Iowa Nutrient Reduction Strategy

Annual Progress Report

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Part One: Progress of the Iowa Nutrient Reduction Strategy

Introduction

The Iowa Nutrient Reduction Strategy (NRS) is a research- and technology-based approach to assess and reduce nutrients delivered to Iowa waterways and the Gulf of Mexico. The strategy outlines opportunities for efforts to reduce 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 their 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 on 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 listed in the elements of 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 around 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 provided the basis for analysis of NRS funding, staff, outreach, practices, and water monitoring to track efforts that have been conducted during the 2017 reporting period (June 1, 2016, to May 31, 2017). A list of these partner organizations is displayed on page 59.

The Logic Model Approach

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, and represents a progression toward goals for achieving a 45 percent reduction in nitrogen and phosphorus loads. This measurement framework assists the annual reporting process, which was recommended by the 2011 EPA memo.

Navigating this report

Each section of this annual report 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. In order to affect change in water quality, there is a need for increased inputs, measured as funding, staff, and resources. Inputs affect change in outreach efforts and human behavior. This shift toward more conservation-conscious attitudes in the agricultural and point source communities is a desired change in the human dimension of water quality efforts. With changes in human attitudes and behavior, changes on the land may occur, measured as conservation practice adoption and wastewater treatment facility upgrades. Finally, these physical changes on the land may affect change in water quality, which ultimately can be measured through both empirical water quality monitoring and through modeled estimates of nutrient loads in Iowa surface water. The measurable indicators that correspond to each category, as outlined in Figure 1, provide quantified parameters in which to track year-to-year changes and continual trends to develop a standardized protocol for evaluating NRS progress.

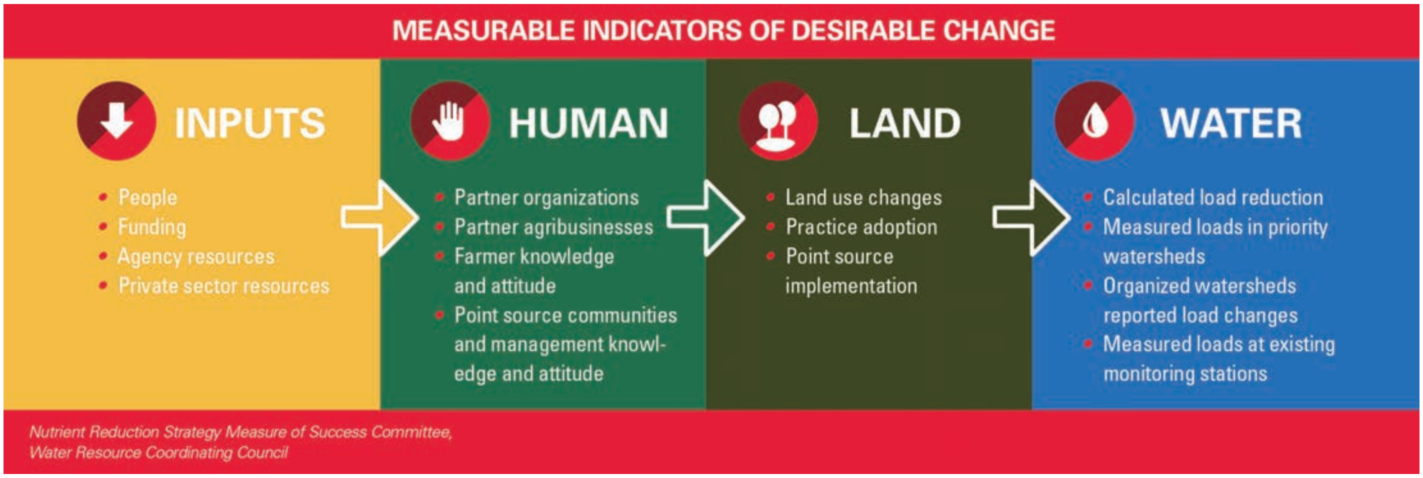


Figure 1. The logic model of the Iowa Nutrient Reduction Strategy, guided by measurable indicators of desirable change.

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 not only a progression of changes, but also can inform improvements in each of the four primary categories. With continually refined measurement of each category, potential adjustments may be made to the inputs and efforts that partner organizations devote to the NRS in order to impact change over time.

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 as follows. 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 management if progress is not made

Data availability to accurately assess progress in each category of the logic model is a primary hurdle. For example, current analyses—as discussed in the "Land" section of this report—rely on governmental conservation program (i.e. cost-share) data to evaluate conservation practice adoption on agricultural land. There is limited knowledge of the extent to which farmers employ conservation without public financial assistance, but efforts are currently underway to capture this critical information. Similar challenges in data availability relate to many of the indicators discussed in this report; specific details and efforts to overcome these data limitations are described within each corresponding portion of this report.

A sufficient period of record is also needed to evaluate progress. In large, 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 may appear be overly elevated due to exceptional runoff. Conversely, in a drought year, nutrients may appear to be well controlled due to minimal runoff. It will take a multi-year period of time to get an accurate handle on progress by detecting an overall trend in what can be very highly variable data.

The following sections highlight and discuss the evaluation of NRS logic model indicators and the progress that was made since June 1, 2016. Indicators of each category and the related data sources discussed are continually under evaluation and may be subject to change in the future.

Inputs

Inputs are a foundational indicator of change in Iowa's efforts to reduce nutrient loading within the state and further downstream. Increases in inputs are necessary to expand Iowa's capacity for encouraging and realizing changes in human behavior, and for promoting 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, but this report aims to provide an overview of statewide funding, staff, research, and demonstrations that are dedicated to NRS implementation. Progress of NRS inputs is measured, in part, through the documentation of annual funding, staffing, and the extent of continued research.

Funding

The total estimated funding for NRS-related efforts in the 2017 reporting period—including education and outreach, research, practice implementation, and water monitoring—was an estimated $420 million. This estimate is an increase from the $388 million reported in 2016[1] (Figure 2).These estimates encompass both public and private funding and were calculated from the voluntarily submitted reports of WRCC and WPAC member organizations and by other partner organizations that conduct work contributing to NRS implementation. 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. 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.

Of the total reported funding for the 2016 and 2017 reporting periods, 93 percent was appropriated through public funds. Conservation Reserve Program (CRP) rental payments accounted for about half of this public funding, at about 58 percent of total funding. Seven percent of total funding was private—landowner contribution to cost-share or funding reported by private and non-governmental organizations.

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. For the 2016 and 2017 reports, funding, staff, outreach efforts, and monitoring efforts were collected 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 Two of this report.

It is vital to note that most public funding comes from sources that could be considered base programs. These programs fund conservation efforts that 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 they 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.

[1] Funding amounts are calculated and reported differently than in the 2016 Annual Progress Report. This discrepancy is due to factors outlined on page 6.

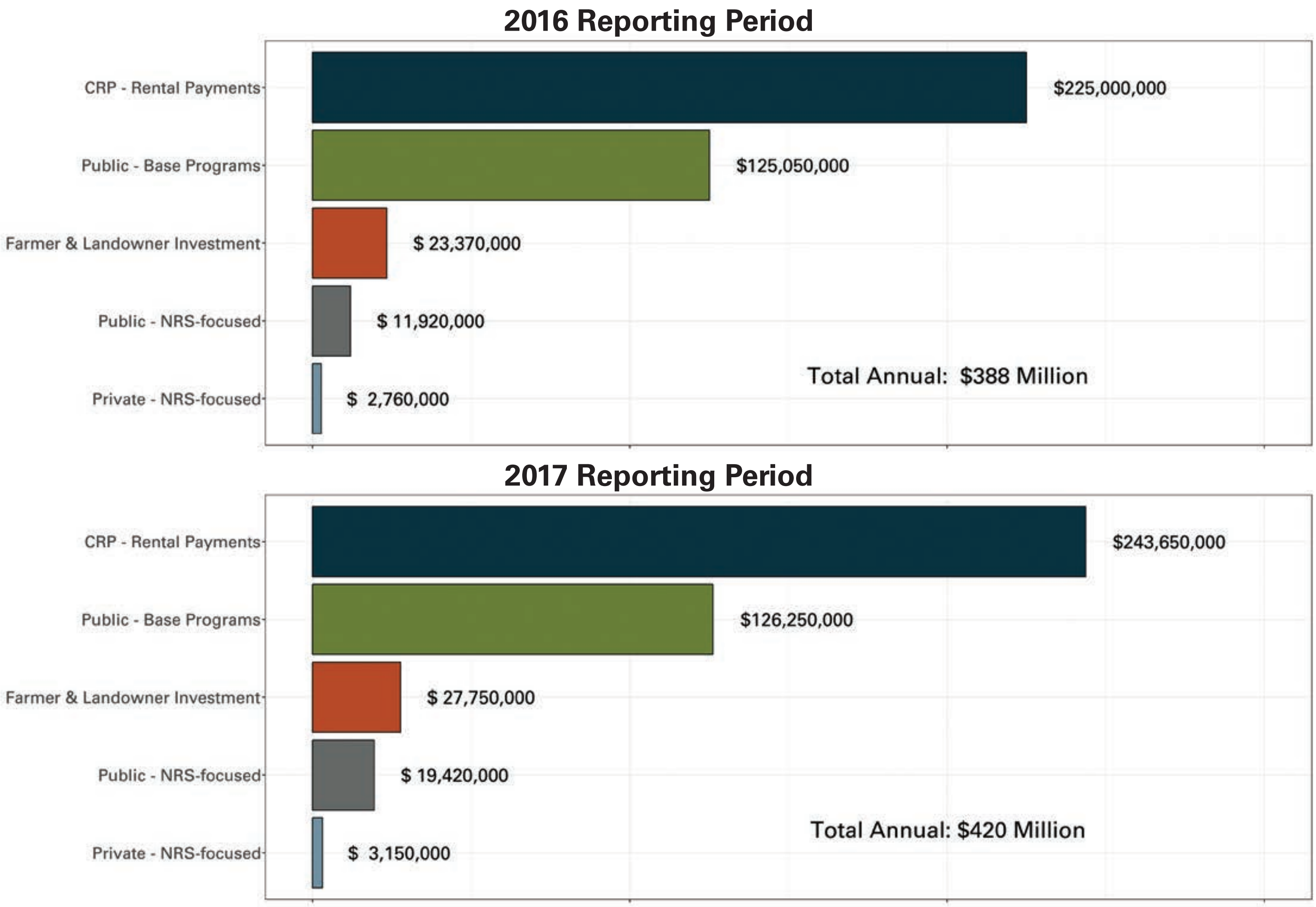


Figure 2. Funding obligated for NRS efforts by partner organizations in the 2016 and 2017 reporting periods. Farmer and landowner investment accounts only for investment in cover crops, terraces, and WASCOBs, and grade stabilization structures that received cost-share funding. Efforts to expand this analysis are underway, so these estimates will likely change in future reports.

Public programs that are NRS-focused (i.e. implement newly established NRS efforts) increased from 2016 to 2017 by about $7.55 million.[2]

While the level of public funding for NRS implementation in the 2016 reporting period accounts for the vast majority of total funding, non-governmental partners reported approximately $3.2 million of private funding for NRS efforts during this past reporting period. This was a 14 percent increase from the $2.8 million of private funding reported last year. Much of this funding was sourced from commodity check-offs and organizations' membership dues.

The 2016 annual report indicated that $112 million and $122 million were obligated for NRS efforts in 2015 and 2016, respectively. The discrepancy between those values and the funding estimates reported in this document is due to:

- The inclusion of CRP rental payments in the total funding estimate.
- The improvement of funding reporting by partner organizations, whereby higher-resolution data on specific programs made it impractical to compare 2016 and 2017 funding to the less standardized 2015 partner reports.
- The ability to account for some landowner investment in cost-share conservation practices.
- Participation by additional partner organizations in the reporting process.

[2] Federal conservation programs assessed for this report include: Conservation Reserve Program, Environmental Quality Improvement Program, Conservation Stewardship Program, Regional Conservation Partnership Program, EPA-319, Conservation Reserve Enhancement Program, and others. State conservation programs assessed for this report include: Iowa Financial Incentive Program, Water Quality Initiative, Resource Enhancement and Protection, and others.

Thus, the total funding estimates reported this year should not be compared to those in the 2016 annual report. Still, there are likely additional sources of funding that have not been accounted for in this process. Measurement of NRS funding is continually improving to track change over time; recent developments—a standardized reporting tool—for gathering annual funding data will allow for consistent reporting from 2016 onward. Additionally, to improve measurement of NRS progress that has occurred since the strategy's introduction in 2013, efforts are underway to retroactively estimate annual funding for the years 2011 through 2015 using similar data collection methods as employed for this report.

Estimated farmer investment in conservation

A new analysis presented in this annual report is an initial estimate of farmer and landowner investment in conservation practices that reduce nutrient loss from agricultural nonpoint sources. Currently, because practice implementation data are limited to cost-share programs and exclude independently implemented practices, this assessment of financial investment in practices is also limited to cost-share programs.

This analysis utilized state program data, which provides the financial data that correspond to specific cost-share contracts, to estimate cost per acre treated for cover crops, terraces, WASCOBs, and grade stabilization structures. These cost-per-acre values were applied to federal cost-share practice data, which exclude landowner financial contributions but indicate acres or units installed. An initial assumption of 50 percent cost-share was applied to this average cost per practice to estimate farmer and landowner investment in federally funded practices. Other conservation practices had insufficient data to make these estimates, but a data-sharing relationship recently established by IDALS with the U.S. Department of Agriculture Natural Resource Conservation Service (NRCS) federal office will contribute to future financial analysis on practices funded through the Environmental Quality Improvement Program, the Conservation Stewardship Program, and additional cost-share programs.

Farmer and landowners invested about $8 million in cover crop cost-share contracts in 2016, while they invested approximately $20 million in terraces, WASCOBs, and grade stabilization structures (Figure 3). Investment in

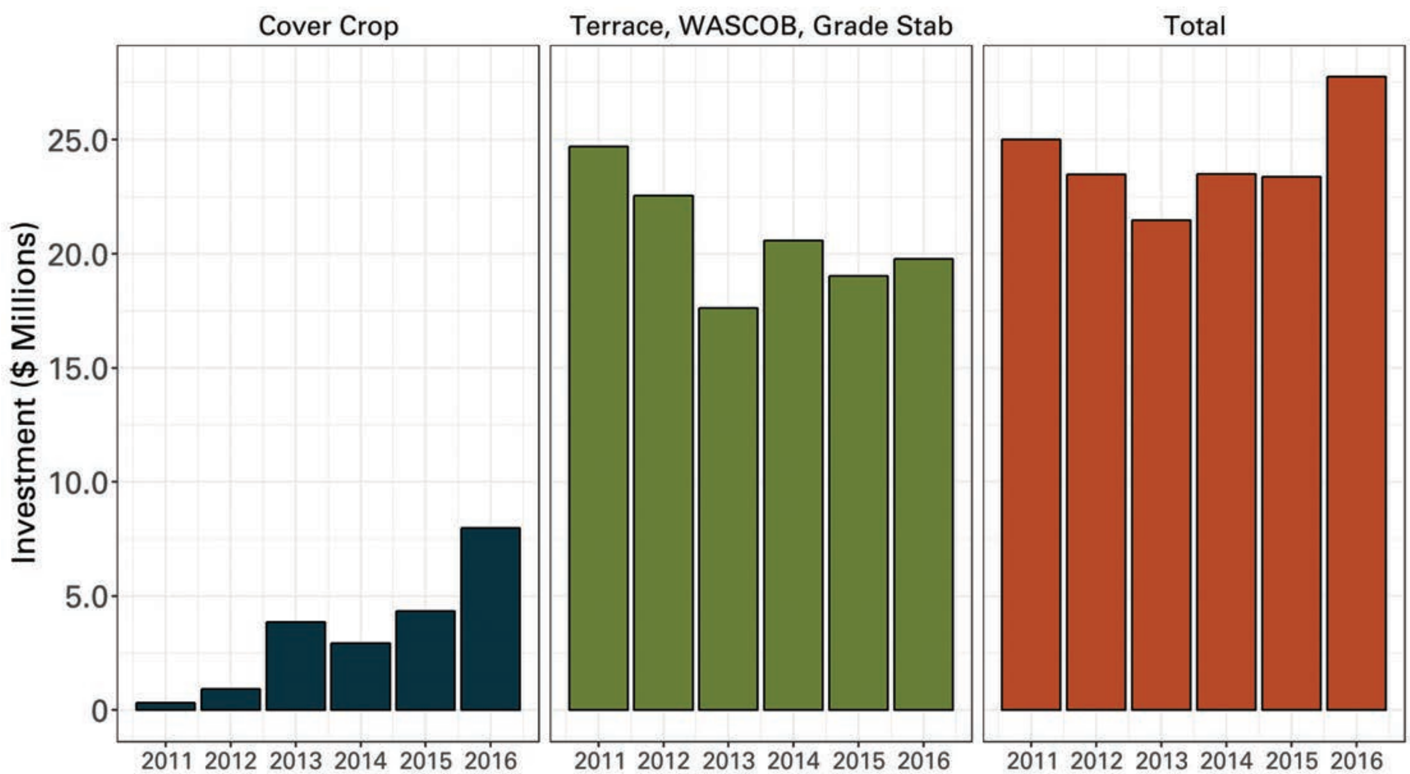


Figure 3. The estimated investment spent by farmers and landowners who used cost-share assistance for cover crops, terraces, WASCOBs, and grade stabilization structures. These estimates exclude investments by farmers and landowners that did not use any state or federal cost-share assistance for these practices.

these selected practices increased by $5 million from 2015 to 2016, but this investment has varied from year to year. Rapid increases in cover crop adoption through cost-share programs drives a steady increase in the associated landowner and farmer investments. However, investment in the structural practices has fluctuated more in the last six years. This fluctuation is partially due to variations in funding levels for these programs, but is also impacted by variations in practice installation affected by weather, time of survey and design, and other factors.

This estimate of farmer investment underrepresents true total investment in cost-share practices, as it only includes selected practices due to data availability. Additionally, this estimate excludes landowner spending for NRS practices that were financed entirely outside of cost-share programs. The lack of data available for independently adopted practices makes for difficult financial assessment, but efforts to track non cost-shared practices (see page 37 for more details), coupled with these insights on overall cost of practices, will aid future efforts to better account for total investment.

The Iowa State Revolving Fund

The State Revolving Fund (SRF) is operated by the DNR and the Iowa Finance Authority, in partnership with 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 $2.9 billion to date.

During the 2017 fiscal year, the Clean Water SRF provided the following assistance for water quality projects:

Project type	Amount
Wastewater and sewer infrastructure	$184,729,000
Soil and sediment erosion control	$1,824,000
Manure management	$2,040,000
Onsite septic system upgrades	$853,000
Wetland, lake, and river restoration	$6,846,000
Green stormwater infrastructure	$8,936,000
Total	**$205,228,000**

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. This program is currently funding 70 projects, up from 57 reported during the 2016 reporting period, with a total of $56 million committed.

Sponsored project priorities are locally directed, allowing communities and their partners to create innovative approaches to watershed protection and urban-rural partnerships. Some examples include:

- The City of Donnellson, which provided cost-share funds to the Soil and Water Conservation District (SWCD) to incentivize use of cover crops.
- The City of Northwood, which is partnering with a drainage district to fund nutrient removal wetlands on agricultural land.
- The City of Fort Dodge, which funded stream stabilization projects on agricultural land to reduce nutrients into Badger Lake.

During the 2017 fiscal year, the Iowa Soybean Association (ISA) initiated an effort to work with three sponsored project applicant communities—Eagle Grove, Charles City, and Des Moines—to develop comprehensive watershed assessments. The goal of the effort is to show opportunities for upstream-downstream cooperation on nutrient reduction practices.

Anticipated funding sources

Substantial sources of funding were announced in 2016. These multi-year projects took effect during the 2017 reporting period, but support long-term efforts and were not reflected in partners' funding reports for 2017. The following list contains highlights of new funding awards that have taken effect and will likely be reflected in partners' reports in the next few years.

- The U.S. Department of Housing and Urban Development (HUD) has awarded Iowa agencies a total of $96.6 million to conduct a five-year demonstration of flood mitigation and nutrient reduction. Over $30 million will be spent in watersheds for structures that assist these goals. One focus of the project is financial support for conservation implementation in the watersheds that have been impacted by significant flooding and federal disaster declarations. The project is in early planning, outreach, and implementation stages; cost-share support for practice construction and implementation has not yet begun.

- A public-private partnership came together, led by IDALS, the Iowa Agriculture Water Alliance, and several other agencies and private partners, to request funding through the NRCS Regional Conservation Partnership Program (RCPP). The Midwest Agriculture Water Quality Partnership was awarded $9.5 million in 2016 for expanded use of practices in conservation demonstration projects over the course of the five-year project. The project will leverage $4.75 million in state funding and $33 million from the private sector. Totaling nearly $47 million, this funding will provide a substantial increase in available conservation resources in targeted watersheds and build private sector capacity to deliver conservation planning and technical assistance. Early use of this project's funds are evident in partner reports as outreach efforts, but practice implementation is only just beginning.
- An urban-rural partnership led by the City of Charles City, has received $1.6 million from the RCPP to leverage existing efforts in the Rock Creek Watershed, where a farmer advisory board is working with local partners to advance practice implementation according to goals set in the Rock Creek Watershed Management Plan. The project will implement conservation practices in agricultural areas and will also conduct outreach activities through partners to increase adoption of practices. As with the above RCPP project, practice implementation is only just beginning, so significant funding is not yet reflected in NRS funding summaries.

Current challenge: the capacity for acceleration

The NRS serves as a foundation for improved partnership and collaboration for nutrient load reduction efforts in Iowa. This summary aims to provide a prospective on the current status of state and federal program delivery, while quantifying non-governmental 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 capacity for accelerating the availability of these inputs remains a distinct challenge. Short-term, grant-based funding constitutes approximately 11 percent of current NRS funding, as reported by partner organizations. Annual appropriations, as potentially more reliable sources of funding with some uncertainty surrounding year-to-year availability, account for 38 percent of NRS funding, as reported by partner organizations. This proportion of funding longevity was similar in 2016. 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 percent 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.

The challenge of developing capacity for implementation will exist even if increased funding becomes available. Reducing nonpoint and point source nutrient contributions will require technical assistance, practice design, and, in some cases, construction. Existing staff tasked with delivering the current set of funding levels are typically at capacity. Therefore, additional resources will likely 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 percent reduction of statewide nitrogen and phosphorus 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 continue to 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 of watershed projects will be necessary.

The 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 advancing the NRS. While many programs are in place to further the NRS, there is great need for developing other opportunities and investments that will support the enormous level of scaling-up that is required. Iowa Secretary of Agriculture Bill Northey and former American Soybean Association Chairman Ray Gaesser have agreed to co-chair this conservation infrastructure effort.

The initiative is working to identify current gaps in conservation and business infrastructure and develop actionable efforts focused on accelerated implementation of NRS conservation practices. The effort is focused on identifying economic drivers and market-based solutions to improving water quality and quantifying both the public and private benefits associated with successful implementation of water quality practices.

The 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. Core teams and working groups have been formed on each of these topics. Additional efforts on other NRS practices may be added later.

Staff

One indicator for NRS progress in Iowa is the number of people working to implement elements of the strategy. There is a persistent need for administrative support, researchers, and technical staff including agricultural, conservation, and engineering specialists, for the continued implementation of conservation practices in rural and urban landscapes.

Member organizations of WRCC and WPAC, as well as other partner organizations, reported having 666 full-time equivalent (FTE) staff members on NRS-related efforts in 2017 (Table 1). This value remains relatively unchanged from 2016, when 665 FTEs were reported.[3] Of these staff members in 2017, 184 FTEs comprise the infrastructure, or administrative and planning support, of the NRS. Eighteen FTEs comprise research staff, 442 conduct on-the-ground implementation of practices that reduce nutrient loss and improve water quality, and 23 were categorized as other forms of NRS support. Tracking of staff inputs will be continued annually through partner organization reports; future data collection will identify potential future changes.

Table 1. A summary of staff dedicated to water quality and the NRS. This summary is virtually the same as in the 2016 reporting period; the 2016 NRS Annual Report estimated 226 full-time equivalent staff working on NRS-related projects and programs, which was adjusted to 665 to account for new partner organizations reporting staff estimates.

Nutrient Reduction Strategy staff - 2017 reporting period			
FTE staff for ***infrastructure***	FTE staff for ***research***	FTE staff for ***implementation***	FTE staff for ***other areas***
184	18	442	23
666 Full-time equivalent staff in Iowa conducting work that promotes the NRS and water quality *No change compared to 665 FTEs reported in 2016*			

Current challenge: Accounting for contractors

Generally, the method by which organizations report the number of NRS-focused staff members accounts for permanent employees who are paid directly by the organization. This method fails to track additional staff support through contractors, contract employees, accounting and legal staff, and various other contracted work. The need for accelerated adoption of conservation practices to reduce nutrient contributions from point and nonpoint sources will require frequent support from contracted or other support staff not commonly tracked through the current reporting structure. This need especially pertains to the installation of structural practices, such as terraces, wetlands, bioreactors, grade stabilization structures, and saturated buffers, which require skilled technical assistance, design, and construction. Efforts to explore options for measuring and tracking the extent of contracted duties did not progress in 2017, but will be considered and explored in the future.

Continued water quality research

Continuation of research in the physical and social sciences is necessary to better understand the processes driving conservation measures that can mitigate nutrient loss. It is

[3] This estimate differs from that displayed in the 2016 Annual Progress Report. This discrepancy is due to new partner reports received in 2017. For consistent reporting year-to-year, the 2016 values were adjusted by assuming no change in staff FTEs for those new reporting organizations.

difficult to quantifiably measure the research updates that address these knowledge gaps. In this section, a subset of research updates are discussed, while more quantitative means of assessing progress in scientific research are under assessment. The subsequent section discusses the addition of new conservation practices as approved NRS nonpoint source practices.

Iowa Nutrient Research Center

The Iowa Nutrient Research Center (INRC) was established in 2013 by the Iowa Board of Regents to address identified research gaps. The INRC, administered by Iowa State University, is working to meet the need for continued research and innovation to address Iowa's nutrient export. INRC research evaluates the performance of current and emerging in-field and edge-of-field practices, provides recommendations on implementing new or tested practices, and develops tools to aid decision-making in adopting effective management practices.

In 2016, the INRC directly funded 11 projects from the center's competitive RFP program. These projects had a total award value of $891,130. In addition to these funds, the INRC allocated $467,000 to University of Iowa's IIHR-Hydroscience & Engineering for a network of water-quality sensors deployed throughout eastern Iowa. These advanced remote sensors collect water-quality data that are relayed back to IIHR every few minutes.

Principle investigators have submitted impact reports as the final assessments for nine projects completed during the 2016 reporting period.

Utilizing beef stocker cattle to enhance the value of cover crops

The main objectives of this pilot project were to determine the value of grazing a cover crop as a source of forage and to evaluate the impact of animal grazing on soil health. Preliminary findings showed that animal grazing on cover crops in the spring had some effect on soil compaction at the soil surface, especially in wet soil conditions. However, the cover crop did reduce bulk density, especially the soil's top six inches, thus reducing the grazing effect on soil compaction. Additionally, it was found that the cover crop contributed to soil carbon in the top six inches and reduced soil nitrate-nitrogen concentration in the top twelve inches of the soil.

Distribution, transport, and biogeochemical transformation of agriculturally derived nitrogen and phosphorus in the Cedar River Watershed

This project was designed to determine the total amounts of nitrogen and phosphorus transported each year through the Cedar River Watershed, and the primary factors that cause nutrient release from subwatersheds. Water and stream sediment sampling from 18 sites in the upper portion of the watershed was done in 2014. In 2015, primary water sampling was done at 10 new sites, with two on tributaries of the Cedar River and the others on the main channel. Data were gathered for total phosphorus, dissolved nitrogen, total suspended solids, total dissolved solids, turbidity, and dissolved oxygen. The results show large amounts of nitrogen and phosphorus move through the Cedar River from April through September. Because of high solubility, nitrogen gets into the watershed through all probable routes, including base flow. Phosphorus movement is linked to intense rain events. In some areas, a late-season peak in phosphorus input to the river occurs because of inadequate surface cover. All data are available online at **www.uni.edu/hydrology**.

Nutrient Trading in Iowa: A Pilot Study in the Catfish Creek Watershed

The goal of nutrient trading is to improve water quality through nutrient reduction in an incentivized and economically advantageous way. Under this framework, contributors of nitrogen and phosphorus could generate tradable credits by adopting best management practices (BMP) that reduce nutrient levels below required levels. Using the Catfish Creek Watershed as a pilot watershed, a hydrologic model to determine nutrient fate and transport was developed and tested. This numerical tool can be used to evaluate different agricultural conservation practices for nutrient and flow reduction. Then these estimates can be used to develop the financial and social components of a nutrient trading system. The successful creation and implementation of a nutrient trading system in Catfish Creek will provide a blueprint for a similar system statewide.

Bioreactor Research and Assessment of Woodchip Tile Denitrification Bioreactors: Optimal Design/ Performance and Experimental Bioreactor Installation and Study

The overall objective of this project was to design and install a pilot scale system that can be used to test carbon-based bioreactors for nutrient reduction potential.

Because of this funding there is now a pilot scale system for testing bioreactors that is unlike any other in the world. The research team will use this resource to answer relevant questions regarding bioreactor performance, and information from these studies will help improve the design of bioreactors for nutrient reduction.

Establishing Pragmatically Dynamic Program for Extending Water Quality Best Management Practices Financial Information: Farmer Tools for Iowa Nutrient Reduction Strategy

The main goal of this project was to develop user (farmer)-friendly financial decision support tools (spreadsheet-based budgets) so as to make transparent the structure and timing of cost parameters associated with using the practices promoted by the NRS. These tools are designed to allow farmers to adjust the assessment to best reflect the parameters of BMP use within their farm systems. This work largely updates a previous financial assessment published in Christianson et al. (2013) for the various in-field and edge-of-field nitrogen and phosphorus management strategies (Lawrence 2013). Iowa farmers and their technical advisors now have a "one-stop" location for comprehensive cost information regarding the BMPs promoted by the NRS. For the first time in Iowa, farmers and technical farm advisors have a suite of decision support tools presenting critical BMP cost information in a format that is up-to-date, comprehensive, and user friendly. View more at **www.nrem.iastate.edu/bmpcosttools**.

Investigating Causes of Corn Yield Decreases Following Cereal Rye Winter Cover Crop

In both field and controlled environment experiments, investigators showed that winter rye cover crops terminated with glyphosate shortly before planting corn increased pathogen levels on dying rye roots and on new corn roots, higher disease incidence on corn roots, reduced corn population and seedling growth, and lower yield in the field experiments. Increasing the interval between rye termination and corn planting decreased the negative effects and helped to explain why this has been a common recommendation when planting corn after a winter rye cover crop. Seed fungicide treatments did not completely eliminate the effects. Future investigation will look at management practices such as different cover crop species, new seed fungicides or combinations, and spatial arrangement of winter rye cover crop rows relative to corn rows as a way to reduce the risk of negative effects on corn growth.

Social-Economic Research Work Plan Updates

Three tasks were funded by this project. First, a more complete understanding of Iowa farmers' current management strategies and attitudes toward innovative approaches to managing nutrients and soil health was developed. This was done by analyzing data from the 2012 Iowa Farm and Rural Life Poll, plus interviews with 20 recipients of the Iowa Farm Environmental Leadership Award. For the second task, the monetary benefits of nutrient reduction practices identified in the NRS were determined. In the third task, interviews with 38 farmers in four watersheds were conducted to determine current practices and willingness to adopt practices identified in the NRS. As a baseline measure, the study shows the NRS has begun to reach farmers with name recognition, and in many instances, shows there is a willingness and commitment to reduce off-field, off-farm nutrient losses.

Identifying and Quantifying Nutrient Reduction Benefits of Restored Oxbows

This project led to the development of a new geographic information system (GIS) toolkit that can be used to identify potential oxbow restoration sites in watersheds. The tool set identifies depressional features in river corridors, creates metrics describing slope, depth, area, and shape, then uses these metrics to identify and rank potential oxbow remnants. The tools were applied to the Boone River Watershed, which has been the focus of oxbow restoration activities. The tool set successfully identified oxbows that already have been targeted for restoration, as well as numerous additional sites with restoration potential, demonstrating its utility as a screening device. Since project completion, colleagues at Iowa State University's Department of Natural Resources Ecology and Management continue development of the tool set. Another key finding of this project was that reconstructing oxbows to receive tile drainage water should be considered a viable practice in agricultural areas. Nitrate loads into a reconstructed oxbow were studied over a two-year period. Researchers found the nitrate retention efficiency was similar to other water treatment practices such as bioreactors, wetlands, and saturated buffers.

Quantification of Nutrient Reduction Practices Benefits from the Hillslope to the Watershed Scale

This project had two objectives. The first objective was to develop a physically based, coupled surface-subsurface hydrologic model of Cedar Creek, which reproduces measured discharge at the watershed outlet. The second objective was to develop a water quality model of Cedar Creek, which reproduces nitrate concentration dynamics. Both objectives were reached. The results of this project will guide future physically based hydrologic and water quality modeling in agricultural watersheds, and serve as a demonstration of the ways to simulate nutrient transport within the landscape. These deliverables will make it possible to quantify the benefits of BMP implementation scenarios.

Addition of new practices in the NRS

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 science team, a group of university and public agency researchers that conducted the NRS Science Assessment for nonpoint sources and continue to review the effectiveness of conservation practices.

In the 2016 reporting period, saturated buffers were approved as an NRS practice. In the 2017 reporting period, blind tile inlets were approved. For more information on these additions, and to view the practices that were submitted and not approved, see Appendix A.

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 Iowa and the EPA. This collaborative effort aims to reduce the nitrogen and phosphorus load of all Mississippi River Basin states by 45 percent 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 collect and utilize to show progress and inform decision-making. 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. This then resulted in data sharing with the federal NRCS office 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.

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.

In addition, the 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 nitrogen and phosphorus 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 1980-1996 time period.

Refining NRS measurement

The 2016 reporting period initiated the three-year NRS Measurement Pilot Project, which aims to develop protocols for measuring annual progress of the NRS. There have been various key improvements made in measuring NRS progress, including, but not limited to, new projects for enhancing conservation practice data and the streamlining of practice load reduction models.

There are two key projects highlighted in this report (page 37) that aim to estimate conservation practice use outside of public conservation programs. First, the Iowa State University College of Agriculture and Life Sciences has partnered with the Iowa Nutrient Research and Education Council (INREC). INREC, a collaboration of agricultural businesses, organizations, and industries, will solicit information from agricultural retailers across Iowa who provide services to crop producers with a goal of gaining more insight into farmers' in-field nutrient management decision-making. These efforts will aim to address the challenges associated with reliable tracking of in-field practices, such as cover crops and fertilizer management. Second, a project for tracking practices using aerial and LiDAR imagery is a partnership between DNR, Iowa State University, INREC, and IDALS. This project digitizes imagery of watersheds across the state to enumerate existing terraces, ponds, WASCOBs, contour buffer strips, and contour strip cropping. Between these two projects, steps have been made toward better accounting for in-field, edge-of-field, and erosion control practices implemented in Iowa. These projects will also facilitate future tracking of these practices.

Another stride made in NRS measurement processes is the streamlining of the nutrient load reduction models that were developed for the NRS Science Assessment. As a complementary approach to empirical water monitoring, this annual progress report aims to present updates in the estimated load reductions affected by newly implemented conservation practices each year (see page 50). In past years, these estimates were labor-intensive and time-consuming. New computational methods have been developed for more efficient calculations, and as the above data projects provide more insight on the extent of practices in Iowa during different time periods, researchers will be able to change the baseline inputs in these models. By doing so, these models may be readily adjusted and improved in the future as new data become available. A public-facing version of this model has been developed for calculating nitrogen loss at a field or watershed scale. A similar, user-friendly version is under development for calculating phosphorus loss. These tools will allow farmers, landowners, watershed coordinators, and other interested parties to estimate the effectiveness of new conservation practices in their own operations or regions.

Nutrient trading: Recent innovative approaches

Interest in exploring nutrient trading has continued as NRS implementation has moved forward. The Iowa League of Cities was awarded a NRCS Conservation Innovation Grant (CIG) in October 2015 to develop a water quality credit trading framework as a means 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 conservation practices 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.

By the end of the summer 2017 the project team anticipates conservation practices inputted from Storm Lake, Dubuque, and Des Moines to begin testing the NRE framework with the DNR and developing a list of incentives for nutrient sources to spur additional watershed investment. The project team is on track with the original goals for the three-year CIG to be completed with a formal NRE structure and water quality credit trading framework by October 2018.

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, 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." Identification of these watersheds was conducted during the 2014 reporting period and has guided the prioritization of watershed-based activities across the state.

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 Iowa Water Quality Initiative (WQI) provides targeted funding and support for 16 projects, three of which began in 2015 (Figure 4). 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.

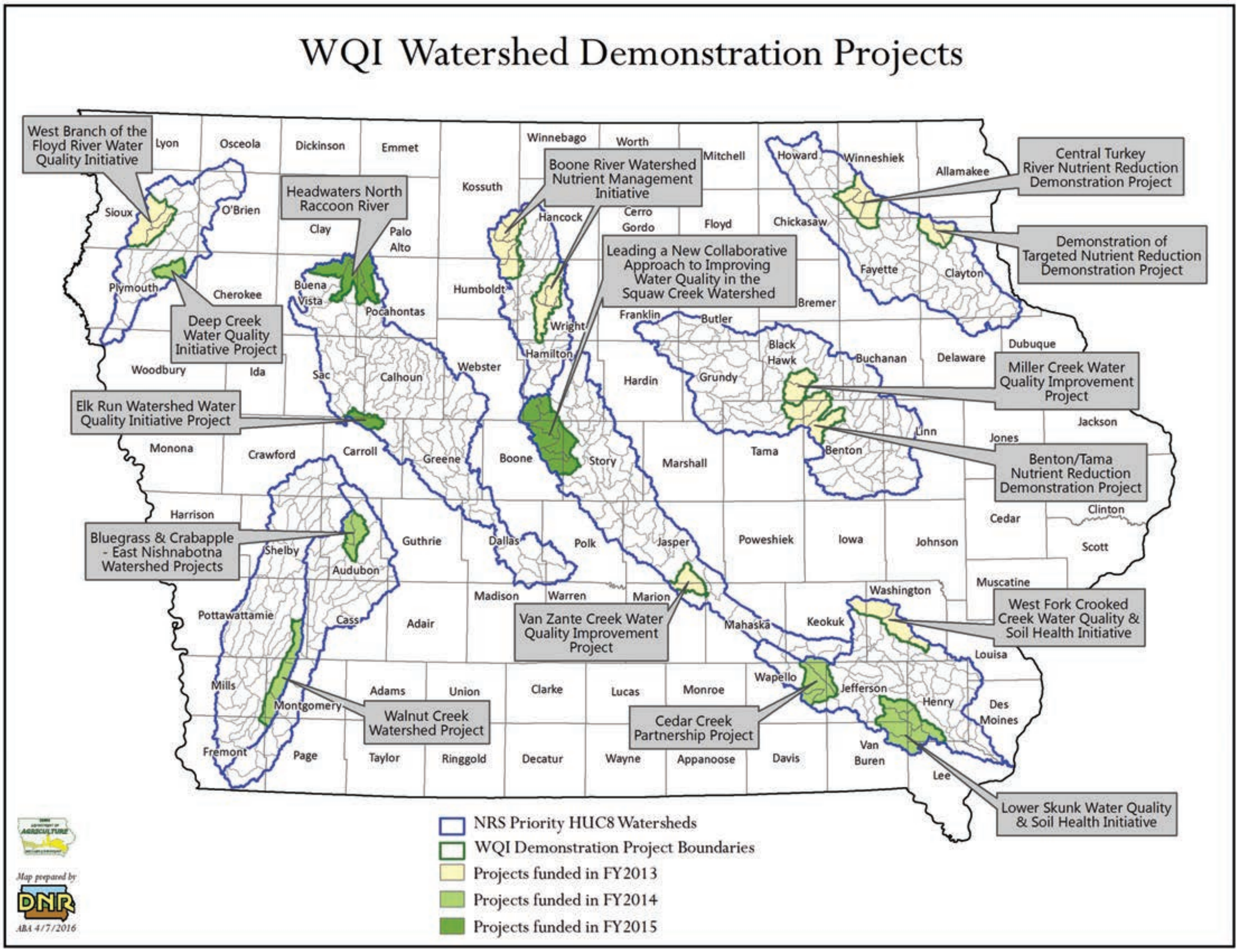


Figure 4. The geographic distribution of watershed demonstration projects funded by the Iowa Water Quality Initiative (WQI).

While these 16 projects target the priority watersheds, there are, in total, 47 ongoing watershed projects in 54 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.

In 2016, HUD awarded Iowa agencies with a total of $96.6 million to conduct a five-year demonstration of flood mitigation and nutrient reduction. This project will target four NRS priority watersheds to implement agricultural and urban practices that assist these goals. The project is in early planning, outreach, and implementation stages and will distribute cost-share funding for practices in the near future.

Stormwater, septic, and minor POTWs

Stormwater

The urban conservation program 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 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.

Septic/Minor POTWs

Upgrading 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 20,000 out of an estimated 30,000 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. There were approximately 4,000 time of transfer inspections of onsite wastewater systems in 2016. Efforts are underway to quantify the improvements that can occur as a result of a time of transfer inspection.

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 and Development, Heartland Co-op, Iowa Certified Crop Advisors, Iowa Corn Growers Association (ICGA), ISA, IDALS, DNR, Iowa State University Extension and Outreach, American Water Works Association-Iowa Section, U.S. Department of Agriculture Farm Service Agency (FSA), and NRCS. Accomplishments this year include a partnership with Conservation Districts of Iowa and DNR to hire two new source water specialists 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 though engaging and coordinating with partners, compiling and branding resources, pursuing additional funding resources and monitoring progress.

In February 2017, the EPA awarded $124,000 of contractor assistance for the cities of Winterset and Spirit Lake to begin implementing source water protection plans with a focus on reduction of nutrients into the lakes that serve as their source water. This includes assistance in identifying resources for implementation of the source water protection plan and coordinating partners. The technical assistance will target conservation practices that can be funded and deployed on the landscape. The project is expected to help reduce nutrient loading to the selected lakes through implementation of practices, show future nutrient reductions through numerical or analytical modeling, and further integrate source water protection with the NRS. The project is expected to be complete by March 2018.

Review of the impact of golf courses

In 2015, the Golf Course Superintendents Association of America, the Iowa Golf Course Superintendents Association, the Iowa Golf Association, and the Iowa Turfgrass Institute funded a University of Iowa study to measure nitrogen and phosphorus concentrations in surface water and groundwater at a subset of Iowa golf courses. The study assessed the risk posed by these facilities to contributing to nitrogen and phosphorus enrichment of Iowa rivers. This project is consistent with a core goal of the NRS that calls for all Iowans to play a role in reducing nutrients to make an impact over time. Specifically, the NRS called for increased education and outreach opportunities for urban stormwater issues with a focus area on golf course management.

The full report of the study can be found at the following link: **gcmdigital.gcsaa.org/i/826977-jun-2017/79** (download pdf).

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. This is the first step in advancing nutrient reductions by point sources. Seventy percent of these permits have now been issued, and progress has also been made in issuing such permits to point sources in priority watersheds. As these feasibility studies are reviewed and approved by the DNR, the schedules they contain for installing nutrient reduction technologies are added to facilities' 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 will then be added to the permit and become enforceable. Table 2 provides a general summary showing the universe of facilities for each metric, where applicable, and progress in implementing the NRS for point sources.

Table 2. Summary of NRS point source implementation.

Metric	Universe of facilities*				Number complete				
	2013-14	2014-15	2015-16	2016-17	2013-14	2014-15	2015-16	2016-17	Total
Permits issued	130	147	149	151	21	32	29	23	105
Permits issued in priority watersheds	37	37	39	39	8	7	9	4	28
Feasibility studies submitted	-	-	20	30	0	1	19	30	51
Permits with construction schedule	-	-	-	-	0	0	2	13	15
Permits with limits	130	147	149	151	0	0	1	38	38
Total nitrogen	-	-	-	-	-	-	1	38	38
Total phosphorus	-	-	-	-	-	-	1	5	5
Permits meeting % reduction targets									
Total nitrogen	-	-	-	-	-	9	14	19	19
Total phosphorus	-	-	-	-	-	2	6	9	9
Total permits with nutrient monitoring (including those not in nutrient strategy)	-	-	-	-	169	201	224	344	344

* Reasons for year-to-year changes are described on page 18.

This year, additional data 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 may 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 was determined what reductions in loadings of TN and TP are occurring today, even before nutrient reduction technologies are installed.

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

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

The NRS established a goal for the DNR 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 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 5 shows that a total of 105 permits have been issued requiring feasibility studies as of May 31, 2017. The goal of 20 permits per year has been exceeded in each of the four years that the strategy has been in place, and 70 percent of the 151 facilities listed in the strategy now have permits that require submittal of a feasibility study.

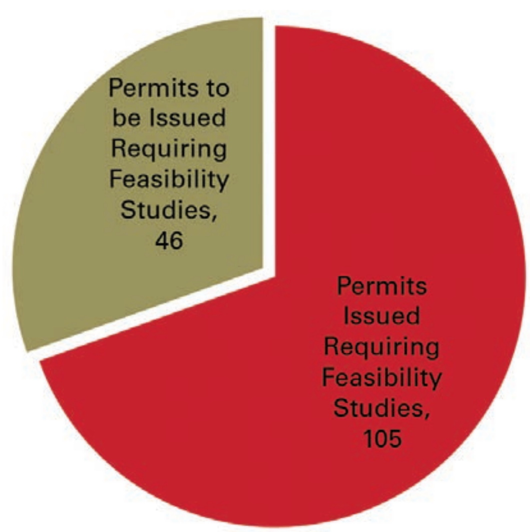


Figure 5. Of the 151 permits that are required by the NRS, 105 requiring feasibility studies have been issued.

The total number of facilities listed in 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 once discharged to a city POTW but then constructed and began operating a biological wastewater treatment facility.
- An industry may cease operations altogether 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 per day (mgd) or more, 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 and 2017.
- 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 mgd, 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 mgd with a new facility that has a design flow of 0.873 mgd.
- 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?

Thirty-nine of the point sources listed in the strategy discharge in one of the nine NRS priority watersheds. Permits have been issued to 28 (72 percent) of these facilities as of May 31, 2017, up from 23 facilities last year. 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 6 shows the progress to date in issuing permits to point sources in the priority watersheds.

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 percent and 75 percent, respectively. The feasibility study must include an evaluation of facility operational changes that could be implemented to reduce

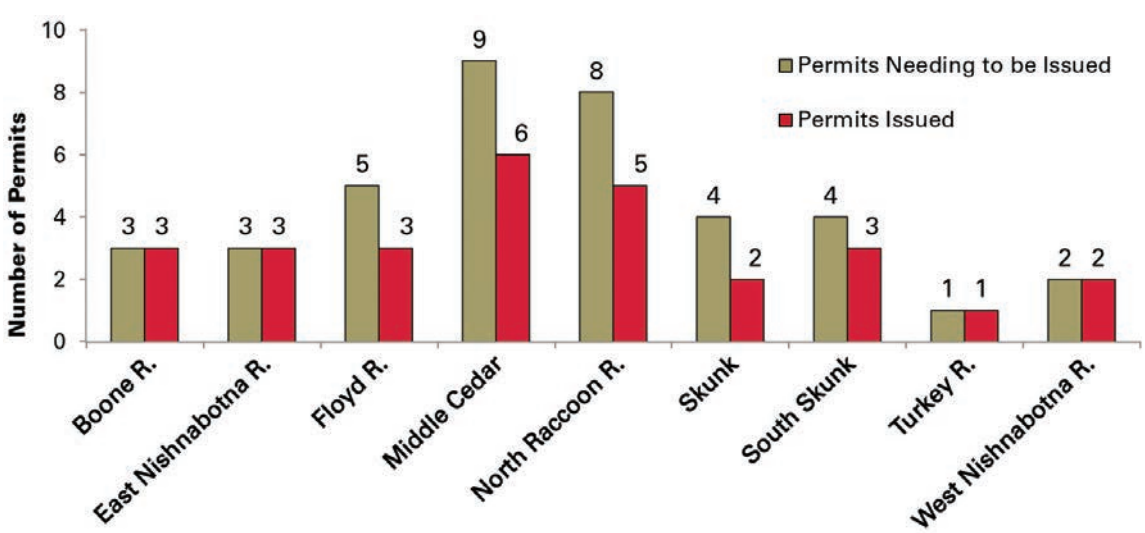


Figure 6. Progress of point source permits issuing in priority watersheds.

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. There was a significant increase in the number of feasibility studies submitted during the past year, as facilities whose permits were issued in 2014 or 2015 completed the required two years of raw waste and final effluent monitoring and evaluated alternatives for nutrient reduction technologies. Fifty-one feasibility studies have been submitted as of May 31, 2017, and another 54 are required to be submitted in the next two years (Figure 7).

Additionally, municipal and industrial wastewater facilities are required to evaluate nutrient reduction prior to constructing new or expanded facilities under Iowa's antidegradation policy. There were 22 alternatives analyses approved during this reporting cycle for minor municipal and industrial facility upgrade projects (21 municipal, one industry). More thorough analyses will be needed to determine if the alternatives analyses resulted in nutrient reduction alternatives being selected. In one example it was determined that the City of Central City constructed a new submerged aquatic growth reactor that included a recycle component to achieve additional nitrogen removal. Improvements are being structured to account for this type of information on a larger scale moving forward.

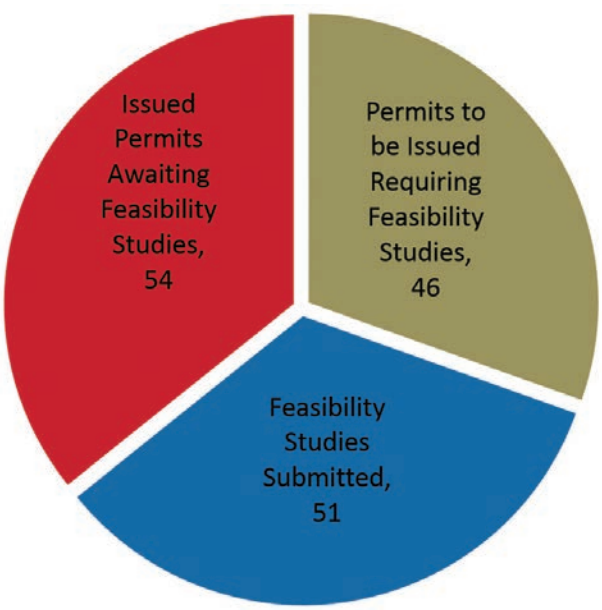


Figure 7. The progress of issued permits and submitted feasibility studies among the total NRS facilities.

Photo courtesy of Lynn Betts, USDA Natural Resources Conservation Service.

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, 13 permits have been amended to include construction schedules, up from two permits last year. The average time frame for construction completion for the 10 municipalities is 3.5 years from 2017 with a date range for completion from 2018-25. The average time frame for the five industries is 2.4 with a date range for completion from 2018-21.

How many permits have been amended to include nutrient limits?

Four permits were amended in 2016-17 to include effluent limits for TN and/or TP. Climax Molybdenum, Rembrandt Enterprises (Thompson), West Liberty, and Grundy Center met the reduction targets established in the NRS and moved forward to establish performance-based effluent limitations.

Table 3. Facilities that have met nitrogen or phosphorus goals, or both, by treatment plant improvement or optimization.

2017 reporting year (5/1/2016-4/30/2017) percent removal (concentration)		
	Facility	%
Municipal		
Nitrogen	Atlantic, City of, STP	78.1
	Clear Lake Sanitary District	72.2
	Eldridge, City of, South Slope	68.3
	Estherville, City of, STP	72.0
	Grundy Center, City of, STP	71.6
	Iowa City, City of, STP (South)	73.5
	Mount Pleasant, City of. STP (Main)	85.8
	Oelwein, City of, STP	91.9
	Sioux City, City of, STP	75.2
	Washington, City of, STP	73.9
	West Burlington, City of, STP	72.6
	West Liberty, City of, STP	79.3
Phosphorus	Coralville, City of, STP	80.9
	Iowa City, City of, STP (South)	82.8
	Mount Vernon, City of, STP	80.9
	Sioux City, City of, STP	75.2
	West Liberty, City of, STP	79.3
Industrial		
Nitrogen	Archer Daniels Midland Corn	66.1
	Associated Milk Producers	78.8
	Grain Processing Corporation	88.5
	Manildra Milling Corporation	73.3
	OSI Industries (Oakland Foods)	89.3
	Rembrandt Enterprises, Inc.	74.6
	Swiss Valley Farms	66.0
Phosphorus	Dairiconcepts	84.8
	Manildra Milling Corporation	80.4
	Rembrandt Enterprises, Inc.	83.6

STP: Sewage Treatment Plant

There are a total of 171 permits that have been issued, primarily to facilities that are not affected by the NRS, which specify limits for one or more nitrogen compounds (excluding ammonia nitrogen). There is one permit that has been issued to a facility that is not affected by the NRS which specifies limits for one or more phosphorus 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 developed by the DNR to address an identified water quality impairment. In many cases these limits do not require a reduction in the amount of nitrogen or phosphorus 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.

This year, data are available that allow the reporting of facilities that have met the NRS point source nutrient removal targets of 66 percent for TN and 75 percent for TP. Table 3 displays cities and industries that have met these percent reduction targets for TN, TP, or both by either treatment plant improvement or optimization.

The following cities and industries have designed and built nutrient reduction facilities to treat BOTH nitrogen and phosphorus: Clinton (biological nutrient removal).

The following cities and industries have designed and built nutrient reduction facilities to treat nitrogen: Iowa City (Activated Sludge MLE), Sioux City (Activated Sludge MLE).

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-reducing practices and cut nitrogen and phosphorus loss by 45 percent, attitudes of people must first shift to affect a change in perspectives and behavior related to water quality.

A variety of factors have been analyzed in order to measure the progress of human attitudes related to the NRS. 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 human behavior. Finally, updates on IDALS' annual cover crop users survey are presented.

Increased public awareness, education, and outreach

Outreach and education events

Outreach and education events that were held across Iowa during the 2017 reporting period reflect the efforts by partner organizations, both public and private, to spread awareness and educate the public about nutrient reduction options for water quality improvement.

Table 4. A summary of the education and outreach events held by partner organizations during the 2016 and 2017 reporting periods. The 2016 reporting period encompasses June 1, 2015 to May 31, 2016; the subsequent 2017 reporting period ended on May 31, 2017.

2016 Revised	Number of events	Average attendance	Total reported attendance
Conference	6	214	1,281
Community Outreach	55	52†	8,877
Field Day	88	47	4,159
Workshop	32	37	1,172
Youth and School Visits	65	88	5,704
2016 Total	**246**		**21,193**
2017			
Conference	13	252	3,279
Community Outreach	168	69†	20,400
Field Day	112	53	10,562
Workshop	55	37	1,695
Youth and School Visits	127	146	18,542
2017 Total	**474**		**54,478**

† Iowa Learning Farms conducted outreach at the Iowa State Fair in 2015 and 2016, and reported 7,555 and 9,802 interactions with visitors each year, respectively. Also, the University of Iowa reported 300 outreach interactions at the 2016 Iowa State Fair. These high fair attendances were not included in the average event attendance, so as to not skew typical event attendance. However, these state fair attendees were included in the total reported attendance column.

These events, which provide information to make informed decisions about conservation practices, were self-reported by WRCC and WPAC members, and include five general categories of events: general community outreach, including fairs, tours, and other community events; field days, which often serve to educate farmers and landowners; workshops, which entail training in a particular skill or topic area; conferences, which facilitate knowledge-sharing, networking, and partnering; and youth education, which focus on spreading understanding about natural resource and watershed issues through K-12 educational programming.

From 2016 to 2017, the outreach efforts reported by partner organizations virtually doubled (Table 4). Total events increased from 246 to 474, and the total number of attendees at these events increased from 21,000 to 54,000. Actual outreach may not have completely doubled during this time, as reporting efforts may have improved within and among partner organizations. However, this summary is strong evidence that, from one year to the next, outreach efforts and the efforts to track these events increased substantially.

Certain areas of the state, particularly central Iowa, receive more outreach than do other areas (Figure 8). Efforts are underway to identify the 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 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.

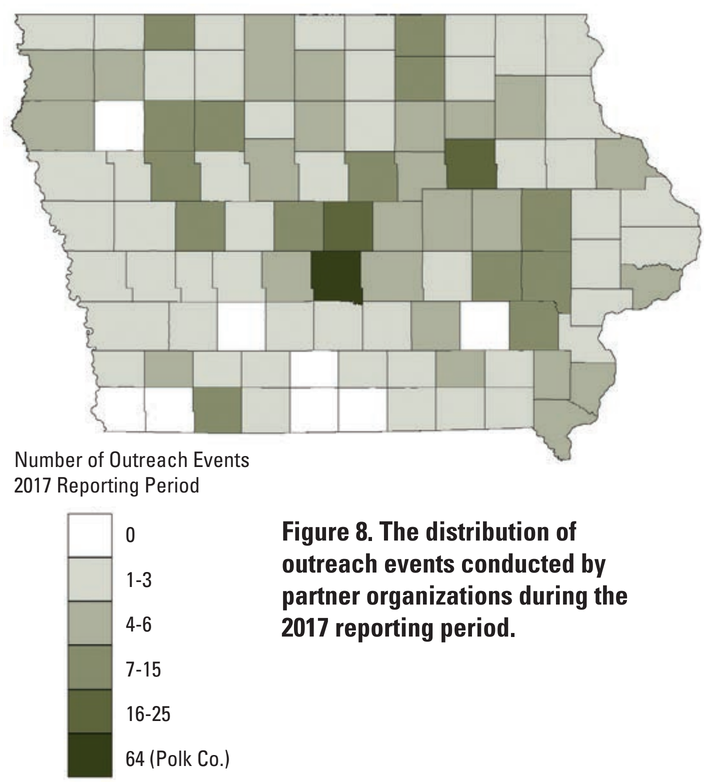


Figure 8. The distribution of outreach events conducted by partner organizations during the 2017 reporting period.

This assessment of NRS outreach excludes events that were conducted by SWCD offices that did not have partnership with the surveyed organizations. Efforts are underway to collect this information from all SWCDs in a standardized, annual survey. This survey was conducted in 2017 but the data have not been processed. The survey will be conducted in 2018, and both years will be incorporated into this annual estimate of NRS outreach and education.

Farmer knowledge and attitude

Survey updates

An ongoing, five-year (2015-2019) survey project aims to increase the understanding of 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 will cover six HUC6 watersheds. These HUC6 watersheds each contain one or more HUC8 watersheds that have been identified as NRS priority watersheds. Within each of these watersheds, the priority HUC8 watersheds are surveyed as the treatment area. Non-priority HUC8 watersheds within each HUC6 are also surveyed to allow comparison between priority areas, where demonstration projects receive dedicated conservation funding, and the watersheds that have not received priority designation. Watershed-level random samples of farmers were drawn from the population of farmers who operate at least 150 acres of row crops (i.e. corn and/or soybean). Table 5 shows the expected number of farmers surveyed in each HUC6 watershed over the five-year period.

In the first three years, four HUC6 watersheds were surveyed (Table 5). Each year, new respondents are sampled in the watersheds of focus. In addition, a subset of repeat respondents are surveyed each year. In the Iowa watershed, a subset of respondents are surveyed in all years. In the other HUC6 watersheds, a subset of respondents are surveyed in the year following the first year that they were surveyed. This sampling approach will allow the project to assess change in awareness, attitudes, and behaviors over time. In addition, the survey design will allow for comparisons between priority and non-priority areas.

This annual progress report highlights summary statistics for selected variables in the survey, focusing solely on the Iowa HUC6 watershed's respondents. At this point, analysis of annual change among all the surveyed watersheds is impractical, as the watersheds are rotated each year; responses vary by geographic region. The Iowa HUC6 is surveyed in every year of the project. Analysis of additional watersheds is conducted as their rotations are completed.

The following summary statistics illustrate trends in responses from respondents of the Iowa HUC6 watershed. First, respondents were provided with the following text describing the NRS:

> The Iowa Nutrient Reduction Strategy is a plan to reduce the amount of nitrogen and phosphorus that enters Iowa's streams and rivers and eventually the Gulf of Mexico. It is designed to help reduce nutrient in surface water in a scientific, reasonable, voluntary, and cost-effective manner. The strategy sets goals for both point sources (e.g., water treatment plants) and nonpoint sources (e.g., agriculture) of nutrients. The goal for Iowa agriculture is that nutrient losses into waterways will be reduced by 41 percent for nitrogen and 29 percent for phosphorus.

Table 5. Expected number of completed surveys each year, by watershed.

	Completed surveys in HUC6 watersheds						
	Iowa	Missouri-Little Sioux	Upper Mississippi-Maquoketa-Plum	Des Moines	Missouri-Nishnabotna	Upper Mississippi-Skunk-Wapsi	Totals
Year 1	800	800					1600
Year 2	400	400	800				1600
Year 3	400		400	800			1600
Year 4	400			400	800		1600
Year 5	400				400	800	1600
Overall	2400	1200	1200	1200	1200	800	8000

Respondents were then asked, "Before reading the description above, how knowledgeable were you about the Iowa Nutrient Reduction Strategy?" In 2015, 69 percent of respondents indicated they were at least somewhat knowledgeable. In 2017, 77 percent reported they were at least somewhat knowledgeable, representing a eight percent increase in NRS awareness in the Iowa HUC6 watershed (Figure 9). This increase is promising in that increased knowledge may ultimately affect positive changes in conservation attitudes and behavior.

The survey also asks respondents to indicate their level of agreement with statements related to NRS attitudes and perspectives. In response to the statement, "I would like to improve conservation practices on the land I farm to help meet the Nutrient Reduction Strategy's goals," there was little change between 2015 and 2017 (Table 6). Similarly, there was little change in the agreement with the statements, "I am concerned about agriculture's impacts on water quality," and, "The nutrient management practices I use are sufficient to prevent loss of nutrients into waterways." Analysis of covariance for these questions found no statistical differences between each year's responses, suggesting that, as measured by selected statements, there has been effectively no change in attitudes toward the NRS among farmers in the Iowa HUC6. These selected results, among others, will be explored further during the 2018 reporting period.

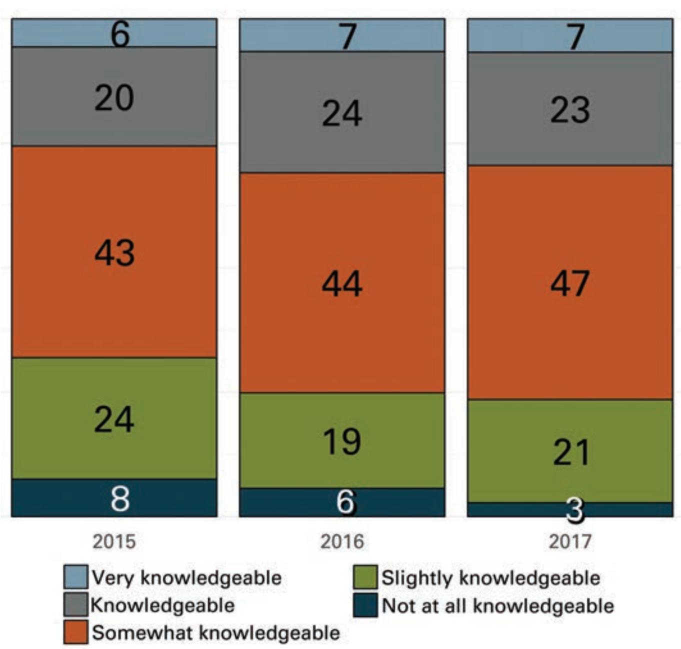


Figure 9. Among respondents in the annually surveyed Iowa HUC6, percent responses to the question, "How knowledgeable [are] you about the Iowa Nutrient Reduction Strategy?"

Table 6. Percent of respondents in the Iowa HUC6 watershed indicating their level of agreement with select statements related to NRS attitudes and awareness.

Statement		Percent				
		Strongly disagree	Disagree	Uncertain	Agree	Strongly agree
"I would like to improve conservation practices on the land I farm to help meet the Iowa Nutrient Reduction Strategy's goals."	2017	1.1	1.7	22.0	60.9	14.4
	2016	0.7	3.2	20.7	59.3	16.1
	2015	0.9	2.0	22.6	59.1	15.5
"I am concerned about agriculture's impacts on water quality."	2017	1.3	4.6	14.5	62.5	17.2
	2016	0.5	2.8	13.5	64.7	18.4
	2015	1.2	3.8	13.2	63.0	18.8
"The nutrient management practices I use are sufficient to prevent loss of nutrients into waterways."	2017	0.2	2.5	40.4	49.7	7.2
	2016	0.5	3.6	42.5	47.0	6.4
	2015	0.7	3.3	42.4	46.9	6.8

During the 2017 reporting period, Iowa State University researchers conducted a causal mediation analysis to test whether certain variables (e.g. farmers' watershed involvement, information sources, organizational influence) showed a statistically significant impact on farmers' knowledge, attitudes, and conservation behavior. This work is nearing completion and will be submitted for publication in a peer-reviewed journal in fall 2018. In addition, new analysis efforts will compare priority and non-priority watershed responses to assess whether increased efforts in priority areas have a statistically significant relationship with changes in survey responses in priority areas.

Results from this project are continually updated and available at **www.nutrientstrategy.iastate.edu/documents**.

Cover Crop Survey

IDALS conducts a cover crop user survey facilitated through the local SWCD offices. The survey was conducted in the fall of 2014, 2015, and 2016. Participants using cover crops (with or without financial assistance) were asked to complete the survey. The goal of the survey was to learn the management practices of these cover crop users; assess their understanding of cover crops; examine what would help facilitate expanded acreage of cover crops on their operation or on other farms in their area; and to inform program design and operation. A question that carried over from 2014 to 2016 asked respondents whether they planned to use cover crops the subsequent year. In 2016, 83 percent reported they were planning to use cover crops the following year, 23 percent reported they were unsure, and less than one percent reported they would not. These results showed an increase in respondents planning to use cover crops the following year, up from 77 percent in 2015.

A separate question asked respondents whether they owned, rented, or managed the fields in which they planted cover crops. Most farmers (60 percent) owned and operated the field in which they seeded to cover crops. Twenty-three percent reported they were the tenant or operator on their cover crop fields, but the landowner did not request the practice be implemented. Ten percent reported they were a tenant or operator, and the landowner had requested the practice be implemented on their fields. These results showed no change from the previous year, and continue to support the view that landowners present an opportunity for adapted outreach efforts that may facilitate increased adoption of cover crops and other conservation practices.

A list of the 2016 survey questions and a summary of responses can be found in Appendix B, available in the online version of this report at **www.nutrientstrategy.iastate.edu/documents**.

Recent innovations in NRS Outreach

As outreach and education on the NRS has expanded significantly, novel approaches to delivering outreach and facilitating capacity-building have been implemented. Three examples are the Iowa Watershed Academy, the retaiN program, and updates on efforts by the Iowa Learning Farms (ILF). This discussion is not an exhaustive overview of new forms of outreach, but serves to illustrate recent innovations in NRS outreach methods.

Iowa Watershed Academy

The Iowa Watershed Academy is a multi-partner effort to provide frequent training to watershed coordinators, who coordinate water projects across the state that support farmers, landowners, and urban residents in transitioning to NRS conservation practices. These academies also serve to better incorporate the goals of the NRS to the frontlines of conservation work. The first academy was held during the 2016 reporting period, while the second and third were held during the 2017 reporting period. The following descriptions highlight those events that were held during the 2017 reporting period.

The second Iowa Watershed Academy was supported by NRCS, the Soil and Water Conservation Society, ISU Extension and Outreach, Iowa Agriculture Water Alliance, Conservation Districts of Iowa, and IDALS, and was held in fall 2016. The fall academy focused on phosphorus management, soil health tools and assessments, communication tools, grant writing, action planning, sales and marketing, developing leaders, and watershed and conservation planning technologies. The group of 27 watershed and basin coordinators learned about urban watershed practices and engaged with ISA Environmental Programs and Services staff and toured their lab facility. Additionally, the coordinators were joined by approximately 40 members of the Iowa Chapter of the Soil and Water Conservation Society for part of the event, which allowed for extended networking and regional planning discussions. Prior to the start of the workshop, participants were asked to make an honest assessment of their ability to carry out or explain a topic proficiency indicator by scoring each indicator on a 1-4 scale, 1 indicating no knowledge of the indicator, and 4 indicating exemplary knowledge of the indicator. Generally, the participants moved up one-half to one scoring category with most skills starting in the 2 (needs improvement) category and moving up to a 3 (proficient) category. Through continued formal and informal assessment, coordinators indicate that the watershed academy training events are valuable training opportunities and they are incorporating information they have learned from the workshops into their projects.

The third Iowa Watershed Academy training event was held in spring 2017. Day one was targeted toward watershed coordinators working on developing messages to effectively communicate with farmers, the media, and project stakeholders to increase public engagement with watershed projects. Day two added an additional audience of commodity group field representatives, NRCS field staff, consultants, and engineers and focused on scaling up edge-of-field practice implementation. Classroom sessions included drainage water management, wetlands, bioreactors, and funding sources. Hands-on field training was conducted on saturated buffer siting, field data collection, construction, and checkout. This event was sponsored by the Iowa NRCS, Soil and Water Conservation Society, ISU Extension and Outreach, Iowa Agriculture Water Alliance, Conservation Districts of Iowa, and IDALS.

A total of 25 watershed coordinators and 25 commodity group field representatives, NRCS field staff, consultants, and engineers attended the training. Evaluation results concluded that nearly 80 percent of the coordinators considered themselves well prepared to give more informative and effective presentations after experiencing a slide presentation and 70 percent were well equipped and confident in their ability to communicate with stakeholders and the media after the communication development session. Participants provided positive feedback on the saturated buffer field session including:

- "Getting to go out and do an actual field evaluation was very helpful in understanding the process that goes into deciding where an edge-of-field practice should be placed."
- "The outdoor installation of a saturated buffer, with not having any experience of what to look for, it was helpful to go through steps to consider ideal locations. Working in a group was a great way to bounce ideas off of one another and learn."

Plans are underway to continue the spring and fall watershed academy events geared toward watershed coordinator professional development. Additional training events for an expanded audience and focused technical skill building are also being explored.

RetaiN

In a partnership between Conservation Districts of Iowa, ISU Extension and Outreach, and Iowa Learning Farms, and with support from the IDALS Division of Soil Conservation and Water Quality, over 780 nitrate concentration test kits were distributed to producers through existing watershed projects, ISU Extension and Outreach field specialists, ICGA and agribusiness partners in 2016. The retaiN project seeks to give farmers the tools and information they need to make conservation decisions on their land, starting by helping farmers test for, understand, and take steps to retain their nitrogen. The test kits facilitate farmer engagement in collecting on-farm nitrate concentration data. The partnership with the ICGA saw significant growth this year with the ICGA distributing over 400 kits at crop fairs, soil health partnership events, and watershed education and outreach events across the state. The evaluation feedback from farmers, agribusiness and organization partners, watershed coordinators, and ISU Extension and Outreach specialists was overwhelmingly positive and has led to expanded on-farm water sampling to gather additional or more precise data, ongoing monitoring to gather baseline results, and community water quality engagement and education. Methods for measuring practice implementation that occurs as a result of participation in the program are under evaluation. For more information and project resources visit **www.retainiowa.com**.

Iowa Learning Farms

Iowa Learning Farms (ILF), as an organization that provides extensive statewide outreach, continues to build a culture of conservation by bringing together farmers, landowners, agribusiness, researchers, and state and federal agency partners. In 2016, ILF hosted 248 total outreach events that reached 34,726 people. That year saw a 22 percent increase in the number of events compared to the previous year. Farmer field days and workshops remained an integral part of Iowa Learning Farms in 2016. Compared to the previous year, the number of these events increased by 13 percent, and 93 percent of participants reported the overall quality of those events was good or excellent. The events continue to attract a mix of both experienced conservation farmers looking to share and learn from peers and technical specialist as well as potential conservationists seeking new information.

Highlights include:

- 89 percent of field day and workshop attendees were farmers, operators and landowners
- Respondents who attended an ILF field day in 2016 planted 38,258 acres of cover crops, 32 percent of which were new acres of cover crops.
- ILF continues to draw an audience that is both experienced with conservation practices as well as just starting to consider the idea. An estimated 38 percent of ILF field day attendees have never planted cover crops and 50 percent reported no current acres in strip-till or no-till.
- Farmers with six or more years of experience with cover crops reported significantly less concern over yield impacts and the knowledge required to implement conservation practices compared to farmers just getting started with cover crops.

Land

This section describes the extent of practices implemented for the reduction of nitrogen and phosphorous loss from nonpoint sources. This portion of NRS progress measurement is a tool for examining the voluntary participation by the Iowa agricultural sector in nutrient reduction efforts. There is a role for participation by urban residents and sectors as well (see page 15), although urban practices for nutrient reduction are under research and evaluation and have not yet been quantified for nutrient reduction effectiveness.

In order to discuss the progress of agricultural nonpoint source nutrient reduction efforts, the following subsections present the current state of land use in Iowa; the effectiveness of approved NRS practices in nonpoint-source nutrient reduction and the status of progress toward NRS scenarios; the implementation of practices based on available data sources; and current efforts and projects to address data gaps.

Iowa's land use—a historical perspective

Iowa's total land area is 35.7 million acres.[4] The state's land is dedicated primarily to agriculture; total agricultural land—as reported by the U.S. Department of Agriculture (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 10). The land area dedicated to field crops—corn, soybeans, 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. More recently, field cropland totaled approximately 24.3 million acres in 2015 and 24.1 million acres in 2016.

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 fifty years (Figure 10).

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 loss of nitrogen and phosphorus, particularly in the spring during the pre-plant period and just after planting, and in the fall after harvest. 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 fifty or more years.

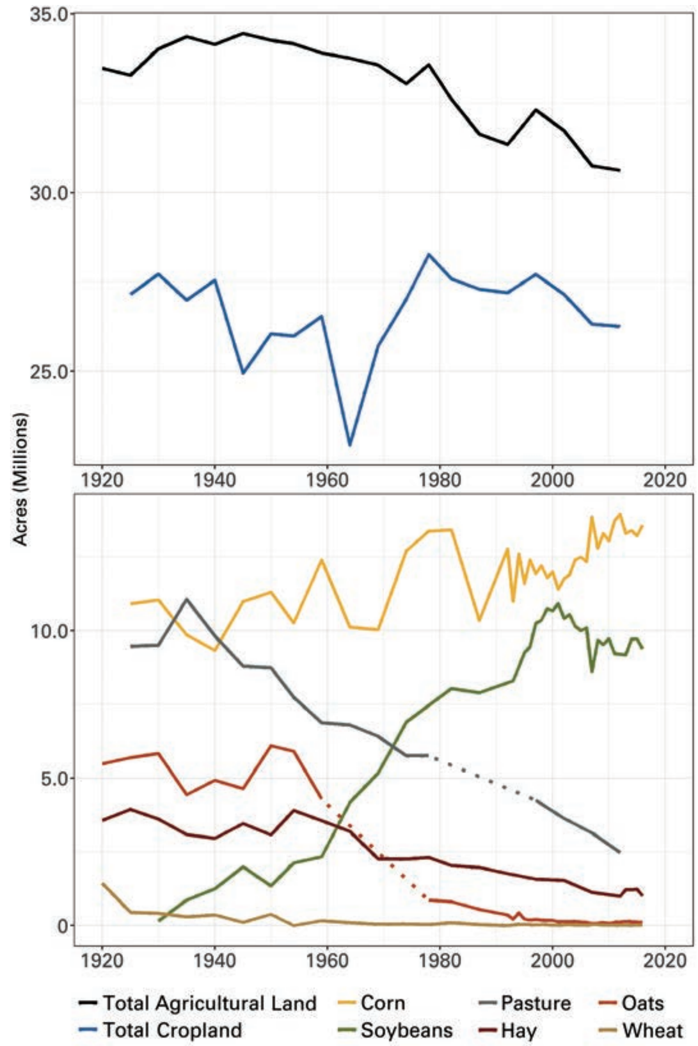


Figure 10. Iowa agricultural land use and major crop acreages from 1920-2016, as reported by the U.S. Department of Agriculture's Census of Agriculture and by the Farm Service Agency. Dotted lines represent periods of insufficient data. The post-1992 fluctuations in corn and soybean acres are attributed to the availability of annual data; prior to 1992, census data at intervals of approximately five years were used.

4 www.census.gov/quickfacts/table/PST045216/19

Practice effectiveness in reducing nutrient load

As noted above, land use is a significant driver of nitrogen and phosphorus loss in Iowa's agricultural sector. Thus, land use change and agricultural land retirement can be highly effective for reducing the loss of nutrients from agricultural areas; however, because land use change may result in taking row crop acres out of production, this nutrient reduction benefit comes at a significant cost to public sector programs and to the economic viability of landowners and farmers of the state. Opportunities for nutrient loss reduction also lie in edge-of-field treatments and in-field management practices (Figure 11). These practices mitigate loss of nutrients while keeping farm land in production.

In-field practices for nutrient reduction comprise management techniques that are conducted on an annual basis for row crop production. Cover crops, tillage, and in-field nutrient (i.e. fertilizer) management. These practices tend to demonstrate lower nutrient reduction potential than do land use change and edge-of-field practices, but are typically implemented with lower up-front financial investment. However, these practices must be conducted annually on an ongoing basis to achieve nutrient loss reduction effectiveness. With the exception of equipment investments, the costs for inputs, seed, and labor must be invested each year.

Finally, edge-of-field and erosion control practices show high effectiveness in reducing nutrient loss. These practices are structural installations (e.g. terraces, bioreactors), so

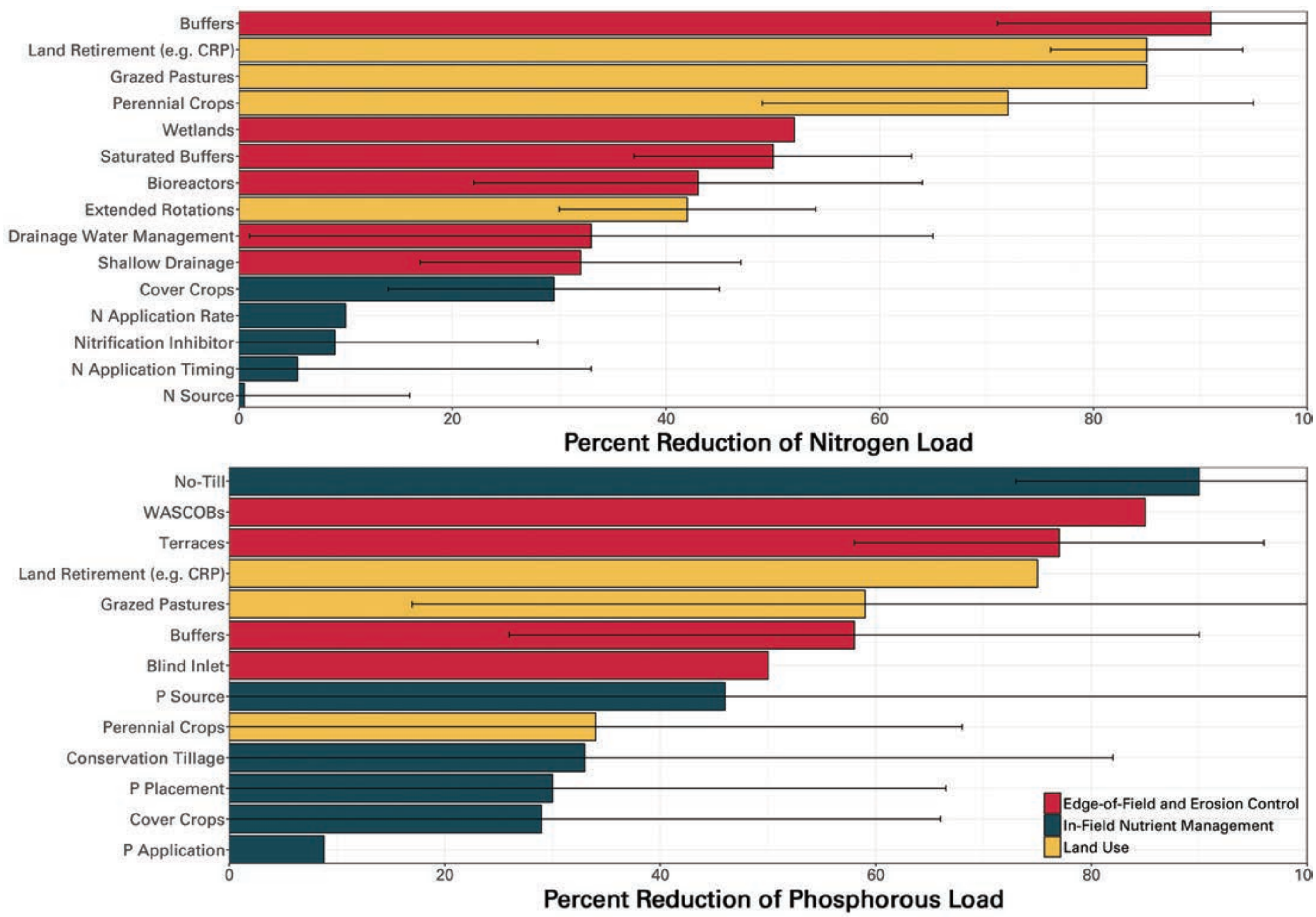


Figure 11. The effectiveness, presented as mean percent reduction of nitrogen and phosphorus loads, of conservation practices that have been approved for the Iowa Nutrient Reduction Strategy. Error bars represent one standard deviation above and below the mean. For some practices, scientific literature suggests a standard deviation larger than the mean reduction, representing high variability in measured effectiveness; review of recent literature will reevaluate these estimates in 2018. Figure concept by the Iowa Soybean Association.

they exhibit a lifespan of a decade or more. As a result, while these practices reduce impacts and allow for continued land use for row crop production, they require a high up-front financial investment. 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 retirement, in-field management, and edge-of-field—that addresses the variety of local resource concerns is necessary for any operation or watershed.

Progress of nonpoint source practice implementation

To evaluate the progress of the NRS, the statewide use of the practices that have been assessed for their effectiveness and ability to reduce nitrogen or phosphorus losses were tracked. Primarily, practices are tracked using data from federal and state conservation programs, but there are ongoing efforts to identify and collect data from other sources (see page 37). This section describes the statewide progress of land use practices, in-field practices, and edge-of-field and erosion control practices.

Land use change for reducing nutrient loss

Land use change from annual crops to perennial vegetation or crops is a highly effective approach for reducing nutrient loss. Conversion to a perennial land use reduces nitrogen loss by 72-85 percent and phosphorus loss by 34-75 percent. The CRP is a widespread land-rental program that incentivizes cropland conversion to perennials in exchange for long-term rental contracts (10-15 years) with participating landowners. The perennial vegetation in CRP acres acts as a temporary land retirement mechanism. This program depends on availability of funds and acreage limits for rental payments and fluctuates as a market structure, but acres were at 1.7 million in 2016, an increase of about 200,000 acres from the previous year (Figure 12). In 2016, the national cap on CRP acres was 24 million. This cap was nearly reached, resulting in a temporary freeze on new enrollments until the start of federal fiscal year 2018.

Currently, CRP is the main source of data for estimating and tracking the extent of land retirement in Iowa on an annual basis. Additionally, county-scale data published by the USDA FSA reflect changes in acres of planted crops; for instance, FSA data will allow for tracking of land use change in the case that row crop conversion to pasture or extended rotations may occur. Programs other than CRP, along with independent action taken by farmers, undoubtedly facilitate annual crop conversion to perennials, but likely not to the vast extent that CRP does at this time. However, CRP acres peaked at 2.2 million in 1993 and have shown a gradual, though fluctuating, decline in recent years. Mechanisms for implementing and for collecting data on non-CRP land retirement may be necessary for the achievement of NRS goals and will continue to be evaluated.

The other advantage of tracking CRP acres is that only lands currently in crop production or CRP are eligible for CRP enrollment. Marginal pasture acres are eligible for certain CRP programs, but this is limited and a small proportion of total CRP acres enrolled, less than 12,000 acres statewide, are eligible for CRP. This provides backing for nutrient loading calculations that increased enrollment corresponds with reductions in row crop acres. If a cost-share program enrolls a given field as perennial land use, then it is much more difficult to assess nutrient loading reductions since the prior land use was already limiting nutrient losses. While it can be assumed that acres that leave CRP enrollment return to row crop production, it is not necessarily true in all instances. It is important to account for this difference by tracking cropland, urban, and other land uses. Improved spatial resolution of CRP acres will also help understand these changes over time.

However, there is a challenge with quantifying the impacts of land in CRP at the current resolution the data is collected. County level data is difficult to track by watershed and the difference between CRP practices is needed to account for the disproportional effect they have on nutrients. For example, a CRP filter strip has advantages in nutrient reduction compared to whole-farm or whole-field CRP practices. These differences should be accounted for when tracking and quantifying progress. When CRP was established in the 1980s, the majority of enrollments were whole-field. As the program has evolved into more targeting and addressing other resource concerns (e.g. habitat), the enrollment has shifted more towards continuous, targeted areas of fields that provide additional benefits.

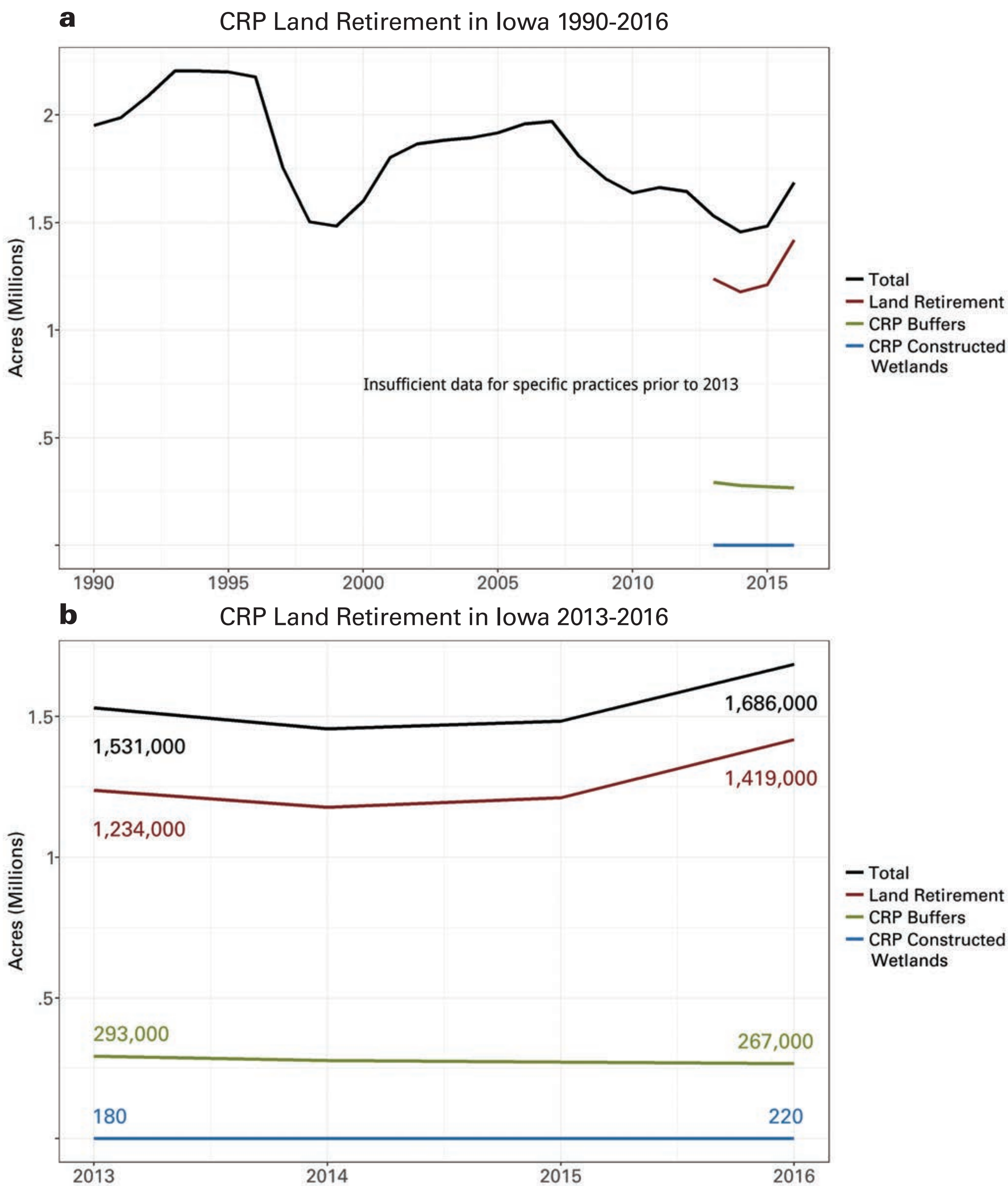


Figure 12. The annual acres of Conservation Reserve Program contracts in Iowa from a) 1990-2016 and b) 2013-2016. General land retirement contracts are represented by a red line from 2013-2016; during this time period, data on specific practices funded by CRP are available. Buffers and wetlands are discussed further on pages 32 and 34, respectively.

In-Field practices for reducing nutrient loss

Cover crops are also an effective practice for reducing nitrogen and phosphorus loss at 28-31 percent and 29 percent, respectively. This practice has experienced substantial uptake in recent years, likely as a result of its integration into corn-soybean operations and its potential for improving soil health.

In fall 2016, 300,000 acres of cover crops were planted through cost-share funding, up from 260,000 in 2015 (Figure 13). This data, however, does not account for the total acres of cover crops implemented in Iowa without cost-share funding. Estimates suggest that at least 600,000 acres of cover crops were planted in fall 2016.[5] This assessment is promising in that cover crop adoption began on a wide scale in 2011. However, to correspond with the NRS scenarios that present cover crops as part of a suite of practices implemented to meet the 45 percent reduction goal, cover crops need to be adopted on a scale of 10-14 million acres. This would require a significant acceleration of adoption rates in subsequent years.

Why are some NRS practices excluded from progress evaluation?

The annual progress of some NRS practices are not displayed in this report due to insufficient data availability:

- In-field nutrient management
- Tillage reduction
- Nitrification Inhibitor
- Extended rotations
- Drainage water management
- Ponds
- Non-CRP perennial vegetation

For more information on how these data challenges are currently addressed through new research and tracking projects, see page 37.

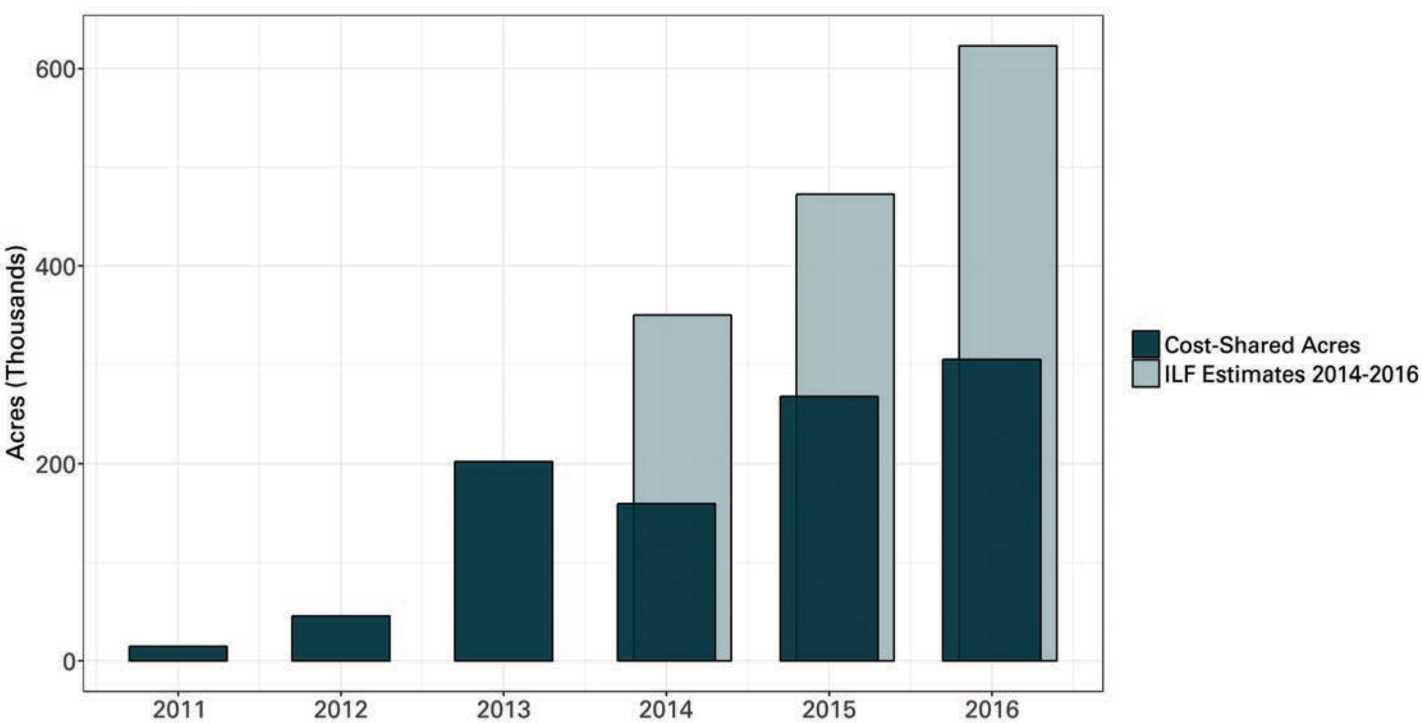


Figure 13. Cover crop acres implemented in each year from 2011 to 2016 with cost-share assistance from state and federal conservation programs. Also displayed is an estimate of total state implementation (regardless of funding mechanism): the annual Iowa Learning Farms' estimate from survey data extrapolated to reflect the entire state.

5 Iowa Learning Farms surveyed farmers who attended their field days, asking how many acres of cover crops they plant. The average number of acres was extrapolated to reflect the entire state. Iowa Learning Farms 2016 Evaluation Report, www.extension.iastate.edu/ilf/content/ilf-reports.

Cover Crops 2016

Government Cost-Share Programs

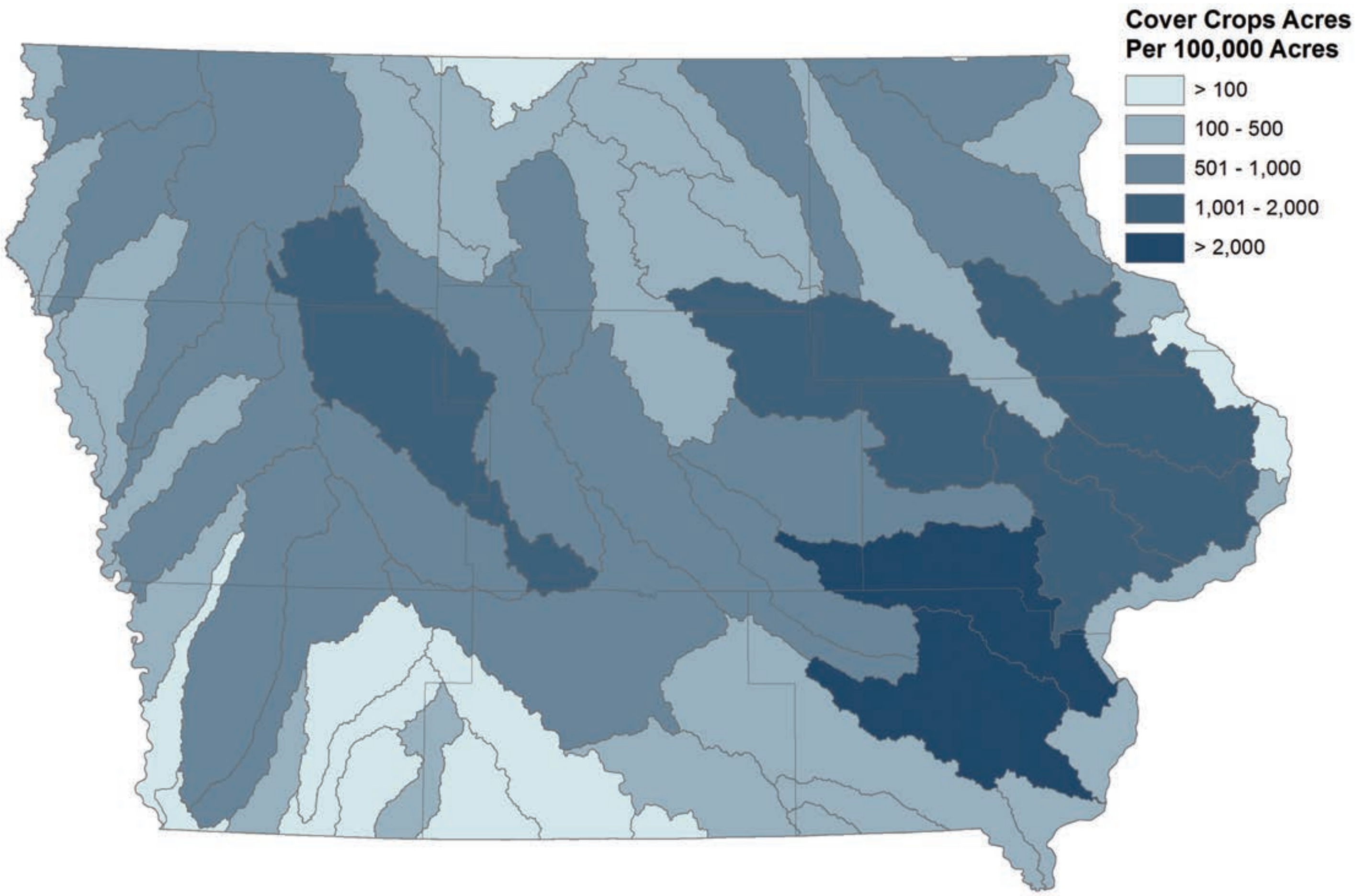


Figure 14. The relative densities of cover crops implemented with state and federal cost-share funding. In each HUC8 watershed, cover crop acres are indicated as acres per 100,000 watershed acres. This image does not include cover crops that were implemented without government funding.

Figure 14 displays the density of cover crop implementation in Iowa's HUC8 watersheds. These densities reflect only government conservation program contracts (i.e. cost-share acres); data for acres implemented without government funding are currently unavailable and not included in the image. Cover crop use is concentrated in the southeast portion of the state, and secondarily in the eastern and Raccoon River regions. A disproportional share of cover crop acres can be partially attributed to more favorable weather patterns to reliably establish and manage cover crops. However, it cannot discount the role of local knowledge and farmers' cover crop experience, the focus of locally delivered programs, and cropping and livestock systems in these areas.

Nutrient management improvements have an effect on nutrient loading to streams of up to 10 percent reduction for nitrogen and up to 46 percent reduction for phosphorus. Public programs can incentivize, promote, and encourage adoption, but the role of programs and ability to track adoption is limited due to a variety of reasons. Most nutrient management decisions are primarily implemented through the private sector and are balanced with considerations for risk and economics of crop production. To date, estimates of the extent of nutrient management practices have focused solely on determining the average rate of nitrogen and phosphorus applied to corn or soybeans annually over time. This assessment involves utilizing existing data on commercial fertilizer sales and animal units to estimate nutrients applied through manure on a county scale. These values have been static over time, though there has likely been more refinement in the timing, source, and use of nitrification inhibitors as these technologies are developed and promoted through both the public and private sectors. This information also has geospatial variation that cannot be determined from the currently available statewide estimates.

Tillage has a potential for large reductions in phosphorus loss from row crop fields. Conversion from moldboard plowing, by which no crop residue remains in the field, to conservation tillage results in an average 33 percent reduction in phosphorus loss, although research shows a wide variability in case-by-case results. Moving from conventional tillage—minimal residue—to no-till results in an average 90 percent reduction in phosphorus loss.

Tillage practices have shifted over the last few decades. According to the USDA Census of Agriculture, there were 6.9 million acres of no-till in Iowa in 2012. Additionally, there were 8.7 million acres of conservation tillage. Conventional tillage was reported as less prevalent than conservation tillage at 7.9 million acres (Figure 15). 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 phosphorus loss.

Data on the progress of tillage since 2012 are limited, as reduced tillage through cost-share programs is minimal and farm operators are likely to reduce their tillage practices independently. The 2017 USDA Census of Agriculture will be completed in 2017, but data will not be available until 2019. For more information on additional efforts to estimate tillage use in Iowa, see page 41. While the extent of no-till is promising for reducing phosphorus loss, there is a need for improved understanding of the extent and change of different tillage practices across each region of the state. An ongoing survey effort aims to fill in this knowledge gap and is discussed further on page 41.

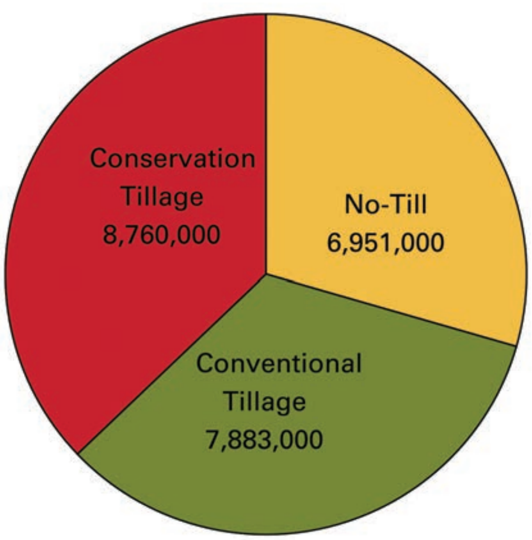


Figure 15. Acres of tillage practices in Iowa cropland in 2012, as reported by the 2012 USDA Census of Agriculture.

Edge-of-Field and Erosion Control Practices

Buffers are an edge-of-field practice that reduce nitrogen and phosphorus by 91 and 58 percent, respectively, on average for the land area contributing to the buffer. Generally, this practice is installed by one of two primary funding mechanisms: private landowner installation and CRP contracts. Data availability currently limits our understanding of buffer use to CRP contracts; private landowner installation of buffers is not captured by any currently available data sources. Federal and state cost-share programs support the installation of some buffers, but it is estimated these programs fund less than one percent compared to the acres that CRP rents for buffers. Additionally, we have not reported the cost-shared buffer installations in this report due to the fact that they are recorded as acres installed annually, without indication of the contract length. By contrast, the CRP dataset captures the existing CRP buffer acres regardless of contract length. The CRP data track the vast majority of government-subsidized buffers in Iowa.

Since 2013, while total acres of CRP have increased, Iowa's buffer acres funded by CRP and the corresponding estimated treated acres have decreased (Figure 12b). The FSA recorded the existence of 267,000 acres of CRP buffers in 2016, which was a nine percent decline from 293,000 in 2013.[6] This decrease is minimal, as indicated by a standard deviation of 11,000 (Figure 16), and our understanding of the extent of Iowa's stream buffers is limited to CRP data. Buffers may be installed through other means, and a decrease in CRP acres does not inherently suggest those acres were converted back to row crop production.

[6] The 2013 baseline for buffers was selected due to data availability. Data on acreage of 2011 and 2012 CRP buffers are publicly available, but are inconsistent with the data provided for 2013-2016 and potentially misreported or underreported. Efforts to explore this discrepancy will be conducted in the 2018 reporting period.

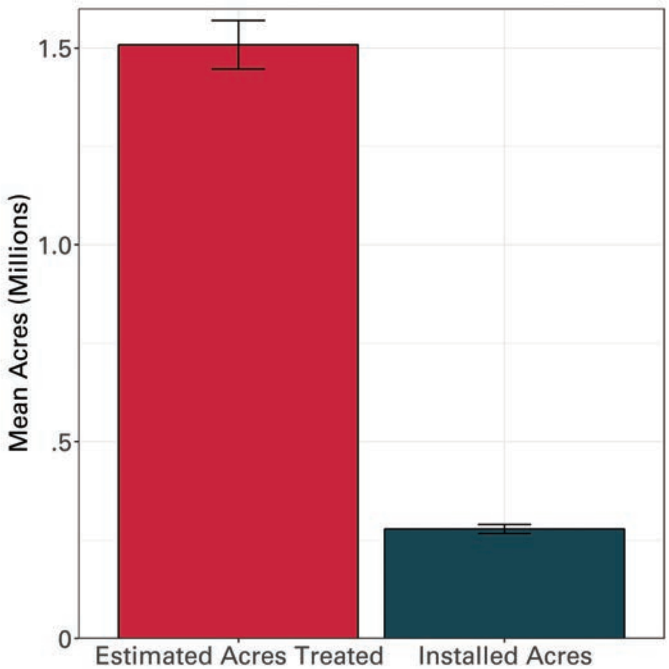


Figure 16. The mean annual CRP buffer acres installed and the corresponding estimated acres treated in Iowa from 2013-16. As a nutrient reduction practice, the extent of buffers implemented through CRP has experienced little change in recent years. Estimated acres treated were calculated using an assumption of 5.4 treated acres per one acre installed, based on a subset of CRP data provided by NRCS that describes the field size associated with buffer installation contracts.

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 percent reduction, respectively, these practices are highly effective at reducing annual nitrate loads to streams.

There are an estimated 20 known bioreactors in Iowa; using a conservative assumption that they each treat 50 acres of drained cropland, at least 1,000 acres are currently treated (Figure 17a). Of these 1,000 known treated acres, 950 acres have been newly treated since 2011. This practice is relatively new, so adoption will likely continue to rise as programs and partners focus inputs and outreach towards implementation, but the level of acres treated by bioreactors needs to increase significantly to address the goals of the NRS based on various scenarios. The NRS Science Assessment proposes that, in one scenario, six million acres—60 percent of drained land—should be treated to meet its goals. A second scenario suggests a need for 70 percent of drained land, or 6.9 million acres, receive treatment from a bioreactor. At 50 acres treated per bioreactor, these scenarios call for up to 138,000 bioreactors to be installed in selected regions of the state. While these scenarios serve as examples of the scope of implementation necessary, it may be that fewer bioreactors, coupled with other practices, will actually be needed for the NRS nitrogen reduction goals. This practice is limited by the topography and drainage system of any given field, so targeted application of this practice is necessary. In addition, this scenario was created prior to development and acceptence of saturated buffers as a viable practice to address nitrate loss. It may be assumed that saturated buffers and bioreactors are synonymous in terms of objective (i.e. reduction of nitrogen lost via drainage tiles) and effectiveness; these two practices may, together, contribute to the vast need for treatment of tile flow, with site characteristics determining the appropriate installation of one practice or the other.

Early installation of saturated buffers and bioreactors was partially hampered by CRP policy that prevented the installation of these practices into acres under contract through CRP. In 2016, after coordinating with multiple stakeholders, the FSA reversed their previous position and began allowing and even incentivizing these practices in CRP buffers. There are currently only a few existing saturated buffers in Iowa, but outreach to promote and facilitate adoption is ongoing.

To date, as with most practices, the true extent of bioreactor and saturated buffer implementation is difficult to estimate due to differences in tracking methods at this time. Data sharing between Iowa State University, NRCS, IDALS, and ISA has confirmed that there are at least 20 bioreactors in Iowa, although more may be in place. Bioreactors currently cannot be tracked using remote sensing or aerial photography because they are not visible once vegetation has established over their footprint. As of 2017, the annual NRS partner organization reports now include data entry on structural practices—including bioreactors—in an attempt to help address future concerns about tracking bioreactors. An improved method of tracking is being explored, given the extent of bioreactor use needed on the Iowa landscape.

Wetlands that treat agricultural drainage for the reduction of nitrogen export have an effectiveness of 52 percent 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. Similarly sited and installed wetlands have been completed historically by other programs and individuals, but data are currently not available to assess the extent of this implementation. Other wetland restoration programs not sited or intended to receive agricultural drainage are considered in nutrient load reduction calculations, but under the land use category due to the nature of their intended and designed function.

Currently, Iowa has 82 CREP wetlands that treat about 103,000 acres (Figure 17b). 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 six wetlands currently in the planning and construction phases. In addition to CREP-funded wetlands, Iowa has 220 acres of CRP wetlands that have a similar design and purpose (Figure 12), although the treated acres from these installations is unknown due to limited data availability. CREP has provided the initial investment required to generate participation by landowners, but future implementation must grow outside of this funding-limited mechanism.

Installation of wetlands that are designed to treat tile drainage will need to accelerate to reach the level of treatment outlined by the NRS Science Assessment scenarios. One scenario suggests a need for 27 percent of agricultural land, or 7.7 million acres, treated by wetlands, and a second scenario suggests a need for 31.5 percent of agricultural land, or 8.9 million acres.

Water and sediment control basins (WASCOBs) and grade stabilization structures are structural, erosion-control practices that reduce the loss of soil-bound phosphorus by 85 percent. These are an established conservation practice in Iowa, and have been a significant focus of cost-share program investment. There are also several thousand units of these practices installed outside of public investment by landowners for livestock watering, recreation, and soil conservation purposes. The ongoing BMP mapping project will provide a key ability to track and document these practices. While these structures have been used for decades to prevent soil loss, the rate of construction since 2011 though public sector programs only has been assessed. Between 2011 and 2016, 112,000 acres were newly treated by WASCOBs and grade stabilization structures (Figure 17c). Each year, between 500 and 770 of these practices were constructed through cost-share. These estimates do not account for practices installed without cost-share assistance. For more information on efforts to account for all WASCOBs (without bias toward government funding data), see page 37.

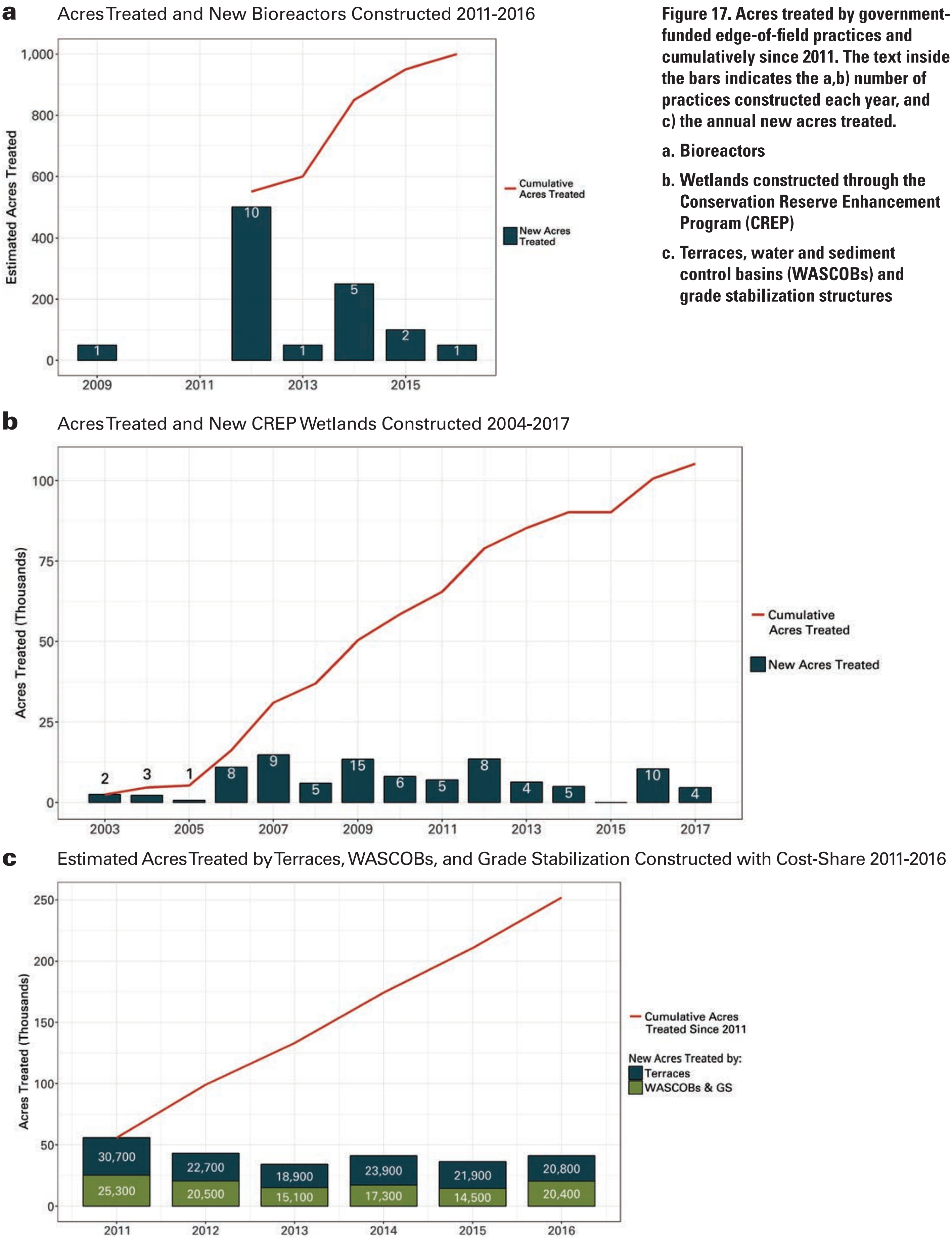


Figure 17. Acres treated by government-funded edge-of-field practices and cumulatively since 2011. The text inside the bars indicates the a,b) number of practices constructed each year, and c) the annual new acres treated.

a. Bioreactors

b. Wetlands constructed through the Conservation Reserve Enhancement Program (CREP)

c. Terraces, water and sediment control basins (WASCOBs) and grade stabilization structures

Terraces reduce phosphorus loss by an average 77 percent and represent an established practice that has seen a large amount of construction over the last few decades. Terraces reduce phosphorous loss through reduced soil erosion, particularly on cropped slopes. This practice requires a relatively high financial investment and, like WASCOBs and grade stabilization structures, has been the historical focus of public sector programs. Currently, it is assumed that a significant amount of terraces are constructed through the financial assistance of government cost-share programs and this report will represent information from those sources. The Iowa Chapter of Land Improvement Contractors of America conducted a survey of their members that indicated approximately 50 percent 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 understand these additional practices and corresponding load reductions. The BMP mapping project will also provide the ability to track these practices over time due to their visibility on the landscape. For more information on this effort, see page 37.

State databases indicate the approximate acres protected by terraces constructed in each cost-share contract. These figures, as averages for each HUC8 watershed, were used to estimate the acres treated by each foot of terrace and applied these estimates to the federal cost-share data on terrace construction. Through this method, the annual acres treated by new terraces have been estimated (Figure 17c). Through cost-share programs, an estimated 137,000 acres cumulatively are treated by terraces constructed since 2011.

Progress toward NRS scenarios

During the development of the NRS, the NRS science team identified several scenarios that were estimated to achieve nutrient reduction goals. These scenarios—combinations of practices and levels of implementation—serve as examples of potential scenarios that meet the goals of NRS nonpoint source reductions in nitrogen and phosphorus loss, 41 and 29 percent, respectively. NRS success may not look exactly like any of these scenarios. Rather, these examples illustrate the scope of practice implementation needed to achieve nutrient loss reduction goals. The three scenarios provide for a comparison and were chosen as examples because, of the various scenarios modeled for the NRS Science Assessment, they are estimated to address the goals of both nitrogen and phosphorus.

Table 7. Three example scenarios estimated to meet the nitrogen and phosphorus goals of the NRS for nonpoint sources, as presented in the NRS. These scenarios were modeled for the NRS Science Assessment and serve to illustrate the potential scope of implementation needed to meet goals. They do not serve as exact recommendations.

Scenario	
Scenario one	Maximum return to nitrogen (MRTN) rate, 60% acreage with cover crop, 27% of ag land treated with wetland and 60% of drained land has bioreactor.
Scenario three	MRTN rate, 95% of acreage in all MLRAs with cover crops, 34% of ag land in MLRA 103 and 104 treated with wetland, and 5% land retirement in all MLRAs.
Scenario eight	MRTN rate, inhibitor with all fall commercial N, sidedress all spring N, 70% of all tile drained acres treated with bioreactor, 70% of all applicable land has controlled drainage, 31.5% of ag land treated with a wetland, and 70% of all agricultural streams have a buffer. Phosphorus reduction practices: phosphorus rate reduction on all ag land, convert 90% of conventional tillage (CS) and cover crop (CC) acres to conservation till and convert 10% of tilled CS and CC ground to no-till.

In 2016, over 302,000 acres of cover crops were planted through state and federally funded conservation programs. This acreage represents about 2.4 percent progress toward scenario one and 1.5 percent toward scenario three. Current data availability limits analysis to cover crop acres funded by cost-share programs; however, as discussed on page 30, general estimates through surveys suggest that there were approximately 600,000 acres after the 2016 growing season, which would effectively double the recent progress of this practice reported here.

Wetlands that treat nitrate from tiled systems have been constructed across Iowa since 2004, but to maintain a consistent benchmark with other practices, only those wetlands constructed after 2011 have been used in this analysis. In 2016, these 32 wetlands collectively treated approximately 40,000 acres, representing 0.6 percent toward scenario one, 1.1 percent toward scenario three, and 0.5 percent toward scenario eight.

Nineteen known bioreactors have been installed in since 2011 and treat an estimated 950 acres, representing 0.02 percent toward scenario one and 0.04 percent toward scenario eight.

Net retirement of agricultural land has increased by 181,000 acres since 2013 (specific CRP practice data are not available for 2011 or 2012; efforts are underway to request these data from FSA). This net acreage represents 17 percent toward scenario three. However, net total acres of CRP, including buffers and additional specific CRP practices, represent a 155,000-acre increase in acres converted from annual crops to perennial vegetation, suggesting 15 percent progress toward scenario three.

Additional practices highlighted in these scenarios were excluded from this analysis due to insufficient data on recent progress that has occurred since these scenarios were modeled. However, ongoing efforts aim to better understand the implementation of many NRS practices. With the future availability of these data, progress toward these scenarios will be updated.

While annual progress continues in the implementation of these practices, early NRS efforts only scratch the surface of what is needed across the state to meet the nonpoint source nutrient reduction. Progress has occurred, but not at the scale that would impact statewide water quality measures. Local water quality improvements may be realized in the short term where higher densities of conservation practices are in use, but the ability to detect early trends in measured water quality will vary from case to case. Statewide improvements affected by conservation practices will require a much greater degree of implementation than has occurred so far.

Data Improvement Efforts – Updates

There are various, ongoing efforts to improve the understanding of practice implementation and capture practice use that occurred outside of government assistance programs. This sections describes two projects: the BMP mapping project to digitize existing structural practice locations and a public-private partnership to survey agricultural retailers about in-field practice use across the state.

BMP Mapping Project—Efforts 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, the 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, 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 will be 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 period will be determined by digitizing a sample—25 percent—of HUC12 watersheds, using aerial photography from that time period. This 1980-96 estimate corresponds to the baseline targeted by the HTF. Third, the same 25 percent sample of HUC12 watersheds will be digitized with emerging 2016-17 LiDAR imagery to estimate potential increased implementation or removal of the structural practices that were located in the 2010 benchmark phase.

Photo courtesy of Lynn Betts, USDA Natural Resources Conservation Service.

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

- Establish an initial summary of structural practices that are already present in the Iowa landscape.
- 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 are already met.
- Assign nutrient and sediment load reduction/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 benchmark years (2007-10).
- Hindcast to past conditions using historic photos to show progress made over time and to evaluate alternative baselines (e.g. the EPA 1980-96 target).

Photo courtesy of Lynn Betts, USDA Natural Resources Conservation Service.

The information generated by this project will supplement cost-share data and will paint a more complete picture of conservation in selected watersheds, while future installations can be tracked against this baseline. Figure 18 displays the progress of this project's mapping efforts in the 2017 reporting period: June 2016, December 2016, and May 2017. The benchmark practices will contribute to improved estimates of nutrient load reductions in future analyses.

a

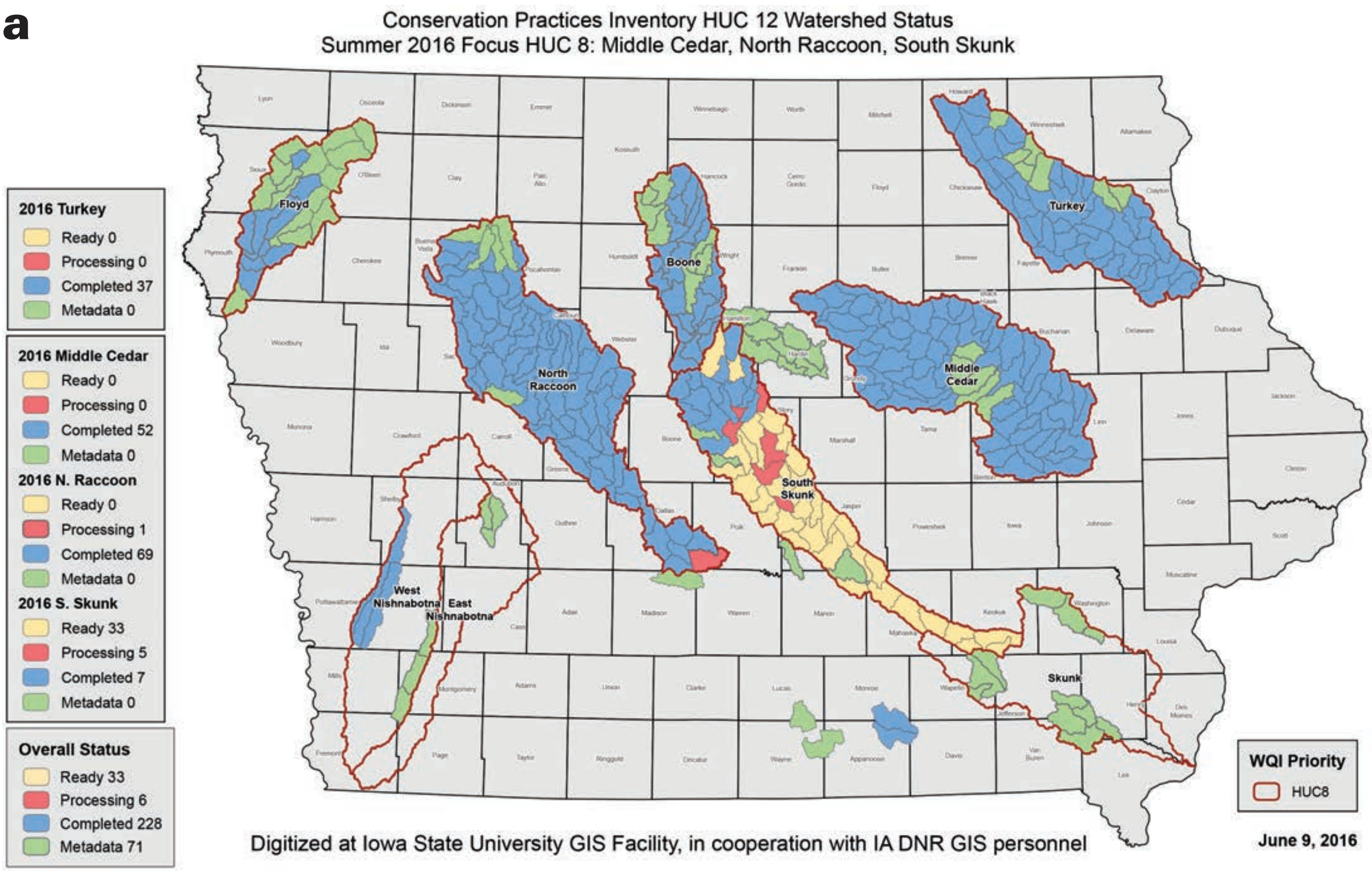
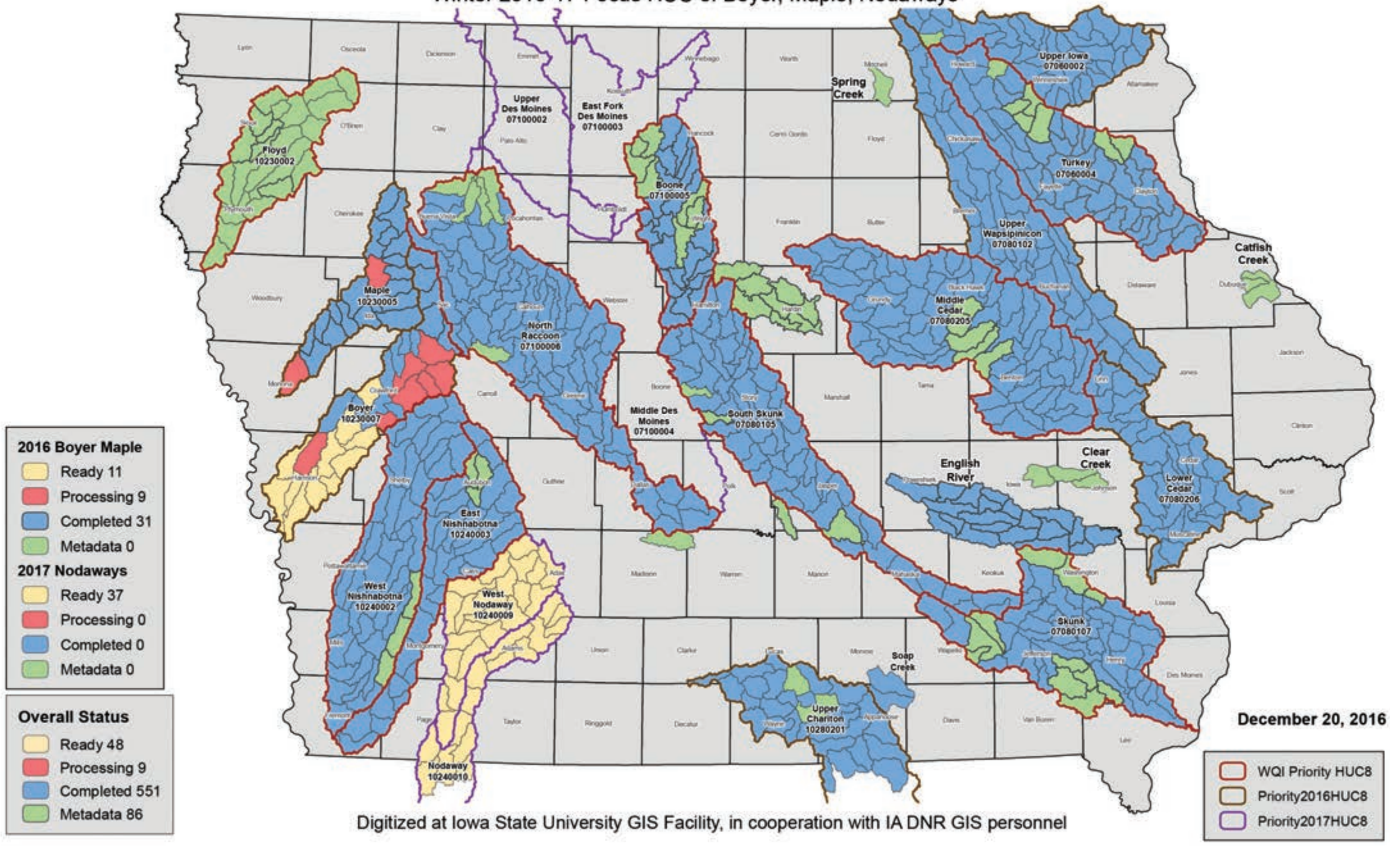


Figure 18. Time series of status of the ongoing BMP mapping project, displaying the completion of digitized watersheds for quantifying the existence of various structural conservation practices as of 2010. The status dates of these maps are a) June 9, 2016, b) December 20, 2016, and c) June 6, 2017. Green watersheds have fully compiled metadata, while blue watersheds are nearing that stage and awaiting quality assurance procedures. Digitization of yellow and red watersheds is currently underway. Researchers are aiming to complete the entire state by the end of 2018.

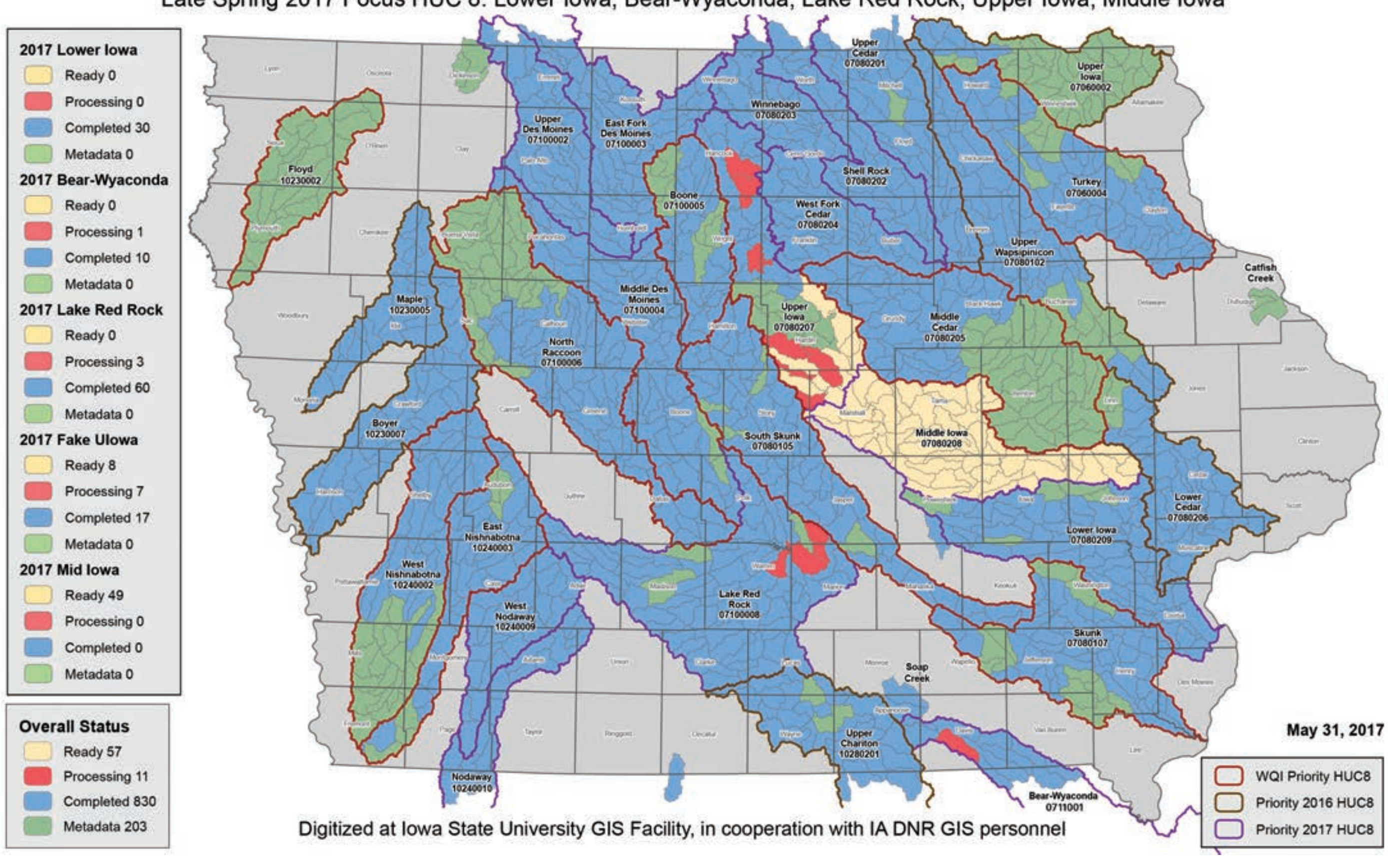
b

Conservation Practices Inventory HUC 12 Watershed Status
Winter 2016-17 Focus HUC 8: Boyer, Maple, Nodaways



c

Best Management Practices Inventory HUC 12 Watershed Status
Late Spring 2017 Focus HUC 8: Lower Iowa; Bear-Wyaconda; Lake Red Rock; Upper Iowa; Middle Iowa



BMP Mapping Project—Example of Utility for Tracking, Planning, and Targeting Conservation

Competine Creek is a southeastern Iowa watershed of approximately 25,000 acres (Figure 19). This watershed serves as a demonstration of the utility of the outputs of the BMP mapping project discussed in the previous section. This example displays the potential for watershed planning and for tracking progress over time. Additionally, watershed-scale mapping contributes to a better understanding of past investment in conservation and allows for estimates of practices' nutrient loss reduction. This demonstration is not meant to represent the progress that has occurred across the state, but rather serves as an example of the utlility provided by the BMP mapping project that would otherwise not be available to watershed coordinators, researchers, and Iowa communities.

Since 1980, Competine Creek Watershed landowners have installed 223 terraces, 32 ponds, and 732 WASCOBs (Table 8). These totals account for all financial methods of practice implementation—through both cost-share dollars and private funds. With the spatial distribution of existing practices at hand, a watershed coordinator and county field staff may identify gaps in practice implementation, such as a hilly area without terraces or contour buffer strips, and prioritize that area by reaching out to specific landowners. This capacity to target outreach efforts and funding is important, as many counties and watershed projects currently have limited staff resources.

The data product of this BMP mapping project may also highlight areas where certain practices are saturated in their applicability. Upon further evaluation, local staff may come to find there are limited additional slopes upon which terraces are needed. Staff can then prioritize their time and outreach efforts to other sections of the watershed or to other practices.

Investment in conservation practices is valuable information for understanding the extent of spending for phosphorus or nitrogen-reducing practices. Some practices are more expensive than others, some are annual (e.g. cover crops), while others are longer-lasting (e.g. wetlands).

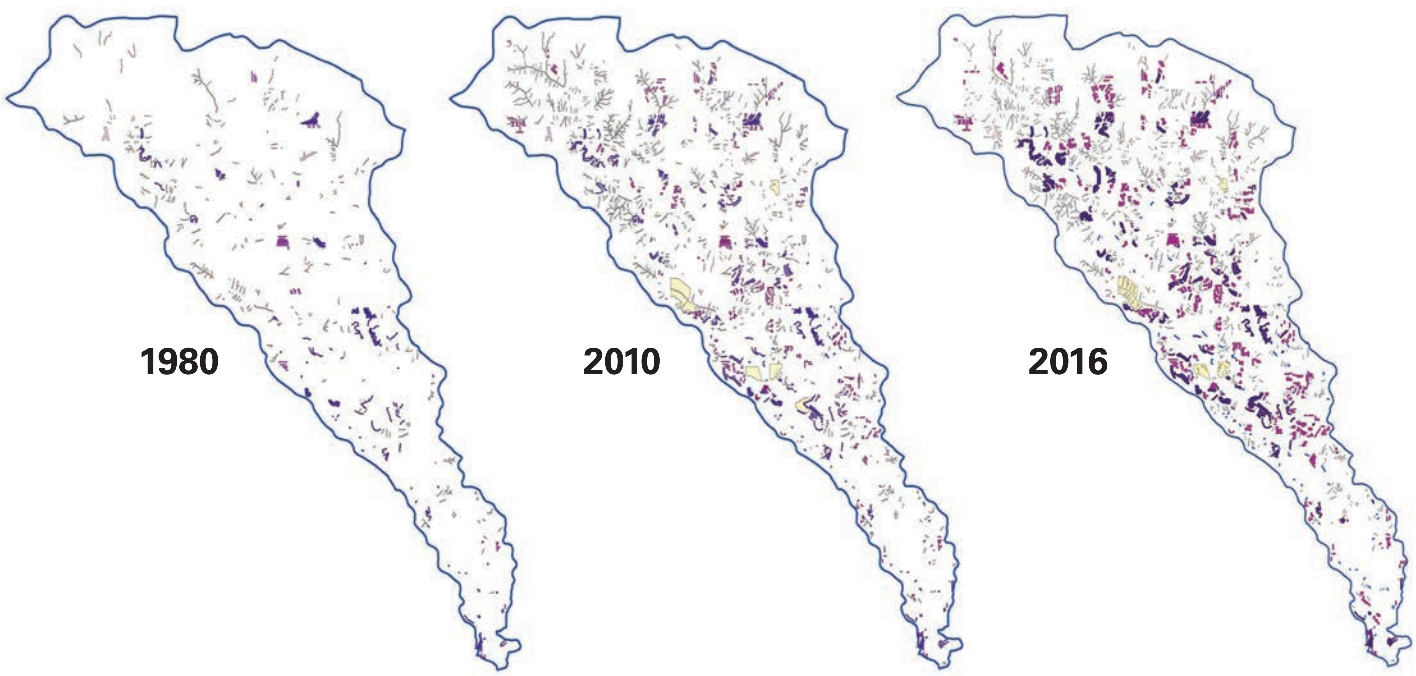


Figure 19. The progression of the existence of structural conservation practices in the Competine Creek Watershed in 1980, 2010, and 2016, as located by the BMP mapping project. These graphics demonstrate the utility of this project for watershed planning, tracking conservation progress, and estimating past investment in conservation practices on a local or statewide scale.

Table 8. The number of existing conservation practices in Competine Creek Watershed, as identified by the BMP mapping project.

Practice	1980	2010	2016	2010-2016 gain	2010-2016 rate - #/yr	2010-2016 percent increase
Ponds	35	59	67	8	1.3	14%
Terraces	96	232	319	87	14.5	38%
WASCOBs	48	479	780	301	50.2	63%
Grassed waterways	308	869	1064	195	32.5	22%
Contour buffers	0	8	7	-1	-0.2	N/A
Stripcropping	N/A	None	0	N/A	N/A	N/A

In-field practice survey

While the BMP mapping project will shed light on the extent of structural practices, another gap is an objective measure of the use of in-field practices such as nutrient management, tillage, and cover crops. It is certain that all practices, to some extent, are adopted and maintained without the use of governmental financial assistance. For example, some estimates suggest there were 600,000 acres of cover crops planted in Iowa in 2016, though cost-share programs financed only about 300,000 acres the same year (see footnote 5, page 32). This rough calculation has limitations, but emphasizes that there are more acres of cover crops than are funded by government programs. It is also certain that other nutrient-reducing practices, including no-till and nutrient management, are also in use by farmers who did not utilize federal or state cost-share.

In partnership with Iowa State University's College of Agriculture and Life Sciences, the INREC will develop and pilot an objective, statistical method to measure Iowa farmers' use of in field management practices to reduce nutrient loss. In the three-year pilot project, INREC will conduct a statistically valid survey of farmers' fields using the objective data held by agricultural retailers who provide services to farmers. The aggregation of field-scale data will contribute to efforts to track conservation practice adoption in Iowa. By combining the information gathered into an anonymized dataset, a more accurate view of nutrient-reducing practices and product implementation will be formed. This project, through its public-private partnership, will contribute to an improved understanding of the extent to which farmers employ practices recommended by the NRS. This project will rely upon the existing roles of Iowa's agricultural retailers and crop advisors who demonstrate a capacity for widespread one-on-one consultations with farmers. INREC will work to enhance retailers' roles by providing increased outreach and training to help these professionals with advising farmer decisions regarding conservation practices. This survey has undergone design and beta testing and data collection scheduled for this fall. While assessment of the 2017 reporting period relies on the limited availability of conservation practice data, the BMP mapping project and the ISU-INREC project will facilitate improved reporting in the coming years.

Water

The goal of the NRS is to reduce Iowa's nitrogen and phosphorus load export by 45 percent; the strategy outlines a process for achieving this goal through increased efforts by both point sources and nonpoint sources to manage nutrient losses affected 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 aims to address 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 changes and nutrient export tracked in Iowa?

In assessing early progress of the NRS, this document employs two complementary approaches. First, Iowa's annual nitrogen export is estimated from the measured nitrate and nitrite concentrations in surface water.

Similar methods for estimating phosphorus export are under assessment. 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 nitrogen and phosphorus in Iowa agricultural landscapes. These efforts are complementary in the way that by tracking both, we get 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 on nutrient loss of individual practices, at the appropriate implementation scale, indicates their ability to reduce nutrients when scaled up. Either approach looked at independently won't 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 sources and nonpoint sources.

The 2015 Nutrient Reduction Strategy Annual 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 as follows, though this represents 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, "Stream Water-Quality Monitoring Conducted in Support of the Iowa Nutrient Reduction Strategy," that describes the current network of surface water monitoring in Iowa, details the challenges and data gaps associated with water quality monitoring, and suggests ways to improve and coordinate the collection and evaluation of water quality data for these purposes.[7] The report gathered participation by the DNR, IDALS, Iowa State University, and IIHR, 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 20. The Nutrient Water Quality Monitoring Framework was developed to graphically show that the length of time needed to show a measureable 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

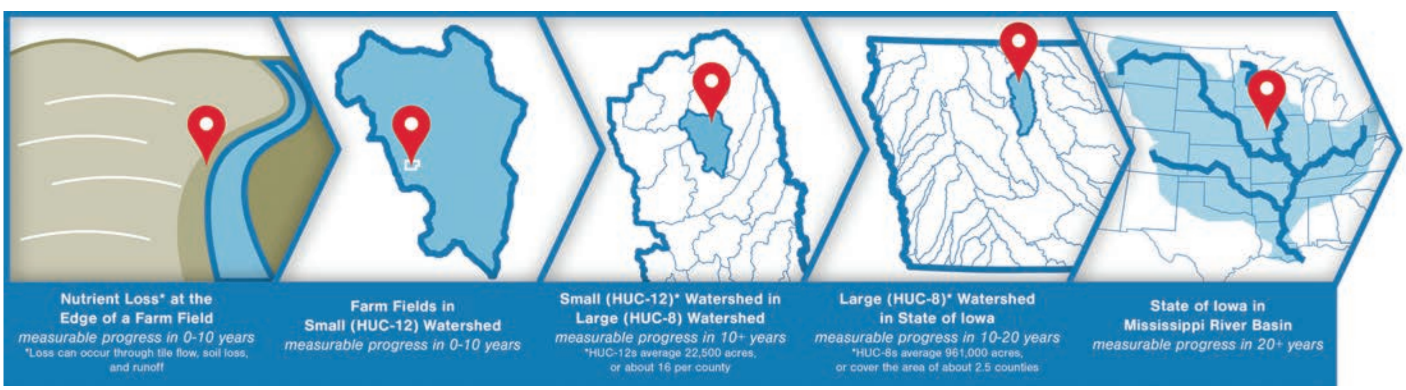


Figure 20. The progression of the existence of structural conservation practices in the Competine Creek Watershed in 1980, 2010, and 2016, as located by the BMP mapping project. These graphics demonstrate the utility of this project for watershed planning, tracking conservation progress, and estimating past investment in conservation practices on a local or statewide scale.

[7] This report can be accessed at http://www.nutrientstrategy.iastate.edu/documents .

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 that 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 become more complex at increasing spatial scales.

Water quality monitoring presents challenges in estimating nutrient load exports from Iowa's watersheds. These challenges are discussed in more detail in the report on Iowa stream monitoring efforts, 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 so distort the effects that conservation has on surface water nutrient loads.

2. **Lag time**, or the difference in time between conservation implementation and measureable change in water quality, occurs on a variety of scales. Lag time is often 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, lend to 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 export contribute to concerns that measurable change in statewide nitrogen and phosphorus 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.

What are the current efforts to track nutrient export?

Monitoring nitrogen and phosphorus at varying geographic scales assists efforts to answer a variety of research questions. The current extent of known monitoring at edge-of-field, small and medium watershed, and large watershed scales are presented. Additionally, we describe select projects that examine water quality for more localized purposes, such as watershed comparisons and watershed snapshots.

Monitoring at the edge-of-field and delivery scale

Nutrient loads at field and sub-field scale can differ substantially from loads actually delivered to surface waters. In addition, nutrient loads at larger watershed scales can differ substantially from loads actually delivered to surface waters due to the effects of in-stream processes (e.g. the effects of bed and bank erosion and phosphorous exchange with stream sediments). The most appropriate scale for assessing agricultural nonpoint source loads to surface water is the scale at which the load is actually delivered. For much of the cultivated cropland in Iowa that would be from a few hundred to a few thousand acres.

At this geographic scale of concern, data are collected to describe the nitrate concentrations of tile flow from specific agricultural fields. With the ISA, farmers participate in edge-of-field tile flow monitoring. During each growing season, grab samples are collected every two weeks and are analyzed in ISA's water lab. Farmers receive summary results that indicate their tiles' average nitrate concentration for the season, and they are offered guidance on management decisions to lower concentrations. Since 2014, participation in this on-farm project has increased from 10 to 374 sites (Figure 21).

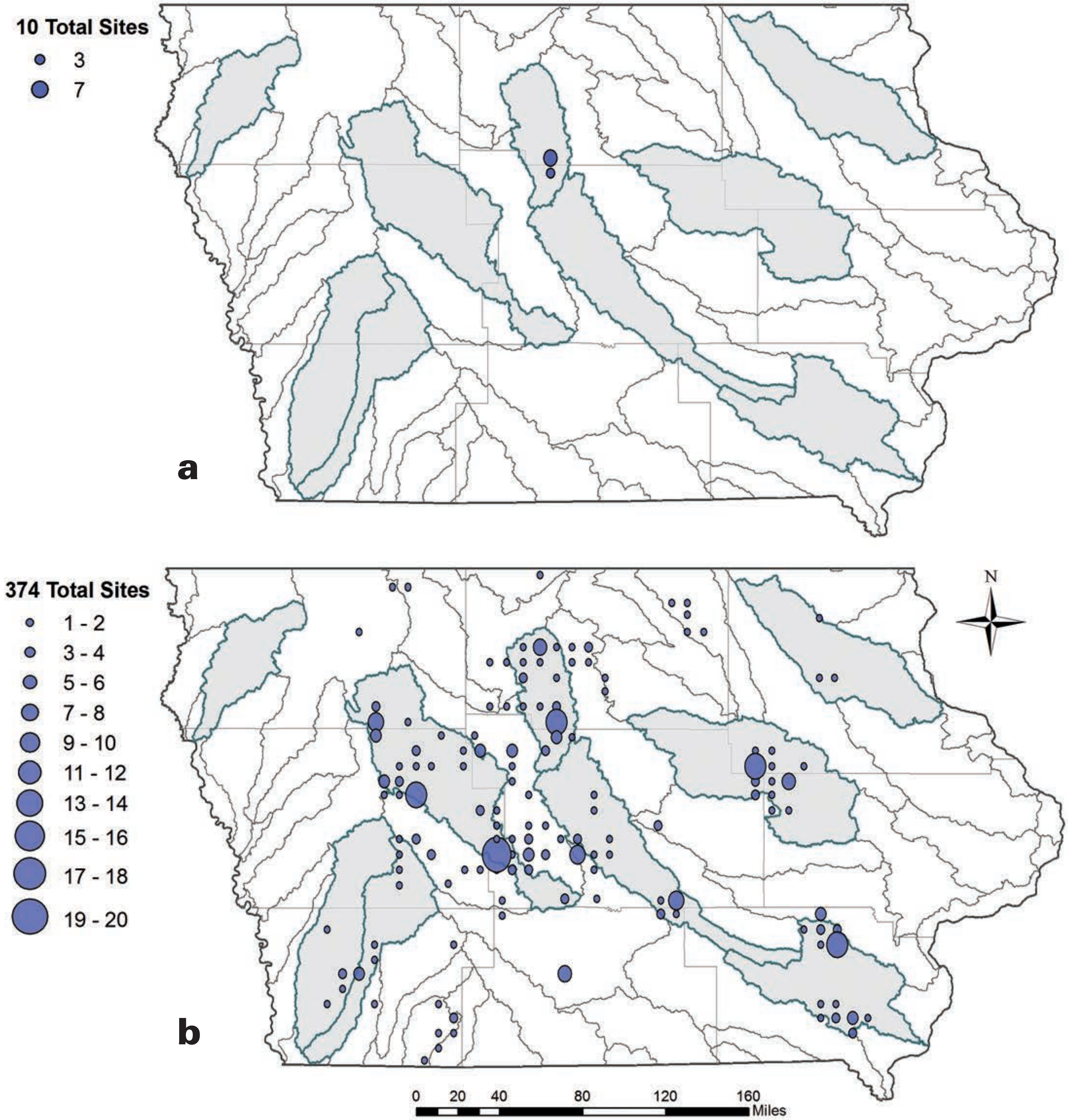


Figure 21. Distribution of tile monitoring sites managed by the Iowa Soybean Association in a) 2014 and b) 2017. The network has grown significantly in recent years and aids farmers in understanding the nitrate concentrations of their tile flow throughout much of the growing season (i.e. April through September). In addition, the project provides insight concerning the impact of field-scale practices on tile nitrate concentration.

In 2016, ISA and additional partners collected and analyzed 2,172 water samples from 272 locations (for the purposes of analysis, some sites were removed: for example, sites that drain multiple cropping systems). The majority of sample collection and analysis occurred between April and October. The primary purpose of the monitoring program is to provide information to farmers and landowners to help them to make decisions about cropping systems and conservation practice implementation and effectiveness. The ISA has data privacy agreements with participants that prohibit sharing of individual results. Aggregated results are used to advance dialogue with groups of farmers at conferences and watershed meetings. Samples are analyzed for nitrate, nitrite, ortho-phosphorous, and additional parameters. Some key findings from 2016 include the following:

- Average tile nitrate concentration levels were highest on the Des Moines Lobe (16.3 mg/L) landform and lowest on the Southern Iowa Drift Plain (10.1 mg/L).
- Average tile nitrate levels from corn fields (16.0 mg/L) were slightly higher than soybean fields (12.9 mg/L).
- The highest nitrate concentrations and loads were observed in May and June.
- There was little correlation between nitrogen application rates to corn and tile nitrate concentrations.
- Fields with cover crops had 29 percent lower tile nitrate concentrations than fields without.

IDALS, with partner organizations, has supported monitoring of nutrient loads at the delivery scale since 2007 (partly in association with monitoring of Iowa CREP wetlands and partly in association with other initiatives). In addition to better characterizing loads at delivery scale, this work aims to improve the predictability of practice performance, improve the understanding of practice uncertainty, and facilitate the validation of load reduction tools developed to evaluate progress toward nonpoint source load reduction.

Delivery-scale monitoring includes automated monitoring of incoming and outgoing loads at 10-15 Iowa CREP wetland sites annually. This allows researchers to assess nutrient loads delivered from the upper lying catchments as well as the effectiveness of the wetlands at reducing nutrient loads to downstream waters. In addition to documenting wetland performance, the ongoing monitoring and analyses support continued refinement of modeling and analytical tools used in site selection, design, and management of CREP wetlands.

Finally, edge-of-field monitoring is prevalent in research plots that are studied by university and agency research groups. These focused projects typically aim to assess practice effectiveness in more controlled environments. As these projects do not typically occur on operating farmland and vary in time span and methods, they are not discussed in detail in this report.

Monitoring small and medium watersheds—up to 1,000 square miles

Surface water monitoring is conducted statewide on an ongoing basis. The primary organizations managing sensors that transmit data are the DNR, U.S. Geological Survey (USGS), and IIHR. These sensors measure nitrogen (nitrate and nitrite), flow, and other site-specific parameters, which may include pH, dissolved oxygen, temperature, and discharge, depending on the site.

Each sensor collects information on some combination of a wide range of parameters, including nitrogen concentrations, turbidity, and flow. Any given sensor measures the surface water that drains from an upstream watershed area.

There are currently about 27 sites with sensors that monitor the outlets of watersheds that are less than 100 square miles in size (Figure 22a). These sensors may provide information on land use and land management and these practices' impacts on the concentration of pollutants immediately downstream, although the ability to draw statistically significant conclusions depends on the understanding of practice implementation in the watershed and the time frame and robustness of the dataset. These types of sensors gather data on proximate water quality changes over a relatively short period of time absent changes in practices or land use.

There are currently about 46 sites with sensors that monitor nitrogen, flow, and additional parameters at the outlets of watersheds that are 100-1,000 square miles in size (Figure 22b). These sites allow for long-term monitoring of watersheds that range in size from a fraction of a county to two or three counties in size. Over the course of several years to a decade, it is predicted that these sensors could detect improvements or declines in water quality following major transitions in land use and practice implementation across the watershed given appropriate data availability. For instance, many watershed projects, which typically cover several HUC12 watersheds, have sites located at the outlets of their natural drainage areas, providing ongoing measurements and, potentially, the capacity to detect trends in water quality over the years if the projects and sites remain in place and have led to significant installation of nutrient reducing practices over that time period. Since the sensors only collect nitrogen levels, this also requires investments of practices that address nitrogen loss. As indicated sites remain in the inputs and land section, a disproportional investment has been made historically in soil conservation practices to address soil and phosphorus loss.

Monitoring large watersheds—greater than 1,000 square miles

Finally, there are about 34 monitoring sites that monitor very large watersheds for nitrogen, flow, and additional parameters that span more than 1,000 square miles. These sites provide the basis for statewide estimates of nitrogen export, as at least 88 percent of Iowa's land drains to monitored locations, allowing for tracking of the vast majority of Iowa's surface water (Figure 22c). Monitoring challenges described on page 43—including lag time, legacy nutrients, and weather variability—contribute to uncertainty and variability in detecting short-term trends in statewide nutrient loss; identifying trends that occur at smaller scales may be a more straight-forward task, although these challenges do apply at smaller scales, as well. To ameliorate these challenges, the continuation of long-term data collection is necessary for monitoring nutrient concentrations and flow at these sites that monitor greater than 1,000 square miles. With Iowa's extensive water monitoring network in place and under continuous evaluation, multi-decade monitoring is needed to evaluate Iowa's statewide water quality trends and to continue tracking Iowa's progress toward NRS goals of 45 percent reduction of annual nitrogen and phosphorus export.

In addition to the sites discussed in the preceding sections, Agriculture's Clean Water Alliance (ACWA) and ISA collect grab samples on a weekly to biweekly basis across the state. Collectively, these organizations collaborate to sample surface water at locations that drain varying spatial areas. Samples are collected at 139 HUC12 or subwatershed sites, 40 HUC10 sites, and eight HUC8 sites. Samples from all of these sites are analyzed for nitrate and turbidity, and selected sites are analyzed for additional parameters, including phosphate and flow.

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

Nitrogen

The NRS called on the DNR to convene a technical work group beginning in 2013 to define the process for providing a regular nutrient load estimate based on the fixed-station stream water quality monitoring network displayed in Figure 22. This work group was to determine the most appropriate estimation method, the acceptability of existing data with which to evaluate methods, a process for making future adjustments based on the latest information and advancements in science and technology, and consider resource efficiency.

An interdisciplinary team of Iowa scientists and engineers from state, federal, university, and commodity groups was assembled to evaluate and recommend a nitrate load estimation procedure for the State of Iowa. Representatives from the DNR, Iowa State University, IDALS, ISA, USGS, and University of Iowa first met on December 3, 2013.

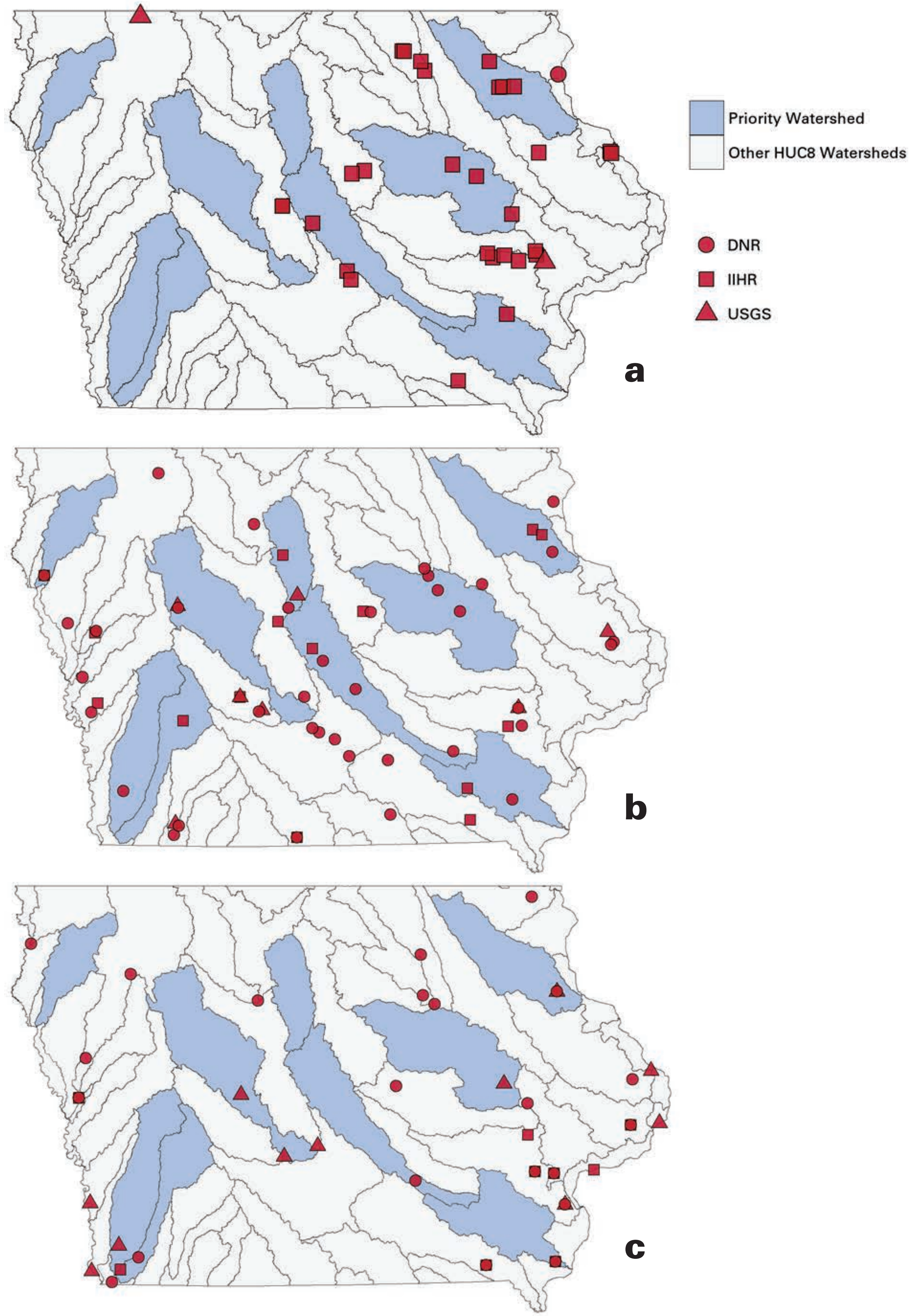


Figure 22. Locations of stream monitoring sites that drain a) less than 100 square miles, b) 100-1,000 square miles, and c) over 1,000 square miles.

The work group first developed a methodology to compare the six most commonly used nitrogen load estimation models and also assembled a single standardized data set to use in comparing model results. Individual work group members were assigned to calculate a load estimate using the standardized data set and one of the load estimation methods. The full work group then compared the results obtained using each method using the same dataset.

The work group recommended using the linear interpolation method because it provides the simplest and most straightforward approach to estimate loads. Linear interpolation fills data gaps between measured concentrations by a straight line. Owing to its simplicity, different users can expect to produce approximately the same load estimate from a given set of data. Linear interpolation was also found to provide the overall best results for load estimation in agricultural and mixed-use watersheds. However, linear interpolation requires consistent and long-term sample collection to be effective. Missing sampling periods that lengthen the interval between measurements will result in greater potential error in the load estimate. The research behind this effort, "Variability of nitrate-nitrogen load estimation results will make quantifying load reduction strategies difficult in Iowa," is expected to be published in summer 2017 in the *Journal of Soil and Water Conservation*.

Table 9. The results of the linear interpolation estimates of annual nitrate export from Iowa. Estimates of nitrate load per acre use a value of 35,748,563 total acres of Iowa land.

Year	Nitrate-N load (tons N/year)	Flow (cm)	Load per acre (pounds)
2000	101,298	10.7	5.7
2001	300,428	25.8	16.8
2002	115,070	12.1	6.4
2003	144,049	12.8	8.1
2004	264,357	22.3	14.8
2005	186,995	15.8	10.5
2006	174,990	14.2	9.8
2007	450,132	36.5	25.2
2008	434,611	46.7	24.3
2009	281,029	32.3	15.7
2010	455,312	52.8	25.5
2011	297,246	28.2	16.6
2012	66,189	8.9	3.7
2013	342,921	26.0	19.2
2014	267,053	27.6	14.9
2015	417,533	33.0	23.4
2016	525,654	40.1	29.4

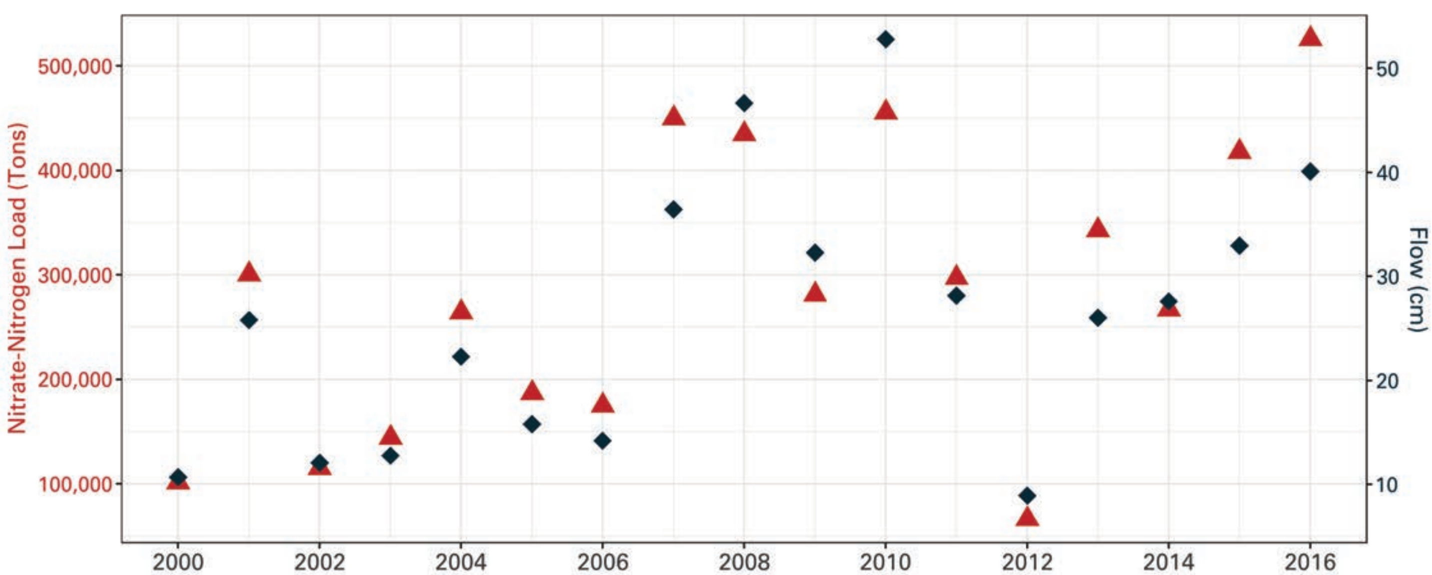


Figure 23. The results of the linear interpolation estimates of annual nitrate export from Iowa. These estimates were modeled using empirical data collected through the ambient stream-monitoring network operated by the DNR and USGS.

The statewide nitrate-N estimates in Table 9 help provide understanding 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 (Figure 23). The technical work group will continue efforts over the next year to better understand the patterns presented in this new dataset and will evaluate options for potential metrics that best capture trend information for concentration and loads in Iowa's surface waters.

Phosphorus

An ongoing effort similar to the above methods for estimating nitrate loads is underway to develop a method for quantifying phosphorus loads. However, quantifying phosphorus loads has challenges distinct from those associated with quantifying nitrogen loads. A work group has compiled multiple phosphorus data sets to be used to evaluate different load estimation methods. Opposite the results from the nitrogen estimation method, the data sets indicate that the monthly frequency of monitoring at fixed-station sites is not sufficient to estimate phosphorus loads because the amount of phosphorus in rivers and streams changes very rapidly with changes in stream flow. It is unlikely that phosphorus load estimates can be obtained without event-based sampling or continuous monitoring. Unlike nitrate however, in-stream phosphorus sensors are not as readily available or functional to help overcome this challenge.

The work 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, 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. Overall, turbidity and orthophosphorus (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 draining the tile-drained Des Moines Lobe region. There is typically less sediment bound phosphorus delivered due to this region's flatter topography. Additionally, subsurface drainage can contribute dissolved phosphorus loads to rivers that are not captured by traditional turbidity-TP relations. The extent of this contribution of dissolved phosphorus is under investigation. Future deployment of sensor technology for continuous OP measurement could substantially aid in estimation of TP concentrations and loads in rivers. When this occurs, the use of surrogate relations will improve the ability of stakeholders to estimate TP loads with greater temporal resolution and increase the potential to detect gradual improvements over time. The work group is now evaluating potential monitoring design configurations that would best reflect total phosphorus export from the state.

Finally, it may be possible to eliminate altogether the need for load estimation models for both nitrate and phosphorus by using in-stream sensors. Although sensors require periodic maintenance and calibration, they provide actual measurements of pollutant concentrations on a nearly continuous basis. When coupled with stream flow measurements made at or near the location of each sensor, loads can be measured rather than estimated.

Calculated nutrient load reductions from practices implemented in 2016

Statewide benchmark loads of nitrogen and phosphorus were estimated for the NRS in 2012 (Table 10). While this initial baseline, an average of 2006-10 modeled estimates, serves as the reference for evaluating NRS progress, particularly pertaining to the impact of conservation practices on nutrient export, future analyses will incorporate more frequent calculations of nutrient loads using the linear interpolation method for nitrogen and, eventually, methods that are under assessment for modeling phosphorus loads (see page 46). Additionally, the load estimate accuracy will improve over time based on the extensive database that has been built as a result of the monitoring conducted by wastewater treatment facilities.

The original 2006-10 time frame was utilized for the model development due to availability of ample data and timeliness with the understanding that efforts to assess previous time frames would be conducted. Work is currently underway to utilize the NRS Science Assessment methodology based on 2006-10 to provide an estimate of nutrient loads for the 1980-96 timeline recommended by the HTF to states developing their strategies. Specifically, data was used from the USDA Census of Agriculture from 1982, 1987, 1992, and 1997 because, while limited, it was the most data available to run the model. Going forward, progress will be measured much more often than previously and will utilize much higher resolution datasets and remote sensing information that was not utilized or conducted previously.

Table 10. The loads of nitrogen and phosphorus in Iowa calculated as an average from 2006-10 data, and the respective goals outlined by the NRS for reductions from nonpoint sources (NPS) and point sources (PS).

Baseline estimates from the NRS	Nitrogen	Phosphorus
Statewide baseline load (tons)	307,000	16,800
Load reduction needed for 45% reduction	138,150	7,560
NPS portion of load reduction	125,870	4,872
PS portion of load reduction	12,280	2,688
% of target load reduction from NPS	91.1%	64.4%
% of target overall load reduction from PS	8.9%	35.6%

The NRS Science Assessment evaluated the effects of conservation practices on nutrient losses from nonpoint sources based on water monitoring data and Iowa or Iowa-like conditions. Utilizing these evaluations of practice effectiveness, load reductions for recently implemented practices were calculated for this document for a subset of practices installed through government cost-share programs (cost-share programs are currently the most complete source of conservation data) based on the relative ability to enumerate the reductions. Efforts are underway to address the lack of data and information that would support a more robust calculation of load reductions; for instance, the ISU-INREC in-field survey project and the BMP mapping project (see page 40) will provide more complete estimates of conservation practice use, regardless of whether practices received cost-share or not.

At 302,000 acres in 2016, cover crops implemented through cost-share programs reduced annual nitrogen loss by 1,375 tons (Table 11). These acres also affected a reduction in phosphorus loss by 104 tons (Table 12). Because cover crops are an annual practice, maintaining these reduction levels will require implementation of these acres each year.

Table 11. Nitrogen loss reduction from practices installed through cost-share programs since 2011.

Practice		2011	2012	2013	2014	2015	2016
Cover crops	Acres installed annually	14,683	43,709	183,776	155,441	252,948	302,136
	N loss reduction (tons)	67.5	195.2	810.1	694.9	1,141.3	1,375.4
Bioreactors	Acres benefitted (cumulative 2011-2016)	0	500	550	800	900	950
	N Loss Reduction (tons)	0.0	2.9	3.2	4.6	5.3	5.6
CREP wetlands	Acres benefitted (cumulative 2011-2016)	6,965	20,484	26,818	31,758	31,758	42,206
	N loss reduction (tons)	44.7	136.0	179.8	214.0	214.0	286.7
Conversion of row crop to perennials (CRP)	Total acres benefitted annually	1,661,876	1,643,927	1,524,532	1,457,053	1,484,119	1,688,616
	Net N loss reduction compared to 2011 (tons)						228.1

Table 12. Phosphorus loss reduction from practices installed through cost-share programs and the Conservation Reserve Program since 2011.

Practice		2011	2012	2013	2014	2015	2016
Cover crops	Acres installed annually	14,683	43,709	183,776	155,441	252,948	302,136
	P loss reduction (tons)	4.1	12.0	60.6	50.3	83.2	103.6
Bioreactors	Acres benefitted (cumulative 2011-2016)						
	P loss reduction (tons)	29,943	52,286	70,867	94,290	116,042	136,759
CREP wetlands	Acres benefitted (cumulative 2011-2016)	18.5	32.7	44.2	58.3	72.1	82.8
	P loss reduction (tons)						
Conversion of row crop to perennials (CRP)	Total acres benefitted annually	1,661,876	1,643,927	1,524,532	1,457,053	1,484,119	1,688,616
	Net P loss reduction compared to 2011 (tons)						10.0

Bioreactors that had been installed between 2011 and 2016 collectively treated 950 acres in Iowa, resulting in an estimated 5.6 tons reduction in nitrogen loss in 2016. CREP wetlands that have been constructed since 2011 collectively treated 42,000 acres in 2016 and reduced nitrogen export by 287 tons that year. Bioreactors and CREP wetlands are structural practices, so the estimated effectiveness of each structure in reducing nitrogen loss will occur annually for the life of the practice.

Acres that had been converted from row crops to perennial vegetation through the CRP program totaled 1.69 million acres in 2016. Since 2011, when CRP totaled 1.66 million acres, there has been a net change of 228 tons of nitrogen and 10 tons of phosphorus reduced statewide. Buffers are included in this estimate as land retirement, though the models are capable of calculating buffers' impacts on nutrient loss. However, data on specific CRP practices are insufficient prior to 2013, so nutrient reductions affected by buffers are not presented here for the 2011-16 period. Buffers implemented by CRP have likely decreased slightly during these years, suggesting an increase in phosphorus loss in those fields that are converted back to row crops, but the true extent of buffers in Iowa is currently unknown. Ongoing efforts to collect data pertaining to this practice are ongoing.

This analysis excludes certain practices from analysis of annual change in nutrient loss reductions due to insufficient data. These excluded practices are:

- In-field nutrient management
- Nitrification inhibitors
- Tillage
- WASCOBs, grade stabilization structures, and ponds

As new data projects progress to better understand the implementation of various in-field and structural practices, these calculations may be conducted.

There are limitations to our understanding of the full impact of conservation adoption in Iowa. These reduction estimates are modeled using relatively complete and reliable cost-share program databases, but they neglect to incorporate estimates of non-cost-shared practices. Therefore, it is likely these estimates are conservative compared to the actual load reductions affected by newly adopted conservation practices. For instance, cost-share data reports 300,000 acres of cover crops statewide, and this value was used for reduction estimates, but the total statewide adoption is likely to be closer to 600,000 acres (Figure 13). Another consideration and limitation of cost-share data is the focus that these programs have had on phosphorus reduction historically. Preliminary analysis of practice-specific funding from selected cost-share programs (i.e. those for which the pertinent data were available) suggest that phosphorus reducing practices have received 34 percent of cost-share funding since 2011. Practices that treat both nitrogen and phosphorus have received 20 percent—plus CRP rental payments for row crop conversion, which was not included in this funding analysis—and practices that treat only nitrogen received four percent. Since 2011, cost-share funding for practices that treat both nitrogen and phosphorus has effectively doubled. The remaining portion of funding went to practices that don't treat nitrogen or phosphorus, or went to practices that treat nutrients but are still under evaluation for effectiveness. This analysis suggests that reliance on cost-share implementation and for data availability may be biased toward program goals that center on soil loss prevention and, therefore, phosphorus reduction.

With the aforementioned data improvement projects (see page 37) underway to address the challenge of total conservation adoption uncertainty, future practice data will likely show greater levels of practice use and therefore greater rates of nutrient load reduction. Additionally, HUC8-scale reduction estimates will be calculated in 2018 to measure the respective progress of priority watersheds and other watersheds; HUC8-scale estimates will provide insight into whether increased efforts in priority watersheds have affected higher nutrient load reductions as compared to other watershed areas.

Targeted water monitoring projects

Paired Watersheds

Paired watershed projects involve the selection of two watersheds of similar size and land use characteristics. In one watershed conservation practices receive additional emphasis through promotion and implementation while the other receives less focus on installing new conservation practices. Water quality is monitored in both watersheds to assess the effect on water quality through 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 NWQI. Data collected in 2016 indicate similar patterns to 2015, which suggest that nutrient losses from the subwatershed with a higher degree of BMP adoption are lower than those measured in the watershed without extensive BMP implementation. It is still early in the project to determine with certainty that these differences are sustainable and statistically significant. Additionally,

there is limited long-term data collected prior to BMP implementation, so some differences in nutrient levels may be attributable to watershed characteristics other than BMP implementation. However, there is better correlation in comparing similar pared watersheds experiencing similar weather patterns versus comparing previous years. Continued sampling and additional analysis will be needed to answer those questions. This project extends through 2019.

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 nitrogen 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 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.

To date, both watersheds have at least 50 percent of their respective agricultural acres planned for seeding a cover crop in fall 2017. Ongoing water monitoring at the base of each watershed will shed light onto the previously unmeasured impact of cover crop adoption on a landscape's local water quality. This project will contribute to the growing body of empirical water quality data that describe impacts of targeted NRS practice implementation.

Nutrient criteria development updates

Lakes - The DNR continues to collect and analyze lake nutrient data as part of the ambient lake monitoring and the lake restoration programs. The development of quantitative indicators of lake health, including nutrient status, remains a high priority within these programs. The EPA recently developed draft nutrient models that were tested using national datasets and sought states to serve as case studies to further test these models. 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. This case study will be ongoing over the next year.

River 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.

Nutrient monitoring by point sources

When permits are issued to facilities listed in the NRS they require that those facilities monitor effluent TN influent and effluent TN and TP once per week. There are currently 105 facilities, up from 82 facilities last year, that are required to monitor their effluent for TN and TP. This number will continue to grow as additional permits are issued that require this monitoring. 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 effluent (but not raw waste) TN and TP. There are currently a total of 246 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 while assuming facilities at that time were not removing any TN or TP. Estimates were also made of the amounts that would be discharged if target concentrations of 10 mg/L TN (66 percent removal) and 1 mg/L TP (75 percent removal) were achieved.

Results of weekly monitoring are now available for 77 facilities whose permits have been issued since the strategy was released. Data in Table 13 reflect the actual results from 63 POTWs for which at least 10 months of weekly sample results are available for both raw waste and final effluent and 14 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.

Table 13. Performance by all facilities with 10 or more months of data.

	Estimate (target)	POTW	Industry
Total nitrogen (average)			
Number of facilities		63	9
Raw waste (mg/L)	25	29.7 (range 11.9 - 83.6)	79.6 (range 16.5 - 314.6)
Final effluent (mg/L)	10	16.6 (range 2.1 - 58.3)	21.7 (range 4.5 - 79.9)
% removal	66%	41.8% (range -10.0% - 91.9%)	69.0% (range 20.9% - 89.3%)
Total phosphorus (average)			
Number of facilities		63	14
Raw waste (mg/L)	4	5.1 (range 1.9 - 31.8)	20.6 (range 2.5 - 51.5)
Final effluent (mg/L)	1	3.1 (range 0.7 - 24.9)	12.8 (range 0.8 -73.0)
% removal	75%	40.5% (range -14.7% - 82.8%)	48.8% (range -41.9% - 84.8%)
Annual load reduction (2015-2016)			
Total nitrogen (tons)	-	5,068	517
Total phosphorus (tons)	-	937	273

Fourteen of the 63 POTWs had an average annual effluent concentration for TN equal to or less than the target of 10 mg/L while three had an average TP concentration equal to or less than the target of 1.0 mg/L.

Twelve POTWs met or exceeded the target percent removal for TN (66 percent) and five met or exceeded the target for TP (75 percent), although it is likely that if data were available for Clinton that it would also show that it met these targets.

By subtracting the average pounds per day in the effluent discharged by each POTW from the average pounds per day in the raw waste, then multiplying the resulting value by 365, reasonable approximations of the total pounds of TN and TP removed by each of the 63 POTWs during 2016-17 could be calculated. Adding the calculated values for all of these individual facilities shows that POTWs removed approximately 5,068 tons of TN and 937 tons of TP in a 12 month period. Industries removed approximately 517 tons per year of TN and 273 tons per year of TP. 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 14 provides a summary of raw waste, final effluent, and percentage removal data for both TN and TP for the same 63 POTWs and 14 industries used to develop Table 13 but breaks down the data by the type of treatment system in use today.

As it was in 2016, it is difficult to draw firm conclusions from this data because so few facilities are represented for most of the treatment types. For example, while the second lowest raw waste and final effluent concentrations and the second highest removal percentages for POTWs were for aerated lagoons, the data is from three facilities which may not be representative of all aerated lagoon systems. Sequencing batch reactors had the highest percentage removal with the average removal for TN slightly exceeding the target removal of 66 percent and raw waste concentrations less than typical domestic sewage. Activated sludge and trickling filter treatment plants had had similar raw waste, final effluent, and percent removal numbers.

It is even more difficult to draw general conclusions with respect to industries because there are so few facilities represented by the data. The one industry with a sequencing batch reactor does not currently have

Table 14. Performance by treatment type for facilities with 10 months or more of data for 2016-2017 reporting cycle.

Treatment type	No.	Total nitrogen			Total phosphorus		
		Raw (mg/L)	Final (mg/L)	% R	Raw (mg/L)	Final (mg/L)	% R
POTW	63						
Aerated lagoon	3	22.5	10.6	53.8%	3.9	2.2	44.3%
Activated sludge	25	33.6	20.0	39.1%	6.0	3.4	45.9%
Rotating biological contactor	6	21.3	12.3	40.3%	3.2	2.3	29.8%
Sequencing batch reactor	9	28.4	9.5	69.0%	5.2	2.4	55.3%
Trickling filter	20	29.2	17.6	31.6%	4.9	3.4	30.8%
Industry	9						
Aerated lagoon	2	167.9	42.2	76.7%	19.8	3.9	78.2%
Activated sludge	6	52.4	17.2	63.1%	18.9	9	55.6%
Rotating biological contactor	0	-	-	-	-	-	-
Sequencing batch reactor	1	66.8	7.2	89.3%	51.5	73.0	-41.9%
Trickling filter	0	-	-	-	-	-	-

the capability for removing biosolids from the treatment process and instead recycles them to the head of the plant. This causes phosphorus levels to continue to build-up in the effluent resulting in a negative removal efficiency; a condition one would not expect to find in other treatment systems. Additionally, the two aerated lagoons for industry meet the goals of the strategy which is unexpected with that treatment type, however additional treatment is provided by other unique mechanisms at these two facilities which separate them from conventional aerated lagoon treatment expectations.

Estimates versus Actual Data

The available data show 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 those for industries are significantly higher. In the case of POTWs, considerable literature 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." The following factors can affect the nutrient content of industrial waste:

- The type of industry
- Production processes and flow rates
- Whether process wastewater is treated by the industry itself or discharged to a POTW for treatment
- The 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 nitrogen and phosphorus due to the nature of wastewater produced than a power plant. 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.

Perhaps the most surprising results in Table 12, and the greatest departure from initial estimates, are 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 they were specifically designed and constructed for biological or chemical nutrient removal. However, the data show POTWs on average remove about 40 percent 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 60 percent of the POTWs listed in the strategy, it is appropriate to begin 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 TN and 20 percent of the TP entering Iowa's streams and rivers annually." The NRS also projected that if the 147 wastewater treatment plants initially listed in the strategy were to reduce TN loads by two-thirds and TP loads by three-fourths, then that would reduce the amount of TN and TP discharged by 11,000 tons per year 2,170 tons per year., respectively. These figures represented a four percent reduction in TN and 16 percent reduction in TP from 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 facility's 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 (Table 15).

Table 15. Comparison of estimated versus actual nutrient levels among NRS point source facilities.

	TN	TP
Estimated potential PS load reductions	11,000 T/yr	2,170 T/yr
Actual load reduction in 2015-16 for 63 POTWs and 9 industries	5,585 T/yr	1,210 T/yr
Estimated % removals w/BNR	66%	75%
Actual % removals by POTWs today (pounds)	40.5%	39.7%
Actual % removals by industries today (pounds)	69.6%	53.6%
Estimated raw waste concentrations[1]	25 mg/L	4.0 mg/L
Actual raw waste concentrations - POTWs	29.7 mg/l	5.1 mg/l
Actual raw waste concentrations - industries	79.6 mg/l	20.6 mg/l

[1] Estimated loads for POTWs at average annual flow and 25 mg/L TN and 4 mg/L TP. Industrial loads were not estimated.

As can be seen from Table 13, 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 failed to take into account was the significant amounts of nutrients already being removed even though most facilities have not yet installed nutrient reduction treatment technologies.

Iowa Point Source Baseline Pilot Project with the Gulf of Mexico Hypoxia Task Force

The HTF 2015 goal framework seeks to reduce nitrogen and phosphorus loading to the Gulf of Mexico relative to the average Mississippi/Atchafalaya River Basin nutrient loading during the 1980-96 baseline period. In 2016, DNR began coordinating with the USGS in an effort to better understand historical nutrient loads from point sources in Iowa. The USGS provided a draft data set containing facility information, effluent flows, nitrogen and phosphorus effluent concentrations, and annual nutrient loads for Iowa point sources for the years 1992, 1997, and 2002. The data were pulled from the EPA permit compliance system database (where available). The approach used to estimate the annual nutrient loads is summarized in "Nutrient loadings to streams of the continental United States from municipal and industrial effluent" Maupin and Ivahnenko 2011. Data from 1992 were of particular interest since this year is within 1980-96 period. The DNR has been reviewing the 1992 annual load estimates to evaluate whether they provide (or could provide with modification) a reasonable baseline for measuring point source nutrient reduction progress in Iowa, and potentially in other HTF states. If feasible, the DNR will seek to integrate this effort into existing point source tracking metrics that are already part of the NRS.

Photo courtesy of Mayland Aerial Photography.

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 that will specify requirements to complete and submit nutrient reduction feasibility studies with a goal of issuing at least 20 more permits within the next year.
- DNR will timely review nutrient feasibility studies as they are submitted and amend NPDES permits to include construction schedules for installing nutrient reduction treatment technologies. Where a feasibility study concludes that 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 DNR's approval of the first study.
- The 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 DNR will attempt to correct or explain anomalies in data submitted by treatment facilities. Such anomalies can include, but are not limited to, the reporting of negative removal efficiencies, single high or low concentrations that are inconsistent with other reported data, and apparent data entry errors.

The DNR will work with point source stakeholders to coordinate a review and update of the point source strategy as Iowa enters the fifth year of NRS implementation. The effort will seek feedback on progress to date and will consider possible adjustments to the point source strategy.

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.

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?

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 will be ongoing.

Electronic: Submit your comments online at **www.nutrientstrategy.iastate.edu/comments**

Mail: Nutrient Reduction Strategy, ANR Program Services, 1151 NSRIC, Ames, IA 50011-3310.

Comments and contact information submitted 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**.

Appendix A: Updates to the Strategy

Nonpoint source updates (Section 2)

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 science team, a group of university and public agency researchers that conducted the NRS Science Assessment for nonpoint sources 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**. In the 2017 reporting period, blind inlets were approved as an NRS practice.

Practice reviewed and added:

Blind inlets

Blind or gravel tile inlets were reviewed by the Iowa NRS science team. The research provided to the team was adequate to support the addition of the practice to the NRS list of approved phosphorus reduction practices with a 50 percent reduction in total phosphorus.

Practices reviewed and not approved at this time:

Small grain and forage legume or summer cover crop rotation-1 year. Extended rotations is already in the NRS.
A rotation of small grains with a forage legume or summer cover crop was reviewed as a cropping system practice by the Iowa NRS science team. The team did not recommend the addition of this practice at this time due to insufficient data on the practice's effectiveness in reducing nitrogen or phosphorus loss.

Nitrification inhibitor timing and use with additional nitrogen sources
The use of a nitrification inhibitor with spring applied anhydrous ammonia, fall applied manure and spring applied urea, urea-ammonium nitrate (UAN) and manure were reviewed by the Iowa NRS science team. The team did not approve inclusion of these practices at this time due to insufficient data quantifying the practice's effectiveness in reducing nitrogen loss.

Point Source Updates (Section 3.3)

During the 2017 reporting period, two facilities were added to the NPDES required permits list. One was removed.

Facilities added:
LeClaire City of, Sewage Treatment Plant
Hampton City of, Sewage Treatment Plant
Wapello City of, Sewage Treatment Plant

Facilities removed:
University of Iowa Power Plant

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Water Resources Coordinating Council Members

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Iowa Department of Natural Resources
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Natural Resources Conservation Service
United States Environmental Protection Agency
United States Geological Survey
University of Iowa College of Engineering

Watershed Planning Advisory Committee Members

Agriculture's Clean Water Alliance
Conservation Districts of Iowa
Iowa Corn Growers Association
Iowa Drainage District Association
Iowa Farm Bureau Federation
Iowa Pork Producers Association
Iowa Soybean Association
Iowa Water Environment Association

Additional Partners

Iowa Agriculture Water Alliance
The Nature Conservancy
Trees Forever