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GETTING DOWN TO THE ROOTS: A SOIL CARBON STRATEGY FOR ILLINOIS

DECEMBER 2017

Part 3 of 3: Soil Carbon Strategy

This document identifies opportunities for broader communication and programmatic alignment within the agricultural section to move toward a recarbonized rural landscape that provides water quality, climate, and community benefits.

This document is one part of a series of three documents created by Delta Institute to illuminate opportunities for various stakeholders to support NLRS implementation.

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About Delta Institute

Established in 1998, Delta Institute is a Chicago-based nonprofit organization that collaborates with communities to solve complex environmental challenges across the Midwest. Delta Institute works to achieve landscape-level impacts through its agriculture and water quality programs by working in partnership with farmers, agricultural retailers, local and national nonprofits, conservation districts, and state and federal partners.
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TABLE OF CONTENTS

SETTING THE STAGE

Even with significant investment of time and resources into reducing nutrient losses from Illinois, limited progress has been made in the last decade. The dominant modes of agricultural production in Illinois over the past century have resulted in significant losses of soil, and the ancillary benefits that soils provide. The carbon contained within the soil organic matter is not only crucial for its role of keeping greenhouse gases from entering the atmosphere, but also for its role in cultivating crops, mediating water quality and infiltration, nutrient cycling, and pest moderation.

Building on Delta's recent work examining market drivers for implementation of the Illinois Nutrient Loss Reduction Strategy (NLRS),[1,2] this strategy report focuses on identifying opportunities and areas for broader communication and programmatic emphasis to move toward a recarbonized rural landscape that provides water quality, climate, and community benefits. Incorporating other important thought leadership in this area (see Appendix for list of relevant reports and studies), this framework presents opportunities to recouple carbon and nutrient cycles, along with strategies that could be used to further engage the agricultural community. Currently there is significant interest in soil health and understanding and harnessing soil's biological properties and growing interest from across the agricultural sector. Though restoring soil health presents an remarkable opportunity, production practices, quantitative tools, conservation programs, and investment models need to be developed and linked in order to truly regenerate soils in Illinois, across the Midwest, and nationally, We present a synthesis of research and current initiatives that provides the basis for such alignment between practices, policies, and investments for shifting agricultural systems. Our recommendations focus on:

- Prioritizing practices with high reduction potential for carbon, nitrogen, and phosphorus;
- Developing alternative financing structures and policies that incentivize adoption.

Focus on soil health

In 2014, the USDA Natural Resources Conservation Service (NRCS) formed a Soil Health Division to "incentivize and facilitate producers in implementing science-based, effective, economically viable soil health management systems on the nation's diverse agricultural lands" through partnerships.[3] The NRCS initiative, building on decades of research and practice, recommends that producers can manage for soil health by incorporating the following four principles into their systems:[4]

- Manage more by disturbing soil less;
- Diversify soil biota with plant diversity;
- Keep a living root growing throughout the year; and
- Keep the soil covered as much as possible

Taken together, these cropping practices make up the foundation of what is commonly referred to as carbon farming.[5] In grazed systems, there is a set of practices that mimics the movement of native herbivores that also acts to invigorate the soil. These healthy soil approaches for crops and livestock can also be integrated, such as in the grazing of cover crops. Globally, there is a growing focus on restoring soil health as the basis for food production and storage for water and carbon.

Carbon stocks and the potential for sequestration

Loss of carbon associated with agricultural land use is documented and highlights the opportunity for working lands to re-capture the carbon. A 2017 study evaluated the effect of 12,000 years of

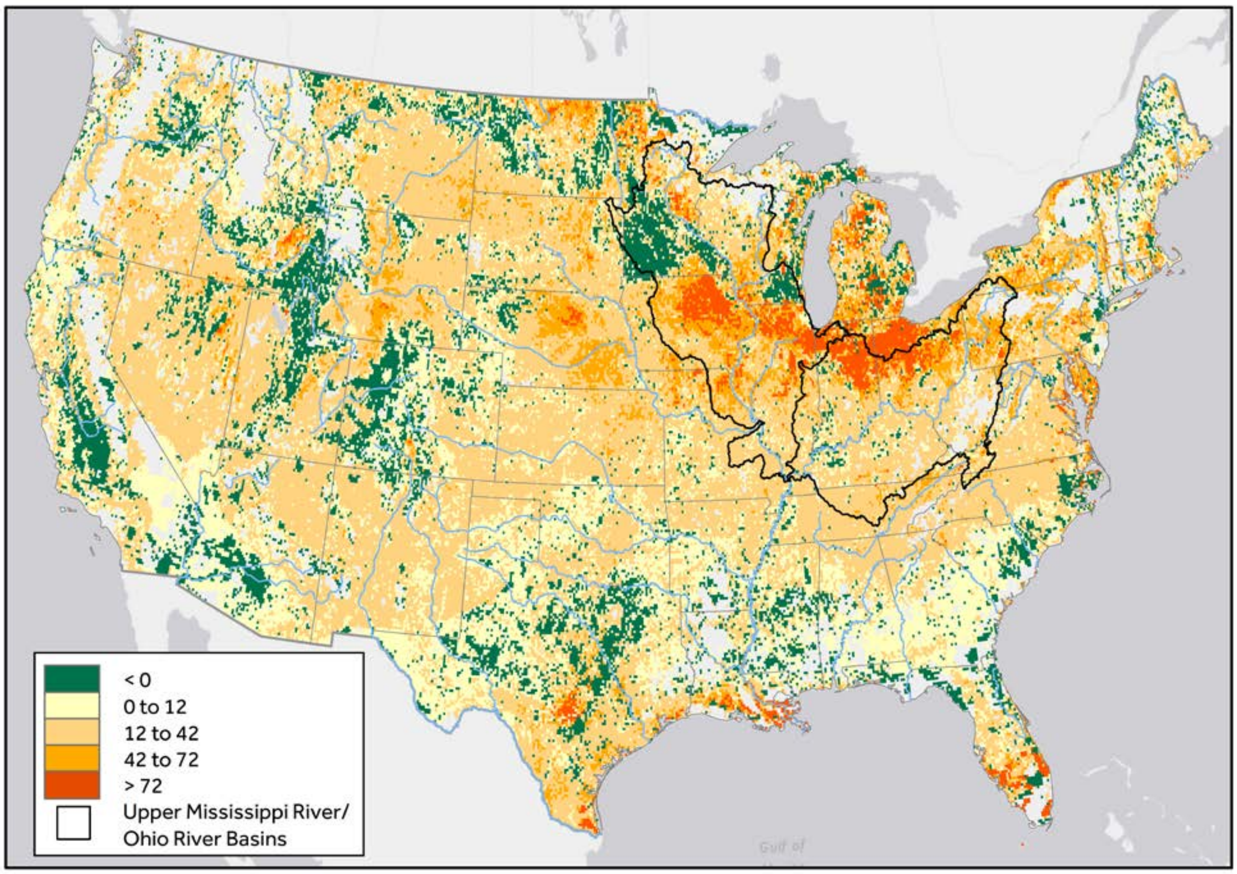

Figure 1. Change in SOC Stocks (0-200 cm), Presettlement to 2010. Adapted from Sanderman et al. 2017.

agricultural land use on soil organic carbon (SOC) stocks globally and estimated a net loss of 133 billion metric tons, or roughly one-third of global fossil fuel emissions since the Industrial Revolution.[6] In the US, the areas that exhibit the highest losses are primarily in the Midwest, including Illinois, Iowa, Indiana, and Ohio, where conventional row crop systems dominate (**Figure 1**). Since this is where the most depletion has occurred, most of the carbon sequestration potential associated with land management changes lies in the Midwest as well.

Taking a closer look at Illinois, the map in **Figure 2** shows estimated carbon losses within two meters of the surface. Average losses of 42 metric tons of carbon per hectare, or 62 metric tons of carbon dioxide-equivalent (MT CO_2e) per acre, suggest significant storage potential. However, it is important to keep in mind that the sequestration potential is not uniform across the state. With this dataset, location-specific carbon storage potentials can be determined for specific areas within Illinois and other states in the Upper Mississippi River Basin. **Figure 2** also includes 7 paired measurement sites referenced in the study, which compare SOC stocks between native prairie and a corn-soybean rotation after decades of conventional tillage. Within the topsoil layer, or 0-30 cm depth, the difference between native prairie and cropland soil carbon ranged from 41 to 98 MT CO_2e per acre.

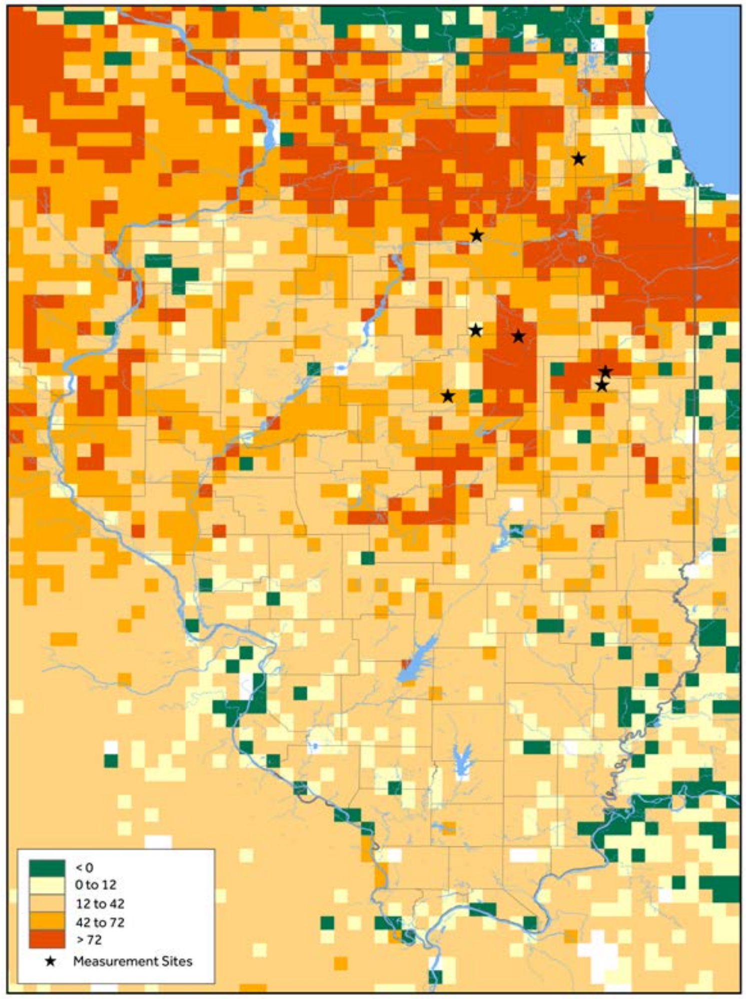

Figure 2. Change in SOC Stocks (0-200 cm), Presettlement to 2010 in Illinois. Adapted from Sanderman et al. 2017. The NLRS priority watersheds can be found in the Appendix.

The challenge now is to identify how much carbon can be restored and through which practices, particularly those that align with the NRCS soil health strategy as well as the Illinois NLRS, which is among the key drivers for implementing conservation in the state. Farmers in Illinois can play an important role in regenerating their soils by adopting practices such as no-till, cover crops, and adding a small grain, especially when used together as a conservation cropping system. As we will show, combining these soil-building practices can return SOC stocks to presettlement levels without converting Illinois cropland back to native vegetation.

Given that cropland has the potential to store carbon in the soil, we can make meaningful strides in rebuilding soil health and water quality by changing how the land is managed and the types of conservation practices that are implemented. The degree to which these opportunities can be utilized depends on combining the technical knowledge about the practices, as well as the right incentives and policies to shift away from current paradigm and toward a more regenerative agriculture system. In the next section, we will examine the conservation practices already listed in the Illinois NLRS, evaluate them based on their carbon storage and nutrient loss reduction potentials and identify approaches for better alignment between the NLRS and soil carbon restoration goals.

PRIORITIZING PRACTICES WITH NUTRIENT AND CARBON BENEFITS

Overview of nutrient reduction and carbon sequestration potentials by practice

Below, we identify the agricultural practices that are impactful beyond nutrient loss and can provide a broader suite of soil health and climate benefits from rural landscapes. In addition to the practices outlined in the Illinois NLRS, we evaluated practices highlighted by American Farmland Trust's report on Conservation Cropping Systems[7] and NRCS practices included in Carbon and Greenhouse Gas Evaluation for NRCS Conservation Practice Planning (COMET-Planner). COMET-Planner is part of USDA's suite of tools to evaluate carbon and other greenhouse gas fluxes.[8] COMET-Planner provides county level estimates of carbon dioxide, nitrous oxide, and methane emissions and sinks. Given a rate of reduction and a reasonable scale at which a practice could be deployed, each practice is ranked by its nutrient loss reduction (N and P, as data availability allows) and carbon sequestration potential. The individual rankings were then combined for a nutrient/carbon ranking. For each practices, we also estimated implementation costs. All source data, assumptions, and quantitative estimates used in **Table 1** can be found in the Appendix.

In our analysis of the soil carbon sequestration potential of practices, a few practices emerge as cost-effective strategies for reducing nutrient losses and sequestering carbon. Of the 36 practices or scenarios analyzed, five ranked highly across both nutrient and carbon reduction potentials. Within the NLRS practices, the cover crop scenarios that encompass all corn and soybean acres ranked highest, mainly because of the large area of agricultural land that they cover (0.32 MT CO_2e per acre per year). Currently, cover crops are planted on just 1.4% of Illinois annual cropland.[9]

Other practices, such as installing a riparian forest buffer ranked lower overall due to smaller potential acreage, but can sequester carbon at a higher rate (2.2 MT CO_2e per acre per year). Some practices have significant nutrient reductions, but little carbon sequestration potential. Others have great potential for both, but have barriers to large scale implementation. Notably, while the N rate or application adjustment practices in the NLRS are important tools for nutrient loss reduction, they have insignificant impacts on soil carbon. Alternatively, Nutrient Management – Replacing Synthetic Nitrogen Fertilizer with Soil Amendments (part of NRCS Conservation Practice Standard 590) ranks highly across nutrient loss reduction and carbon sequestration, and given the number of acres that could use this practice, it could be a significant contributor to addressing carbon and nutrient loss challenges. The major impediment to scaling this practice is the lack of available soil amendments, whether derived from animal waste, human waste, pre/post-consumer food waste, or landscaping materials. This gap presents an opportunity for investment and innovation in the sector. An example of a program, currently at pilot scale, is described in **Panel 1**. To implement wide-scale composting initiatives, there is a need for policies that, depending on the type of waste stream, incentivize collection, processing, and distribution of compost for agricultural use.

	N Reduction Potential	P Reduction Potential	C Sequest-ration Potential	Combined Nutrient/ Carbon Reduction Potential	Practice Cost
IL NLRS- Example statewide practice or scenarios					
Buffers	High	High	Medium	Medium	Medium Cost
Conservation Tillage	N/A	Low	Medium	Medium	Low Cost
Cover Crops (Scenario 1)	High	High	High	High	Low Cost
Cover Crops (Scenario 2)	High	N/A	High	High	Low Cost
Cover Crops (Scenario 3)	N/A	Low	Medium	Medium	Low Cost
N Rate Reduction	Low	N/A	N/A	N/A	N/A
N Application Timing	High	N/A	N/A	N/A	N/A
N Inhibitor Product	Low	N/A	N/A	N/A	Low Cost
N Application Timing (Scenario 1)	High	N/A	N/A	N/A	N/A
N Application Timing (Scenario 2)	Low	N/A	N/A	N/A	N/A
Perennial/Energy Crops (Scenario 1)	Low	Low	Medium	Medium	Medium Cost
Perennial/Energy Crops (Scenario 2)	High	Low	Medium	Medium	Medium Cost
Practices recognized by AFT in the CCS strategy					
Crop Rotation	Low		High	Medium	Low Cost
Strip Crops	Low		Low	Low	Low Cost
Practices recognized by NRCS COMET-Planner					
Nutrient Management (Replacing N Fertilizer with Soil Amendments)	High		High	High	High Cost
Riparian Forest Buffer	High		Medium	High	High Cost
Tree/Shrub Establishment - Farm Woodlot	Low		High	Medium	High Cost
Windbreak/Shelterbelt Establishment	Low		Medium	Medium	High Cost
Hedgerow Planting	Low		High	Medium	High Cost
Alley Cropping	Low		High	Medium	High Cost
Multi-story Cropping	Low		High	Medium	N/A
Conservation Cover - Retiring Marginal Soils	High		Low	Medium	Medium Cost
Herbaceous Wind Barriers	Low		Low	Low	Medium Cost
Vegetative Barriers	Low		Low	Low	N/A
Contour Buffer Strip	Low		Low	Low	Medium Cost
Filter Strip	High		Low	Medium	Low Cost
Grassed Waterway	Low		Low	Low	High Cost
Field Border	Low		Low	Low	Low Cost
Silvopasture Establishment on grazed grassland	High		High	High	High Cost
Range Planting	Low		Medium	Medium	Low Cost
Windbreak/Shelterbelt Renovation	Low		Low	Low	High Cost
Mulching	Low		Medium	Medium	Medium Cost
Conventional Tillage to No Till	Low		Medium	Medium	Low Cost
Prescribed Grazing	Low		Medium	Medium	Low Cost
Forage and Biomass Plantings - Partial Conversion	Low		Medium	Medium	Low Cost
Forage and Biomass Plantings - Full Conversion	Low		Medium	Medium	Medium Cost

Table 1. Comparison of conservation practices based on their reduction potential for nitrogen, phosphorus, and carbon, and cost.

Our analysis also highlighted silvopasture, the combination of trees and grazing, as a way to both stem nutrient loss and sequester carbon in the soil. Tree species could be selected for timber, or fruit or nut trees (e.g. hazelnuts) could be chosen as food-bearing options. Integration of silvopasture practices is an opportunity to return some of the land into native forest landscapes while still providing food, feed, and fiber. However, wide adoption of this practice is currently unlikely without significant changes in technical support, incentives, and policies that make silvopasture viable for farming operations in Illinois.

In order to ensure that those practices that align with both nutrient loss reduction goals and restoring soil health, we need to take action to prioritize these practices within conservation programs and initiatives across the state. For example, an existing though underfunded program, Partners for Conservation, could be turned into a healthy soils program that prioritizes adoption of cover crops. Furthermore, the NLRS Policy Working Group should consider including new practices that help address nutrients and carbon, such as the ones identified in this section.

Panel 1. In Michigan, Delta Institute is partnering with the City of Lansing's Public Service Department's CART program, Hammond Farms Landscaping Supply, and Live Green Lansing to develop and implement an innovative food scrap collection pilot program. The program is working with over 20 businesses in Lansing, MI to divert up to 500 tons of food scraps from landfills, and convert the scraps into a rich soil amendment that will be distributed back to the community, and to institutionalize food scrap diversion practices in a number of the restaurants beyond the pilot. While the focus of the pilot is on building out the collection side of the waste management system, the need to figure out how to scale the production and distribute the compost products to the farmers remains.

While this analysis only assessed potential benefits for adopting a single practice, we can use the NRCS COMET-Farm tool to further examine carbon benefits resulting from the integration of multiple practices at the field-scale.

Comparison of field-specific scenarios

Among the practices we highlighted in the previous section for their potential to have nutrient and carbon benefits, there are several practices that have been shown to work synergistically to improve soil health, inclusive of internal nutrient cycling and carbon sequestration. Broadly, these practices reflect the principles of reducing disturbance, increasing soil coverage, diversification, and the addition of animals or their manure. While the best combinations of practices will be site-specific to address local resource concerns, these general principles can be integrated in current or future management practices. This analysis is meant to be the first step to identify practices that have both water quality and carbon benefits, with future work needed to prioritize practices based on geography, climate, history, culture and knowledge, and access to markets.

Given the potential of carbon sequestration in Illinois soils, we explored a suite of scenarios that capture sequestration rates for a range of practices and rotations on typical fields across Illinois. COMET-Farm was used to estimate greenhouse gas fluxes for representative fields in Fulton, Richland, Livingston, Macon, and Iroquois Counties. COMET-Farm is similar to COMET-Planner, but it allows analysis at the field scale. The data in **Figure 3** represents average predictions for a 10-year period (2017-2026) across the 5 fields (weighted by acreage) for 6 different scenarios. The model outputs include above- and below-ground fluxes of carbon and nitrous oxide, which are converted to MT CO2e per acre per year. **Figure 3** also shows the total net emissions, with a positive value indicating that the field is a source and negative indicating a sink. The scenarios represent the types of practices reflecting the core soil health principles outlined by NRCS.

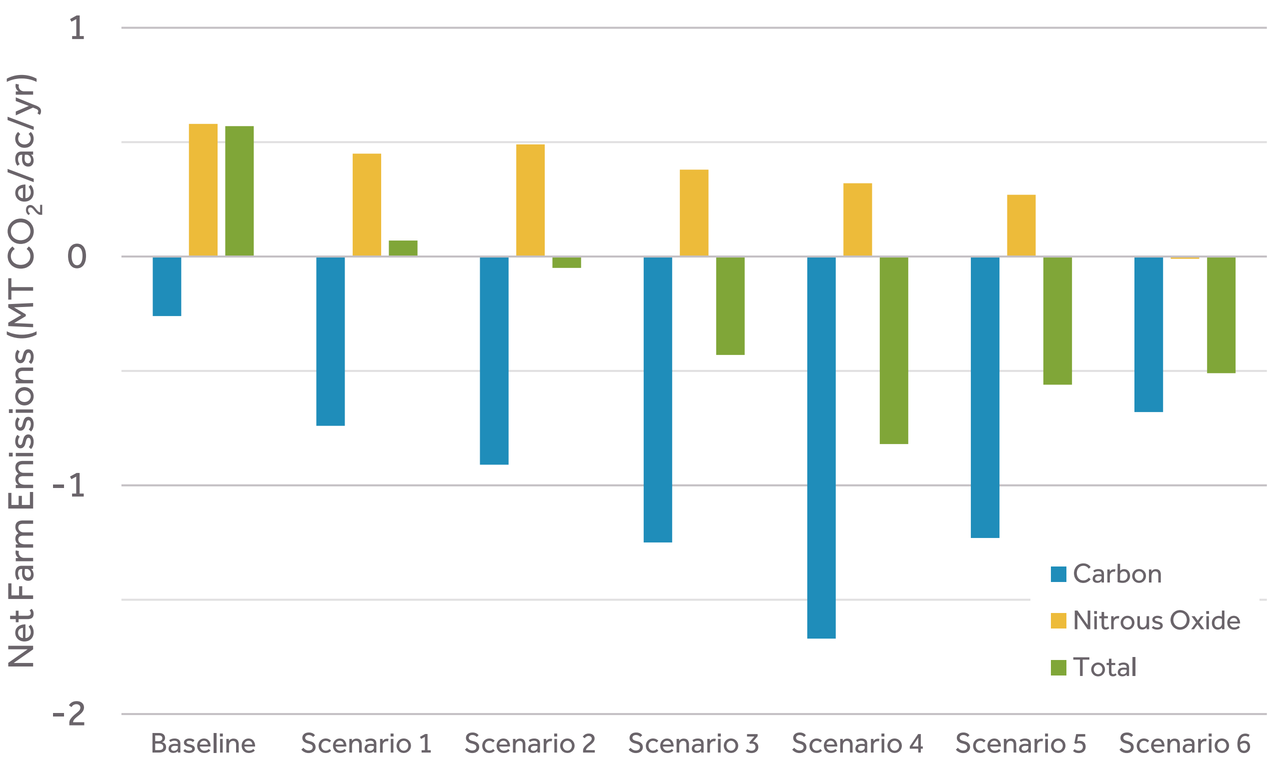

Figure 3. Net farm emissions based on COMET-Farm estimates for scenarios for 2017-2026 period compared to baseline conventional corn-soy rotation. The scenarios include: 1- Reduced tillage to no-till; 2 - Cover crops (oilseed radish after soy and cereal rye after corn) with reduced tillage; 3 - Cover crops plus no-till soy/corn; 4 - No-till soy/corn plus replacing synthetic N with legume cover crops and composted manure; 5 - No-till soy/wheat/corn plus replacing synthetic N with legume cover crops and composted manure; 6 - Conversion to switchgrass.

It is apparent that as we move from a conventional tillage system with synthetic fertilizer to one with cover crops (scenario 2) to one with cover crops and reduced tillage (scenario 3, 4) to introduction of organic amendments (scenario 5), to conversion to switchgrass (scenario 6) we see that the synergistic benefits of implementing these practices together grow. Looking at just the carbon storage, the rate reaches 1 MT CO_2e per acre per year suggesting that replenishing soil carbon to its potential in Illinois soils (62 MT CO_2e per acre) is a long-term process limited by physical and biological properties of the soils. This physical limit, in turn, ensures a supply of carbon for environmental markets for the next 50-70 years.

Research on soil biology continues to shed more light on synergistic benefits of implementing these practices as part of an integrated system. COMET-Farm and COMET-Planner are powerful tools that can help producers understand and quantify carbon storage benefits and track improvements in their soil health. **USDA-NRCS should be more proactive in training conservation practitioners in using COMET tools to help guide farmers in adoption of conservation practices. The addition of economic costs and benefits into the COMET suite of tools would also increase their utility.**

In addition, due to the significant historic carbon losses in Illinois soils, these results suggest that implementing conservation practices would allow for carbon storage for the next 50 years or more based on available sequestration capacity. Given the lack of current incentives and policies for carbon farming, opportunities to evaluate potential effectiveness of emerging mechanisms that offer market premiums to producers and associated policies are discussed in the following sections.

INVESTMENT & FINANCING BASED ON PRIVATE RETURNS

Development of financing strategies for emerging economic sectors has recently been demonstrated, such as the investment case for renewable energy, which 30 years hardly existed and nearly $250 billion was invested in 2016.[10] To reorient the agricultural system to one that provides foodstuffs while building soil, sequestering carbon, cleaning water, and enriching rural communities will require leadership in developing new financing strategies that draw on both public and private sources.

There is not only a need for additional capital to begin recarbonizing rural landscapes, but also a need for new ways of thinking about return on investment. A report released by Encourage Capital[11] in 2017 laid out opportunities to engage private capital and, in some cases, to leverage existing federal programs to improve natural resource conservation on agricultural landscapes. The report provided a conceptual framework to engage investors from across asset classes in investing in conservation-related outcomes and the outlined the steps to be taken by USDA or through new programs or initiatives.

The report also clearly provides opportunities to research, design, and test new pathways to mobilizing the capital needed to shift the investment and finance landscape. For instance, the report concedes that there is no current potential for private returns to be generated (and hence no opportunity for private investment) in activities like cover cropping, no-till, or installation of fences for managed grazing. This is mostly because of the lack of data on the financial performance of these practices. When taken together and implemented as a soil health management plan, there is early evidence showing that there is potential for a suite of private and public returns on these investments.[12] Private returns come in the form of reductions of labor and input costs, increased yields, and more resilience to extreme events.

Methodologies such as true-cost accounting, are being developed to reflect the full suite of costs and benefits of different agricultural production systems.[13] Internalizing those costs provides an opportunity for conservation investments that build soil, sequester carbon, and keep nutrients on the farm, all while supporting a more profitable farming enterprise. Advancements are still needed in the underlying measurement of physical changes (e.g. soil organic matter, nutrient cycles), developing financing mechanisms that better account for the social and environmental benefits of conservation cropping systems, and ultimately integration of biophysical and financial data that can inform farmers and investors about benefits and tradeoffs in investing in different cropping systems on the land.

One approach that can improve the decision support tools needed to shift land management systems is to integrate data from farmers (especially the early adopters) that demonstrate the costs and benefits of implementing suites of practices into existing databases such as the University of Minnesota's farm financial database (FINBIN), Iowa State University's Ag Decision Maker (AgDM), or the University of Illinois' Farm Business Farm Management (FBFM) program.

There may be opportunities to participate in formal or informal markets for water quality or carbon, but many of those are still in development, or have encountered policy-related roadblocks at the national level. An example of a program that engaged producers in carbon trading is described in **Panel 2**. Additional efforts have continued in the voluntary market, including the American Carbon Registry, Climate Action Reserve, and Verified Carbon Standard. The Coalition on Agricultural Greenhouse Gases (C-AGG) and the Noble Foundation are leading efforts to identify barriers and work on solutions to create market-grade carbon credits. Major hurdles include high transaction costs due to factors like verification, the challenges associated with ensuring that sequestered carbon actually stays in the soil long-term, and the lack of supportive national and global climate policies. An alternative to formal credit trading approaches are product certifications where consumers or supply chains pay a premium for a set of practices used in production.[14] These private returns are coupled with public returns, such as improvements in water quality, water infiltration (flood reduction), and carbon sequestration.

Panel 2. The Chicago Climate Exchange (CCX) offset program, active from 2003 to 2010, involved more than 15,000 farmers, ranchers, and forest landowners who enrolled over 25 million acres in agricultural and forestry carbon sequestration projects. The Iowa Farm Bureau and North Dakota Farmers Union operated the largest credit aggregation programs, with a combined 6 million acres of cropland earning credit for adopting continuous no-till practices. Delta Institute served as a project developer, starting with a small group of Illinois no-till farmers in 2005 and expanding to over 1,300 participants with 400,000 enrolled acres across 18 states by 2010.

Delta Institute also aggregated and sold carbon credits on behalf of the landowners to CCX cap-and-trade program members, who could use offsets for a portion of the greenhouse gas reduction commitments. The enrolled land was verified by a certified third-party organization, and the revenue from the sale, minus aggregation and trading fees, was returned to the landowners. While the CCX pilot ended in 2010 after a national climate and energy policy failed in Congress, the success of the offset program illustrates that it is possible to use a market mechanism to trade agricultural carbon credits on a large scale.

To engage investors and others with the ability to finance land, farm operations, and supply chain businesses, a stronger business case, in conjunction with a pipeline of investable opportunities, needs to be developed. Several projects led by nonprofit and supply chain partners are actively working to build this business case.[15] Early data has shown that potential exists for generating returns across several types of agricultural operations, practices, and geographies. **Additional work is needed to evaluate potential effectiveness of emerging mechanisms that offer market premiums to producers whose practices result in environmental benefits and to identify where it is most appropriate to engage investors interested in generating market-rate returns. Furthermore, there is a need to clarify where other sources of capital, such as government grants or philanthropic programs, may be more appropriate.**

As work is ongoing to develop comprehensive and sustainable funding frameworks for regenerative agricultural systems, numerous opportunities for investment have emerged. Drawing from the analysis in **Table 1**, to encourage the adoption of practices such as cover cropping, crop rotations, and nutrient management (specifically the replacement of synthetic N fertilizer with soil amendments), as strategies with both nutrient and carbon benefits, **significant investments will be needed to finance the supporting infrastructure. This includes expanding the capacity of: grain elevators to accept and process a wider variety of crops; supply chains to grow, collect, process, and distribute cover crop seeds; and the facilities and distribution networks to produce soil amendments from pre-consumer or post-consumer agricultural or food waste.** While investments are not the only barrier to broader adoption of soil health improving practices on the agricultural landscape, there is also a role for policy to encourage widespread adoption and provide supporting resources.

POLICY FOR IMPROVING SOIL HEALTH

In addition to technical knowledge and significant investments, shifting to regenerative agricultural systems will require policy changes that incentivize their adoption. A number of states have recently introduced or enacted legislation that create policies and programs to incentivize farmers and ranchers who adopt practices that improve soil health and enhance soil carbon. **Table 2** briefly summarizes their status and scope.

State	Bill # & Status	Description	Applicability to Illinois
Hawaii	Act 033 Signed into law June 2017	Establishes a Carbon Farming Task Force to develop policy/program recommendations	Appropriate starting place given the importance of agriculture in the state
New York	Bill 3281 Committee on Agriculture	Would establish a tax credit for farmers who use land management strategies that reduce GHG emissions or sequester carbon on farms, proposes to use COMET-Farm and COMET-Planner to quantify reductions	Most analogous to IL in terms of growing conditions and agricultural practices
Vermont	Bill S43 Committee on Natural Resources	Would establish a Regenerative Soils Program that would certify land as regenerative. Funding would come from certification fees and other appropriated funds/grants	Certifications tend to be onerous for producers and confusing for consumers
Maryland	HB 1067 Signed into law May 2017	Establishes the Maryland Healthy Soils Program	Signals to producers that it's a priority, but success uncertain without dedicated funding mechanism
Massachusetts	HB 3713 Joint Committee on Environment, Natural Resources and Agriculture	Would establish, develop and implement the Massachusetts Healthy Soils Program	See Maryland
California	Healthy Soils Initiative created in August 2016, $7.5M appropriated	Grants for implementation of approved practices and for setting up demonstration sites	Funding provided by the Greenhouse Gas Reduction Fund, which is unlikely in Illinois in the short term. However, the demonstration component of the initiative could be adopted for Illinois to foster education and outreach efforts

Table 2. Overview of state level policy proposals across the US and their potential applicability to Illinois.

The California Air Resource Board implements a cap-and-trade program for greenhouse gases that, in 2017, committed $7.5 million to fund the state's Healthy Soils Program, which supports implementation of agricultural conservation practices aimed at keeping more carbon in the soil. California's program also supports a set of projects specifically intended to serve as demonstration sites to further education and outreach for producers.

The approach being taken by New York State, which would require quantification tools such as COMET-Farm or COMET-Planner, could be effective in Illinois given similarities in cropping systems practices. Even though there is still a need for advancements in models and tools used, as discussed in previous sections of this strategy, this is a significant step to ensure that there is verification and consistency throughout. Furthermore, the link to tax credits could help incentivize conservation behavior among non-operating landowners, an important target group in Illinois where 60% of cropland is leased. Other states that proposed a healthy soils program, with exception of California, lack the dedicated funding mechanisms needed to support program implementation.

While it's too early to evaluate the success of these programs and proposals, it's encouraging to see a variety of approaches being explored. As it may not be currently feasible to shift Illinois' agriculture sector to focus on soil carbon through such legislation, the state should consider adapting Hawaii's program, which would create an entity that provides policy recommendations to support soil carbon and soil health in Illinois.

To take advantage of the opportunities to restore soil health, capture carbon, and improve water quality in Illinois, decision makers should be engaging with constituents to establish a program that drives resources and investment to support initiatives that aims to rebuild soil health in Illinois. Robust verification and tracking should be incorporated regardless of the financial mechanism involved. Of the states that are considering soil carbon programs, New York is probably the most analogous in terms of growing conditions and agricultural practices, and an indicator of what's feasible. California's program that supports demonstration projects could be an applicable model for Illinois to create a demonstration network program for public land that's leased for farming. This and other approaches to managing land owned by public agencies in Illinois are outlined in the Policy Briefs focusing on the role of state agencies In the NLRS implementation.[16] To advance this agenda in Illinois, leadership, innovation, and new partnerships will be key.

OPPORTUNITIES FOR ACTION

Based on our research and analysis, we have identified a number of action items for agencies and conservation stakeholders that can help further progress toward achievement of the Nutrient Loss Reduction Strategy goals and recarbonization of Illinois soils. Changing agricultural systems and rebuilding healthy soils across the Midwest is a long-term process and will not occur until programs and policies aimed at protecting farmland and natural resources come in alignment with our increasing understanding of soil biochemistry. In order to make progress, land management decisions should be guided by tools incorporating the latest research and be financially feasible. Though these components are rapidly developing, more work is needed to link the right information with the suitable tools and sufficient investment. This report outlines areas to focus on and actions that can help move Illinois toward recarbonized rural landscapes that provides water quality, climate, and community benefits.

Focus on practices with a C, N, and P benefits

Practices that can be implemented in synergy as part of a more regenerative cropping system to maximize environmental benefits and cost effectiveness should be prioritized for adoption. In addition to practices already identified in the NLRS, the practice of replacing synthetic N with soil amendments has high potential for water quality and carbon benefits and should be considered. However, for widespread adoption, further development of the supply chain for soil amendments is needed. The tools currently used to quantify potential benefits provide a snapshot of what's possible, but are not widely used. The tools are important factors in informing land managers and producers regarding practice benefits and provide practical information needed for more buy-in and implementation of practices. Furthermore, practices work in synergy with one another with the sum of the parts greater than the whole and the models need to be further improved to capture these interactions. Conservation programs should focus on adoption of a suite of practices to amplify benefits. In addition, aligning practice implementation with local soil characteristics and historical vegetation in Illinois would optimize the reductions.

Actions:

- Advocate for funding and redesigning the Partners for Conservation Program into a healthy soils program that focuses on priority practices;
- Amend the NLRS to include soil amendments and other high potential carbon practices;
- Conduct training workshops for NRCS staff in the Midwest on the suite of existing COMET tools and integrate financial information into the tools.

Develop novel investment mechanisms and finance infrastructure

Shifting the agricultural paradigm in Illinois, and across the United States, toward conservation will take investment not only in physical infrastructure, but in the tools, markets, and social capital needed for systemic change. There are also clear gaps in existing infrastructure that further investment can help address to facilitate changes in cropping systems.

Actions:

- Integrate data from farmers (especially the early adopters) that demonstrate the costs and benefits of implementing suites of practices into existing farm management databases and planning tools;
- Evaluate potential effectiveness of emerging mechanisms that offer market premiums to producers whose practices result in environmental benefits;
- Build and expand the capacity of production, collection and distribution infrastructure needed for implementation of new practices.

Implement policy

As states launch programs and advance legislation focused on rebuilding healthy soils through regenerative agriculture and carbon sequestration, Illinois, where agriculture is a prominent part of the physical, economic, and cultural landscape, should also be pursuing similar initiatives. Given the significant loss of carbon from soils, the scale of agriculture, and positive environmental outcomes, Illinois is poised to reap the benefits of integrated approach to carbon sequestration and nutrient loss reduction.

Actions:

- Develop a legislative strategy that includes establishing a taskforce, authorizing a healthy soils program, or expanding the Partners for Conservation Program to promote carbon farming.

APPENDIX

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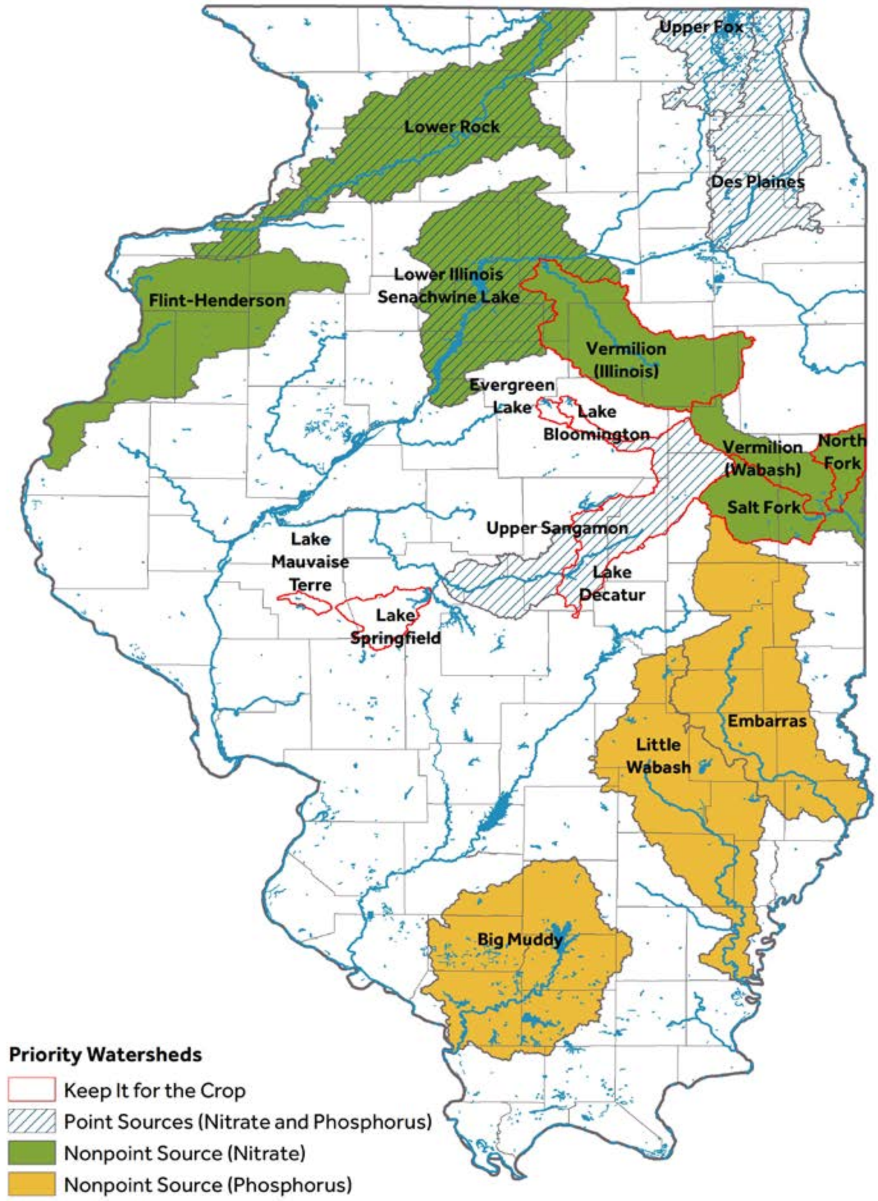
NLRS priority watersheds



Nutrient reduction and carbon sequestrations estimates and associated assumptions

(#) – designates assumptions used in estimating, see table below for explanation

		Nitrate-N reduced		Practice Physical Effects (nutrients in surface water) (15)	Total P reduced		CO_2 reduced per year			
	Acres per practice	per acre (%)	Total (million lb)		per acre (%)	Total (million lb)	CO_2e (MT per acre) (16)	N_2O (MT CO_2e per acre)	Total CO_2e (MT) (17)	Cost (18)
Practices recognized in the IL NLRS										
Buffers-Buffers on all applicable cropland	217,212 (1)	90	36		25-50	4.8	0.98	0.28	212,868	$623.65/ac
Conservation Tillage-1.8mn acres of conventional till eroding >T converted to reduced/mulch/no-till	1,800,000 (2)	NA	NA		50	1.8	0.13	0.07	234,000	$16.15/ac
Cover Crops (Scenario 1)-Cover crops on all corn/soybean tile-drained acres	9,263,000 (3)	30	84		30	4.8	0.32	0.05	2,964,160	$62.60/ac
Cover Crops (Scenario 2)-Cover crops on all corn/soybean non-tiled acres	12,281,000 (4)	30	33		NA	NA	0.32	0.05	3,929,920	$62.60/ac
Cover Crops (Scenario 3)-Cover crops on 1.6mn acres eroding >T converted to reduced/mulch/no-till	1,600,000 (5)	NA	NA		50	1.9	0.32	0.05	512,000	$62.60/ac
N Rate Reduction-Reducing N rate from background to MRTN on 10% of acres	2,236,100 (6)	10	2.3		NA	NA	0	0.11	0	NA
N Application Timing-Spring-only application on tile-drained corn acres	5,337,160 (7)	15-20	26		NA	NA	0	0.11	0	NA
N Inhibitor Product-Nitrification inhibitor with all fall applied fertilizer on tile-drained corn	5,337,160 (8)	10	4.3		NA	NA	0	0.11	0	$23.78/ac
N Application Timing (Scenario 1)-Split application of 40% fall, 10% preplant, and 50% side dress	5,337,160 (9)	15-20	26		NA	NA	0	0.11	0	NA
N Application Timing (Scenario 2)-Split application on 50% fall and 50% spring on tile-drained corn acres	5,337,160 (10)	7.5-10	13		NA	NA	0	0.11	0	NA
Perennial/Energy Crops (Scenario 1)-Perennial/energy crops equal to pasture/hay acreage from 1987	1,100,000 (11)	90	10		90	0.3	0.27	0.1	297,000	$473.40/ac
Perennial/Energy Crops (Scenario 2)-Perennial/energy crops on 10% of tile-drained land	970,600 (12)	90	25		50	0.3	0.27	0.1	262,062	$473.40/ac
Practices recognized by AFT in the CCS strategy										

Crop Rotation-Doubling the amount of extended rotation acreage (removing from CS and CC proportionally)	12,281,000 (4)	3	0.01	2	3	0.0005	0.21	0.01	2,579,010	$4.75/ac
Strip Crops-Strip cropping applied on 231,000 acres in the upper Midwest	100,000 (13)	NA	NA	2	23	1	0.11	0.13	11,000	$1.33/ac
Practices recognized by NRCS COMET-Planner										
Nutrient Management	2,236,100 (6)			5			1.8	0	4,024,980	$1000/ac
Riparian Forest Buffer	217,212 (1)			5			2.2	0.28	477,866	$694.18/ac
Tree/Shrub Establishment - Farm Woodlot	1,100,000 (11)			1			2	0.28	2,200,000	$664.00/ac
Windbreak/Shelterbelt Establishment	122,810 (14)			1			1.8	0.28	221,058	$0.66/ft
Hedgerow Planting	970,600 (12)			2			1.4	0.28	1,358,840	$0.81/ft
Alley Cropping	970,600 (12)			3			1.7	0.03	1,650,020	$4.91/ea
Multi-story Cropping	970,600 (12)			1			1.7	0.03	1,650,020	NA
Conservation Cover - Retiring Marginal Soils	122,810 (14)			4			0.98	0.28	120,354	$454.13/ac
Herbaceous Wind Barriers	122,810 (14)			1			0.98	0.28	120,354	$0.07/ft
Vegetative Barriers	122,810 (14)			2			0.98	0.28	120,354	NA
Contour Buffer Strip	122,810 (14)			2			0.98	0.28	120,354	$402.65/ac
Filter Strip	122,810 (14)			5			0.98	0.28	120,354	$125.32/ac
Grassed Waterway	122,810 (14)			2			0.98	0.28	120,354	$3513.65/ac
Field Border	122,810 (14)			2			0.98	0.28	120,354	$111.88/ac
Silvopasture Establishment on grazed grassland	1,800,000 (2)			5			1.3	0	2,340,000	$4.91/ea
Range Planting	1,800,000 (2)			1			0.5	0	900,000	$165.37/ac
Windbreak/Shelterbelt Renovation	122,810 (14)			1			0.4	0	49,124	$0.30/ft
Mulching	1,100,000 (11)			2			0.32	0	352,000	$243.55/ac
Conventional Tillage to No Till	1,800,000 (2)			2			0.42	-0.11	756,000	$15.21/ac
Prescribed Grazing	1,800,000 (2)			1			0.26	0	468,000	$51.68/ac
Forage and Biomass Plantings - Partial Conversion	1,800,000 (2)			1			0.21	0.01	378,000	$134.17/ac
Forage and Biomass Plantings - Full Conversion	1,800,000 (2)			1			0.27	0.1	486,000	$327.54/ac

Assumptions
(1) Buffers on all applicable cropland - 40,000 miles of rural streams x 35ft of buffers (per side) @ 64% (in NLRS scenario)
(2) 1.8mn acres of conventional till eroding >T converted to reduced/mulch/no-till
(3) Cover crops on all corn/soybean tile-drained acres - From NLRS Table 3.6 (.43*(12,412,000+9,132,000))
(4) Cover crops on all corn/soybean non-tiled acres - From NLRS Table 3.6 1-.43*(12,412,000+9,132,000)
(5) 1.6mn acres eroding >T converted to reduced/mulch/no-till
(6) Reducing N rate from background to MRTN on 10% of acres
(7) Spring-only application on tile-drained corn acres
(8) Nitrification inhibitor with all fall applied fertilizer on tile-drained corn
(9) Split application of 40% fall, 10% preplant, and 50% side dress
(10) Split application on 50% fall and 50% spring on tile-drained corn acres
(11) Perennial/energy crops equal to pasture/hay acreage from 1987 - From NLRS page 3-43
(12) Perennial/energy crops on 10% of tile-drained land - 9,706,000*.1 (NLRS table 3.6)
(13) Approximate IL share of Upper Midwest stripcropping
(14) From NLRS Table 3.6 .01*(1-.43*(12,412,000+9,132,000))
(15) Conservation Practice Physical Effects (nutrients in surface water) from https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/cp/ncps/?cid=nrcs143_026849
(16) From COMET-Planner, results from IL
(17) Acres per practice * CO_2 (MT CO_2e per acre per year). Note: Some practices also result in a N_2O change, a greenhouse gas, but given the focus of this report on soil carbon, those emissions are not included here
(18) IL Practice cost data from https://www.nrcs.usda.gov/wps/PA_NRCSConsumption/download?cid=nrcseprd1327812&ext=pdf, where available
(18a) Compost price ($50/ton) * application rate (20 tons/acre)
(19) Upfront cost associated with practice implementation on per acre basis (Low Cost- $0-$203; Medium Cost- $204-$652; High Cost- $653 and up)
(19a) Windbreak/Shelterbelt establishment- ft. converted to ac. Following NRCS job sheet
(19b) Hedge row planting-ft. converted to ac. Following NRCS job sheet
(19c) Alley cropping-each converted to ac. Following NRCS job sheet
(19d) Herbaceous wind barriers-ft. converted to ac. Following NRCS job sheet
(19e) Windbreak renovation-ft. converted to ac. Following NRCS job sheet
(19f) Silvopasture establishment on grazed grassland-each converted to ac. Following NRCS job sheet

Proposed legislation overview

The **State of Hawaii's** Act 033, signed in June 2017, establishes a Carbon Farming Task Force (until 2025) within the Office of Planning that is responsible for identifying agricultural and aquacultural practices that provide carbon sequestration benefits that may be used to provide a carbon farming certification. The Task Force will provide a report with recommendations on proposed legislation, discussion of practices and policies with on-farm greenhouse gas mitigation benefits, benchmarks and criteria for certification, and associated incentives to promote the identified activities.

The **New York State Assembly** has introduced Bill 3281, which is currently in Committee on Agriculture, to establish carbon farming tax credit to reward and incentivize farmers to maintain or adopt practices that help maximize NY's carbon sequestration potential. Quantification and certification should occur via USDA's COMET-Farm and COMET-Planner tools as determined by the commissioner of Environmental Conservation. Department of Environmental Conservation should also cooperate with the Department of Agriculture and Markets to develop educational materials to promote carbon farming and use of quantification tools.

The **Vermont State Senate** has introduced Bill S43, which is currently in Committee on Natural Resources, to establish a Regenerative Soils Program. The program would be implemented by the Agency of Natural Resources to encourage landowners, including farmers engaged in conventional farming, to transition to regenerative soil practices and implement certification to give regenerative farmers and landowners the opportunity to be certified as a regenerative, soil-building, carbon-sequestering, watershed-cleaning property. The bill also calls for the creation of the position of the Director of Regenerative Soils, charged with administering the Regenerative Soils Program, creating policies and programs to help conventional farmers transition away from dependency on tillage and chemicals and to regenerative, soil-building practices, and creating policies and programs to incentivize regenerative farmers to continue their work. The Regenerative Soil Fund from certification payments will fund the Regenerative Soil Program.

In May 2017, **Maryland's** House Bill 1063 was signed into law. It established the Maryland Healthy Soils Program. The program administered by the Maryland Department of Agriculture is to encourage adoption of healthy soil practices through research, education, technical assistance, and financial incentives, subject to available funding. The state has not yet identified funding sources to provide financial assistance to farmers to implement farm management practices that contribute to healthy soils.

The **Massachusetts** legislature is considering Bill H3713, that would create a Massachusetts Healthy Soils Program, similar to that of Maryland and California. The program would be administered by the state's Department of Agricultural Resources to "enhance the education, training, employment, income, productivity and retention of those working or aspiring to work in the field of regenerative agriculture" and develop a basis for further incentives in the future. The bill is currently referred to the Joint Committee on Environment, Natural Resources and Agriculture. There is currently no specified source of funding to implement the program.

California's Healthy Soils Initiative, established in 2016 to help achieve the state's greenhouse gas emissions reductions through carbon sequestration in and on natural and working lands, is a collaboration of state agencies and departments, led by the California Department of Food and Agriculture (CDFA). The Healthy Soils Initiative's goal is to promote the development of healthy soils on California's farm and ranchlands. In fiscal year 2016-2017, California's budget appropriated $7.5 million to develop and administer a new incentive and demonstration program through the Healthy Soils Initiative supported by the Greenhouse Gas Reduction Fund. Applications for implementation and demonstration projects (3 year timeline) were due in September 2017 with awards announcements scheduled for December 2017.