American Farmland Trust

Conservation Cropping Systems

AN IMPACTFUL LONG-TERM STRATEGY FOR ACHIEVING ILLINOIS' NUTRIENT LOSS REDUCTION STRATEGY GOALS

Reducing fugitive nutrients should start with improving our soils

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Purpose

The following paper from American Farmland Trust (AFT) advocates for promoting the voluntary implementation of Conservation Cropping Systems (CCS) to improve agricultural soils as the **first line of defense** to protect water quality as Illinois implements its Nutrient Loss Reduction Strategy (NLRS). Building better soils through CCS is a long-term strategy that will pay off over decades while reinforcing the sustainability of the NLRS.

CCS is *"a managed system of conservation practices consisting of conservation cropping rotation, no-till/strip-till, cover crops, nutrient management and other supporting practices as needed integrated into a cropping system where each practice complements or enhances the others for overall improvement of the health and function of the soil resource which leads to enhanced environmental protection and production efficiency."* (USDA NRCS 2012).

Although studies by University of Illinois show that both in-field and edge-of-field practices will be needed on many farms to meet NLRS goals, the policy and production systems currently in place coupled with budgetary restrictions will make this difficult, if not impossible, to achieve (David et al. 2015). Emerging research[1] shows the improvements in soil biology that result from implementing CCS help corn and soybean farmers maintain and improve yields, increase the efficiency of nutrient use, reduce sediment and nutrient run-off and make farms more resilient to changing weather patterns. Working with farmers to change their systems of production will require time, so we need to start now.

> If we look at an individual conservation practice as a stand-alone management tool, it will likely fail. Many of our conservation practices are dependent on one another and on a healthy soil for their success. Therefore instead of looking at an individual conservation practice, we should look at a system of conservation practices. A conservation system considers soil quality factors such as adequate drainage, soil erosion, compaction, soil structure, nutrient management, surface crusting, water infiltration, and organic matter content….[It is] a system of practices that work together to improve soil health, water quality and crop production.
>
> **MARK SCARPITTI**
> STATE CONSERVATION AGRONOMIST, OHIO

1. See *www.sustainablecorn.org* for more information. This is a USDA National Institute of Food and Agriculture funded project that gathers data from 35 field sites and thousands of farmers in nine Midwestern states with the goal of creating a suite of practices for corn-based systems that ensure continued crop productivity while also minimizing environmental impacts. Ten universities are involved.

Introduction

The Illinois Nutrient Loss Reduction Strategy (NLRS) hopes to achieve a 15 percent reduction in nitrate-nitrogen (N) and a 25 percent reduction in total phosphorus (P) by 2025, hitting an ultimate target of a 45 percent reduction in N and P, perhaps by 2040.[2] Illinois' strategy is one of 12 state strategies that contribute to a national plan developed by the Mississippi River, Gulf of Mexico Watershed Nutrient Task Force (also known as the Gulf Hypoxia Task Force).

> Achieving significant water quality improvements in water bodies as large as the Mississippi River and Gulf of Mexico takes time, and the increasing impacts of climate change such as more frequent extreme weather events pose additional challenges.
>
> **NANCY STONER**
> ACTING ASSISTANT ADMINISTRATOR FOR WATER FOR THE U.S. ENVIRONMENTAL PROTECTION AGENCY AND THE [HYPOXIA TASK FORCE] GROUP'S CO-CHAIRWOMAN, SEPTEMBER 2013

The 12-state nutrient reduction strategies do not directly address the implications of a changing climate (see section on *How the Other State Strategies Stack Up* below), but the Gulf Hypoxia Task Force (HTF) announced in February 2015 that it would extend the time of attainment from 2015 to 2035 (HTF 2015). The HTF recognized that it would take more time to reach its goal, given the size of the Mississippi and Atchafalaya River Basin and the Gulf; the many actions that need to be funded and implemented; the reservoir of excess nutrients in soils and groundwater; and the impacts of more intense and frequent rain storms leading to more nutrient runoff and warmer waters that are not able to hold as much dissolved oxygen.

Projected changes in the climate for the Midwest include greater extreme precipitation events and seasonality shifts, longer and warmer growing seasons and increased humidity (Hatfield et al. 2014). Some of the probable impacts include a decrease in workable field days during the spring, increases in soil erosion from fields and stream banks, a need for more drainage and water management, more extreme heat events during the summer, and excessive precipitation or warmer weather in late fall (Hatfield et al. 2014). Modeling nine climatic protections between 1970-2090, Illinois was one of the five states forecast to experience the highest mean vulnerability to erosion due to the effects of climate change-induced rainfall runoff (Segura et al. 2014). The other states are Ohio, Vermont, Indiana and Maryland.

In light of climate projections, Illinois' current NLRS may have problems staying on track. The most compelling option is to explicitly prioritize a systems approach to making improvements in soil health within the framework of the NLRS. By incorporating year-round cover on farm fields and making significant improvements in soil biology, many farmers will be able to curb erosion, increase nutrient use efficiency, and soak up excess nutrients without additional edge-of-field practices. If conditions merit it, edge-of-field practices can then be implemented as needed.

2. To do this, the Agricultural Water Quality Partnership Forum will steer and coordinate outreach and education efforts to help farmers address nutrient loss and select the most appropriate BMPs (e.g. *N management, cover crops, reduced tillage, saturated buffers, drainage water management, bioreactors, wetlands*).

But from the onset, it is important to recognize that improving soil health is not "the silver bullet" that will solve all of the problems. Although the widespread use of CCS can play a strong role in helping farmers meet NLRS goals, farms on tile-drained lands may also need edge-of-field practices (e.g. bioreactors, saturated buffers, filter strips, wetlands, etc.). Even with soils that are high functioning and deemed 100 percent healthy, there may still be leakage of nitrates out of tile-drained systems (Laura Christianson, personal communication).

The various practices within a CCS also have to be managed carefully to avoid N losses. Nitrogen can be lost from a green manure system (i.e. cover crop) almost as easily as from chemical fertilizers and in comparable amounts depending on management, soils and weather.[3] Furthermore, although improving soil health can help address many of the problems with P runoff, some practices such as no-till can lead to a surface accumulation of applied P. This, in turn, can increase the runoff of dissolved P and lead to a greater potential for leaching through intact macropores unless there is a concomitant change in fertilizer and manure management or occasional soil destratification (Sharpley 2015).

In the following sections, we lay out the reasons why prioritizing the widespread implementation of CCS—despite some potential trade-offs listed above—is our best option for achieving long-term success.

In 1993, the National Academy of Sciences concluded that **conserving and enhancing soil quality is the fundamental first step to preventing water pollution** (NRC 1993). Good soil quality is critical to protecting water quality by functioning to hold water, adsorb nutrients and retain other contaminants. The National Academy further recommended a systems approach as the delivery mechanism (as opposed to prescribing specific farm practices) as the only way to ensure that farms achieve long-term improvements in soil and water quality (NRC 1993). They envisioned that each farm-specific management-conservation system would help the farmer increase soil cover, reduce insect, disease and weed problems, utilize excess nutrients and control runoff and leaching.

3. See Building Soil Fertility provided by the USDA Sustainable Agriculture Research & Education Learning Center for a lengthy explanation of challenges: *www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition/Text-Version/Building-Soil-Fertility.*

Conserving and Enhancing Soil Quality Is the Fundamental First Step to Preventing Water Pollution

Achieving soil health through CCS will be increasingly important

The current Illinois NLRS suggests several best management practices (BMPs) that can individually improve soil characteristics, but we have the opportunity to rebuild long-term capacity of Illinois crop production by emphasizing a CCS approach to improved soil health in NLRS implementation. Fugitive agricultural nutrients are a wasted investment to producers and represent water quality costs to society. Declining organic matter and soil erosion are costs to both farmland owners and society. A systems approach allows the flexibility to match the combination of conservation management practices to best address local conditions and resource concerns.

In 2011, USDA Agricultural Research Service (ARS) scientists reviewed the science of conservation as the frequency of high-intensity rain events or droughts increase, and they concluded that the best approach was to meet three basic principles: 1) minimum soil tillage disturbance; 2) diverse crop rotations and/or cover crops; and 3) continuous plant residue cover, loosely described as no-till/direct seeding systems. They strongly recommended that wherever it was economical and viable to do so, farmers should integrate these aspects of conservation agriculture and use site-specific precision conservation practices to increase conservation efficiency (Delgado et al. 2011).

USDA-NRCS PHOTO BY RON NICHOLS

> Conservation farming put first things first by attending to the needs of the soil—by seeing to it that the starting-off place, the base, is put into sound health and kept that way. Any other approach, no matter what it may be, always has and always must lead eventually to agricultural disaster.
>
> **H. H. BENNET**
> SEPT. 18, 1943

Using a systems approach that wholly integrates production and conservation plans for farms is critically important (Prokopy et al. 2014). For example, several USDA National Institute of Food and Agriculture Conservation Effects Assessment Project (CEAP) studies have indicated terraces and grassed waterways reduce soil loss but can increase N leaching and that removal of terraces to accommodate larger no-till machinery increases erosion (Osmond et al. 2012). Researchers reached similar conclusions in 2013, predicting that higher erosion rates will significantly contribute to lower soil productivity, lower soil organic matter content, lower soil quality and higher rates of nutrient loss (Nearing et al. 2013). They felt key strategies would be conservation tillage, management of crop rotations and crop residues (including use of cover crops), precision conservation, management of livestock grazing intensities and improved management of irrigation systems.

Healthy soils increase yields, buffer against variable weather and reduce nutrient runoff

Soil health (also referred to as soil quality) is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals and humans.[4] An alternative definition is that soil health (quality) is how well soil does what we want it to do.[5] The USDA Midwest Regional Climate Hub promotes conservation practices that increase soil organic matter, enhance the soil, increase the water infiltration and water holding capacity and form a strong foundation for resiliency based on an increasing body of evidence (Sauer et al. 2015; USDA NRCS 2015).

Crop productivity is directly related to the quality of the soil, of which water is the major limiting factor. Soils with more available soil water and enhanced soil structure show less variation among years due to variable rainfall and higher productivity. The Climate and Corn-based Cropping Systems Coordinated Agricultural Project (at *www.sustainablecorn.org*) is measuring practices with the potential to provide resilience in times of drought, reduce soil and nutrient losses under saturated soil conditions, decrease field N losses, retain carbon in the soil and ensure crop and soil productivity. These practices include extended crop rotations, cover crops, tillage management, drainage water management, N management and integrated pest management, all of which can be incorporated into a farm-specific CCS.

Using a systems approach to adoption is critical because each practice can influence the others. For example, farmers using adaptive nutrient management may utilize manure, cover crops, no-till, different forms of N, variable rate N application, multiple N applications and N stabilizers to be efficient—and as the soil's capacity to cycle nutrients improves—adjust applications accordingly.

According to a recent survey by the Precision Ag Institute, 74 percent of farmers strongly agreed that they are motivated to see how high they can get their yields and most are paying keen attention to potential limiting factors, including soils (Johnson 2016).

One respondent stated, **"A game changer is ability to manage water in the soil and sunlight falling on the plant. If I can manage water, I can manage the fertility."** Another said, **"To increase yields, we need a better understanding of soil characteristics."** Yet another, **"Can we learn more about the mysteries of the soil and environmental interaction with crop genetics so that every acre is the most productive is can be?"**

In addition, the survey found that compaction is still limiting yields for growers, and they are hoping to be able to reduce or remove soil compaction. This survey implies farmers are likely receptive to improving soils to produce higher yields.

Improving soils is the first step to producing high yields—a positive for farmers

Most farmers focus on—and respond to—increasing crop yields. Currently, Midwest corn and soybean farmers lose 20 percent of their potential yields 80 percent of the time due to short-term

4. See USDA NRCS Soil health at w*ww.nrcs.usda.gov/wps/portal/nrcs/main/soils/health.*

5. See USDA NRCS Colorado Soil Quality and Soil Health: *www.nrcs.usda.gov/wps/portal/nrcs/detailfull/co/home/?cid=nrcs144p2_063020.*

water stress (Hatfield 2012). This yield loss can make the difference between a profit or loss. Since 1989, 55 percent of the crop insurance claims filed by Midwest corn farmers cite excessive moisture and/or precipitation (mostly in the spring) and drought (mostly in late summer) and exceeded $12 billion in crop loss payments (Hatfield 2016; US EPA FRRCC 2015).

The weather and soil quality are the primary factors that influence fertility and high yields, and the first step to better soil quality is improving soil's biological activity and improving root development (Hatfield 2006). Higher yielding crops are produced on soils with higher organic matter, good soil structure with water holding capacity, and no compaction layers. Yields improve when there are no limitations to early-season crop growth; high organic residue for CO_2 to the growing crop; adequate soil water throughout the growing season; and a proper nutrient supply throughout the growing season. Soils that promote an active root system can allow roots to penetrate more deeply and utilize available moisture and nutrients. Fields with the highest yields do not have extreme temperature events during pollination; have cooler night temperatures during the grain-fill periods; and have maximum solar radiation throughout the growing season (Hatfield 2006).

Improving soil health increases nutrient use efficiency

Increasing N use efficiency in corn crops is particularly important (AFT 2013). Although high yield corn being tested on U.S. experiment stations has achieved use efficiencies as high as 70 percent, the corn grown on most U.S. farms only achieves 40 percent use efficiency (Wortmann 2011). The Iowa Soybean Association, based on their experience with their on-farm network, estimated that the average grower is about a "2" for managing N on corn on a 10-point scale, while university researchers are about a "4" to "5." In other words, we have a long way to go to understand how to better manage fertilizer use and N use efficiency (Tracy Blackmer, personal communication). Hatfield (2006) concludes that achieving high yields requires patience to first improve the soil and then adopt management strategies to increase water efficiency, solar radiation and N use (e.g. applying fertilizer closer to the time of crop uptake and stabilizing the N).

The 4R nutrient stewardship effort undertaken by the International Plant Nutrition Institute, The Fertilizer Institute, The Canadian Fertilizer Institute and the International Fertilizer Industry Association explicitly states that *"Other agronomic and conservation practices, such as no-till farming and the use of cover crops, play a valuable role in supporting 4R nutrient stewardship.* ***As a result, fertilizer BMPs are most effective when applied with other agronomic and conservation practices****."*[6] Conversely, nutrient management is critical for maintaining adequate, but not excessive, nutrient concentrations for crop production and for maintaining soil quality.[7]

Building organic matter is the key to improved yields and reduced nutrient runoff

Typical soils are 50 percent pore space (25 percent air and 25 percent water) and 50 percent solid, including 45 percent mineral (clay, sand, etc.) and five percent organic matter—85 percent humus (decayed plant material), 10 percent roots and five percent biological organisms (USDA NRCS and

6. More information at w*ww.nutrientstewardship.com/what-are-4rs.*

7. More information at *http://soilquality.org/home.html.*

ISCA 2010). The biological component of soils is easily overlooked but is the essential ingredient of healthier soils. These bacteria, fungi, insects and other microorganisms decompose organic matter and transform nutrients into forms that crops can use. They also help build good soil tilth, enhance crop growth and control pests. CCS manage the soil biological community by recognizing that these communities thrive on organic matter (maximize crop residue, apply compost or manure and plant cover crops), increased variety (diverse landscape and rotated crops) and a protected habitat (reduce tillage, minimize compaction, minimize fallow periods, minimize the use of pesticides and improve water drainage).[8]

NRCS PHOTO BY RON NICHOLS

By reducing tillage, keeping the soil covered, and diversifying their crop rotations, farmers are increasing soil organic matter and microbial life—making their soils more productive and resilient to weather extremes.

On average, 58 percent of soil organic matter is soil organic carbon (C). Soil organic matter provides improved water infiltration, increases nutrient availability and improves the soil structure, all of which enhance soil fertilizer and resilience to extreme weather events (Sauer et al. 2015; Lynch 2015). Ehmke (2013) cites USDA Natural Resources Conservation Service (NRCS) for "*a 1% increase in organic matter equates to a 0.5 acre-inch increase in available soil water capacity (i.e. 13,577 gal/acre of additional water)*." The surest way to build and maintain organic matter involves: 1) reducing or eliminating tillage, and 2) increasing residue. The fastest way to accelerate the rate and amount of organic matter and carbon in soils is to rotate high-residue crops in a no-till system—and to use cover crops to keep a live root in the soil year-round to feed the soil's food web.

Cover crops can restore organic matter to soil at the rate of about one percent every five years, improving water-holding capacity. Ehmke (2013) also cites research by the USDA-ARS National Soil Tilth Laboratory (now known as the National Laboratory for Agriculture and the Environment) that indicates cover crops could be used on 70 to 80 percent of the U.S. corn and soybean acreage to help reduce soil nitrate-N losses (Ehmke 2013). In 2015, the USDA ARS lab used an agricultural systems simulator model (APSIM) over a 45-year simulation period (over-winter rye cover crop in corn-soybean rotation) to show that cover crops could play an important role in protecting soil and water resources (Basche et al. 2015).

In Michigan, total C in soil under continuous, conventional, chisel-plowed management declined over 20 years (Senthikumar et al. 2009). During the same time, there were no C losses under no-till or organic management with cover crops but no C gains either. Observing higher winter temperatures over the last two decades, the researchers concluded, *"With the projected increase in*

8. More information at *www.extension.umn.edu/agriculture/tillage/soil-management/soil-management-series/soil-biology-and-soil-management.*

global temperature, the adoption of No Till or the inclusion of cover crops in the crop rotation may be one of the prerequisites to sustaining the present soil C levels." It is worth noting that the Morrow plots in Illinois have shown that losses of organic matter have generally occurred more slowly in plots treated with manure, but the only plots that no longer appear to be losing organic matter are the two- and three-year rotation plots that are treated with both the manure and inorganic fertilizer.[9]

In Iowa, similar studies across all systems found that soil organic carbon storage was significantly correlated with the quantity of below-ground organic matter inputs (Russell et al. 2009). They found that adding fertilizer N to stimulate organic carbon decomposition would likely counteract the positive effects of N fertilization on inputs of organic carbon to the soil, at least for annual crops. They concluded that the selection of crops for higher below-ground net primary production, in rotation with crops that fix N, could maximize both yields and soil C sequestration without excessive N-fertilizer additions. In other studies, corn root-derived soil organic carbon contributed 1.6 times more C to soil organic carbon than did above-ground inputs (stover) (Balesdent and Balabane 1996).

The CCCS Initiative in Indiana, started in 2009, created four regional hubs to better conduct outreach to farmers and coordinate data collection. CCSI advocates for the use of continuous no-till/strip till, cover crops, precision farming and nutrient and pesticide management to improve soil heath, water quality and increase profits. More than 8,000 producers have been reached through 131 meetings, and cover crop acreage in the state has increased by 400 percent (to 600,000 acres) (Chou et. al. 2015).

At present, few Illinois producers focus on building the organic matter in their soils. Soils are generally managed as a commodity to maximize short-term economic gain, and the consequences for the vast array of biotic and abiotic soil processes that affect air and water quality and, most importantly, the soil itself, are almost entirely ignored (Mulvaney et al. 2010). However, long-term studies are beginning to document the loss of soil organic matter and soil organic carbon in response to various commodity production systems over time. The Morrow Plots at the University of Illinois show that cropping and management practices markedly affect corn yields. These have long been lowest for continuous corn and highest for a corn-oats-hay rotation. This difference, averaging 33 percent between 1929–2002, is consistent with soil storage of C and N and has persisted despite much more intensive inputs of synthetic N and residue C when corn is grown continuously (Mulvaney et al. 2010).

Achieving Healthy Soils Through CCS

The Indiana CCS Initiative emerged from a 2002 statewide program to promote and support no-till farming.[10] Switching directly from conventional tillage into no-till often caused a drop in crop yields for the first few years. Eventually, the soil specialists concluded soils that had been conventionally tilled were likely to be so biologically unhealthy that they could not longer carry out basic functions like providing nutrients and minerals to plants while making good use of water. They realized they

9. More information at: *http://agronomyday.cropsci.illinois.edu/2001/morrow-plots.*

10. See *http://landstewardshipproject.org/posts/804.*

would need to focus on soil health in general, not just on one tool or method like no-till. In other words, they had to change the very nature of how farmers view soil, not just lay out a menu of innovative practices for them to follow. They found that farmers were especially enthused about using their own creativity to supercharge the biological activity in their soils, but they also were intrigued by what improvements in soil structure could mean.

The CCS approach is now backed by research and is catching on with farmers (see References for useful websites). It can serve as a unifying implementation strategy that is not prescriptive and focuses on improving soil health on farms with a suite of practices, offers flexibility, encourages long-term maintenance and achieves the dual outcomes of greater resiliency and productivity and fewer environmental impacts. CCS combines and custom tailors effective practices like quality no-till, advanced nutrient management, prescribed cover crops, crop rotation and strip cropping, and controlled traffic and precision technology (Fisher 2012) for each farm in order to improve the soil's capacity to cycle nutrients, soak up excess water and become less vulnerable to erosion. Helping producers take small realistic steps to transition to CCS can maintain the farm's productivity—and ultimately increase its profitability by making it more resilient to fluctuations in weather.

USDA-NRCS PHOTO BY JASON JOHNSON

Using a no-till planter, north-central Iowa farmer, Tim Smith, plants soybeans into a terminated cereal rye cover crop. Using a combination of no-till planting and cover crops keeps living roots in the ground throughout much of the year and minimizes soil disturbance, all of which dramatically reduces erosion and improves soil health.

Improving the Resiliency of Production Systems Can Reinforce the Long-Term Success of the Illinois NLRS

The IL NLRS Science Assessment averaged riverine loads of N and P for 1980–1996 and 1997–2011 and attributed possible changes in nutrient loads to more intense winter and spring storms. However, projecting the future impacts of more extreme weather events on recommended BMPS was beyond the scope of the NLRS, so it incorporates adaptive management to periodically evaluate whether new strategic actions must be considered. The need to prepare for the high probability of more severe weather events from the start is yet another strong argument for promoting CCS.

Climatic changes could offset benefits of individual BMPs

The trend towards greater precipitation events increases the erosivity of rainfall, leading to greater erosion without changes in management. The Iowa Daily Erosion Project has been using remotely sensed rainfall and soil and crop management practices, a web-based soil database, and modeling to calculate daily estimates of rainfall, runoff and soil erosion in every HUC12 (hydrologic unit code: HUC12 = 10,000 -40,000 acres) watershed in Iowa (Miller 2015). They have found that the amount of soil actually lost is much more than models predicted because not all types of erosion are included in the soil erosion models. They conclude that farmers cannot keep soil in place by growing just corn and soybeans, no matter how many conservation practices they use. Rebuilding soil takes time—the best science indicates that the replacement rate is only a half-ton per acre per year. Most agencies use five tons per acre per year (10 times the replacement rate) as an acceptable level of soil loss. And although farmers can rebuild eroded soil with soil organic matter, replacing minerals that are the product of centuries of weathering and other processes is a very long-term undertaking.

Increases in seasonal precipitation (mainly April through June) may also increase the fraction of water drained by subsurface tiles (and hasten the installation of more tile), leading to greater N losses, all other factors being constant (Gentry et al. 1998; Carlson et al. 2013; Hatfield 2012). Grassed waterways and riparian filter strips lose effectiveness when damaged by prolonged sediment deposition and concentrated surface flows. Frequently, new tile systems are installed through filter strips and bypass them altogether, along with their opportunity for nutrient loading removal. The effectiveness of BMPs for N leaching can also be offset by increased amounts of tiled farm fields, and by increases in the fraction of land in a continuous corn rotation as opposed to a corn-soybean rotation. A long term, 21-year study of the Embarras River watershed observed no significant trend in reductions in river nitrate yields over time. Researchers hypothesized that conservation benefits may have been offset by increased tile drainage installations and that gains in N use efficiency may have been offset by increases in corn acreage (David et. al. 2015). Thus, the level of implementation of BMPs sufficient for water quality improvements may change over time depending on trends in climate, land use and agricultural management systems.

Offsetting climate factors may also influence P losses. A study evaluating BMPs for nutrient losses to surface waters warns, *"If reduced tillage is used to control P losses from rainfall runoff, the rates of P loss during snowmelt may increase due to greater trapping of snow and solubilization of P from*

crop residues. And if rates of erosion decrease due to the implementation of BMPs, but there is no corresponding decrease in total volume of water runoff, there may not be any decrease in sediment loading due to increased streambank erosion" (Mulla et al. 2006).

A warming climate may also affect the level of adoption of certain BMPs

A longer, warmer fall may provide a longer window for planting cover crops while reducing the window to apply anhydrous ammonia (fall application requires a soil temperature of 50°F or below). This could nudge farmers away from fall application of N and support farmers planting cover crops in the heavy soils in central Illinois. An analysis of weather extremes and the adoption of conservation tillage found that farmers tend to increase adoption of conservation tillage following abnormally dry conditions but that abnormally wet conditions (e.g. floods) do not have a significant effect on the choice of tillage systems (Ding et al. 2009). However, short wet springs can pose a critical impediment to farmer consideration of no-till systems, but education and technical assistance can help those producers in the early stages of no-till adoption. Crop insurance was singled out for its significant and negative effects on the process of self-protection (such as the adoption of no-till). Farmers purchasing crop insurance are less likely to adopt no-till practices since it provides partial protection against multi-peril crop losses (Ding et al. 2009).

USDA-NRCS PHOTO BY JASON JOHNSON

Farmers will need to maintain BMPs, despite high intensity rain events, to hit NLRS milestones

Even without significant weather events, many BMPs will lose their effectiveness over time as a result of degradation, damage, neglect or removal (Bracmort et al. 2004). But a recent analysis of climate change scenarios showed an exponential increase in soil erosion runoff and watershed sediment yield, stressing current conservation practices or future practices designed with present day practice standards (Garbrecht et al. 2014). Unfortunately, most watershed efforts focus on the implementation of *new* practices rather than on maintenance of *existing* practices, and this may affect long-term outcomes over time (Osmond et al. 2012).

A recent evaluation of projects focused on improving water quality in agricultural watersheds finds that practices based on management changes (e.g. nutrient management) are less likely to be sustained by farmers than structural practices, and that many conservation practices designed to control nutrients are disliked by farmers—e.g. nutrient management and buffers (Osmond et al. 2012). Because farmers cannot readily observe nutrient losses (as opposed to soil losses from erosion that they may be compelled to address), it was

In Iowa, aerial imagery from USDA's National Agriculture Imagery Program was used to track stream buffers and grassed waterways between 2011 and 2014 in eight watersheds prioritized in the Iowa Nutrient Reduction Strategy (Rundquist and Cox 2016). Along 1,020 miles of waterways, there was a net loss of 74 acres of grassed filters planted to protect stream banks. Landowners added 45 acres of new stream buffers but—during the same period—removed 119 acres of existing buffers within 75 feet of the shoreline.

much more difficult to persuade farmers to change their practices (Osmond et al. 2012). However, being persistent in convincing a producer to adopt a practice makes it more likely that the producer will maintain it (Prokopy et al. 2014). Failure to maintain individual BMPs is less likely to occur if the farmer is following an integrated farm management plan incorporating both production and conservation goals. It provides a flexible framework in which the farmer can adaptively manage his or her operation (Prokopy et al. 2014).

JASON LINDSEY/ALAMY STOCK PHOTO

USDA-NRCS PHOTO BY RON NICHOLS

ABOVE LEFT: *Corn field and buffer strip along the Salt Creek in Dewitt County Illinois.* ABOVE RIGHT: *NRCS Soil Conservationist Katie Alexander examines a diverse species cover crop field on the farm of David Harold, near Montrose, Colorado.*

AFT PHOTO BY JENNIFER FILIPIAK

At a Rock Island County field day, Illinois farmers examine soybeans that were planted into a living crop of cereal rye.

CCS Also Comes with Additional Benefits

Several other benefits of CCS are worth mentioning, including increasingly positive impacts over time, the possibility of fewer legacy nutrients as CCS catches on, the opportunity to engage absentee landowners by showing them potential improvements in their land's productivity (i.e. improvements to their investment) and the ability to make progress toward NLRS goals by using the systems approach strategically.

As the climate changes, crop rotations and tillage systems will have a greater impact on nutrient loadings

Research modeling four agricultural management scenarios on crop production and pollutant loads exported from cropland in the Upper Mississippi River Basin under the current climate and projected midcentury climate (2046–2065) found that continuous corn resulted in increased N pollution. No-till was the most environmentally effective (sediment reduction approached 70 percent and P reduction was 40 percentage) and able to sustain production at almost the same levels. Rye cover crops within the fallow period also reduced erosion and both sediment-bound and soluble forms of nutrients (25–30 percent reduction). And an extended five-year rotation of corn, soybean and three years of alfalfa resulted in about a 50 percent load reduction of both sediment and P (Panagopoulos et al. 2014).

Improving soil health may also mean fewer legacy nutrients in the future

In watersheds dominated by agriculture, achieving short-term improvements in water quality may be masked by accumulations of P and N in the soil that result from decades of agricultural production and continue to contribute to nutrient loading for decades to come (Sharpley et al. 2014; VanMeter et al. 2016). One estimate, using a combination of mass balance and process-based modeling, puts cropland N accumulation in the U.S. equal to 17 percent of fertilizer N inputs (US EPA SAB 2011). An investigation of isotopically labeled N fertilizers over three decades showed that 61–65 percent of applied fertilizer N was taken up by plants and 12–15 percent was still residing in soil organic matter more than 25 years after tracer application (Sebilo et al. 2013). Between 8–12 percent of applied fertilizer had leaked into surface water and groundwater, and researchers predicted this leakage would continue for at least another five decades.

The study reinforced the importance of soil organic matter management in agricultural soils as a buffer to mitigate diffuse N pollution of surface waters and groundwater. The same researchers showed that bypassing the retention capacity of the soil organic matter pool by intensive tile drainage systems significantly increased the transfer of fertilizer-derived nitrate (Sebilo et al. 2013). Policies that improve soil health by protecting soil C, increasing microbial activity or raising pH may help in areas of elevated N input (Bingham and Cotrufo 2016).

Improving soil health will also tangibly benefit landowners who rent farmland

Delivering conservation education and information on nutrient management for non-operator farmland owners will also be important to successful NLRS implementation (IL NLRS 2015).

AFT PHOTO BY JENNIFER FILIPIAK

Healthy soil resulting from a corn-soybean-wheat crop rotation where a multi-species cover crop mix is seeded after the wheat to replenish and hold nutrients. This McLean County, Illinois farm has been in continuous no till for a decade.

According to USDA's annual Agricultural Resource and Management Survey (ARMS), 41 percent of farmland acreage in Illinois is owner-operated.[11] Farmers often bring up landlords as an impediment to implementing conservation practices: *"On my own land, conservation is an investment. On rented land, conservation is a cost."*[12]

Improving soil health and reducing erosion is in the interest of both the landowner and the land operator. By improving the land's productivity, the value of a landowner's investment is protected, whether it is for long-term financial gain or a family inheritance (Duffy 2012; Jewitt 2013; Hamilton and Russell 2013). For this reason, USDA's NRCS has developed fact sheets, videos and learning resources for landowners to help them understand why soil health is so important and how they can work with tenants to increase their land's long-term production potential.[13] Flexible farm leases have been devised by various organizations to give equitable treatment to both the landowner and tenant when conservation improves soil productivity.

The stepwise approach of CCS can start with practices that are easiest to promote (soil health), giving us more time to tackle the "tough practices" that are harder to promote

Since improving soil health provides documented agronomic benefits and results in a more resilient production system, it is relatively easy to promote and farmers are generally receptive. In contrast, edge-of-field practices that trap nutrients tend to be harder to promote because wetlands, bioreactors, saturated buffers, etc. don't produce any agronomic benefit for the individual farmer and can be expensive to implement. Since CCS is a systems approach, getting farmers comfortable with changing their practices to improve the health of their soils and achieving some success in improving water quality may make them more receptive to adding additional edge-of-field practices to make further improvements.

11. More information at *www.ers.usda.gov/data-products/arms-farm-financial-and-crop-production-practices/arms-data.aspx.*

12. Farmer quote taken from Rick Cruse in comments to Tom Bumen's Be-the-Expert blog (at *http://agrentools.com/be-the-expert.*)

13. Resources available at *www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/soils/health/?cid=stelprdb1048859.*

How the Other State Nutrient Strategies Stack Up

All 12 states (Louisiana, Mississippi, Arkansas, Illinois, Missouri, Wisconsin, Minnesota, Iowa, Ohio, Indiana, Kentucky and Tennessee) have either drafted or completed their plans, and none attempt to factor in the possible impacts of increased weather variability (see References for citations). Climate change continues to be a polarizing issue within agricultural community. Most farmers do not believe that climate change is caused by human activity, although a majority (66 percent) now believe it is occurring and most support adaptive actions (Arbuckle 2013). Including climate-related adjustments in the state Nutrient Reduction Strategy (NRS) would have required the use of complex predictive climate modeling and caused further delays in implementation if stakeholders, already skeptical about climate change, called for even more science before taking action. However, all of the plans incorporate adaptive management. The Minnesota NRS (2014) goes further by raising concerns in its chapter on water quality evaluation that future trends in flow may make it more difficult to discern trends in nutrient loading and states that *"Predicting future trends in flow is beyond the scope of the NRS but it is an active area of research and debate in Minnesota."*

Currently, two states (Minnesota and Indiana) place a heavy emphasis on soil health as the first line of defense, and a third (Iowa) is headed in that direction with their implementation strategy.

Minnesota (September 2014) seeks to incorporate soil health promotion as an overarching educational emphasis and singles out the importance of protecting soils during increasing frequency of high-intensity rains. The strategy concludes: *"By focusing attention on soil health and by providing education about the positive impact healthy soils can have on productivity and sustainability, Minnesota farmers will understand the multiple benefits of the BMPs to reduce nutrient losses to waters. This will increase the motivation for adopting these practices under the current policy framework."*

Indiana (October 2015) prioritized soil health and CCS in its early drafts and expands on a system approach to conservation practices in its final draft. A nutrient management/soil health 10-year strategy framework developed in parallel by Indiana's agricultural commodity groups (A Partnership for the Management of Nutrients and Protection of Water Quality 2012) is included in the final version of the Indiana NRS as the agricultural industry implementation of their strategy. The Partnership concludes that the primary focus of a sustainable and successful nutrient reduction strategy should be increasing the adoption of nutrient management and improving soil health. They recommend implementing no-till, cover crops, advanced nutrient and pest management, crop rotations, buffers and smart drainage (where appropriate) together as a system.

Their reasoning: *"Improved soil health leads to greater ability to manage water and nutrient resources by reducing runoff and erosion, improving water holding capacity, raising levels of organic matter within the soil, and creating the possibility that nutrient inputs can be reduced in some cropping systems. Of significant importance is that improved soil health should lead to reduced nutrient and sediment loading to lakes, streams and rivers. Additionally, improved ability to retain water will reduce the impacts of excessive rainfall and drought…. By adopting a strategy for soil health which is supported by the principles underlying the 4R approach, we can immediately work to achieve greater understanding and implementation of strategies by farmers."*

USDA-NRCS PHOTO BY LYNN BETTS

As part of the conservation cropping system on this Iowa farm, corn leaves are tested to determine how much nitrogen is needed.

Iowa (November 2012) stressed a menu of in-field management practices, land use changes and edge-of-field practices. The strategy did mention the importance of increased organic matter in soils to improve the soil structure and resist erosion and soil compaction and support increased soil fertility, soil water holding capacity and drought resistance. However, the actual implementation of the Iowa strategy will most likely incorporate soil health. Business leaders recently convened the Iowa Soil and Water Future Task Force to identify strategies and funding sources leading to **soil and water health** to help implement the Iowa NRS (Iowa SWFT 2016).

Several other state strategies mention the need for systems approaches or promote the elements of CCS. **Arkansas** (2015) acknowledges the need for whole farm planning, which encourages farmers to identify long-term farm, environmental and production goals. **Kentucky** (March 2014) relies on the full implementation of the 1994 Kentucky Agricultural Water Quality Act (AWQA) to achieve its nutrient reduction strategy. Under the BMPs listed for crops in the AWQA, conservation cropping sequence, conservation cover, conservation tillage/crop residue use, contour farming and nutrient management are listed first (when written, building and improving soil health wasn't recognized as a focus). **Missouri** (December 2014) lists "demonstration of whole farm system approach to soil and water conservation" as a solution to both improved grazing management and controlling sheet, rill and gully erosion.

To address erosion, the Missouri NRS states: *"Wherever practicable, farmers should consider implementing conservation tillage practices, preferably no-till and cover crops as the most affordable and cost-effective conservation practices on cropland for reducing N, P and sediment export. In many areas, these practices may serve as a possible cost-effective alternative or as part of a conservation systems approach with the implementation of other structural conservation practices."* **Ohio** (June 28, 2013) promotes the 4Rs as an "important first step" and, for uplands, recommends an increase in whole farm conservation planning. **Tennessee** (January 2015) intended to develop a farmer-led approach but was recommending nutrient management (4Rs), conservation tillage or continuous no-till, cover crops and vegetative buffers.

Where Does Illinois Go from Here?

The current Illinois NLRS includes the necessary elements to make a CCS approach the first line of defense

The activities already underway under the NLRS include a variety of approaches. Examples include: the Nutrient Research & Education Council is funding efforts to evaluate the effectiveness of various nutrient management practices and improve outreach; the Lake Springfield watershed project is working with agricultural retailers and farmers to adopt management systems and BMP; "Keep it for the Crop by 2025" focuses on education and in-field work with agricultural retailers and their farmer customers; N-WATCH is an on-farm nitrogen rate trial program and several non-profit programs and projects are focused on implementing BMPs and studying approaches; the Illinois Council on Best Management Practices (IL CBMP) has been working with the Soil Health Partnership, a five-year farmer-led partnership to identify, test and measure farm management practices that improve soil health (led by the National Corn Growers Association); the Illinois Conservation Cropping Systems Partnership (led by the Illinois Department of Agriculture (IDOA) and AFT with USDA NRCS, IL CBMP and the Illinois Stewardship Alliance) sponsors three Illinois Conservation Cropping Seminars annually that rotate around Illinois; IDOA is also leading a three-year USDA NRCS Resource Conservation Partnership Program (RCPP) project establishing 60 "soil health" demonstration farms across Illinois and training regional cover crop specialists; and AFT is leading a 2015 North Central Region Sustainable Agriculture Research and Education Professional Development Grant to provide in-depth soil health training to 27 Illinois professionals and farmers with experience in cover crops and introductory soils training with the goal of reaching at least 400 farmers, landowners and their advisors by 2018.

PAIGE BUCK, USDA NRCS ILLINOIS

This soybean crop is off to a great start with high organic matter, no-till residue from last year's corn, and adequate moisture. Healthy soil management benefits soils of all kinds, on all slopes, and in all cropping systems.

The NLRS envisions expanded outreach and education tailored to the needs of specific watersheds or counties, and these efforts will be steered by the Agricultural Water Quality Partnership Forum. Promoting CCS takes the challenges ahead into account (a changing climate, production systems driven by markets, reduced funding for technical assistance and conservation practices) and finds a unifying approach that creates synergies among these various and critical efforts.

Prioritizing CCS can help ensure a sustainable NLRS

Given 1) the critical role that soil health plays in improving crop yields, protecting water quality and buffering against weather extremes and 2) the need for a systems approach to ensure that farms achieve long-term improvements in soil and water quality, the foundation for a sustainable NLRS should be helping farmers manage their operations with healthy soils as the end goal. This is particularly important because it takes farmers years to rebuild the aggregate stability in the upper

soil horizon that is critical for infiltration, root growth and resistance to water and wind erosion. As aggregate stability decreases, the potential for a soil to form a surface crust rapidly increases. With continuous no-till, it takes one to five years to rebuild aggregates and reestablish microbial biomass, five to 10 years to start increasing crop residues and soil organic matter, and 10-20 years or longer to restore fully functioning, highly productive soils with high nutrient cycling (Hatfield 2015).

In other words, because **building better soils is a long-term strategy**, it needs to begin now. The guiding principles are to 1) minimize soil disturbance, 2) maximize diversity (plants, animals, amendments, inoculants, etc.), 3) keep the soil covered and 4) maximize living roots. Farmers can achieve better soils by combining and custom-tailoring effective practices like quality no-till, advanced nutrient management, prescribed cover crops, crop rotation and strip cropping and controlled traffic and precision technology. These practices must be implemented as a system, and they are specific to each farm enterprise. The use of other conservation practices featured in the NLRS (buffers, bioreactors, agricultural drainage management, grassed waterways, restored wetlands, etc.) can provide shorter-term solutions that may be particularly important in high-yielding watersheds.

USDA-NRCS PHOTO BY RON NICHOLS

With diverse cropping rotations and cover crops, farmers who improve soil health below ground are also improving pollinator habitat above ground.

Recommendations

To incorporate CCS as the primary approach to implementing Illinois' NLRS will take additional planning. It will require a unified message and consideration of how best to fit the separate projects and initiatives into a broader systems framework that starts with building soil health and expanded training for technical service providers. It may also require the addition of new indicators or metrics, a consideration of how best to help farmers with long term maintenance, some support from state and federal policies along with possible policy reforms and the identification of other possible resources that could be tapped by reframing the NLRS approach.

Encourage a Systems Approach

- **Stress importance of soil health as the first line of defense** both in protecting water quality and in improving and maintaining long-term crop productivity. Many farmers, Certified Crop Advisors (CCAs) and others involved with production agriculture think that soil with 4 percent organic matter is black and productive and can't get any better (D. Towery, personal communication). But increasing the amount of ***active*** organic matter (biological activity) improves nutrient cycling and moisture holding capacity.
- **Integrate conservation and production plans.** We tend to separate conservation and production plans rather than integrating them into a full-systems approach. But if we start with a systems approach to building soil health (to help sustain higher yields), whether the farmer is talking to conservation staff, chemical dealers or crop consultants, the language will be the same (Prokopy et al. 2014). Examples of systems-level conservation practices include adaptive nutrient and pest management, use of continuous no-till and use of cover crops. Each of these practices influences the others. For example, farmers using adaptive nutrient management may utilize manure, cover crops, no-till, different forms of N, variable rate N application, multiple N applications and N stabilizers to be as efficient as possible—and as the soil's own capacity to cycle nutrients improves, adjust applications accordingly.
- **Provide expanded training in systems approaches to improving soil health.** Provide expanded training for CCAs and other advisors, using soil health training curriculum on advanced principles of soil health, especially soil biology, and methods to manage for soil health on the farm, modeled after Indiana's "Conservation Cropping Systems Initiative" training. In 2015, the USDA-NRCS initiated a new Soil Health Division to provide new focus to soil health training for NRCS personnel, farmers and conservation partners. While in its fledgling state, this new national focus on soil health holds great promise to assist Illinois in improving soil health and water quality.

Help Ag Retailers Lead the Way

- **Help agricultural retailers expand the services they can deliver to customers.** Ag retailers are starting to use the 4R stewardship messaging and approach. Ramping up their involvement in helping clients improve soil health should be a priority for the NLRS. An on-going project in the Sandusky River watershed in the western Lake Erie basin in Ohio is showing that retailers can lead the elimination of water quality impairments (in this case, high levels of P in Lake Erie) by 1) profitably offering products and services that reduce nutrient, soil and other agrichemical

losses from cropland, 2) effectively targeting farmers and cropland most at risk, and 3) generating and reporting quantifiable improvements in resource management.[14] Building soil health is a key strategy. The project is finding that ag retailers have the expertise, effective products and services, existing trust relationships with farmers and familiarity with virtually all cropland acres. The Sandusky approach includes tools for retailers (an agronomist handbook including an agronomist wallet card that helps retailers quickly assess a farm to identify fields most at risk); an online nutrient loss reduction calculator (which can test scenarios of how many acres of products and services are needed to reach water quality goals); farmer fact sheets; a NRCS Nutrient Management Conservation Activity Plan sample plan that simplifies the NRCS Conservation Activity Plan 104 (CAP 104) writing process; sell sheets for key products and services (e.g. cover crops); and webinars for retailers on different products/services (see below).

- **Provide advanced training on soil health-building practices to support ag retailers and other technical service providers.** Provide webinars that promote service opportunities for ag retailers (e.g. soil testing, variable rate application, custom strip tillage, increasing cover crop sales, companion cropping strategies, presentations from farmers who have recently made the decision to implement cover crops, new technology and software, etc.) and award continuing education credits (see Partnership for Ag Resource Management website (*http://partnershipfarm.org*).

Use Unified Messaging

- **Lead with the importance of improving soils.** Regardless of what a project or initiative focuses on under the NLRS (e.g. promoting use of a 4R approach, using cover crops, employing two-stage ditches or bioreactors), lead with the importance of enhancing soil quality, explain why it is so important to do this as a first step and provide contacts for additional information. For example, as cited previously, the 4R nutrient stewardship effort undertaken by the International Plant Nutrition Institute, The Fertilizer Institute, The Canadian Fertilizer Institute and the International Fertilizer Industry Association explicitly states that *"Other agronomic and conservation practices, such as no-till farming and the use of cover crops, play a valuable role in supporting 4R nutrient stewardship. As a result, fertilizer BMPs are most effective when applied with other agronomic and conservation practices."*[15] Conversely, nutrient management is critical for maintaining adequate, but not excessive, nutrient concentrations for crop production and for maintaining soil quality.[16]
- **Target factors that motivate changes in behavior.** Soil health can be a unifying message as well. Adoption of conservation practices is often influenced by a farmer's motivations. While all farmers are motivated by financial gain, many may be predominately motivated to maximize profits on their investments (yields), others by land stewardship (improving the quality of their soils to ensure future productivity) and still others by off-farm environmental benefits (and likely to adopt actions that improve the downstream environment) (Prokopy et al. 2014). Focusing on soil health covers all of those bases.
- **Broaden the audience to include all of the key players.** Key advisors to farmers not only include the CCAs, agronomists, nutrient management specialists, NRCS and Soil and Water

14. More information can be found on the Partnership for Ag Resource Management website at http://partnershipfarm.org.
15. More information at *www.nutrientstewardship.com/what-are-4rs.*
16. More information at *http://soilquality.org/home.html.*

Conservation District (SWCD) technical specialists and university and state agencies, but also their tax advisors, bankers and tiling contractors (Kean 2013).

Support the Long Term Maintenance of Practices

- **Encourage a social norm among community groups/farmer networks that reinforces conservation practice maintenance.** Conservation maintenance is a neglected and underfunded area of research and outreach (Prokopy et al. 2014). As more farmers and landowners become connected to community groups, they are more likely to maintain conservation practices (e.g. covering soils as the new norm).
- **Promote a sense of ownership for implemented practices.** Adopters who feel a sense of ownership for conservation practices are more likely to maintain them (Prokopy et al. 2014).
- **Support USDA NRCS enforcement of compliance and maintenance.** Federal cost-share recipients are responsible for the proper operation and maintenance of all conservation practices under their contracts, including normal maintenance and repairs that are needed during the lifespan of funded conservation practices, but there may be challenges with enforcement. A USDA Office of Inspector General report (USDA 2014) found that state offices did not make on-site visits for 139 out of 432 EQIP practices to ensure they were completed by the participant and allowed contractors and participants to self-certify. USDA NRCS agreed with the report findings and pledged to revise its policies to enforce compliance and maintenance by the end of 2014, but whether this has had the desired effect is not known.
- **Coordinate with, advocate for and expand the Precision Conservation Management Program.** The goal of this newly awarded (February 2016) USDA NRCS RCCP grant to the Illinois Corn Growers Association is to integrate conservation into the foundational farm management of commodity crop operations. Through "Precision Conservation Management" (PCM), advisors will provide financial impact analysis of conservation practices, technical assistance from trained conservation specialists, supplemental privately funded financial assistance, data-rich assessment tools and precision conservation technology. Illinois is the lead state along with Iowa and Kentucky.

Consider Policies That Can Support a Sustainable NLRS

- **Promote a systems approach in cost-share programs.** The USDA NRCS RCPP provides grantees an opportunity to propose their own ranking criteria for awarding cost-share funds (e.g. applications with practices X, Y, and Z will get an additional 50 ranking points—or applications that have 100 points will be immediately funded and not have to go through additional "hoops"). This kind of flexibility in awarding cost-share funds could help encourage the use of a systems approach in the future, if it is more widely adopted by NRCS and encouraged by State Technical Committees.
- **Consider multiple ways to "incentivize" BMP adoption.** States have struggled with ways to "incentivize" BMP adoption by linking them to other enforcement mechanisms to make them something more than voluntary (Environmental Law Institute 1997; Environmental Law Institute 1998). First, some laws make BMPs directly enforceable in connection with required plans and permits. A second approach makes BMPs enforceable, but only after the fact when a "bad actor" is causing pollution. A third approach makes BMPs the basis for an exemption from a regulatory

program (certainty program). Fourth, compliance with BMPs may be an allowable defense to a regulatory violation (for example, a state could be prohibited from taking action under a water pollution control statute against a farm that is implementing BMPs, whether or not the operation is causing pollution). Finally, many states make compliance with BMPs a defense to nuisance actions, for example a neighboring landowner could not sue under state nuisance laws if BMPs are implemented (Dexter 2010). *A careful consideration of the pros and cons* of the following approaches may be warranted:

- **Certainty programs.** Creating a certainty program is one possible approach for promoting a basic set of standards (AFT 2013), and the Illinois NLRS is considering this. Minnesota established its Agricultural Water Quality Certification Program in 2012 and piloted it in four selected areas beginning in June 2014. It expanded statewide in 2015. The program now has 418 active certifications, 183 completed certifications (over 100,000 certified acres) and 360 new integrated conservation practices (Brad Redlin, personal communication, 6/22/16). The effort has also led to a $9 million USDA NRCS Resource Conservation Partnership Program grant, an ecosystems service USDA NRCS Conservation Innovation grant and a full partnership with Land O-Lakes and WinField Solutions to certify farms. Funding comes from the MN Clean Water Fund. Minnesota adapted the USDA NRCS agricultural water quality index model (WQIag) and requires a final adjusted score of 8.5 or higher on its 1–10 scale for certification.
- **Certification of fertilizer applicators.** According to state regulations (accessible online) and the states' Nutrient Reduction Strategies, at least four of the 12 states with Nutrient Reduction Strategies have taken steps towards certification of fertilizer applicators. Ohio requires growers applying inorganic fertilizers to more than 50 acres to obtain certification by September 17, 2017 and has established fertilizer and manure application restrictions in the western basin of Lake Erie (effective as of July 3, 2015). Arkansas has enacted three laws to preserve water quality that apply to agricultural operators and landowners operating in nutrient surplus areas as well as any producers using federal or state funds to create or implement nutrient management plans regardless of where they are located. These laws require certifying all those who apply nutrients to crops or pastureland, certifying nutrient management plan writers, registering all poultry feeding operations and developing and implementing nutrient and poultry litter management plans for those operating in nutrient surplus areas. In Indiana, anyone who uses or distributes commercial fertilizer or manure must be certified and licensed by January 1, 2012. Indiana now has a statewide standard for applicator certification and training.
- **State-certified nutrient management plan requirement.** Delaware, Maryland and Virginia require farmers to follow a state-certified nutrient management plan with very uneven results showing that engaging farmers early in the policy deliberation process and enforcing compliance are the only ways to make this approach work (Perez 2015).
- **Establishment of performance standards both at the farm and watershed levels.** These would be innovative regulations that clearly tell producers what they need to accomplish but that would provide producers and their technical advisors with the flexibility to determine how to accomplish it (SWCS 2007). Note that many groups are currently researching ways to integrate soil health into goals and metrics for on-farm environmental performance (e.g. Field

to Market;[17] the Soil Health Institute[18]). For example, Wisconsin adopted administrative rules in 2002 (NR 151) with revisions effective in 2011 that set statewide performance standards and prohibitions for all Wisconsin farms (these include a tillage setback of 5-20 feet, meeting a P index, applying nutrients according to a nutrient management plan, meeting a tolerable soil erosion rate and several other standards) (WI DNR 2013).

- **State-level certification programs for farmers who are improving their soils.** Vermont is considering a bill (S. 159) that would create a state-level certification program under which farmers could have their land and farming methods certified as "regenerative." To be certified, farmers have to meet one of three criteria over a three-year period with each successive year (if topsoil has increased; if carbon has been sequestered; or if soil organic matter has increased). Standard testing would include a total soil carbon test, nitrogen tests at three soil levels from an amalgamation of eight sample points within a specified plot of land, a test for the presence or absence of inorganic carbon, a test of soil for water infiltration times, a test for bulk soil density, a test for percentage of bare ground within a specified plot of land and a test for diversity of ground cover within a specified plot of land. Farmers would pay $500 annually to participate. If passed, the act will take effect July 1, 2016.[19]

Consider Possible Funding Options

- **Establish tax credits for farmers/landowners who install a select group of BMPs.** Iowa House Bill 251 (from the Iowa Soybean Association) would allow a tax credit for 75 percent of the cost of establishing environmental practices, not to exceed $10,000 per practice. No more than $3 million in tax credit certificates may be issued in any state fiscal year.
- **Incentivize edge-of-field practices by reducing property taxes for farms that implement them.** Tax credits, a freeze in property taxes or a reduction in property taxes could be piloted first in the NLRS priority watersheds. The use of these practices will ultimately save all taxpayers money but could perhaps be funded by federal block grants through the state USDA NRCS to local communities in the prioritized watersheds.
- **Establish a sales tax. Missouri sales tax helps support their SWCDs.** One-tenth-of-one-percent sales tax is evenly split between Missouri State Parks and SWCDs and generates up to $31 million/year. This covers 4,000 to 6,000 contracts with producers for up to 75 percent cost share.
- **Remove the sales tax on conservation equipment.**
- **Establish a Conservation Trust Fund.** Iowa established a Natural Resources and Outdoor Recreation Trust Fund in 2010 with a dedicated funding source generated by a sales tax rate of three-eights of one percent. Twenty percent goes to soil conservation and water protection and 14 percent to watershed protection.
- **Establish a revolving loan fund for conservation practices.** Iowa plans to establish an Iowa Soil and Water Health Revolving Loan fund.

17. See www.fieldtomarket.org.
18. See http://soilhealthinstitute.org.
19. See: http://legislature.vermont.gov/bill/status/2016/S.159.

Support Policy Reforms at the Federal Level That Support the Illinois NLRS

- **Reform the Federal Crop Insurance Program to encourage soil-building practices and reduce weather-related risks.** The FCIP could: 1) offer lower premiums to farmers who lessen their risk of crop loss by investing in conservation practices and cropping systems that reduce short-term crop loss risk and build soil health and increased productive capacity in the long term (O'Connor 2013); or 2) Offer different levels of crop-insurance-subsidized premiums based on producers' stewardship levels to incentivize conservation practices. USDA NRCS is currently developing Resource Assessment tools that can effectively measure stewardship levels and is discussing the implications with the USDA Risk Management Agency.

  An effort is also underway to merge USDA data about conservation practices, soil health, crop yield and crop yield variability to: 1) Help make the business case to producers that adopting conservation practices is good for both the environment and their own farm's profitability; 2) Drive changes in the crop insurance program by better integrating the risk management benefits of conservation practices into rates and supporting an incentive-based approach through procedures established under Section 508(h) of the Federal Crop Insurance Act; 3) Inform the development or improvement of corporate sustainability standards; and 4) Support the development of ecosystem service markets (Mercier 2015).

- **Advocate for specific changes to federal crop insurance policy to support practices recommended for the NLRS.** These kinds of policy changes would support innovations like eliminating cover crop termination rules or establish that all conservation practices as adhered to by USDA NRCS standards meet qualification for Good Farming Practices (AGree 2015; Lynch 2015).

Concluding Remarks

The Illinois Nutrient Loss Reduction Strategy (NLRS) harnesses the right array of outreach and education efforts to help Illinois farmers address nutrient loss and select the most appropriate individual BMPs (e.g. nutrient management, cover crops, reduced tillage, saturated buffers, drainage water management, bioreactors and wetlands). But the successful long-term implementation of this strategy rests on the ability to: 1) persuade farmers to voluntarily adopt conservation and management practices to prevent a loss they can't readily observe; and 2) anticipate and adjust to the impacts of increasingly variable weather patterns. Unfortunately, the policy and production systems currently in place coupled with budgetary restrictions may make this an uphill battle.

EDMUND LOWE/ALAMY STOCK PHOTO

Improving soils is the first step to both producing higher yields and reducing nutrient runoff. For farmers, the best way to do this is through an integrated approach of CCS that combines conservation cropping rotations, no-till/strip-till, cover crops, nutrient management and other supporting practices as needed, making sure that each practice complements or enhances the others for overall improvement of the health and function of the soil resource. The Illinois NLRS provides the ideal framework for this paradigm shift—but it will take planning and unified messaging, fitting projects and initiatives into a broader systems framework that starts with building soil health, expanding training for technical service providers, adding new indicators or metrics, considering public support for long-term practices maintenance, supporting state and federal policy reforms and identifying and securing resources to fully implement the NLRS.

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USEFUL WEBSITES FOR RESEARCH ON CONSERVATION CROPPING SYSTEMS AND CONSERVATION AGRICULTURE

Iowa State University: Soil management/environment: tillage and cropping systems: *www.agronext.iastate.edu/smse/tillage*

USDA ARS Soil Management Research: *www.ars.usda.gov/main/site_main.htm?modecode=50-60-05-00*

Cornell University Conservation Agriculture: research database has over 2,0000 articles; also links to equipment, networks and groups, related websites, etc. *http://conservationagriculture.mannlib.cornell.edu*

Sustainable Corn: *http://sustainablecorn.org*

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