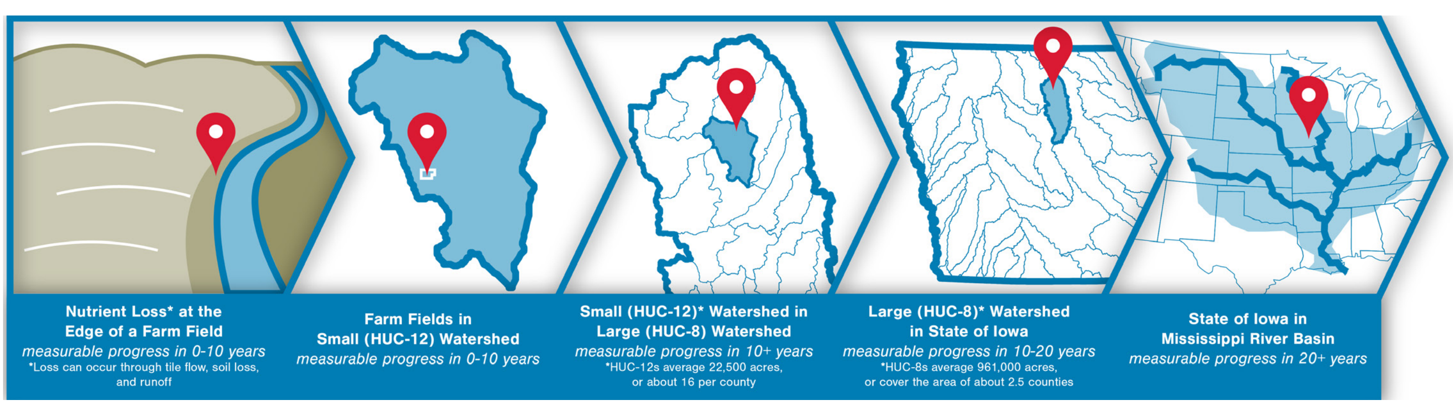


Figure 21. The Nutrient Water Quality Monitoring Framework, a summary of reasonable expectations regarding conservation practice implementation and its impact on measured water quality at increasing spatial scales.

coordinate the collection and evaluation of water quality data for these purposes[4]. The report was generated with participation by DNR, IDALS, Iowa State University, and the University of Iowa's IIHR-Hydroscience & Engineering, and serves as a working document of the existing nutrient monitoring strategies in Iowa. This effort is consistent with the WRCC commitment highlighted in the NRS "to continue to coordinate and evaluate opportunities for monitoring locations and focused study areas in order to track progress." The following sections provide a summary of many of these discussions, along with an overview of current monitoring projects in Iowa.

Current known stream nutrient monitoring efforts in Iowa are reported in the context of the Nutrient Water Quality Monitoring Framework presented in Figure 21. The Nutrient Water Quality Monitoring Framework was developed to graphically show that the length of time needed to show a measurable change in water quality increases as the size of the monitored watershed increases. Generally, less time and fewer samples are needed to measure a change in the quality of runoff from an individual field of 10 to a few hundred acres in size following implementation of nutrient reduction practices, whereas more samples collected over a longer period of time are needed to show a change in water quality at the terminus of a larger watershed that consists of tens of thousands of acres or more. There are a variety of reasons this is the case, pertaining to challenges associated with monitoring surface water quality, but, in general, as the watershed size increases there is an increase in the number of factors that affect water quality. Natural systems also become more complex as spatial scale increases.

Water quality monitoring presents challenges when estimating nutrient load exports from Iowa's watersheds. These challenges are discussed in more detail in the report on Iowa stream monitoring efforts, cited above, and are summarized in this report to highlight the need for increased research into options for addressing these challenges.

1. Legacy nutrients, which are present in the soil and groundwater from natural and anthropogenic sources, are released to surface water through bank erosion and groundwater movement. These legacy nutrients can be detected in surface water under a variety of landscape conditions, and distort the effects conservation has on surface water nutrient loads.
2. Lag time, or the difference in time between conservation implementation and measurable change in water quality, occurs on a variety of scales. Lag time often is dependent on watershed size, and the design of monitoring projects can impact the capacity to detect change in surface water quality.
3. Variable precipitation and stream flow, as well as extreme weather events, including heavy rainfall and flooding, cause variability in measured nutrient concentrations. Increased intermittent heavy rainfall will make it more difficult to detect reductions or trends in nutrient export.
4. The importance of having comprehensive data on nutrient reduction practice implementation, as a means of assessing the causal human actions potentially associated with observed changes in water quality.
5. The value of long-term monitoring to measure progress, and the importance of properly situated and maintained monitoring locations.

These considerations related to reliable water quality monitoring and estimated nutrient exports contribute to concerns that measurable change in statewide N and P loads will not be detected in the short-term. Therefore, the following assessment provides an overview of the current monitoring network in Iowa, and highlights progress in measuring nutrient concentrations and subsequently estimating annual nutrient export.

Ambient water monitoring network

Surface water monitoring is conducted statewide on an ongoing basis. The primary organizations managing water quality grab samples and water quality sensors that transmit near real-time data are the USGS and IIHR, with support from the DNR, through the Iowa Ambient Water Monitoring Network. The sensors currently measure N (nitrate and nitrite), turbidity (a potential surrogate for TP), flow, and other site-specific parameters, which may include pH, dissolved oxygen, temperature, and discharge, depending on the site. Any given sensor measures the surface water that drains from an upstream watershed area.

The fixed-location monitoring sites collect information on a regular time interval (e.g., monthly) on some combination of a wide range of parameters, including N concentrations, turbidity, and flow. In 2018, 60 monitoring sites comprised the Ambient Water Monitoring Network, which represents the longest-term water quality data set in Iowa. The Ambient Water Monitoring Network, maintained by DNR, is displayed in Figure 22.

[4]The report can be accessed at www.nutrientstrategy.iastate.edu/documents.

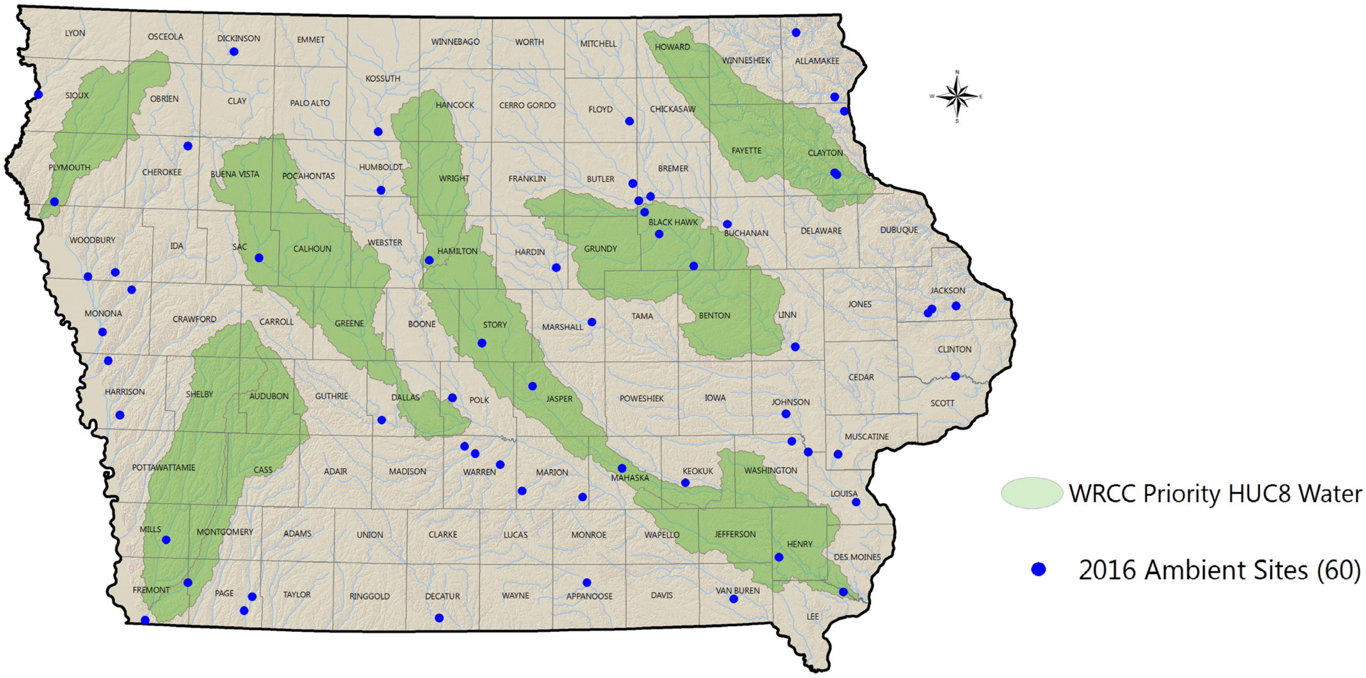


Figure 22. The ambient water monitoring sites operated by Iowa DNR. The green areas indicate the HUC8 watersheds prioritized for nutrient reduction efforts by the Water Resources Coordinating Council (WRCC).

Figure 23. The results of the linear interpolation estimates of annual nitrate export from Iowa. These estimates were modeled using empirical data collected through the ambient stream-monitoring network operated by the Iowa DNR and stream gauges operated by the USGS.

What are the recent findings from these efforts to track Iowa nutrient export?

Nitrogen

As reported in greater detail in previous annual reports, annual N loads are estimated using a linear interpolation method, which provides a simple and straightforward approach to calculating total N loads from the statewide monitoring data each year. Linear interpolation fills data gaps between measured concentrations by a straight line. Because of its simplicity, different users can expect to produce approximately the same load estimate from a given set of data. Linear interpolation also was found to provide the overall best results for nitrate-N load estimation in agricultural and mixed-use watersheds. However, linear interpolation requires consistent and long-term sample collection to be effective. Missed sampling periods that lengthen the interval between measurements will result in greater potential error in the load estimate. The research behind this effort, titled "Variability of nitrate-nitrogen load estimation results will make quantifying load reduction strategies difficult in Iowa," was published in 2017[5].

The statewide nitrate-N estimates in Figure 23 help provide an understanding as to what events may be occurring in a calendar year that are related to elevated or decreased loading levels. The annual load estimates are displayed along with streamflow, as streamflow amounts have the largest known impact on nutrient loading (Table 13)[6].

Phosphorus

An ongoing effort has been completed for quantifying P loads, similar to the above method for estimating nitrate loads. Quantifying P loads has challenges distinct from those associated with quantifying N loads. A work group has compiled multiple P data sets to be used to evaluate different load estimation methods. Opposite the results from the N estimation method, the data sets indicate the monthly frequency of monitoring at fixed-station

Table 13. The estimated annual nitrate export from Iowa. Estimates of nitrate load per acre use a value of 36,002,722 total acres of Iowa land.

YEAR	Nitrate-N Load (tons N/year) (tons N • year-1 cm-1)	Flow (cm)	Load Per Acre (pounds)	Nitrate-N Load Weighted by Flow
2000	101,298	10.71	5.6	9,458
2001	300,428	25.83	16.7	11,631
2002	115,070	12.07	6.4	9,534
2003	144,049	12.78	8.0	11,271
2004	264,357	22.3	14.7	11,855
2005	186,995	15.81	10.4	11,828
2006	174,990	14.22	9.7	12,306
2007	450,132	36.46	25.0	12,346
2008	434,611	46.69	24.1	9,308
2009	281,029	32.3	15.6	8,701
2010	455,312	52.84	25.3	8,617
2011	297,246	28.19	16.5	10,544
2012	66,189	8.92	3.7	7,420
2013	342,921	26.04	19.0	13,169
2014	267,053	27.61	14.8	9,672
2015	417,793	32.92	23.2	12,691
2016	531,776	40.03	29.5	13,284
2017	318,111	26.56	17.7	11,977
2018	426,416	45.33	23.7	9,407

[5] Schilling, K. E., Jones, C. S., Wolter, C. F., Liang, X., Zhang, Y.-K., Seeman, A.,Skopec, M. (2017). Variability of nitrate-nitrogen load estimation results will make quantifying load reduction strategies difficult in Iowa. Journal of Soil and Water Conservation, 72(4), 317–325. https://doi.org/10.2489/jswc.72.4.317.

[6] The streamflow values presented as centimeters in Table 12 are estimated based on the amount of annual statewide rainfall that was expected to become surface runoff, which varies based on factors such as soil saturation and total precipitation. These estimates are augmented with stream gauge data for the areas with flow meters.

sites is not sufficient to estimate P loads because the amount of P in rivers and streams changes rapidly, from less than detection to a few milligrams per liter, with changes in precipitation and stream flow. It is unlikely that P load estimates can be obtained without event-based sampling or continuous monitoring; however, unlike for nitrate, in-stream total P sensors are not available to help overcome this challenge.

The working group explored the possibility of using surrogate parameters that can be measured with currently available and deployed sensors. Research of these potential surrogates was completed in 2017 and the results were published in the Journal of Hydrology: Regional Studies in spring 2017. In this study — "Use of water quality surrogates to estimate total phosphorus concentrations in Iowa rivers" — the relation of TP concentrations to water quality surrogates (turbidity, ortho-phosphorus (OP), discharge, chlorophyll a, and chloride) was evaluated for 43 river monitoring sites in Iowa. Results indicate various combinations of these surrogates are capable of estimating TP concentrations with a high degree of accuracy at medium to large watershed size. Overall, turbidity and OP are the dominant surrogates needed to estimate TP concentrations in Iowa rivers. Adding OP measurements to the regression models improved the model performance for nearly all sites, but the importance of OP was particularly apparent for rivers in the tile-drained Des Moines Lobe region. There typically is less sediment bound P delivered due to this region's flatter topography. Additionally, subsurface drainage can contribute dissolved P loads to rivers that are not captured by traditional turbidity-TP relations. The extent of this contribution of dissolved P has been investigated and does not affect the larger river systems where these discharge to the border rivers. Based on this work, the DNR, IIHR, and USGS have worked together to deploy turbidity sensors at existing fixed monitoring sites where major rivers drain into the Mississippi and Missouri Rivers. These locations have little or no influence from OP and the relationship of turbidity to TP is strong. Thirteen turbidity sensors were placed at these sites in 2018. Figure 24 displays the location of turbidity sensors, deployed in 2018. The relationship between TP and turbidity are currently being developed at each of these sites. Once this work is completed, this monitoring network will facilitate the first estimates of annual P loads leaving the state.

Modeled nutrient loads during baseline and benchmark periods

The following subsections describe the second of the two complementary approaches to tracking changes in nutrient loads. While the first approach, as described in the preceding subsections, evaluates empirical water monitoring data, the second approach models nutrient reductions from nonpoint source practices (e.g., agricultural conservation practices). This process was created to estimate statewide benchmark loads of N and P for the NRS in 2012 to determine the average annual loads for the 2006-10 period (Table 1). The original 2006-10 timeframe was utilized for the model development due to availability of ample data and timeliness with the understanding that efforts to assess previous timeframes would be conducted. In 2018, in order to maintain consistency with the work of the Gulf of Mexico Hypoxia

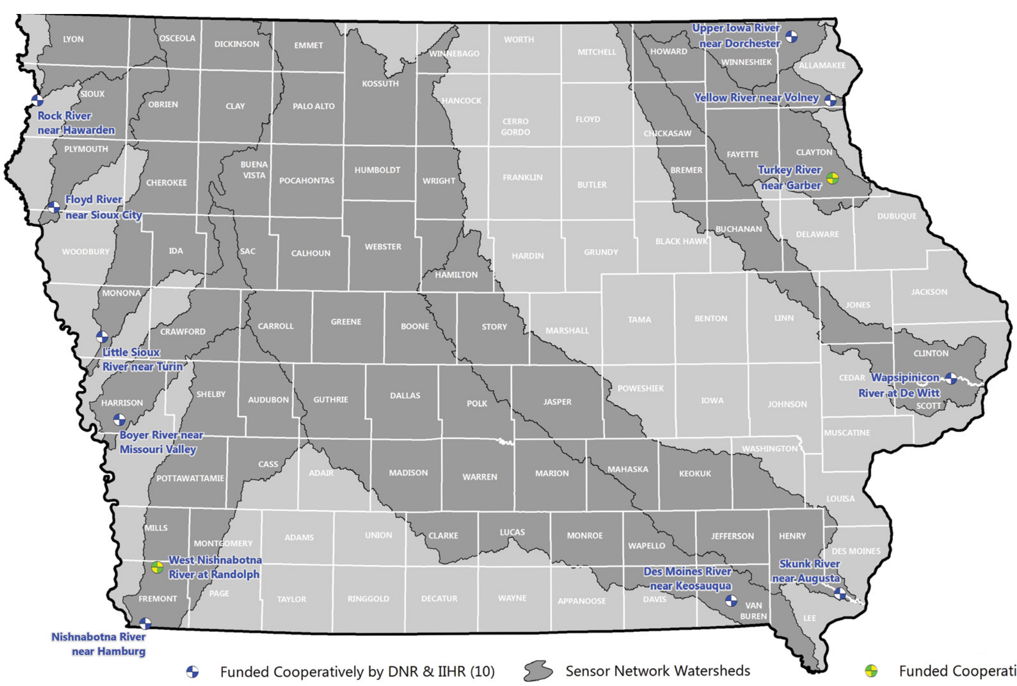


Figure 24. Locations of real-time turbidity sensors in Iowa. Turbidity serves as a surrogate measure of TP, facilitating annual estimates of P loads.

Task Force, a historic baseline of 1980-96 was established for the NRS in Iowa Code 466B.42 and 466B.3. Studies completed during the 2018 reporting period outlined the estimated average annual nutrient loads from point and nonpoint sources during this time period (Table 1). For more information and context about these efforts, see page 9. Going forward, progress will be measured against the 1980-96 baseline and the 2006-10 benchmarks time periods, and will aim to utilize much higher resolution datasets and remote sensing information, such as the BMP Mapping Project (see page 50), than were available for the evaluations of the baseline and benchmark time periods.

Modeled nutrient load reductions from practices implemented during or before 2018

Using the same modeling approaches as in the original NRS documents, nutrient load estimates for this document were calculated for a selection of recently implemented nutrient reduction practices. The acreages and extent of these practices were determined using various data sources, including public conservation program databases, the CDL, and the USDA Census of Agriculture. For more information on the approximation of conservation practice use in Iowa and efforts to fill existing data gaps, see pages 48-50.

With at least 973,000 acres of cover crops estimated to be planted in 2016, cover crops reduce annual N loss by 4,300 tons (Table 14). These acres also reduced P loss by up to 330 tons (Table 15). Because cover crops are an annual practice, maintaining these reduction levels will require implementation of these acres each year.

Bioreactors and saturated buffers installed between 2011 and 2018 collectively treated an estimated 2,000 acres in Iowa, resulting in an estimated 12-ton reduction in N loss in 2018. CREP wetlands constructed since 2011 collectively treated 49,000 acres in 2018 and reduced N export by 330 tons that year (Table 15). Efforts to account for load reductions attributed to pre-2011 CREP wetland installations (treating approximately 60,000 additional acres) is ongoing. Bioreactors, saturated buffers, and CREP wetlands are structural practices, so the estimated effectiveness of each structure in reducing N loss will occur annually for the life of the practice.

In addition to the increasing acres of cover crops and of acres treated by edge-of-field practices, tillage practices on Iowa farms have continued to change. There were an estimated 8.2 million acres of no-till and 10.1 million acres of conservation tillage in 2017. These changes in tillage intensity are associated with a P loss reduction of up to 420 tons annually (Table 15). Terraces that have been installed since 2011 – 22.5 million feet treating 174,000 acres – reduced P loss by 40 tons in 2018 (Table 15).

The nutrient reductions associated with cover crops, edge-of-field practices, tillage, and terraces are notable; however, these improvements occurred within a broader context of increasing row crop acres and, in some cases, increasing rates of commercial N fertilizer. There was a net loss of extended rotations – converted to row crops – of 1.1 million acres between 2010 and 2018, amounting to an increase in N loss of 6,800 tons in 2018. Similarly, a conversion of 790,000 acres of pasture, CRP, and grasses to row crop increased N loss by 9,600 tons and increased P loss by 380 tons in 2018 (Tables 14-15).

For some nutrient reduction practices, there are insufficient data available to conduct affordable statewide assessments. For example, the extent of stream buffers, and the change in their use over time, currently are unknown. Evaluation of remote sensing data and other data sources for tracking stream buffers and other practices over time are ongoing.

There are several NRS nonpoint source practices that have not been included in this analysis due to either ongoing data processing, current data availability, or dataset validation. Estimates for the effect of in-field practices, including commercial fertilizer application rates and methods, on nonpoint source nutrient loads are in the process of being integrated with updated manure application data, which have not been compiled and assessed since the 2006-10 benchmark study described in the NRS Nonpoint Source Science Assessment. Recently compiled data from the USDA Census of Agriculture and the DNR Animal Feeding Operation database are currently being evaluated for an updated understanding of manure practices. Finally, the extent of and change in the implementation of various structural practices are in final stages of analysis through the BMP Mapping Project (page 50). The inclusion of these sets of in-field and structural practices will provide a more robust understanding of the nutrient loads associated with conservation practice adoption.

Table 14. The modeled nitrogen load changes attributed to nonpoint source practices in 2018. To calculate the percent change compared to the baseline, the nitrogen load change attributed to each practice is presented as a percent of 292,022 tons of nitrogen. Cover crop acreages were sourced from the 2017 USDA Census of Agriculture, edge-of-field practices were estimated with state and federal conservation program databases, and land-use change was evaluated using the USDA CDL.

	Level of Implementation		Impact on Nitrogen Load in 2018 (tons)†	Percent Annual Load Reduction from 2018 Practices†
	1980-96 BASELINE	CURRENT	Negative value indicates a reduction in N loss	
In-field Practices				
Cover crops - USDA	0 ac	973,000 ac	-4,279	-1.5%
Edge-of-field Practices				
Bioreactors and saturated buffers	0 ac	2,000 ac	-12	0.0%
CREP wetlands	0 ac	107,000 ac	-329	-0.1%
Land-use Change ‡				
Extended to continuous corn	Net change since 2010	212,000 ac	1,658	0.6%
Extended to corn-soybean		917,000 ac	5,120	1.8%
Pasture, grass, hay, or CRP to continuous corn		152,000 ac	1,866	0.6%
Pasture, grass, hay, or CRP to corn-soybean		636,000 ac	7,714	2.6%

† This table represents a partial picture of the nonpoint source practices and load reductions. These load change estimates reflect selected NRS practices for which there are data available to track changes and calculate nitrogen load reductions. For other practices, emerging data are available, but are under evaluation for integrating into these modeled load calculations. University and public agency researchers are working to incorporate additional practices into this table by processing and evaluating emerging data sources. In addition, the load change affected by each practice does not factor in the effect of "stacking" multiple practices within one field (e.g. a bioreactor plus cover crops in one location).

‡ Land-use change estimates are based on field-level changes in crop rotations and assume that shifts in land-use occurred across whole fields; thus, they do not account for potential subfield land-use changes that may mitigate the resulting nutrient loads.

Table 15. The modeled phosphorus load changes attributed to nonpoint source practices in 2018. ID represents periods for which there is currently insufficient data. To calculate the percent change compared to the baseline, the phosphorus load change attributed to each practice is presented as a percent of 23,822 tons of phosphorus. Cover crop and tillage acreages were sourced from the 2017 USDA Census of Agriculture, terraces were estimated with state and federal conservation program databases, and land-use change was evaluated using the USDA CDL.

	Level of Implementation		Impact on Phosphorus Load in 2018 (tons)†	Percent Annual Load Reduction from 2018 Practices†
	1980-96 BASELINE	CURRENT	Negative value indicates a reduction in P loss	
In-field Practices				
Cover crops	0 ac	973,000 ac	-329	-1.4%
Conservation tillage	5,190,000 ac	10,133,000 ac	-96	-0.4%
No-till	1,969,000 ac	8,196,000 ac	-326	-1.4%
Erosion Control Practices				
Terraces	ID	132,000 ac	-43	-0.2%
Land-use Change ‡				
Pasture, grass, hay, or CRP to row crop	Net change since 2010	788,000 ac	381	1.6%

† This table represents a partial picture of the nonpoint source practices and load reductions. These load change estimates reflect selected NRS practices for which there are data available to track changes and calculate phosphorus load reductions. For other practices, emerging data are available, but are under evaluation for integrating into these modeled load calculations. University and public agency researchers are working to incorporate additional practices into this table by processing and evaluating emerging data sources. In addition, the load change affected by each practice does not factor in the effect of "stacking" multiple practices within one field (e.g. cover crops plus terraces in one location).

‡ Land-use change estimates are based on field-level changes in crop rotations and assume that shifts in land-use occurred across whole fields; thus, they do not account for potential subfield land-use changes that may mitigate the resulting nutrient loads.

PART TWO:
Continuing Strategic Work and Building Capacity

Coupled Point and Nonpoint Source Efforts

The Iowa State Revolving Fund

The State Revolving Fund (SRF) is operated by the Iowa Department of Natural Resources (DNR) and the Iowa Finance Authority (IFA), in partnership with the Iowa Department of Agriculture and Land Stewardship (IDALS). The Clean Water SRF finances water quality projects eligible under the Clean Water Act and the Drinking Water SRF covers water system improvements under the Safe Drinking Water Act, including source water protection. Cumulatively, the SRF programs have financed more than $3.6 billion to date. Table 15 displays the assistance provided for water quality projects by the Clean Water SRF during the 2019 fiscal year.

The Clean Water SRF Water Resource Restoration Sponsored Projects program leverages investments made by municipalities to upgrade wastewater facilities to include additional resources for projects that address urban and agricultural runoff. Sponsored project priorities are locally directed, allowing communities and their partners to create innovative approaches to watershed protection and urban-rural partnerships. Through June 2019, the program has awarded 99 sponsored projects in 81 communities and one state park for a total commitment of $66.5 million.

Table 16. Assistance provided for water quality projects by the Clean Water SRF during the 2019 fiscal year.

Wastewater and sewer infrastructure	$202,933,854
Soil and sediment erosion control	$1,747,488
Manure management	$5,331,462
Onsite septic system upgrades	$981,480
Hydromodification	$17,101,950
Green storm water infrastructure	$2,224,667
Total	**$230,320,901**

Senate File 512 and other anticipated funding sources

The capacity for accelerating the availability of funding and resources has been a distinct challenge. Long-term funding constituted approximately 11% of Iowa Nutrient Reduction Strategy (NRS) funding in 2018, as reported by partner organizations. Annual appropriations, as potentially more reliable sources of funding with some uncertainty surrounding year-to-year availability, accounted for 38% of NRS funding, as reported by partner organizations. Funding sources that are stable, predictable, and incrementally increased may help government agencies, non-governmental organizations, and private industry develop a greater capacity to hire staff, fund long-term research projects, and conduct multi-year education and outreach to better implement physical changes that will reduce nutrient losses to surface water. In short, stability and predictability of funding sources, coupled with increased funding, can assist the acceleration of NRS implementation. In the long term, grant and annual funding, which accounted for 55% of reported funding, may be most appropriate for trials of innovative new approaches and studies, but are difficult to rely upon for long-term management programs that maintain ongoing NRS progress.

Capacity-building and scaling up currently are the primary focal points to develop programs that support NRS implementation. Partner organizations aim to build the funding resources available for these efforts. A few key influxes of funding were formalized in 2018 and will support efforts to scale up. These multi-year projects took effect during the 2018 reporting period, but support long-term efforts and were not reflected in partners' 2018 funding reports. The following list contains highlights of new funding awards that have taken effect and likely will be reflected in partners' reports in the next few years.

In 2018, the Iowa Legislature passed and Governor Reynolds signed into law new legislation that will provide more than $270 million for water quality efforts in Iowa over the next 12 years. This long-term funding source will provide significant additional resources for water quality programs in the state.

The funding will be divided into four areas:

Wastewater and Drinking Water Treatment Financial Assistance Fund
Amends an existing program to give grants to water and wastewater projects. Grants would be awarded annually and used for improvements to wastewater and drinking water treatment facilities, including source water protection projects.

Water Quality Financial Assistance Fund
This is a new revolving loan fund, which is to be a permanent source of water quality financial assistance. The purpose is to provide financial assistance to projects that improve water quality with a higher prioritization to collaborative efforts.

Water Quality Agriculture Infrastructure Fund
The purpose of this program is to support projects for the installation of practices detailed in the NRS Science Assessment to reduce nutrient loss to surface waters.

Water Quality Urban Infrastructure Program
The purpose of this program is to support projects that reduce runoff and improve infiltration rates in urban areas consistent with the Iowa Stormwater Management Manual.

Iowa's role in the Hypoxia Task Force

Iowa has continued to play a significant leadership role in the Gulf of Mexico Hypoxia Task Force (HTF), a regional effort led by 12 states and five federal agencies. The HTF is co-chaired by the Iowa Secretary of Agriculture and the United States Environmental Protection Agency (EPA) Assistant Administrator of the Office of Water. This collaborative effort aims to reduce the nitrogen (N) and phosphorus (P) load of all Mississippi River Basin states by 45% before 2035.

IDALS serves as co-chair of the Nonpoint Source Measures Committee for the HTF. This committee has worked to establish a set of common measures all participating states can use to show progress and inform decision-making to guide future progress. To date, this committee has focused on improving data collection of practice installation across all identified sectors – federal, state, and private – through a variety of methods. Early progress includes development of a set of key parameters of the data being collected, which resulted in data sharing with the Natural Resources Conservation Service (NRCS) to facilitate data availability of their programs. As a result, all basin states will have a source of common data that is compatible with state program data and, eventually, private program data; this effort will increase the understanding of the implementation of conservation programs in their states and in two pilot states (Arkansas and Indiana). This process and key findings from the pilot projects will be instrumental in advancing similar efforts in other HTF states. The first report from the Non-Point Source Measures Workgroup can be found at www.epa.gov/ms-htf/report-nonpoint-source-progress-hypoxia-task-force-states.

In part, by the work of the committee, the HTF was able to work through member federal agencies, states, and researchers of the Southern Extension and Research Activities committee 46 (SERA-46) to secure funding to help advance and bring capacity to the nonpoint source measures effort. With support from the Walton Family Foundation, this project will advance through the leadership of SERA-46 researchers and state and federal agencies in the basin to build a quantitative assessment of practice implementation from state and federal sources. Next steps include replicating the work from the initial two pilot states into four additional HTF states (specific states yet to be determined).

In addition, the Iowa DNR co-leads the HTF Point Source Measures Committee. This committee has established and populated metrics to determine the amount of facilities that monitor and have effluent limits for N and P established in their national pollutant discharge elimination system (NPDES) permits for all 12 HTF states. Current efforts are focused on creating a reliable point source nutrient loading metric and estimating a point source baseline for the 1980-96 time period. The 2019 report from the Point Source Measures Workgroup can be accessed at www.epa.gov/ms-htf/report-point-source-progress-hypoxia-task-force-states.

Storm water, septic, and minor Publicly Owned Treatment Works (POTWs)

Storm water

The urban conservation program within IDALS was established in early 2008. Early on, funding was limited, which lead the urban conservation team to focus attention on education and training activities to help promote green infrastructure practices. Assistance was provided to many homeowners to implement small-scale projects with small amounts of cost-share from Resource and Enhancement Protection program funds. Since then, the program has started to hit its stride. Currently, it has evolved from education and small-scale practices to implementing $12-15 million worth of urban conservation projects annually through partnerships with the DNR Sponsored Projects Program, the Iowa Economic Development Authority's Community Development Block Grant Program, and the IDALS Water Quality Initiative (WQI) program. In the past three years, urban conservationists have worked with more than 100 communities to help plan, design, and implement urban projects totaling over $54 million of work.

Septic and minor POTWs

Upgrading of failing septic systems continues through implementation of Iowa's "time of transfer" law that took effect in 2009. Database improvements continue to progress to better enumerate the success of this program. Approximately 12,000 out of an estimated 49,500 time of transfer records have been entered into a database that allows systems to be sorted by condition and type. These records are being loaded to a cloud-based storage system that will allow easier access to the records.

Analysis was completed for last year's annual report to quantify annual statewide N and P reductions based on the information collected during time of transfer inspections (Table 17). Of the approximately 12,000 inspections studied, there were 657 failed systems that have been replaced between 2009 and 2018. This translates to a septic replacement rate of 5.35% as a result of the time of transfer law and program. Using this rate, it is estimated 2,644 failed systems have been repaired or replaced when extrapolated to a full universe of approximately 49,500 inspections since 2009, resulting in the annual nutrient reductions outlined in Table 17 below. Database improvements are in development that will aid in reporting nutrient reductions from onsite wastewater improvements on an annual basis.

Table 17. Nutrient load reductions based on analysis of Iowa's time of transfer program.

	Effluent (with failures) (lbs/yr)	Effluent (with fixed) (lbs/yr)	Extrapolated nutrient reduction (lbs/yr)
Nitrogen	1,070,000	1,050,000	20,000
Phosphorus	40,000	27,000	13,000

Source water protection

The Iowa Source Water Ag Collaborative, formalized in 2016, is dedicated to providing Iowans information and resources to protect their drinking water. Partners in the collaborative include the Agri-business Association of Iowa, Brinkman Ag Solutions, Conservation Districts of Iowa, Golden Hills Resource Conservation & Development, Heartland Co-op, Iowa Certified Crop Advisors, Iowa Corn Growers Association, Iowa Soybean Association (ISA), IDALS, DNR, Iowa State University Extension and Outreach, Iowa Section of the American Water Works Association, US Department of Agriculture (USDA) Farm Service Agency (FSA), and the NRCS. The partnership with Conservation Districts of Iowa and DNR continues with two water specialist positions to facilitate phase-two plan development and implementation with local stakeholders. The collaborative received a McKnight Foundation grant to assist in increasing capacity to develop a comprehensive source water protection program in Iowa, through engaging and coordinating with partners, compiling and branding resources, pursuing additional funding resources and monitoring progress.

In February 2018 EPA contractors completed Source Water Protection (SWP) plans with a focus on reduction of nutrients and sediment into the lakes used by the cities of Winterset and Spirit Lake. These plans were approved by the DNR as "Phase 2" SWP plans. The plans identified resources for implementation and coordinating partners. The plans, utilizing the Agricultural Conservation Planning Framework (ACPF) model and the mapping of existing conservation practices, targeted best management practices (BMPs) that can be funded and deployed on the landscape. Implementation efforts are underway. Winterset Municipal Utilities has hired a watershed coordinator and conducted outreach events with landowners and coordinating partners in summer and fall 2018. Both Winterset and Spirit Lake applied successfully to be pilot projects under new flexibilities in the NRCS NWQI. Over $500,000 has been allocated for practices to date with more expected over the next five years. Additional SWP planning efforts are underway for several communities that may be eligible for funding.

Nutrient criteria development updates

Lakes

The DNR continues to collect and analyze lake nutrient data as part of the ambient lake monitoring and lake restoration programs. The development of quantitative indicators of lake health, including nutrient status, remains a high priority within these programs. Iowa, along with the states of Utah, Connecticut, and Oklahoma, continue to partner with EPA to provide data for and to test new nutrient models that were developed using national datasets. After expressing interest in participating, Iowa was selected as one of the case studies, given the extensive datasets available for Iowa lakes and the commitment in the NRS for the continued assessment and development of suitable nutrient criteria as a long-term goal.

Progress to date includes using national and Iowa data to estimate chlorophyll-a and microcystin relationships. Preliminary results have shown that combining state and national data can improve the performance of these new models. The documentation and review of the underlying science now is complete and the research behind this effort, titled “Combining national and state data improves predictions of microcystin concentration,” was published in 2019[7]. EPA is expecting to release the draft lake numeric nutrient criteria in early 2020 that incorporates this research in addition to other pending research publications.

Rivers and streams

The DNR continues to collect and analyze stream nutrient data to evaluate draft recommendations for wadeable streams and to support the development of recommendations for headwater creeks and large rivers. A focused three-year project (2018-20) now is underway on the South Fork Iowa River that is researching the interaction of nutrients in the wadeable stream environment and the impact of this interaction on the biological condition of the system. A goal of this project is to help address gaps in the understanding of how nutrients are expressed given dynamic environmental factors such as hydrology, stream morphology, substrate stability, riparian condition, and annual climatic conditions.

The South Fork Iowa River was chosen for this project due to the overlap between observed biological condition, a signature of possible nutrient expression and the many active and historic outreach and research partnerships in the watershed. The South Fork Iowa River also has been the subject of numerous monitoring and assessment efforts over the last 20 years by multiple agencies and organizations. This project has included communication and collaboration with Iowa State University, IDALS, Iowa NRCS, IIHR-Hydroscience & Engineering (IIHR), USDA, USDA Agricultural Research Service (ARS), DNR, private landowners, and the South Fork Iowa Watershed Alliance.

Nonpoint Source Efforts

Continued research on nutrient reduction

Continuation of research in the physical and social sciences is necessary to better understand the processes driving conservation measures that can mitigate nutrient loss. A primary source of research funding and direction has stemmed from the Iowa Nutrient Research Center (INRC). An overview of the INRC’s history and key accomplishments are discussed in the following sections.

The Iowa Nutrient Research Center

The INRC was established in 2013 to support the most up-to-date understandings of nonpoint source N and P pollution to help inform the NRS and support its implementation. The INRC is headquartered at Iowa State University and operates in collaboration with the University of Iowa and the University of Northern Iowa. The INRC director, appointed by the dean of the Iowa State University College of Agriculture and Life Sciences, receives input from an eight-member advisory council mandated by state authorizing legislation.

Table 18. Annual and total awards to identified science assessment nutrient reduction practice categories.

Science Assessment Nutrient Reduction Practice					
Fiscal Year	Nutrient Management Research	Land Management Research	Edge-of-Field Research	Multi-Objective Research†	Total Number of Projects
FY 14	2	1	3	4	10
FY 15	2	3	2	4	11
FY 16	6	3	2	3	14
FY 17	2	1	5	4	12
FY 18	4	3	2	4	13
FY 19	4	5	2	5	16
TOTAL	20	16	16	24	76

†Includes annual funds to University of Iowa, IIHR for sensor work

[7]Lester L. Yuan, Amina I. Pollard. (2019). Combining national and state data improves predictions of microcystin concentration. Elsevier, Harmful Algae 84(2019), 75-83.

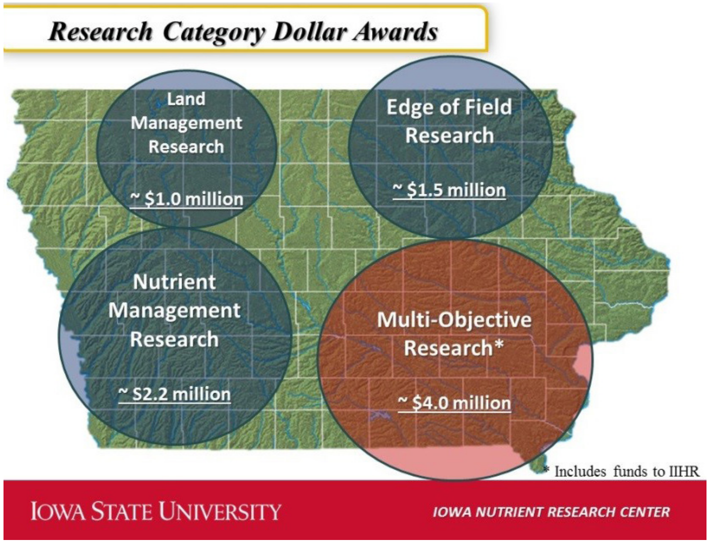


Figure 25. Distribution of research funding by the Iowa Nutrient Research Center, as of the 2019 fiscal year.

Since 2013, the INRC has received approximately $8.7 million in state appropriations and supported 76 water quality projects led by scientists at Iowa's three Regent Schools. More than 95% of INRC funding has gone directly for research projects in categories aligned with the NRS Nonpoint Source Science Assessment: nutrient management, edge-of-field, and land use or land management. The fourth category, multi-objective research, was added to accommodate projects that do not fit neatly into other categories. Approximately one-third of the project funding continues to support collection and aggregation of data on hydrology, water quality, weather, and land use to interpret and implement the NRS, led by IIHR at the University of Iowa. Significant additional leveraging of center-supported projects comes through federal, state and non-governmental organization (NGO) funding.

With the addition of a half-time communications specialist, coverage of research projects expanded and the INRC website was updated, at www.cals.iastate.edu/inrc. The INRC Advisory Council met October 31, 2018, and assembled for a council teleconference May 13, 2019; notes from each are available on the INRC website.

Last year, the NRS Annual Report highlighted INRC-supported research on cover crops, bioreactors, and saturated buffers, all practices that represent extensive research that continues to be supported by the INRC (updates on ongoing and new projects are available on the INRC website). This year, the NRS report highlights examples of the multi-objective research being supported by the INRC and partners to encourage innovation and explore ways to expand adoption of diverse conservation practices by making these more practical and cost-effective. Such projects are exemplified by the four diverse research projects summarized below.

Cover crops provide value as forage resource

Recognized as one of the main conservation tools that can reduce both N and P loss and prevent erosion, nevertheless, cover crop adoption continues to be slow in many areas of Iowa. New research shows the potential as livestock feed, which may encourage use. The research, which continues through 2019, has been led by Dan Loy, professor at Iowa State University and director of the Iowa Beef Center, and Erika Lundy and Rebecca Vittetoe with ISU Extension and Outreach. Their preliminary results show forage from cover crops can provide valuable feedstock, though yields varied widely from year to year, due to weather, planting dates, and field locations. On a good year, at stocking rates of about 1.5 head of cattle per acre, a cereal rye cover crop offered 20-27 days of spring grazing. A cereal rye and oat cover crop mix provided suitable fall grazing for 8-13 days. Weight gain was similar for stocker cattle grazed on cover crops compared to cattle grazing pasture.

The research also is examining how grazing cover crops may affect soil health. Researchers say it's too soon to tell the long-term impacts on soil carbon. Preliminary bulk density tests that measure compaction levels indicated no increase in compaction in areas where cover crops are grazed.

Parts of this project were leveraged by funds from The Leopold Center for Sustainable Agriculture, the Iowa Beef Center, and ISU Extension and Outreach.

Prairie potholes found to be "hotspots" to reduce losses of nitrogen and dissolved phosphorus

A new look at the landscape distribution of "hotspots" for nitrate and P loading to surface water can inform strategic management interventions to improve water quality. Research led by Steven Hall, assistant professor in Iowa State University's Department of Ecology, Evolution and Organismal Biology, has found that drained and cropped depressions (former prairie pothole wetlands) that flood intermittently often contribute disproportionately to nitrate and P loading to water entering tile drainage systems. The depressions also were linked to high field-scale emissions of the greenhouse gas nitrous oxide.

The study suggests targeting such hotspots for alternative management or restoration could provide significant nutrient reductions with potentially low overall impact to farm operations. This project leveraged additional funding from the USDA and EPA.

Road ditches provide water quality functions

New research documents N-reduction benefits from road ditches across the landscape, raising the question, "How can we better realize their potential?" A research team led by Keith Schilling, state geologist and director of the Iowa Geological Survey at the University of Iowa, studied six ditches along paved and gravel roads in an eastern Iowa watershed predominated by row crops. The team monitored water quality upstream, midstream, and downstream, looking at levels of nitrate-N, P, dissolved oxygen, salts, and heavy metals. Researchers also analyzed soils in the ditches, vegetation, and surface and groundwater levels. They were not surprised to find soil and groundwater conditions within the ditches favorable for denitrification, based on similar studies elsewhere. However, the extent of the ditches' nitrate-processing capacity was a surprise. Nitrate concentrations decreased an average of 60% in subsurface water from upstream to downstream locations in four of the six ditches – levels comparable to nitrate-removal wetlands. (N levels in water coming into the other two ditches were low enough that the nutrient processing capacity did not have a significant impact.) While the ditches were effective at removing nitrate, these did little to alter P levels or concentrations of heavy metals from water flowing into them.

The researchers suggest further study to explore increasing ditches' nitrate reduction capacity through modifications that could capture additional drainage or increase retention time and infiltration of flow. These could include adding features such as check dams or swales or using two-stage ditch designs that increase interaction of water with biologically active plants and microbes.

This project leveraged additional funding from the University of Iowa, University of Northern Iowa, and Coe College.

Building cost-effective prairie for nutrient reduction

More landowners are interested in planting strips of deep-rooted prairie within crop fields or on marginal land as a soil conservation and water quality practice. For the practice to catch on, prairie plantings need to be more dependably successful and cost-effective. Research led by the University of Northern Iowa's Tallgrass Prairie Center studied seed mixes and management guidelines that might improve landowners' results with prairie establishment. The study, conducted on several sites in eastern Iowa, compared three seed mixes. The results showed the importance of considering soil conditions and site location, with seed mix design the biggest influence on costs and ecological outcomes. The project helped validate a new tool, the Tallgrass Prairie Seed Calculator, at www.tallgrassprairiecenter.org.

The research also looked at the impact of mowing prairie as a management tool. Early mowing resulted in better, faster establishment and significantly decreased weed competition. By the third year, these benefits had leveled off, but the study showed that more intensive early management accelerates benefits from a prairie planting, especially weed suppression and stem density, which is associated with aspects of water quality improvement.

Parts of this project were leveraged by funds from FSA, The Leopold Center for Sustainable Agriculture, and the New York Community Trust/Monarch Joint Venture.

Addition of new practices in the NRS

As research continues, new insights are developed regarding practices to reduce N and P use and their effectiveness. Those who want to propose an addition to the NRS practice list may submit data and literature reviews to the NRS Science Team, a group of university and public agency researchers coordinated by the director of the INRC. This group conducts the NRS Science Assessment for nonpoint sources and reviews the effectiveness of conservation practices for possible additions or modifications to the NRS practice list.

The NRS Science Team continued to meet on a regular basis through the 2019 reporting period to review potential practices and share information. Multi-purpose oxbows – specifically, the restoration of oxbows in tiled row crop fields for the purpose of nitrate removal – were reviewed as a potential nitrate reduction practice by the NRS Science Team. The team recommended the addition of the practice to the NRS Nonpoint Source Science Assessment. For more information on the review process and to view the practices that were submitted and not approved, see page 53.

Building capacity and accelerating change

The NRS serves as a foundation for improved partnership and collaboration for nutrient load reduction efforts in Iowa. This summary provides details on the current status of state and federal program delivery, while quantifying NGO investments. This effort is not complete and will continue to be refined and improved to gather additional information from other sectors currently not included in this assessment.

The challenge of developing capacity for implementation continues to grow as increased funding becomes available. Reducing nonpoint and point source nutrient contributions will require technical assistance, practice design, and, in some cases, construction. Often this issue is exacerbated when trying to implement new or emerging practices. Existing staff tasked with delivering the current set of funding levels are typically at capacity. Therefore, additional resources likely will need to include new staff, which will require training. Whether this is in the private or public sector, staff capacity will need to be available to review and implement the practices that must occur across Iowa's landscape in order to reach the goal of 45% reduction of statewide N and P export. Current efforts operate this way to some extent, but are only able to deliver at the level of current focus and funding levels. Depending solely on existing efforts, processes, and staff levels to deliver more will influence progress. Streamlining and prioritizing will help, but the challenge will be to scale up these efforts and to incorporate new practices that are not widely deployed. Multi-year watershed projects and others that are supported by state and federal programs are helping to address this need for increased infrastructure and capacity for NRS implementation, but continued increases in capacity and semi-permanency in support of these efforts is necessary.

The Iowa Conservation Infrastructure initiative

The Iowa Conservation Infrastructure initiative was started with a broad cross-section of leaders within and outside of the agriculture industry to help identify potential economic development opportunities associated with addressing barriers to implementing conservation practices and advancing the NRS. The initiative seeks to increase the investment and engagement from both public and private sectors in implementing the NRS. This will be achieved by accelerating farmer and landowner demand for conservation practices – through outreach, education, and training – and harnessing economic drivers, innovative market-based solutions, and new revenue streams to improve water quality.

The Iowa Conservation Infrastructure initiative identifies barriers and solutions to scaling up conservation practices from current rates of adoption to the levels necessary to achieve the nutrient load reduction goals of the NRS. It also recognizes that as the pace and scale of conservation practices increase, there will be job creation and economic development opportunities, as well as water quality improvements, that benefit all Iowans. At the same time, it seeks to signal to the private sector that there are robust, long-term business opportunities for investing in conservation-related business lines.

Current action items and expected outcomes

The Iowa Conservation Infrastructure initiative has brought together technical experts and industry representatives to initially look at three aspects of this challenge: the overall conservation infrastructure strategy, conservation drainage (e.g., bioreactors, saturated buffers, drainage water management, and nutrient removal wetlands), and cover crops. Since announcing its initiation in August 2016, representatives from the public and private sectors have been engaged in defining and developing the initiative. This includes rural and urban organizations, agricultural associations, conservation and environmental groups, agribusinesses, food companies, engineering firms, farmers, academic institutions, and federal, state, and local governments.

The expected outcomes for the Iowa Conservation Infrastructure initiative include reduction or elimination of identified barriers to progress on implementation of the NRS, increased private sector engagement and role in delivering conservation, and increased private sector economic activity that is driven by conservation.

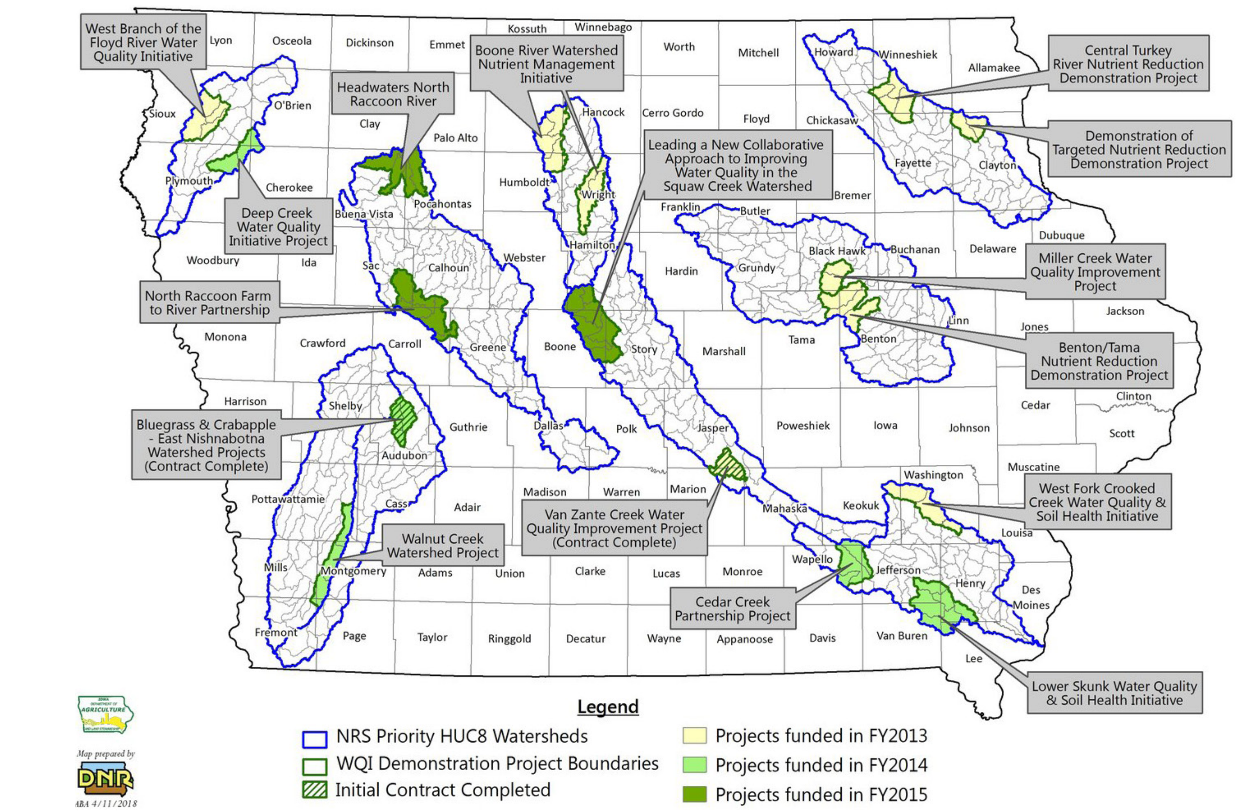


Figure 26. The geographic distribution of watershed demonstration projects funded by the WQI.

More information on the Iowa Conservation Infrastructure initiative can be found at www.iowaci.org. The 2019 annual report for the Iowa Conservation Infrastructure initiative can be found in Appendix A and on the Iowa Conservation Infrastructure website.

Prioritization of watersheds

The 2011 memo, "Working in Partnership with States to Address Phosphorus and Nitrogen Pollution through Use of a Framework for State Nutrient Reduction Strategies," through which the EPA urged states to develop plans for reducing nutrient loss, and called for the identification of watersheds that account for a substantial portion of the state's nutrient load export through surface water and to the Mississippi River. This work was further supported in the 2016 EPA memo, "Renewed Call to Action to Reduce Nutrient Pollution and Support for Incremental Actions to Protect Water Quality and Public Health."

In an effort to establish targeted action in watersheds that carry the majority of Iowa's nutrient export, demonstration projects have been established in hydrologic unit code-12 (HUC12) watersheds that lie within the priority HUC8 watersheds, with the goal of spreading awareness of nutrient-reducing practices that can affect change in the nutrient load of these catchments. The WQI provides targeted funding and support for 15 projects, three of which began in 2015 (Figure 26). These projects are working to address critical gaps and opportunities to advance a subset of practices underutilized through traditional funding programs or in certain situations that present a unique opportunity or method of targeting certain practices. These projects are prioritized to these watersheds and would result in providing information critical to advancing implementation in other key areas.

While these 15 projects target the priority watersheds, there are, in total, 36 ongoing watershed projects in 61 Iowa counties. The majority of these projects operate as locally led efforts, and are supported through leadership from Iowa's Soil and Water Conservation District commissioners, who, in partnership with watershed coordinators, tailor the projects to meet the specific needs, concerns, and values of the surrounding communities.

Table 19. Selected results of the 2017 and 2018 INREC Survey of Agricultural Retailers. Results are reported in acres, unless the unit is otherwise noted. Italicized values in parentheses indicate the standard error.

	2017		2018	
Average N rate on corn in rotation (lb/ac)	170.0	(1.0)	172.3	(1.1)
Average N rate on continuous corn (lb/ac)	200.4	(3.4)	201.9	(3.0)
Cover crop planted	1,597,614	(216,951)	2,015,688	(244,917)
Fall anhydrous applied †	8,579,390		5,283,236	
Nitrapyrin used with fall anhydrous †	6,232,354		3,906,059	
Spring pre-plant †	13,018,154		16,270,199	
In-season only †	470,531		231,098	
Commercial P incorporated with planter	2,523,799	(268,686)	862,841	(170,834)
Commercial P applied in knifed bands	656,919	(130,326)	627,900	(133,481)
Commercial P broadcast and incorporated within 1 week	10,807,030	(409,178)	16,143,905	(334,296)
Liquid P injected into soil	416,049	(116,801)	865,364	(143,614)
Other P application type	8,591,331	(410,207)	4,468,931	(304,265)
Conservation tillage acreage	11,611,287	(399,307)	10,247,229	(394,776)
No-till acreage	7,707,695	(348,811)	6,972,434	(378,385)
Conventional acreage	3,676,146	(274,009)	5,733,407	(277,628)

† The acreage estimates for commercial nitrogen fertilizer timing and nitrification inhibitor were adjusted from the original survey report (Appendix B) to account for soybean acres that are part of corn-soybean rotation systems. This adjustment allows for a direct comparison to the NRS Nonpoint Source Science Assessment and baseline period estimates, which factor in both corn and soybean acres to model nutrient loss. The adjusted acreage was calculated by multiplying the survey's original acreage estimate by the ratio of total corn and soybean acres to total corn acres (1.67).

In 2016, the US Department of Housing and Urban Development awarded Iowa agencies with a total of $96.6 million to conduct a five-year demonstration of flood mitigation and nutrient reduction. This project targets four NRS priority watersheds to implement agricultural and urban practices that assist these goals.

Emerging data for tracking in-field practices: The INREC Survey of Agricultural Retailers

The Iowa Nutrient Research and Education Council (INREC) developed and conducted a survey of agricultural retailers to improve existing understanding of agricultural in-field practices and fill data gaps. Survey methodology was developed in collaboration with members of the NRS Nonpoint Source Science Assessment Team and the Iowa State University Center for Survey Statistics and Methodology as part of a public-private partnership to measure practice adoption levels and calculate their impact on nutrient loads as called for in the NRS. For the survey, INREC sampled agricultural retailer locations for randomly selected and anonymously recorded client fields utilizing sales data and records specific to each farm field that was surveyed. In partnership with Iowa State University, the survey results were extrapolated to statewide acreages and values (see Appendix B for survey methods). The survey estimates the extent of cover crops, fertilizer management practices, tillage, and soil testing practices, among other in-field practices. The following section reports the statewide extent of these practices for the 2017 and 2018 crop years; the findings for selected practices are displayed in Table 19.

The INREC survey estimated 1,598,000 acres of cover crops were planted fall of 2016. The following year, INREC estimated 2.0 million acres were planted. It estimated the average rate of commercial fertilizer applied to corn in corn-soybean rotations was 170 pounds of N per acre in 2017, and 172 pounds per acre in 2018. The average rate applied to continuous corn was 200 pounds of N per acre in 2017 and 202 pounds in 2018. These estimates represent statewide means, but the distribution across farmers and operators varies (Figure 27). For instance, for the 2017 crop year, the survey estimated 24% of corn-soybean acres received 150 pounds or less and 10% of continuous corn acres received 175 pounds or less. Conversely, some fields received higher rates of N fertilizer, with 7% of corn-soybean acres receiving more than 200 pounds and 17% of continuous corn acres receiving more than 225 pounds. This understanding of the distribution of commercial

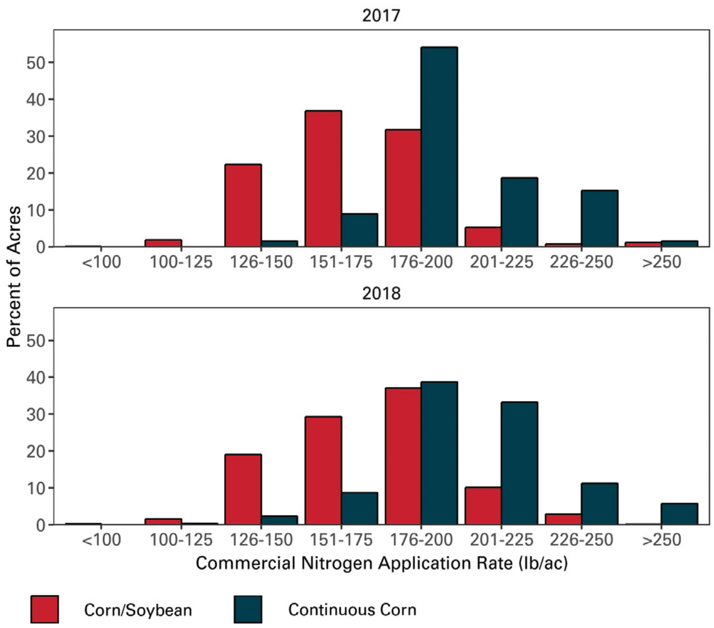


Figure 27. The percent of acres reported to apply commercial nitrogen fertilizer at various application rates (pounds per acre). Data was collected through the Iowa Nutrient Research and Education Council's Survey of Agricultural Retailers for the 2017 and 2018 crop years.

fertilizer rates across differing agricultural fields is an insight that the INREC survey provides and which is not available through other available data sources (e.g., the state commercial fertilizer sales data).

Between 2006 and 2018, the total sales of commercial fertilizers in Iowa increased from approximately one million tons of nitrogen to nearly 1.2 million tons. To compare and validate these new estimates of fertilizer application rates provided by the INREC survey, analyses exploring the fertilizer sales data are underway, including a replication of the Science Assessment's estimate of nitrogen application rates using more recent fertilizer sales data. The INREC survey and the fertilizer sales data approach provide complementary views of Iowa's use of commercial nitrogen fertilizer; the assessment of fertilizer sales since 2010 will be completed in 2020.

According to the survey, in preparation for the 2017 crop year (fall 2016), fall anhydrous was applied to an estimated 8.6 million acres of corn-soybean and continuous corn acres, with 6.2 million acres receiving nitrification inhibitor. For the 2018 crop year, fall anhydrous was applied to 5.3 million acres, with 3.9 million acres of nitrification inhibitor. Thus, nitrification inhibitor was used on approximately 75% of fall-applied acres each year. Spring pre-plant was deployed on 13.0 million acres in 2017 and 16.3 million acres in 2018. In-season N (i.e., side-dress) was the primary application timing for 470,000 acres in 2017 and 231,000 acres in 2018[8].

The INREC survey estimated 14.4 million acres received P fertilizer incorporated, injected, or knifed into the soil within 24 hours of application for the 2017 crop year, and 18.5 million acres for the 2018 crop year. These estimates account mostly for commercial fertilizer, with a small portion of these acres receiving manure. In addition, the survey reported 8.6 million acres received P fertilizer – commercial or manure – for 2017 by another method, which likely accounts mostly for broadcast methods without incorporating within 24 hours; 4.5 million acres received this form of application for the 2018 crop year. Soil testing for P occurred on 81% of fields in 2017 and 72% in 2018.

The survey estimated that, in 2017, there were 11.6 million acres of conservation tillage, 7.7 million acres of no-till, and 3.7 million acres of conventional tillage. In 2018, the relative proportions of tillage practices were 10.2 million acres of conservation tillage, 7 million acres of no-till, and 5.7 million acres of conventional tillage.

With survey results available and statistically extrapolated for two crop years, representatives from Iowa State University, IDALS, and DNR are developing a protocol for integrating these data with existing information about in-field practices, with the aim of answering the following questions. First, can 2017-18 survey results be compared directly to the baseline 1980-96 and benchmark 2006-10 findings, given that those time periods were evaluated using different measures and data sources? Second, how can these survey data results be evaluated and integrated with other contemporary practice data to estimate changes in nutrient loads? Finally, with what frequency should these survey results be reported and tracked moving forward, with options for annual, multi-year rolling averages, and other approaches providing different insights into in-field practice trends in Iowa. Variations in reported results from 2017 to 2018 make it difficult to discern clear trends in practice use from these two survey years. Repeating this data collection in the near future may help address this year-to-year variation and contribute to better understanding of temporal trends in practice use. This process of evaluating different approaches for using and integrating the survey data will continue in 2020.

[8] See note on Table 18 regarding acreage adjustments to account for corn-soybean rotation acres.

The BMP Mapping Project — An ongoing effort to improve tracking of structural practices

In an effort to help support progress measurement and accountability efforts of the NRS, a collaborative project between Iowa State University, DNR, INREC, and IDALS aims to identify and enumerate the aggregate amount of certain structural best management – or conservation – practices (BMPs), independent of government programs, outlined in the NRS Science Assessment. Practices include terraces, water and sediment control basins (WASCOBs), grassed waterways, pond dams, contour buffer strips, and contour strip cropping. These practices are identifiable by use of LiDAR elevation data and aerial photos, thereby enabling an accurate accounting of the practices present on the Iowa landscape.

This project is conducted in three parts. First, the 2010 benchmark existence of structural conservation practices was digitized for 1,712 HUC12 watersheds in Iowa. These watersheds represent all HUC12s that are contained within or intersect the state border. Second, a historical tally of practices that were in place in the 1980-96 baseline period will be determined by digitizing a subsample – 20% – of HUC12 watersheds, using aerial photography from that time period. This 1980-96 estimate corresponds to the baseline targeted by the Gulf of Mexico HTF. Third, the same 20% sample of HUC12 watersheds will be digitized using aerial photography from 2016-18 to estimate potential increased implementation or removal of the structural practices that were located in the 2010 benchmark phase.

Beneficial outcomes and potential utility of this project include the following:

- Establish an initial summary of structural practices already present in the Iowa landscape (see Appendix C).

- Aid watershed planning efforts and encourage efficient use of available resources by highlighting areas for future conservation targeting and by indicating areas where nutrient reduction needs already are met (See Winterset and Spirit Lake sourcewater protection efforts on page 42).

Table 20. The statewide extent of structural and landscape practices in place based on LiDAR and aerial imagery from the 2006-10 time period. Data was collected through the BMP Mapping Project. These results are preliminary and are subject to additional quality assurance and quality control before they are finalized. The quality assurance and control process will be complete in spring 2020.

HUC 12s mapped	Pond dams (number)	Grassed waterways (acres)	Terraces (miles)	WASCOBs (miles)	Contour buffer strips (acres)	Strip cropping (acres)
1,710	111,721	281,088	89,081	11,144	386,258	108,681

- Assign nutrient and sediment load reduction and prevention amounts to current and future practice levels.

- Assess conservation implementation in a way that is blind of public or private investment, encapsulating all conservation activity.

- Track progress going forward from the 2006-10 benchmark period.

- Hind cast to past conditions using historic photos to show progress made over time and to evaluate alternative baselines (e.g., the EPA 1980-96 target).

The information generated by this project will supplement cost-share data and paint a more complete picture of conservation in selected watersheds, while future installations can be tracked against this baseline. Digitization of the entire state has been completed; quality assurance and publication of all data was completed in spring 2019. The benchmark practices will contribute to improved estimates of nutrient load reductions in future analyses. Statistical analysis is nearing completion to extrapolate results from the sampled 1980s and 2016 imagery to estimate statewide implementation and subsequently estimate nutrient load reductions associated with the practices. Table 20 presents the preliminary statewide results from this project for the 2010 benchmark period, and Appendix C displays these values by HUC8 watershed. For more information about this project, visit www.gis.iastate.edu/gisf/projects/conservation-practices.

Targeted water monitoring projects

Paired watersheds

Paired watershed projects involve the selection of two watersheds of similar size and land use characteristics. In these comparison projects, one watershed receives extensive financial and outreach support for conservation adoption, while the other receives limited or no additional support. Stream water quality is monitored in both watersheds to assess the effect on water quality of the installed practices. There are four examples in Iowa of the use of the paired watershed approach to evaluate water quality effects associated with nutrient reduction conservation practices. Three of these projects were completed prior to the 2016 reporting period, but the Black Hawk Lake project commenced in 2015 under the NRCS National Water Quality Initiative (NWQI). Data collected in 2018 indicate similar patterns to 2015, 2016, and 2017, which suggest reduced nutrient losses from the subwatershed with a higher degree of BMP adoption than those measured in the watershed with less extensive BMP implementation. It cannot yet be determined if differences seen are sustainable and statistically significant given the different variables and challenges associated with the project (see Semi-Annual Report for NWQI Monitoring in the Black Hawk Lake Watershed (December 15, 2018 through May 31, 2019). Therefore, to better gauge the effects of BMP implementation on water quality over time, the EPA has approved continuing Section 319 funding for several additional years of sampling and analysis of this paired watershed study. This project highlights the challenges of using water monitoring data over short time periods to capture the impacts of practice implementation on the landscape (see pages 33-34). Additional data and analysis will improve understanding, and better connect the link between conservation practices and instream water quality improvement.

Conservation Learning Labs

Iowa Learning Farms has partnered with IDALS and the NRCS to implement a watershed project that will measure the impact of widespread cover crop adoption on nitrate export in small watersheds. This project, the Conservation Learning Labs, targets small watersheds – between 500 and 1,300 acres in size – to promote and fund the adoption of cover crops. With water monitoring at the outlet of each watershed, the project aims to detect changes in N export over time as a result of high cover crop adoption rates. Landowners and farmers in two pilot watersheds, one in Story County and one in Floyd County, have received additional promotion and financial assistance for installing new conservation practices. In these watersheds, existing Conservation Reserve Enhancement Program (CREP) wetland projects provide the water monitoring necessary for establishing background nutrient losses and for detecting change following the widespread use of cover crops within the watershed.

By spring 2018, approximately 77% of the Floyd County watershed had been enrolled in three-year cover crop contracts, about 18% in first time strip-tillage, and 1.7 acres enrolled in the Conservation Reserve Program (CRP). In Story County, enrollments treated about 49% of the watershed's acres with cover crops and about 42% with first-time strip tillage. Enrollment from the following season has yet to be reported, so this section will be updated in the next NRS Annual Report.

Data collection for conservation plans included crop rotations, management practices, and nutrient application data for each field. Bulk density, infiltration rate, soil aggregate stability, and manure nutrient analyses have been conducted to inform the modeling component of the project. Preliminary flow weighted annual nitrate-N concentration monitoring indicates the greatest impact of the cover crop treatments occur in the spring months. Monitoring and data analysis will continue and will be reported in the future. Project updates can be found at www.iowalearningfarms.org/conservation-learning-labs.

Point Source Efforts

Nutrient trading: Recent innovative approaches

The Iowa League of Cities was awarded a USDA-NRCS Conservation Innovation Grant (CIG) in October 2015 to develop a water quality credit trading (WQCT) framework to advance the goals of the NRS and beyond. This work has steered toward the development of a pre-regulatory compliance strategy titled the "Nutrient Reduction Exchange" (NRE) that could serve as a tracking system and would allow nutrient sources across the state to register and track nutrient reductions resulting from installed BMPs that target NRS goals. In addition to nutrient reduction, the NRE acts as a registry to track additional benefits that drive watershed investment, such as flood mitigation and source water protection.

The formal NRE structure is built and being administered by the DNR and Iowa State University for implementation. The DNR and Iowa State University continue to work closely with interested stakeholders as implementation begins. Currently, there are five main areas of focus:

1) Process – National Pollutant Discharge Elimination System (NPDES) permit integration (DNR) and practice application submittals (Iowa State University and DNR)

2) Incentives – evaluation of regulatory authority and potential for use

3) Database – USACE RIBITS Iowa Pilot which ensures an easy-to-use electronic application submittal process

4) NRE placement – evaluation of NRE placement in rule or policy

5) Nutrient load reduction model – evaluation and implementation of a specific model or models for load reduction estimates such as the Nutrient Tracking Tool (NTT)

Public Comment

Iowans and other interested parties are invited to review the updated Iowa Nutrient Reduction Strategy and supporting documents. The Iowa Department of Agriculture and Land Stewardship, the Iowa Department of Natural Resources and Iowa State University seek to continue to broaden the engagement of stakeholders and further advance the strategy.

The public is invited to provide feedback on implementation of the strategy and comment on additional partnerships that could help strengthen the strategy and help achieve the goals of continuous improvement and broad participation by all stakeholders. The comment period is ongoing.

Areas of focus include

Strengthen collaborative local, county, state, and federal partnerships.

- Are there additional partners with a demonstrated ability to advance implementation of nutrient reduction technologies and conservation practices to improve water quality? Identify additional opportunities for accelerating cost-effective nitrogen and phosphorus load reductions from both point and nonpoint sources.

- Are there additional or emerging practices or technologies that should be considered for inclusion in the NRS Science Assessment? The WRCC annual report on the strategy identifies a process for these new and emerging practices and technologies to be included in the list of practices.

- Are there additional delivery methods and opportunities that should be considered to increase the rate of adoption?

Electronic: Please use the form below to submit your comments at nutrientstrategy.iastate.edu/comments

Mail: Comments may be mailed to: ANR Program Services, attn: Nutrient Reduction Strategy, 1151 NSRIC, Ames, Iowa 50011-3310.

Comments and contact information submitted here are considered public and are subject to Open Records Law requests from the media or others.

Comments received to date can be found at www.nutrientstrategy.iastate.edu/public.

Updates to the Strategy

Nonpoint source updates

As research on nonpoint source conservation practices is conducted, new insights are developed regarding the effectiveness of practices in reducing nitrogen and phosphorus loss. Data and literature reviews may be submitted by the public to the NRS Nonpoint Source Science Team, a group of university and public agency researchers that conducted the NRS Nonpoint Source Science Assessment and continue to review the effectiveness of conservation practices.

When approved, new practices are added to NRS documents. Updated versions of the NRS can be found at www.nutrientstrategy.iastate.edu/documents.

Practices reviewed and approved

Multi-purpose oxbows — The restoration of oxbows in tiled row crop fields for the purpose of nitrate removal was reviewed as a potential nitrate reduction practice by the NRS Nonpoint Source Science Team. The team recommended the addition of the practice to the NRS Nonpoint Source Science Assessment.

Submitting practices for review

Procedures for submitting a practice for review by the NRS Nonpoint Source Science Team can be found at www.nutrientstrategy.iastate.edu/documents.

Point source updates

Two facilities were removed from the NPDES required permits list: City of Waukee Sewage Treatment Plant (connected to City of Des Moines Wastewater Reclamation Authority), and John Deere Dubuque Works.

Laurie Nowatzke
Measurement Coordinator of the Iowa Nutrient Reduction Strategy
Iowa State University
515-294-0527
lwissler@iastate.edu

Matt Lechtenberg
Water Quality Initiative Coordinator
Iowa Department of Agriculture and Land Stewardship
515-281-3857
matthew.lechtenberg@iowaagriculture.gov

Adam Schnieders
Water Quality Resource Coordinator
Iowa Department of Natural Resources
515-725-8403
adam.schnieders@dnr.iowa.gov