DIVERSIFYING AGRICULTURE IN THE MIDWEST

By

Sarah Bellaire

A practicum submitted
in partial fulfillment of the requirements
for the degree of
Master of Science
School for Environment and Sustainability
in the University of Michigan
August 2021

Practicum Advisor:
Professor Jennifer Blesh

Abstract

Conventional agricultural practices prioritize yield over other ecosystem services, resulting in large monocultures with high synthetic inputs. This type of farming leads to many negative environmental externalities. As this is not sustainable, alternatives are being sought. Diversified agriculture is an alternative, holistic farming framework that prioritizes increased functional biodiversity which supports ecosystem services on the farm. An extensive literature review was conducted on common diversified agricultural practices and their related ecosystem services, culminating in a matrix detailing the number of ecosystem services each practice supported. To better understand how these practices were supported by popular conservation programs within the Farm Bill, an analysis of contract data for the Environmental Quality Incentives Program (EQIP) was conducted in three states in the Midwest. It was found that diversified conservation practices receive only a fraction of the total funding for EQIP. Interviews were conducted with Natural Resources Conservation Service (NRCS) officers who oversee these programs to understand their perspective on diversified agriculture and its lack of funding. Interviews showed that many NRCS officers struggle to depart from the agency's conservation framework when engaging with the concept of diversified agriculture. In the context of the new Climate Smart Agriculture initiative from the Biden Administration, there may be a window to increase salience and adoption of diversified agricultural practices, but under the guise of carbon sequestration, an ecosystem service that many diversified agricultural practices support.

Table of Contents

Introduction	**4**
Project Goals	**5**
Literature Review	**5**
Definitions of Commonly Studied Diversified Farming Practices	**6**
Farm Bill Programs	**9**
Data	**11**
Interview Methods and Locations	**19**
Interview Results	**21**
New Policy Direction	**27**
Conclusion	**29**
Appendix	**30**

Introduction

Over the past 150 years, food production and the policies that shape it have shifted toward a yield-centric model. The result has been agricultural simplification, resulting in today's large monocultures of commodity crops, primarily corn and soybean. This shift was driven by federal policy and subsidies and increasing concentration in globalized supply chains and markets. Conventional agriculture, which emphasizes yield above other goals, sustains production in monocultures through use of synthetic inputs. This has resulted in degraded soil, polluted waterways, erasure of habitat for wildlife, and a general decline in the health of surrounding ecosystems.

Simplified production systems are unsustainable given projected population growth, changing climate and extreme weather events, and degraded soils. An alternative approach to agriculture which considers crop production alongside ecosystem and planetary health is agroecology. By combining farmer knowledge with knowledge from the disciplines of agronomy and ecology, food can be grown in an ecological beneficial way, while maintaining or increasing yields. The concept of diversified farming systems, a component of the broader framework of agroecological management, has a specific focus on managing and conserving biodiversity. **Diversified agriculture is defined as a farming system that increases functional biodiversity at multiple spatial and/or temporal scales to reduce use of synthetic inputs and restore ecological interactions that support ecosystem services.** Diversified agriculture at its core, then, focuses on increased biodiversity. This can be spatial diversity (in field, edge of field, belowground), or temporal diversity (diverse crop rotations, winter cover crops). It is via this commitment to managing biodiversity (in combination with changes to related management practices that indirectly affect diversity) that diversified farming systems (DFS) are able to provide a wider array of ecosystem services compared to low-diversity crop rotations.

Ecosystem services are the suite of benefits that healthy ecosystems provide to society, including regulating, supporting, cultural, and provisioning services (*Tamburini et al. 2020*). While many ecosystem services have declined because of conventional agriculture practices, one of the underlying goals of diversified agriculture is to restore these services. Key services for farming systems including nutrient cycling and retention, water infiltration and retention, soil erosion control, pollination, and weed, pest, and pathogen reduction. For example, by increasing carbon and nitrogen inputs to soil through the use of cover crops, farmers are able to fertilize their land using natural ecosystem processes like nitrogen fixation and decomposition. Managing crop diversity to build soil fertility lessens the need for excessive use of synthetic fertilizers, which leads to many negative environmental externalities, such as water pollution and eutrophication, and greenhouse gas emissions. A recent global synthesis of research on DFS found that, on average, they can provide the same yield as conventional systems while providing at least one other ecosystem service, such as decreasing synthetic inputs (*Tamburini et al. 2020*).

An important insight from ecological research is that realizing different (or multiple) ecosystem services often depends on the presence of functional diversity, specifically. Functional diversity

highlights the different and complementary traits, and associated “benefits,” that different organisms bring to the table. Rather than simply increasing species diversity, adding new functional groups of crops (e.g., legumes and grains, perennials and annuals, harvested and non-harvested crops) is more likely to substantially increase multiple ecosystem services. For example, while planting multiple corn cultivars in a field may be beneficial compared to just one variety, a grain rotation that includes a legume cover crop or forage crop (which can fix nitrogen) will lead to even greater ecosystem services. Although researchers have identified some general principles of diversified agriculture, such as the importance of increasing functional diversity, diversified farming is also context dependent, requiring farmers to manage more ecological complexity compared to conventional agriculture rotations and management. DFS are not amenable to a “one size fits all” management approach. To practice diversified farming to its highest capacity (i.e., for realizing the greatest ecosystem benefits) thus requires in-depth knowledge about the land and ecological principles.

In addition, DFS are typically characterized by the integrated use of multiple, complementary diversification practices. For example, while an overwintering cover crop represents an important increase in crop diversity, a farm could provide a wider range of services if cover cropping is combined with other diversification practices, such as a more complex crop rotation, intercropping, or diversification of habitats on the edge of fields. Diversified agriculture is complex, and our definition in this project aims to capture a myriad of practices that have been developed to increase crop diversity across scales.

Project Goals

This project was conducted in partnership with the National Wildlife Federation and commissioned on their behalf to provide an in-depth overview of diversified farming, where it occurs, and to assess the potential for accompanying policy levers. Below are the guiding research questions that shaped the scope and content of this practicum and report:

1. What are the current funding mechanisms within the Farm Bill Conservation Title that incentivize diversification practices?
2. Which diversification practices balance the optimization of ecosystem services and feasibility of farmer adoption?
3. Are there administrative barriers or hurdles to implementing diversification practices within the Natural Resources Conservation Service (NRCS)?

These research questions translated into 4 main tasks of the practicum: A literature review of DFS practices, selection of case study locations within the Midwest for detailed analysis, analysis of Farm Bill program participation data, and interviews with NRCS officers.

Literature Review

To begin answering these questions, we first summarized foundational knowledge of diversified agriculture practices and their associated ecosystem benefits. An in-depth literature review was

conducted to examine 7 common diversified farming practices and document their associated ecosystem services. Based on saliency and NWF preference, the diversified farming practices reviewed were: Intercropping, Complex Crop Rotations, Cover Crops, Cultivar Mixtures, Agroforestry, Non-crop Plantings, and Integrated Crop & Livestock Systems. This review did not focus on no-till or reduced tillage, which have indirect, rather than direct, effects on biodiversity

These DFS practices were evaluated for evidence of providing 10 different ecosystem services. The ecosystem services considered were: Weed, Pest, and Disease Reduction, Synthetic Fertilizer Reduction, Water Quantity and Quality, Nutrient Management and Soil Heath, Soil Retention, Carbon Sequestration, Pollination, Energy Efficiency, Climate Change Resilience, and Yield. The following section presents a high-level summary of the literature review findings, including both an overview and paragraph for each DFS practice.

These diversified farming practices are meant to be tailored to a specific piece of land and management plan. Many meta-analyses (i.e., quantitative syntheses of multiple experiments) have shown overall positive benefits associated with these practices with increased ecosystem services and yields equivalent to simplified systems. However, there are cases where yields have decreased. Though generally positive in their ecosystem benefits and yield stability, the exact outcomes of diversification practices will depend on the system deploying these practices and the combination of practices they undertake.

In a recent meta-analysis, *Tamburini et al. (2020)* summarized all DFS meta-analyses to date and found the current scientific literature on this topic to be increasing in frequency and interest, but still lacking in assessment of some specific ecosystem services. They found that pollination and pest management were underrepresented in comparison with the other services, with nutrient cycling being highly researched and represented.

Definitions of Commonly Studied Diversified Farming Practices

Intercropping: The practice of planting two or more different crops in alternating rows. There are many different types of intercropping including mixed, row, strip, and relay.

Intercropping is largely practiced in developing countries and by small scale farmers. It is not common in the United States because of a lack of appropriate equipment (e.g., for planting and harvesting). Small scale farmers, which rely heavily on hand, rather than mechanized, labor are more likely to pursue this practice. In a meta-analysis of 33 intercropping studies (*Raseduzzman & Jensen 2017*), no studies were from the United States and only one study was from Canada. Currently, intercropping is most commonly practiced in China and regions of Africa. Combinations of crops with contrasting traits can have synergistic effects on nutrient cycling, access to scarce soil nutrients, and crop nutrient and water uptake. Intercropping can also reduce pest pressure through multiple ecological mechanisms such as increasing the population of natural enemies of pests.

On average, crop yields tend to be higher in intercropping systems, especially for cereal grain and legume intercrops, which have strong functional complementarity (*Raseduzzaman & Jensen 2017).* Intercropping is also beneficial for increasing farm resilience to climate change, as it is often practiced in developing countries and can increase yield stability (*Raseduzzaman & Jensen 2017*).

Complex Crop Rotations: Planting one or more harvested crops in succession to produce a rotation.

Crop rotations can increase yields, protect against disease, and maintain soil health. Crop rotations that include a legume crop also provide the benefit of increasing soil nitrogen, which generally leads to higher yields (*Robertson & Vitousek 2009*). In the Midwest, the most common crop rotations are corn and soybeans or corn, soybeans, and wheat. Greater diversity in crop rotations generally leads to lower weed densities and higher water quality in surrounding waterways as compared to a monocrop system.

Crop rotations with legumes have been found to utilize up to 25% more water in controlled experiments over conventional systems (*Lotter et al. 2003)*. This suggests that crop rotations including legumes could improve climate resiliency in certain areas as water use becomes more precious. Complementary crops decrease the amount of synthetic fertilizer needed, and experiments have shown that diverse crop rotations reduce freshwater toxicity by two orders of magnitude (*Davis et al. 2012, Sanderson et. al 2013*). In a meta-analysis, 21 studies out of 27 had decreased weed density with more complex crop rotations (*Liebman & Dyck 1993*). When adding a perennial crop to rotation, 80% of survey respondents reported weed reduction (*Entz et al. 1995).* Other studies have shown that including perennial crops in rotations also builds soil organic carbon (SOC) as compared to annual grain rotations (*Zan et al. 2001*, *King & Blesh 2018).*

Cover Crops: Generally defined as any non-harvested crop planted to cover bare ground; typically grown in periods between harvested crops in a rotation.

Cover crops can be defined by two main functional categories: legume and non-legume. Common legume cover crops (also called green manures) include hairy vetch, clover, field bean, and pea varieties. Legume cover crops are used as natural fertilizers, as they can increase soil nitrogen availability through biological nitrogen fixation (*Blesh 2019*). Grass cover crops (or catch crops) scavenge soil nutrients, prevent soil erosion, and reduce weed and pest pressure (*Schipanski et al. 2014*). Cover crops have been used for centuries (*Meisinger et al. 1991*) and are gaining favor again as a popular conservation practice in the Midwest due to their easy to adopt nature and potential for providing multiple ecosystem services (e.g., by planting mixtures of complementary species; *Finney & Kaye 2016, Blesh 2018*).

While providing a myriad of benefits, especially reductions in nitrate leaching losses to surface and groundwater (*Tonitto et al. 2006*), it is not clear if cover crops reduce N_2O emissions. This uncertainty comes from the high spatial and temporal variability of gaseous nitrogen emissions,

and their complex ecological drivers. Other factors such as specific cover crop management practices, and whether N_2O fluxes are measured during cover crop growth or following termination and decomposition will influence the outcomes (*Han et al. 2017*). It is currently thought that non-legume cover crops managed using no-till methods have the greatest potential to reduce N_2O emissions. This is an obvious trade off, as legume cover crops provide a nitrogen input through fixation.

Cultivar Mixtures: Planting different genetic variants of the same species in a field

Cultivar mixtures are a relatively easy diversified farming practice to adopt due to the limited behavioral change needed by farmers. Cultivar mixtures have historically been used in grain cropping systems and can increase resilience to extreme weather events and pests (*Reiss & Drinkwater 2017).* Cultivar mixes have been shown to reduce crop loss from disease by up to 94% in rice cultivars and 80% in barley (*Zhu et al. 2000, Vallavielle-Pope 2004*). A few studies have also shown that cultivar mixes reduce water consumption, however there has been no meta-analysis on this topic (*Song et al. 2010, Adu-Gyamfi et al. 2015*).

Agroforestry: The incorporation of trees into cropland. There are many different kinds of agroforestry including alley cropping, windbreaks, edible forests, and silvopasture.

In general, agroforestry supports a unique habitat for many species that a typical conventional agricultural field does not, due to the incorporation of trees and woody plants. When combined with other non-crop plantings, agroforestry is highly beneficial in terms of water quality and nutrient retention. One study found that riparian buffers that included both woody plants and switchgrass were 20% more effective at capturing nutrients than just switchgrass alone (*Lee et al. 2003*). Alley cropping, where grain or horticultural crops are grown between rows of trees or shrubs, has been shown to promote soil nutrient cycling and retention. In an experiment with cotton, when cotton was alley cropped with pecan trees the soil had higher SOM than mono-fields of cotton (*Lee & Jose 2003*).

Non-crop Plantings: Any planting of vegetation that is not harvested, such as insectary strips, hedgerows, or riparian buffers.

This increased wildlife habitat leads to pollination services, pest reduction, as well as nutrient and soil retention. Non-crop plantings have been shown to increase natural predators for pests, while not increasing actual pest populations (*Isbell et al. 2017*). Riparian buffers can reduce pollution from row crop production (*Udawetta et al. 2002*). One of the greatest benefits of non-crop-planting is the increase of pollinators, especially non-managed pollinators, which farmers usually need to pay to bring in (*Potts et al. 2009, Kremen et al. 2007, Garibaldi et al. 2014*).

Integrated Crop & Livestock: Having both crops and livestock within the same farming system.

Integrated crop-livestock systems have many benefits, although there can be an increased risk of excessive or mismanaged manure, which can lead to increased nitrogen and phosphorus

runoff and exacerbate water pollution (*Russelle et al. 2007, Saam et al. 2005).* Integrated crop and livestock systems can reduce water usage. In a study in Texas, there was a 25% reduction in water use in a cotton-forage-cattle system compared to a cotton monoculture, while also reducing soil erosion (*Allen et al. 2007*). However, cattle can also increase soil compaction (*Sanderson et al. 2013).* There are also large potential benefits to nutrient building and retention with the addition of cattle, and more specifically their manure, to farming systems. For instance, land that had been depleted of soil carbon was restored to 90% of its original carbon stock after incorporating pasture for 9 years (*Romkens et al.1990).*

The table below depicts the ecosystem services associated with each practice.

DFS Practice ➡ Ecosystem Services ⬇	Intercropping	Complex Crop Rotations	Cover Crops	Cultivar Mixtures	Agroforestry	Non-crop Plantings	Integrated Crop & Livestock
Weed, Pest, and Disease Reduction	X	X	X	X	X	X	X
Synthetic Fertilizer Reduction	X	X	X				X
Water Quantity & Quality			X	X	X	X	X
Nutrient Management & Soil Health	X	X	X		X	X	X
Soil Retention		X	X		X	X	X
Carbon Sequestration			X		X	X	X
Pollination	X	X	X		X	X	
Energy Efficiency	X	X	X		X	X	
Climate Change Resilience	X	X	X	X	X	X	X
Yield	X	X	X	X	X	X	X

Adapted from Kremen & Miles 2012: http://dx.doi.org/10.5751/ES-05035-170440

This table highlights that certain DFS practices support more ecosystem services than others. For instance, agroforestry supports almost all of the ecosystem services reviewed, whereas cultivar mixtures only support a few.

Given their potential to restore ecosystems degraded by simplified production systems, in the following sections we seek to understand if these diversification practices - especially the ones that support a greater number of ecosystem services - were included in the Farm Bill or other government programs that provide funding for environmental conservation.

Farm Bill Programs

After synthesizing the latest scientific literature on diversified farming practices of interest, the next step of this project was to understand the policy landscape surrounding conservation in the United States. Although the federal government heavily subsidizes corn and soy production, it also supports the conservation of working lands via technical and financial assistance. Understanding these programs is central to addressing Research Question #1: “What are the

current funding mechanisms within the 2018 Farm Bill Conservation Title that incentivize diversification practices?”.

The Farm Bill, an omnibus bill renewed every 5 years, has become a tenant of agricultural and nutrition program legislation since its origin in 1933. With the political support of both parties due to the unique interests in the bill, it has grown into a behemoth and politically has proven difficult to slim. The Conservation Title (II) was created in 1985 and had moderate increases in funding starting in the early 2000s, which leveled off in 2018. The 2018 Farm Bill has a mandatory spending budget of $428 Billion, with the Conservation Title receiving 7% of this total, or about $29 Billion over the course of 5 years.

At its origin, the Conservation Title was focused on protecting or regenerating land via reserves, by taking land out of production in exchange for government payment. In 1996, the title expanded to include programs geared toward “working lands” that did not need to be taken out of production.

The Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP), both working lands programs, are the second and third largest programs by funding allocation within the Conservation Title. The highest funded program in Title II is the Conservation Reserve Program (CRP), illustrating the persisting legacy of conservation reserves in the Conservation Title.

In the working lands programs, landowners receive technical and financial assistance to either adopt new conservation practices that address on-farm resource concerns (EQIP), or to further increase the level of conservation happening on their land (CSP). Landowners enter into contracts with the federal government whereby they agree to implement or improve agreed upon practices in return for federal payments. The two are ideally seen as successional programs, with farmers who have successfully completed EQIP contracts moving on to CSP, though this may be shifting. Due to their origin in the Farm Bill, which is renewed every 5 years, both programs have seen a myriad of changes throughout their history.

EQIP was started under the 1996 Farm Bill and is generally a respected working lands program. The program supports general conservation practices which are broken into funding pools based on land use, but also includes special funding pools for socially disadvantaged and beginning farmers. Contracts can range in duration from one to 10 years, though they are generally about three years. EQIP also oversees special initiatives, which have their own funding pool for a specific practice (i.e. initiative) such as organic farming or high tunnels. The maximum payment for an EQIP contract is $450,000 for the duration of the 2018 Farm Bill. This program received an extra $2.5 billion (over a 10-year time period) in funding in the 2018 Farm Bill, as compared to the 2014 Farm Bill.

CSP started as a pilot program in 2002. It was originally called the Conservation Security Program, and prioritized funding in key watersheds targeted for conservation. It was later rebranded as the Conservation Stewardship Program in the 2008 Farm Bill and expanded to the

entire US. CSP contracts are 5 years in length and provide landowners with yearly payments for continuing or bettering conservation practices on their land. The program has faced a turbulent history of funding cuts and varied support. During the last Farm Bill cycle, the house version moved to completely eliminate the CSP program, instead incorporating some aspects into EQIP. CSP was cut by $3.6 billion (over a 10-year time period) as compared to the funding levels in the 2014 Farm Bill. The 2018 Farm Bill ended up reducing enrollment size in CSP, while adding a Conservation Incentives Contract (CIC) option under EQIP. CIC has contract lengths of 5 years and has a two-tiered payment structure, first for adopting the practice and second for maintaining it. This is largely seen as a combination of EQIP and CSP programs, potentially forecasting continual political battles over the future of CSP.

The NRCS has a list of over 160 approved conservation practices that landowners can elect through EQIP or CSP. As of the last Farm Bill, there are currently 18 new potential practices being considered. We conducted a review of the current practices to identify which practices are potentially compatible with the definition of diversified agriculture. This subset of practices was divided into two categories: in-field diversity and edge of field diversity. In-field practices were given a priority and were the focus of further analysis. Specific conservation practices of interest were: Alley Cropping (311), Conservation Crop Rotation (328), Cover Crop (340), Critical Area Planting (342), Herbaceous Wind Barriers (603), Prescribed Grazing (528), Strip Cropping (585), Multi-Story Cropping (379), Range Planting (550), Silvopasture (381), and Contour Orchards & Other Perennial Crops (331).

Even though a landowner may apply for a specific practice or a range of practices, there is no guarantee that they will get funded. A primary complaint of the programs is the limited funding compared to the high demand. The goal of the conservation practices is to improve upon a resource concern on the land, such as low soil fertility. A landowner will work with the local NRCS district conservationist to select an array of practices that they feel comfortable initiating, and which would address their resource concern(s). This application is then internally ranked by USDA's Conservation Assessment Ranking Tool (CART) and given a score. These scores, compiled from all the applications from the local offices, get sent to the state NRCS office, where funding is delegated to the highest scoring applications in each funding pool until the funding runs out. The state office does not see which practices are within each contract; all it sees are the scores.

Data

In an effort to address Research Question #3: “Are there administrative barriers or hurdles to implementing diversification practices within NRCS”, we selected the Midwestern U.S. as a region of focus due to its high agricultural productivity and variability of diversification efforts. Specifically, three states were selected: Michigan, Iowa, and Indiana. Michigan was selected due to its high variability of agricultural products, Iowa because of its high percentage of conventional production of corn and soy, and Indiana due to its high adoption of cover crops. Indiana also falls on a gradient between Michigan’s high diversity of cropping system types and Iowa’s vast monocultures of corn and soy. To further examine the identified DFS conservation

practices in our selected study area, county-level contract data on EQIP and CSP was requested via the Freedom of Information Act (FOIA) from the USDA NRCS for all three states. National Agricultural Statistics Service (NASS) Ag Census data were also examined for conventional farming baselines, the number and acreage of existing farms, and other supplemental information.

To understand these practices and their prevalence within these states we took a two-pronged approach. First, we analyzed data across states to identify which counties had the highest level of in-field diversification practices. States were also analyzed by county for both percentage of corn and soy acreage in relation to total cropland acreage. Second, counties with a high percentage of DFS conservation practices were compiled for potential interviews with their district conservationists. To further understand the nature of these practices and why there was such a high variability of uptake, we sought to talk directly to NRCS officers at the state and local level to understand more about their process of supporting conservation practices in their counties.

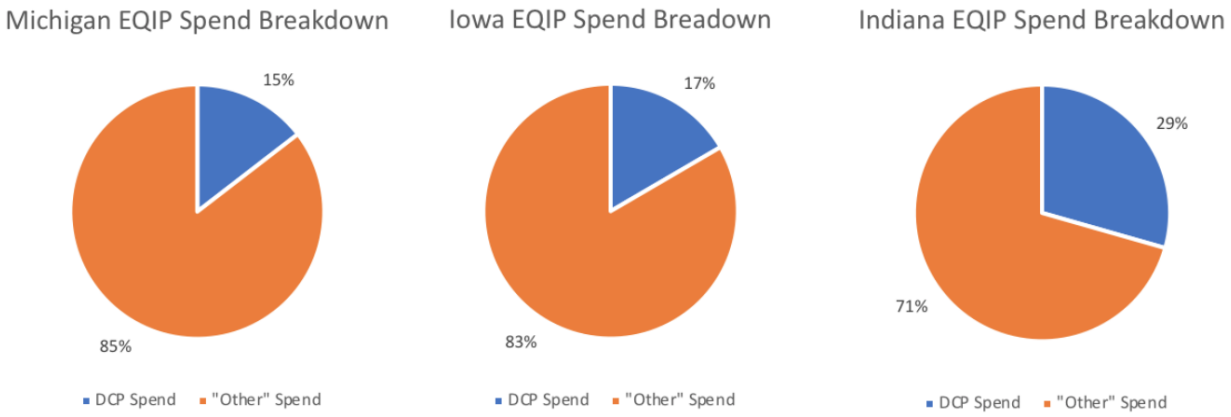
The data provided for EQIP at the county level was granular, including practice code, payment amounts, and sometimes acreage. The CSP data on the other hand was coarse, with many contracts lumped under the general category of “crop land annual payment” or “pasture land annual payment” with other contracts specifying “cover crops”. Due to this inconsistency, CSP data was not analyzed as part of this project, though is available for further study. Another drawback to the dataset is the absence of farmer or contract identifiers. This protects privacy but prevents analysis on the retention of landowners in the programs. EQIP and CSP contracts often include multiple practices. Given the way the data are organized it is not possible to identify which contracts are indeed individual practices, versus those that should be grouped into one contract, because all of the data are presented as individual practices (i.e., contract components). Without landowner or contract IDs to reference, this is impossible to distinguish. Connecting practices to specific farms is an important future research need that would help inform our understanding of how landowners utilize these practices in combination with each other, or which practices are often elected individually.

EQIP data was provided for both completed and active practices from 2005-2026 for Indiana and Iowa, with some planned contracts for Michigan spanning until 2030. Only 21 practices were listed for 2027 to 2030 with none of them constituting our list of Diversified Conservation Practices (DCPs). To give a complete picture of the funding history of DCPs over the past 15 years, we decided to examine the data from 2005-2020 only, with a caveat that 2020 practice numbers and funding might be lower because of COVID, which is evident in the graphs below.

Data on total EQIP funding for all practices was also analyzed from the same dataset to better understand the history of total EQIP funding compared to the funding levels for diversified conservation practices. Below is a chart detailing these ratios for all three states:

	Total # of EQIP practices funded (2005-2020)	Total funding amount for all practices (2005-2020)	Total # of DCP practices funded (2005-2020)	Total funding amount of DCP practices (2005-2020).
Michigan	34,599	$195 Million	5,684	$28.4 Million
Indiana	68,856	$223 Million	16,018	$65.6 Million
Iowa	87,284	$301 Million	21,313	$50 Million
Total	190,739	$718 Million	42,833	$144 Million

These numbers show that DCPs make up a small fraction of the total practices funded by EQIP, suggesting that even though these practices have demonstrated ecosystem benefits, they are not prioritized based on total funding allocated. DCP funding percentages range from 15% to almost 30% of the total amount spent on EQIP practices. The pie charts below further illustrate the DCP funding percentages in comparison to all other EQIP practices per state over the 2005-2020 timeframe.



We then examined the funding allocation breakdown within the diversified conservation practices. These data show a stark imbalance of funding, with over 85% of going to cover crops in all three states. The chart below compares the total number of DCPs funded to the number of cover crop practices funded.

	Total # of DCP practices funded (2005-2020)	Total funding amount for DCP practices (2005-2020)	# of Cover Crop (340) practices funded (2005-2020)	Total funding for Cover Crops (2005-2020)
Michigan	5,684	$28.4 Million	3,647	$26.3 Million
Indiana	16,018	$65.6 Million	13,930	$63.7 Million
Iowa	21,313	$50 Million	13,939	$42.3 Million
Total	42,833	$144 Million	31,516	$132.3 Million

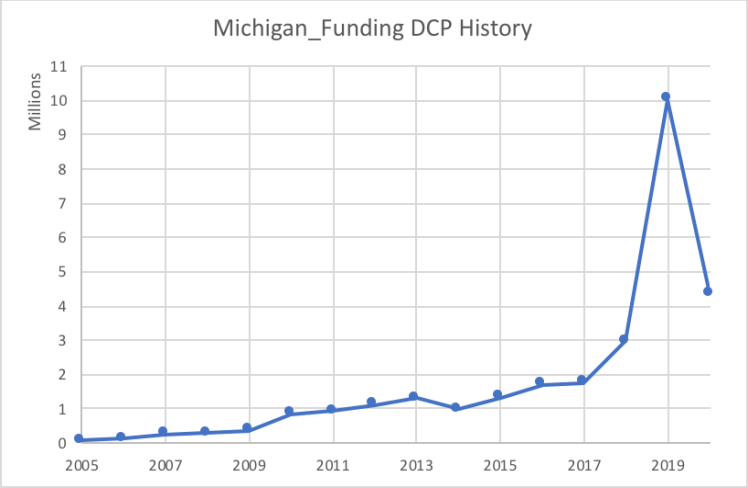
As this chart shows, cover crops on average make up almost 90% of the total DCPs funded across all three states. While cover crops do support a wide range of ecosystem services, they overshadow other practices and systems that could be adopted to further promote the overall ecological health and functional biodiversity of a farming system. Below is a breakdown of the funding and number of contracts allocated to the remaining DCP practices, excluding cover crops (top funded).

Total funding per DCP across all states, omitting cover crops (2005-2020):

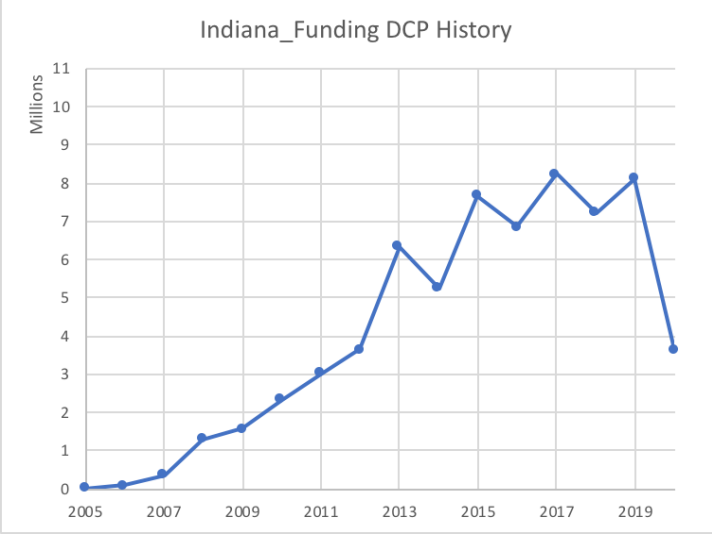
	Total Number Contracts	Total Funding Allocated
Prescribed Grazing (528)	4,526	$6 Million
Conservation Crop Rotation (328)	1,587	$4 Million
Critical Area Planting (342)	4,917	$1.4 Million
Strip Cropping (585)	35	$72,657
Range Planting (550)	1	$25,800
Alley Cropping (311)	4	$11,309
Silvopasture (381)	9	$9,997
Herbaceous Wind Barriers (603)	3	$1,826
Multi-Story Cropping (379)	-	-
Contour Orchards & Other Perennial Crops (331)	-	-

We also analyzed the overall funding trends for DCPs over time, to determine if funding has increased, decreased, or remained stagnant. This data is shown by state over the same 15-year time period (2005-2020). It is important to note that the trend of increased funding is likely driven

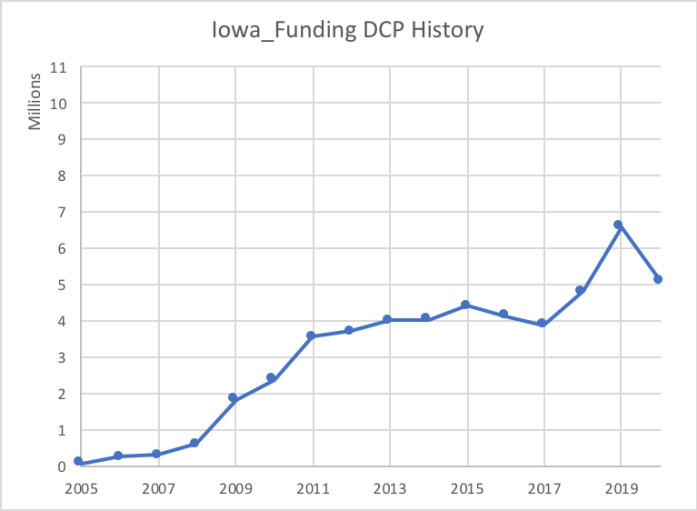
by increased adoption and promotion of cover crops, given that they comprise at least 85% of all three states' total DCP spending.



Michigan's DCP funding remained low between 2005 and 2017 compared to Indiana and Iowa. Funding levels spiked after 2017 and then dropped sharply in 2020. This is constant across the three states and can largely be attributed to the shocks of COVID-19.



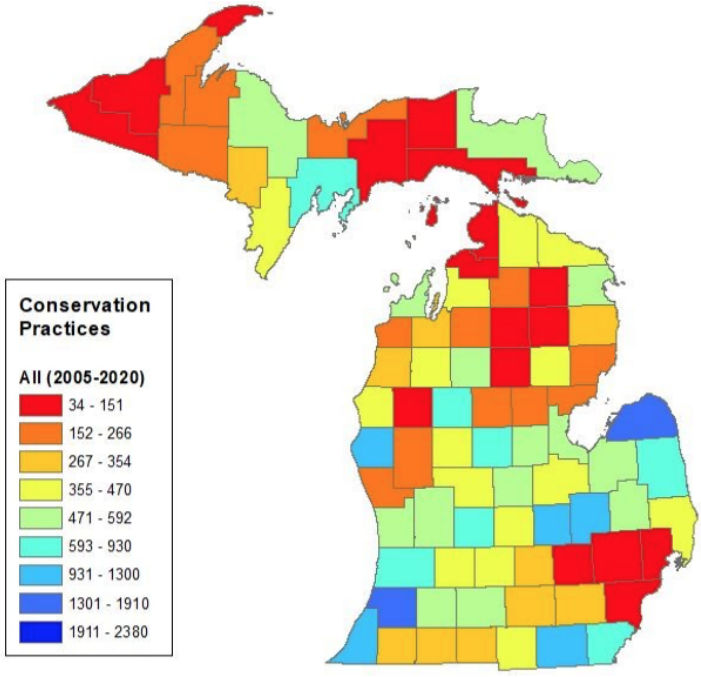
Indiana had steady growth in DCP funding from 2006 until 2012, where large jumps and partial declines in funding began, with an overall increase until about 2017-2019 where it appears that funding levels will hold steady. Again, the drop in funding in 2020 is evident.



Iowa had much steadier growth in funding DCPs over time than both Indiana and Michigan. Funding remained steady from 2011 until 2017, when DCP funding increased by almost 2 million dollars. The drop in 2020 funding was not as sharp for Iowa as it was for the other states. This could be due to pre-existing contracts or potential shut-down measures that were not taken in Iowa.

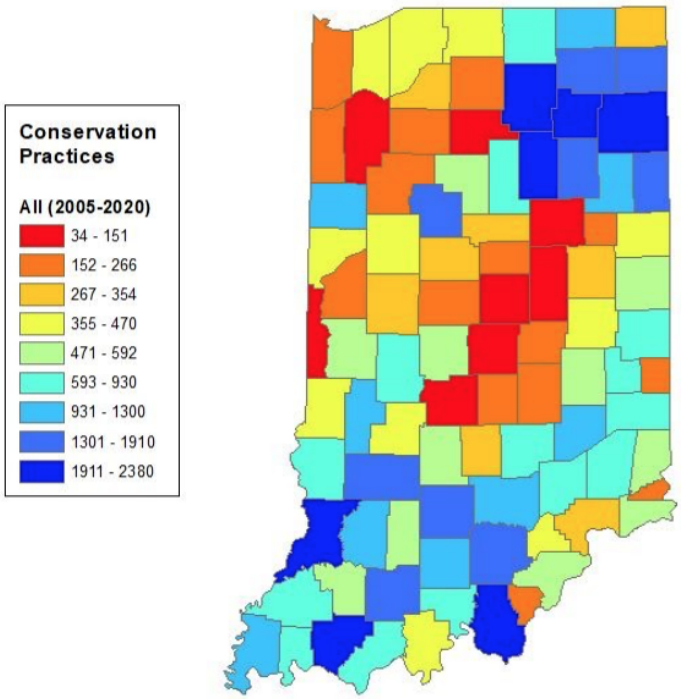
Another way to visualize the frequency and therefore funding levels of DCP, is to map the practices contracted by county. Below are county-scale maps for all three states for both total EQIP practices and specifically for DCP practices to identify if there were differences in trends between the total and subset (for 2005-2020).

Michigan Total EQIP Practices per County (2005-2020)



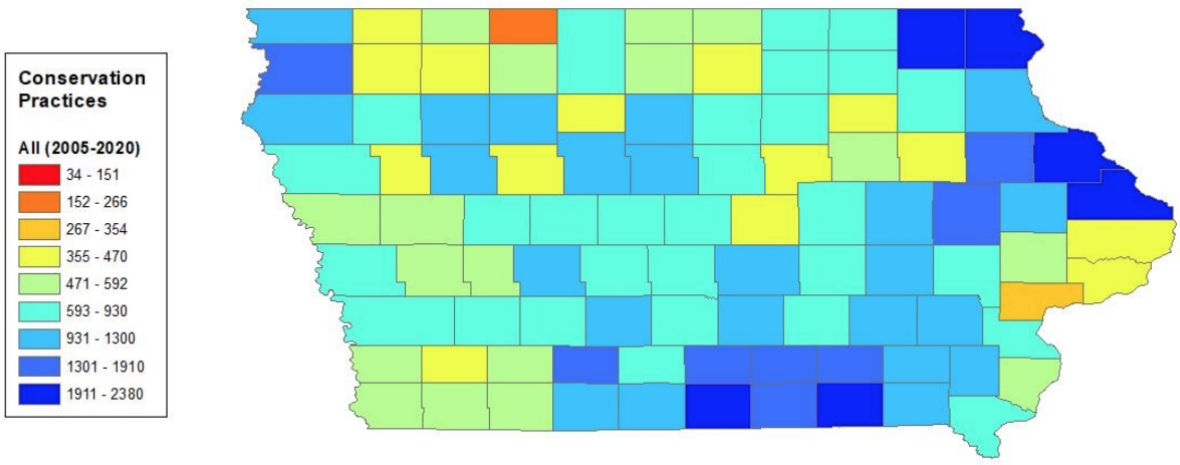
Michigan had a lower % of contracts than both Indiana and Iowa. More practices were contracted in the southern half of the lower peninsula, though a few notable counties in the upper peninsula were in the 400-500 contract range.

Indiana Total EQIP Practices per County (2005-2020)



The majority of Indiana's contracts were clustered in the southwestern tip and northeastern corner of the state.

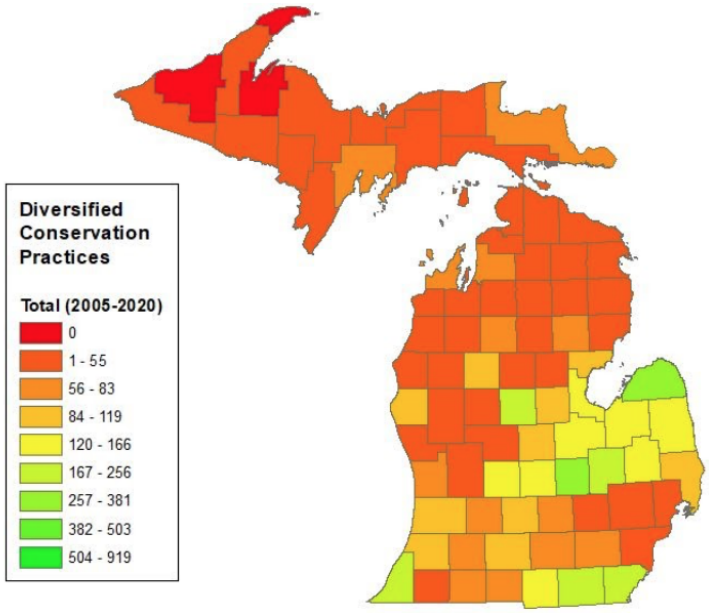
Iowa Total EQIP Practices per County (2005-2020)



Iowa had a much more uniformly distribution of contracts among its counties, with almost no red or orange counties. It is starkly different from both Michigan and Indiana.

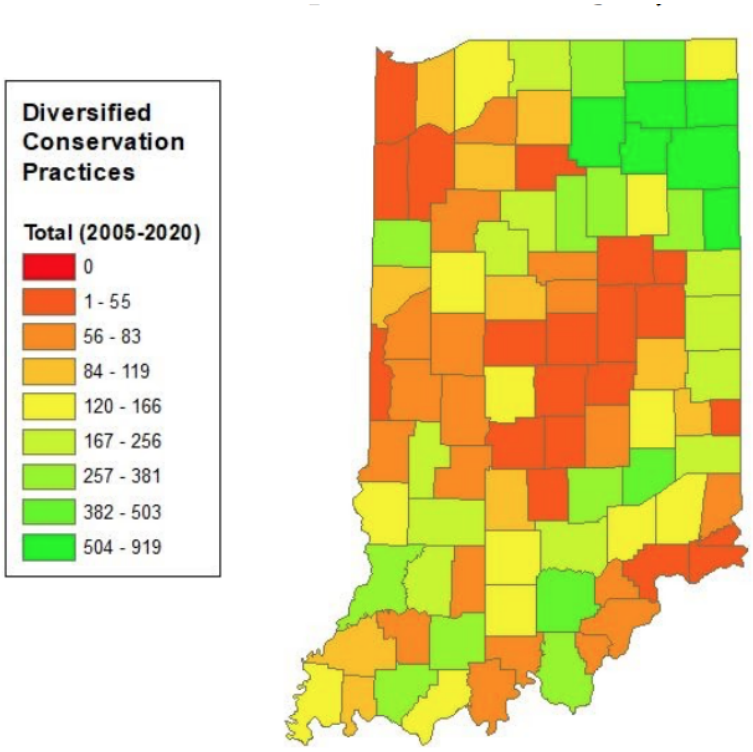
The following maps show the subset of DCPs at the county level from 2005-2020 for all three states.

Michigan Total DCPs per County (2005-2020)

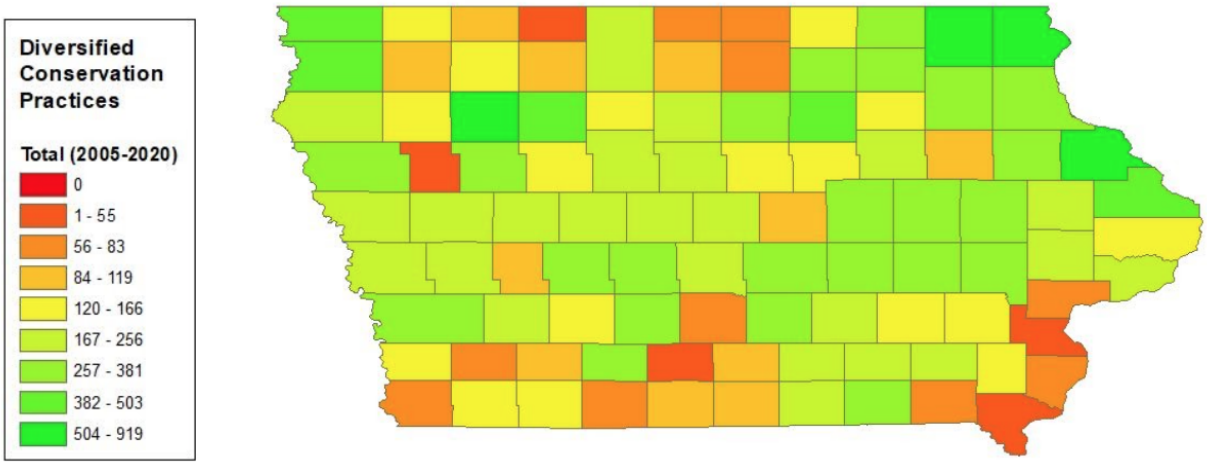


This map shows that Michigan DCPs followed similar trends to overall EQIP practice distribution, with high numbers of DCPs within the thumb, lower western and eastern corner on the border.

Indiana Total DCPs per County (2005-2020)



Iowa Total DCPs per County (2005-2020)



These maps of the subset of DCPs show a similar geographic distribution as the full set of EQIP practices, however at a much lower percentage which was expected due to the spending data.

Interview Methods and Locations

Because NRCS officers oversee both EQIP and CSP implementation on the ground, we conducted interviews to help contextualize the data on program contract history, and to gain a more nuanced understanding of their perceptions of the different diversified conservation practices. District conservationists interact directly with landowners, often making multiple site visits and shepherding individuals through the contract options and eventual obligations if they submit an application and are selected. The state NRCS office is responsible for general program management, educational training for district employees, and most importantly the ranking and allocation of funding for contracts across the state. Though many states, including the three that we focused on, have area offices which serve as an intermediary between state and district offices, we decided that state and district level interviews would serve our purposes best.

We developed a semi-structured interview guide for both state and district conservationists, with some questions edited to reflect a finer level of detail for county level interviews. The primary goal of the interview questions was to further understand how the NRCS perceived diversified agriculture, and if the agency was amenable to and/or supportive of this framework. The interview guide for State conservationists was 15 questions. The District conservation guide had an additional 9 questions focusing on more county-level specifics.

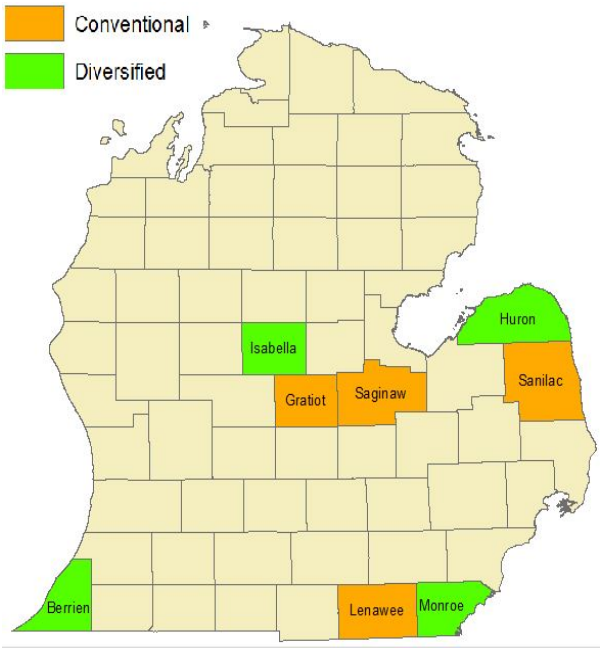
As a matter of decorum, each state conservationist (the highest-ranking position within the state) was contacted to request permission to conduct interviews with a list of employees within

their state office and district offices. Interview guides were also shared and were approved by state conservationists. Following the wishes of the head state conservationist in both Iowa and Indiana and the response rate across those contacted, the majority of district conservationist interviews were conducted in Michigan.

14 interviews were conducted in the Winter of 2021. Requests were made by email, with two reminder emails being sent before abandoning the targeted interviewee. Interviews were conducted over Zoom or via phone. They ranged from 30 minutes to 2 hours in length, with the average being about an hour. There were 5 interviews conducted at the state level: 1 in Michigan, 2 in Iowa, and 2 in Indiana. There were 9 interviews conducted at the district level: 7 in Michigan and 2 in Indiana.

While we made an effort to ask all of the interview questions on the guide, sometimes time was a barrier for getting through all questions. Often interviews inevitably took on their own unique tones, with each interviewee digressing to emphasize what they wanted to discuss or were most interested to convey. Often interviews achieved a comfortable tipping point, where the conservationist would begin to relax and start to speak more freely.

For the Michigan analysis, the goal was to select 4 pairs of counties that represented similar agricultural profiles but had differences in diversified farming practice uptake. Within the pair one county was considered more “diverse” due to the high number of EQIP contracts with diversified conservation practices that we had identified, while the other county was deemed more “conventional” due to its lack of EQIP contracts with diversified conservation practices and high percentages of corn and soy production. Special preference was given to “diversified” counties that had high numbers of DCPs aside from cover crops, because NWF was especially interested in understanding these other overshadowed practices. However, because cover crops are a popular conservation practice, it inevitably came up multiple times during interviews at both the state and county level. Because these county pairs were clustered geographically and had similar baseline farming conditions, we hoped that district conservationist interviews would highlight why such a difference in diversified conservation practices existed. In an effort to ensure interviewing at least 3 county pairs, 5 potential pairs were identified, and interview requests were sent to the 9 district conservations who oversaw those counties (one DC oversaw 2 counties). 7 district conservationists responded, resulting in 3 complete county pairs and two solo counties (one diversified and one conventional). The pairs are below:



Sanilac (C) - Huron (D)*
Gratiot (C) - Isabelle (D)
Lenawee (C) - Monroe (D)

**Could be considered both diversified and conventional*

Incomplete Pairs:
Berrien (D) - ~~*Branch (C)*~~
Saginaw (C) - ~~*Genesee (D)*~~

Interview Results

One potential factor that may impede conservation adoption and therefore DCP adoption is the general work environment of the DCs. The vast majority of DCs at some point in the interview expressed that they were overworked. This ranged from side comments, to full discussions of their workload. This was accompanied by discussions of feeling overwhelmed, scared, tired, accomplished, and enjoyment. Some female DCs reported that sexism in the workplace and from some landowners, make it difficult to do their job effectively.

DCs also tended to move between county offices, with some having worked in multiple states. Given this some DCs had been working in their counties as temporary cover, for only a few years, or upwards of 20 years. There were a fair number of DCs who were also managing two or three counties at the same time when we had our interviews, which could have also contributed to the feelings of being overworked. Nearly all had some sort of farming background or connection: married a farmer, grew up on a farm, just started a farm five year ago, etc.

Conservation vs. Diversified Agriculture

While conducting the interviews, one of the quickest realizations was that diversified farming was not a construct that the NRCS operated within. This may seem obvious in retrospect, but initially we had thought the framework of diversified farming would fit nicely within the priorities of NRCS. NRCS operates within a conservation framing, often focusing on a few key resource concerns to guide their priorities. However, contracts are evaluated based on how the selected practices work holistically to address key resource concerns. This element should supposedly lend itself to the larger DFS framework, but often failed to translate when discussing diversified agriculture with NRCS officers. We categorized three types of responses to the concept of diversified agriculture when it was brought up in the interviews: Aggression, Assimilation, and Separate, but not incompatible. Aggression might be too harsh of a term, but this response categorizes any negative affect toward diversified farming systems, including defending farmers who chose not to diversify, discussing how difficult diversification is, turning the question back around on us, further and repeatedly asking us to define diversified agriculture again, or framing it as something that could not truly be defined. A few interviewee quotes highlight this range including, "*Diversified Ag has potentially lots of definitions, then it can be in the eyes of the beholder*" and, *"So, diversified agriculture can mean different things to different people, so can you clarify for me what you mean when you say diversified".* While not necessarily captured by the stand-alone quotations, we found that after we got an "aggressive" reaction toward diversified agriculture, the tone of the interview would change, with the conservationist being a bit more closed off during the interview or giving sharper replies. After this happened a few times, we changed the way we introduced diversified agriculture, attempting to slowly and gently introduce the concept and present an open-minded and welcoming persona so that our interviewee felt comfortable discussing whatever they thought diversified agriculture was.

The second reaction, assimilation, would sometimes happen after a small bout of the aggressive reaction or happen immediately. Those that assimilated would take the idea of diversified agriculture and simply assimilate it within their conservation framework. However, by doing this, many conservationists missed the true meaning of DFS which is a holistic framework focusing on functional biodiversity facilitating a wide suite of ecosystem services, by assimilating it to a much narrower framework of conservation. The conservation framework seems to focus on one to two ecosystem services and the conservation practices that can help attain these services. Soil health seemed to be the top focus that the Midwest states currently coalesce around. This quote highlights the narrow nature of the conservation framework on soil health, *"But I will say in Indiana, soil health is a very big public health priority for us, and partly because we're an agency that has a history of focusing on soil erosion in the soils...And so if you've heard of soil health, that's really what drives us, focusing on practices like cover crops and crop rotation, because those are maybe two of the most important practices to improving soil health."*

The third reaction to diversified agriculture was "separate, but not incompatible". This response was rarer than the first two, and often manifested in brief moments throughout the interviews, even if they had previously assimilated conservation and diversified agriculture earlier in the interview. The ephemeral nature of this response may reflect that conservationists were just starting to grapple with what diversified farming was and how it related to their conservation

framework subconsciously. In one interview that seemed more aware of the distinction throughout, this quote highlights how they present the two frameworks, *“So the first thing I guess that will pop into my head with diversified ag would probably be, you know, kind of mixing up what the operation has, for example….. If you're looking more conservation wise**,** I'd say a conservation crop rotation would be something you'd look at, prescribed grazing, cover crop, you can throw a multi-species cover crop in there and help with your soil health but also will help with diversified ag.”* In this quote the conservationist clearly distinguishes between conservation and diversification but does not present the two as incompatible. At the end of the quote they relate how the two frameworks could in fact fit together.

Role of the District Conservationist

Given the district conservationists proximity to landowners, and their role in writing and finalizing the contracts, the DCs were also integral to the adoption of different practices including DCPs. First, DCs had differing views on their specific roles within their job. Generally, two distinct types of roles emerged throughout our interviews. First, was the “seller” of conservation. This type of DC thought it was their duty to try and convince farmers to adopt conservation practices, or market specific conservation practices in various ways depending on the landowner. Though this might have been from a training or addressing a specific resource concern, some DCs seemed to almost have favorite conservation practices. These would often come up repeatedly in stories they told, or examples where they were recounting conversations with landowners. The second type of role that district conservations fell into was the “helper”. This type of DC saw their role solely as a resource to the landowner. They were not trying to convince farmers to take on certain practices but were there to provide information about the conservation practices that would best address a landowner’s resource concerns. These roles were not fixed, but perhaps best conceptualized as two ends of a spectrum that most DCs fell between.

For the “seller” of conservation, one interviewee described the dynamic nature of the DC role, “*I would say it’s a bit of an art,*”. Another interviewee described it directly as categorized, “*That’s what I’m here for, is that I am selling conservation*”. Another quote from an interviewee highlights the complex communication skills that DCs often employ, while engaged in the “seller” mindset, *“And the framing is definitely important. And it's like I don't want to say, like, you should be deceitful, but if you can sell your farmer, like this is going to get you three bushel to the acre or more corn and they are like 'heck yeah, I want that!' And if it's also going to benefit soil, if you sell it as, "hey we're going to increase your yields. Plus you're taking better care of your soil' like it's a win for everybody. So really knowing your audience is important. Whatever practice you're selling...like I can tell you about cover crops in six different ways, depending on who I'm talking to.”*

The “helper” role on the other hand, drew clear distinctions with one interviewee saying, *“Everything is voluntary, and nothing is forced on the producer; they decide which practices they want to do based on that conservation plan that the field office comes up with”.* This is a drastic departure from the previous quote highlighting the different ways in which they would try to sell their farmer on different practices, going out of their way to state that they weren’t suggesting deceit of the landowner.

A quote from yet another interviewee highlights the “seller” and “helper” in context of a spectrum. This interviewee said, *“Getting conservation accomplished, it's about developing a relationship and a trust and respect of the people that you work with and that doesn't come easy and it doesn't come quickly sometimes.”* This quote reads more in the context of the DC as a helper but understanding that relationship building is an important part of the trust required for a landowner to make a significant change within their operation.

Conservation Stewardship Program (CSP)

When talking about CSP there were definitely mixed reactions from the conservationists. Some did not express their opinion about the program, sticking to the facts and its structure. Others expressed annoyance and frustration with it. One conservationist said, “*CSP, in my eyes and my other counterpart, is a very difficult program to understand”*. Another echoed this sentiment saying, “*I wish I'd never known CSP in the form it started in. Because I only had to roughly know what was going on with it at that time. I wasn't involved in processing applications and sitting down with producers, but I knew enough to be dangerous, and so, when it came to the point that I was working with it some things had changed it just made it more difficult to work, and it's changed again….”.* The DCs who had been at NRCS a long time had almost all complained about program changes and trying to understand the new versions of both EQIP and CSP but were especially frustrated by CSP. One conservationist talked about how it was hard to contract farmers for CSP, “*I think the biggest, the hardest sell for CSP, for some reason, is the length of the contract. In my experience, it's hard... I mean, farmers are busy in the fall, it's hard to get like a binder of their records so they could get paid, depending on what enhancements they're doing by October 1st. I start reminding them in July. They get so busy!”* While some conservationists might view their job as selling conservation, there was a general understanding of not forcing a farmer into a contract that they could not fulfill. With the duration of CSP being 5 years and the requirements of the practices being very strict, some conservationists worried about farmers not being able to fulfill the contract and be in a position where they would need to pay NRCS back their contract amount.

However, many conservationists suggested CSP as a good program to further promote diversified agriculture, due to the nature of the program. One conservationist talked about the flexibility within the program, “*I think CSP definitely has more potential to help diversify ag. With EQIP identifying just existing concerns, CSP has more wiggle room. More options that could fit*.” Another conservationist detailed how conservation efforts can be amplified by CSP, “*But through CSP if they're going to step up the level of the conservation, so let's say, they've got a cover crop already within their, their rotation and normal management of their operation, but they're only using like a one seed mix, so like rye cover crop. CSP kind of gives ‘em that incentive to maybe step it up to like a three seed species cover crop*”

Application Funding

Conservationists were asked what percentage of applications were selected to be funded. The goal of this question was to first assess levels of interest in the programs, but also to try and understand if there were applications for diversified conservation practices that were simply not

getting funded. The answers to this question varied widely with some interviewees saying, "*60%*", or *"75%*", or *"13 funded out of 23 applications and one canceled"* with other conservationists on the lower funding rate saying, *"30-55%"*, *"I only had one funded out of 13"* or choosing to avoid directly answering by saying, *"Last year was a rough year, so I am a little bit on edge about what's going to happen this year to be honest"*. Others gave answers that signaled it was hard to generalize, *"Some years you get lots of applications approved, some years you hardly get any"*.

These ranges show how variable the funding can be between counties and the range of applications that are submitted in the first place. Some DCs thought it was something they had done wrong, especially since their application funding rate had gone down since CART. While the CART ranking system is supposed to be unbiased with the state office funding the applications solely by the CART rankings without seeing the applications, some DCs said that they had a sense when they were putting an application together whether it would be funded or not. Some DCs also talked about the nuances to CART and how it could be possible that not every DC would be using it in the same way, or in the most efficient way to secure a high ranking. This doesn't suggest that the system is biased per se, but it does suggest that DCs who are more savvy at the CART system, or understand the big picture behind the rankings, might be able to craft applications that have a higher chance of getting funded, even if this is simply an intuitive advantage.

However, most DCs were able to specify the types of applications that had a high chance of getting funded. Many DCs mentioned that applications with multiple practices had a higher chance of getting funded than applications that just had one practice. As one conservationist put it, none of the "*just cover crops*" applications got funded. Some DCs mentioned that applications that included a "plan" practice, like a Nutrient Management or Pest Management Plan, had a very high chance of getting funded in combination with other practices. While DCs discussed that applications with multiple practices had a better chance of getting funded, one of the state conservations said, *"So we try to stress with our employees and that, is like, don't go big the first time on a contract ask, let's just do something that we think that they can get done first and have a positive experience with and then, you know, start showing them the benefits of conservation that they're applying and what else that they could apply,*" showing perhaps a bit of tension in how district conservations are directed versus what they know experientially to be most effective.

Budget constraints were also brought up as a limiting factor, both for diversified agriculture (based on their own definitions) and general conservation practices. One conservationist gave a poignant juxtaposition saying, *"I mean, we always have every year there's more applications in than we can get funded, for example, in southeastern Michigan this year in our EQIP cropland group, so if you're looking at east of 127, south of US-10, that whole southeastern part, there was nine hundred thousand dollars. Well, the applications for that funding totaled twenty-three and a half million. Wow.".* Other conservationists highlighted that current funding levels are only a fraction of what could be utilized, *"We probably get approximately 13 million dollars for just for the state of Michigan. I believe that in my 19-county area, we could spend that 13 million dollars*

alone, and I think that it would be helpful if caps put on some of the practices." Following the last line of that quote, some DCs discussed how quickly the general or cropland budget could get used when large farms applied. One DC contextualized it within diversified practices, "*We've had in recent years, especially with commodity prices being down, we've got a lot more interest in guys doing cover crops and stuff like that, but they're still only a certain amount of money in the crop land pool, which is where a lot of my producers qualify. So and because they're big farms, it doesn't take long to put together a 400 thousand dollar application"*.

Cover Crops & Conservation Crop Rotation

Most interviews ended up touching on two of the top funded diversification conservation practices: cover crops and conservation crop rotation. Conceptually, these two practices are highly compatible because more diverse crop rotations increase opportunities for including cover crops in rotation. Cover crops came up the most frequently, which makes sense in relation to the data on funding allocation. Many conservationists labeled cover crops as a "gateway practice" that would further the adoption of diversified farming practices or levels of conservation (it was framed both ways). Some conservationists saw cover crops as becoming more normalized as this quote details, "*And I think cover crops are becoming a little more mainstream than they were five, six, seven years ago. So people that weren't the early adopters, the mid-adopters, they're coming in now like, oh yeah, my neighbor is doing it. I want to try this, I heard there is money, I want to try it….And then people come in, we try to get them maybe a cover crop contract, and then we talk to them about reducing tillage or adding some pollinator habitat or something like that,*". This quote also illustrates the nature of "selling" conservation as previously discussed. Another important point is that cover crops are a very visible change to the landscape that other farmers pick up on. Other DCs also mentioned that neighboring farmers adding cover crops also piqued their landowners' interest. One state conservationist talked about how cover crops were an easy adjustment to a farmers overall management system, "*Cover crops, on the other hand, are fairly low risk to a farmer. They don't necessarily have to change their crop rotation, but they still get a lot of the benefits by just growing a cover crop outside of the normal growing season*".

Conservation crop rotation had more diverging views. One conservationist said, "*The conservation crop rotation, you know that's, that practice, it's not as highly used as what it used to be in the past, because we do have more of those producers that have already incorporated this into their system, because there is the benefit for pest management, soil management, you know, uh, they've already utilized that.*" Another conservationist echoed the sentiment that conservation crop rotation was already being utilized, *"But a lot of farmers are doing some level of conservation crop rotation already on their own. They've got a grain and corn and soy and wheat, and they're already really adapted to conservation crop rotation. So that's not something that I necessarily contract"*. While winter wheat increases the functional diversity of a crop rotation (i.e., a winter annual), and is known to reduce nitrate leaching compared to rotations with just corn and soy, based on these interviews, this practice is not currently used to support more substantial increases in the functional diversity of crop rotations.

Climate Crisis

There was also a seeming lack of awareness and concern about the global climate crisis, with only a few interviews even mentioning climate change. One DC said, *"You know, help with climate change or whatever you want to call it doesn't matter what you call it, like we need to save our soil and we need to try to get back to a little bit more of working with the Earth rather than against it".* This quote again reflects the relatively narrow framing of conservation as soil health and is quite dismissive of climate change. Despite the large body of evidence showing that DFS increase resilience of agroecosystems to climate change, only one state conservationist framed DCPs as a climate resilience strategy, *"And it not only does it diversify the environmental aspect of farming, but it diversifies their income, so there's less risk to insects destroying their crop or climate change affecting their crops, the more different types of crops they plant, the less risk they have".* This is striking that only one conservationist was able to frame diversified agriculture in this way, or relate their work to climate change resilience, especially with the new priorities from the Biden Administration.

New Policy Direction

Since the Biden Administration oversees the USDA, which includes the NRCS, it is important to understand the direction of the current administration and how it relates to conservation funding, and therefore DFS support. With the Biden Administration shifting the federal government to prioritize climate change, there has been a slew of agency announcements and programs involving Climate Smart Agriculture. In January 2021, President Biden signed E.O 14008 *Tackling the Climate Crisis at Home and Abroad*. Among other things, this directed the USDA to solicit input from multiple stakeholders to develop a climate-smart agriculture strategy.

Climate-Smart Agriculture (CSA) was a concept originally developed by the FAO in 2009 as a way to address global food security in a changing climate. Since its inception there have been international CSA conferences and the formation of the Global Alliance on Climate Smart Agriculture (GACSA). There are currently 521 members including countries, nonprofits, universities, farmer interest groups, and corporations. Notable partners of GASCA include the World Bank, WRI, CGIAR, and UC-Davis among others. The links between CSA and climate finance quickly became apparent and the principles and definitions of CSA have shifted over the years. The Biden Administration now defines CSA in the context of carbon sequestration and economic support for farmers, pivoting from the original food security framing.

The USDA released their general framework in May 2021, titled: *Climate-Smart Agriculture and Forestry Strategy (CSAF): 90-Day Progress Report.* The report gave a broad range of CSA strategies, but specifically mentioned no-till, cover crops, and prescribed grazing. It also strongly alluded to the creation of a voluntary carbon market, while explicitly addressing the lack of soil carbon data and central database. USDA stated they would increase soil carbon testing and efficacy of CSA practices. It also clearly stated the Biden Administration would "invest substantial resources" in "improved carbon data collection and synthesis techniques that can confirm additional, measurable, and verifiable carbon reductions and sequestration." The report

also detailed that the USDA would train and hire new employers to communicate and help farmers adopt CSA practices.

Tom Vilsack, at his confirmation hearing in February, mentioned that the USDA's Commodity Credit Corporation (CCC) could be utilized to support the creation of a carbon market. The CCC has $100 million in stock and can borrow up to $30 billion from the U.S. Treasury, though it is the funding source for most Farm Bill programs.

The first concrete program to be announced after the report was the addition of $10 million in pilot funding to support voluntary CSA through EQIP. The funding will be available in 10 states in 2021 and all 50 states in 2022. The announcement outlined CSA practices as: building soil health, improving nitrogen management, improving livestock waste management systems, enhancing grazing and pasture management, improving agroforestry, forestry, and upland wildlife habitat, and improving conservation management for rice production. These practices are compatible with DFS but would depend on how the practices are implemented.

The announcement also highlighted an investment of $25 million for On-Farm Conservation Trials, with CSA being a priority of the program. This suggests that more announcements of program additions may come out soon. The CSAF 90-Day Report also mentioned CSP, Agricultural Conservation Easement Program (ACEP), Conservation Innovation Grants (CIG), and the Regional Conservation Partnership Program (RCPP) as further vehicles to promote CSA. The USDA Climate Hubs also appear to be re-activating. There have been recent trainings in partnership with the NRCS on CSA adoption for landowners.

In Congress there is growing bipartisan support for voluntary carbon markets. *S.1251 Growing Climate Solutions Act of 2021* just passed the Senate (92-8) and is currently in the House. The bill creates a certification program to lower the barriers for land managers who mitigate GHG or sequester carbon to enter into carbon markets. Landowners, those that give landowners technical assistance, and third-party verifiers can participate in the program. The USDA would be responsible for defining the scope, protocol, and investigating via an appointed council the best practices for a verification system for entry into a carbon market. The bill also includes a civil penalty (up to $1,000) and removal from the program for 5 years in the case of false information from the involved party.

There seems to be growing momentum and a shift in administrative priorities toward conservation practices that sequester carbon in the ground or mitigate GHGs. With such high political support for the Growing Climate Solutions Act, is it looking quite likely that the USDA might be encouraging farmers and landowners to partake in CSA practices so that they can get paid within existing carbon markets. Many diversified conservation practices also sequester carbon, as shown in our DFS ecosystem matrix, signaling that CSA may help increase the adoption and funding of DCPs, but under the auspices of carbon sequestration rather than the more holistic focus on multiple ecosystem services of the diversified farming systems framework.

Conclusion

Diversified farming systems focus on increasing functional biodiversity, and by doing so, start to rehabilitate many of the ecosystem services lost under more conventional input-heavy management. Our literature review showed that there is a gradient of common DFS practices and the range of ecosystem services they provide. Aside from cover crops, DCPs were hardly funded over the past 15 years. The funding landscape for diversified agriculture within the federal government is currently quite limited, compared to the total amount of resources allocated to conservation programs. This could largely be because the DFS framework does not appear to easily fit within the conservation framing of the NRCS as our interviews found. Further adoption of DCPs may require a large culture shift within the NRCS. This could be difficult given the deep history of the NRCS with soil health and the weighty influence of the district conservationists with their ability to connect with landowners and sway them on different conservation practices. There might be a limit to how far the conservation framework, which developed within a political and economic context that supports simplified production systems, can accommodate more complex DFS management systems. Further, adoption of more transformative management practices is risky within the current market, and many DCs think that farmers would not be adopting DCPs without financial incentive. Especially as DFS can be a more holistic management shift to a high diversity system like integrated crop-livestock systems. It is important to consider financial levers, like the CSA EQIP initiative, that could be utilized on behalf of DFS.

Appendix:

Interview Guide

1) Could you tell me about your position? What programs do you oversee & what are the responsibilities associated with them?
    a) Prompt: What are your day to day responsibilities to oversee “X” program?
    b) Follow up (if not answered): How long have you been in your current role at NRCS?

2) From your experience, what are the practices that constitute diversified ag?
    a) My definition, follow up (potentially): Does that meet your understanding or experience with diversified ag?

3) How would you characterize the farmers in your state? How do they approach diversification?
    a) Follow up: Any cutting-edge practices you are seeing pop up?

4) Which conservation practices do you think are most relevant for increasing in-field diversity?

5) Has funding for these practices changed over time?
    Prompt: Have you seen a trend toward funding practices that increase field and farm scale diversity (i.e., crop and/or livestock)?

6) Do you perceive any shift in priorities or programs in the next few years?

7) Are there any changes to the (EQIP/CSP) program that you think could help diversify agriculture?
    a) Follow up: Interesting, how would a change like this happen?

8) Are there any practices that you think of as “gateway” practices for increasing farm diversity? Or other practices that do not directly increase crop or livestock diversity, but might support other diversification efforts on farms?

9) I’m particularly interested in two specific practices: prescribed grazing and conservation crop rotation. Can you tell me a bit more about how these practices are used by farmers?

10) How does your office decide which conservation strategies to promote? And how do you promote them?

11) I’m curious about your relationship with the field offices. How do you coordinate on reviewing applications?

12) I’m curious about the technical committee and how you perceive their role? Has this changed over time?

13) I was also wondering about your partnerships, are there organizations you work closely with to promote CSP or EQIP?

a) What organizations or stakeholders are involved in decision making processes around diversified ag funding or prioritization?

14) Generally, what percentage of applications do you receive that are not funded? Do these applications fall into a certain category of conservation practices?

15) Can you shed light on your ranking system for the conservation practices and applications?

County-Specific:

16) I'm curious how many farmers in your county are "repeat" customers, i.e. continually apply for funding?

17) How are applications (CSP/EQIP) processed in your office? Has this changed over time?

18) What types of farming systems are in your county? Has this changed much in recent years? Are there any emerging changes you see happening?

19) Do you have a perception of the attitude and values of farmers in your county regarding farming, land management, biodiversity?

20) What are your relationships like with farmers in your area? I am curious how much time is dedicated to reaching out to farmers, both in general and on diversification.

21) I was curious about your partnerships...what organizations do you work closely with in the county or in the state? (**sub for 13**)
    a) What organizations or stakeholders are involved in decision making processes around diversified ag funding or prioritization?

22) I have found that X conservation practices are common in your county, which could be considered diversified agriculture. Are there other practices that you see on farms in your county that could also be considered diversified Ag?

23) (Depending on county) I see that your county is one of the top funders for "X diversification/conservation practice". Have you been prioritizing outreach or applications for this practice? Why do you think it is popular in your county?

24) ALT (Depending on county) I see that your county funds a lot of cover crop applications but doesn't fund "X diversification practice - crop rotation" as often as some other counties. Do you have an idea of why this is? Are cover crops highly promoted in your county?

Literature Cited

Adu-Gyamfi, P., Mahmood ,T., Trethowan, R. (2015) Can wheat varietal mixtures buffer the impacts of water deficit?. *Crop and Pasture Science* 66, 757-769. https://doi.org/10.1071/CP14177

Allen, V. G., et al. (2007). "Integrated Irrigated Crop-Livestock Systems in Dry Climates." Agronomy Journal, 99, 2, 346–360., doi:10.2134/agronj2006.0148.

Blesh, J. (2018) Functional traits in cover crop mixtures: biological nitrogen fixation and multifunctionality. Journal of Applied Ecology, 55, 38-48.

Blesh, J. (2019) Feedbacks between nitrogen fixation and soil organic matter increase ecosystem functions in diversified agroecosystems. Ecological Applications, https://doi.org/10.1002/eap.1986.

Davis, A., et al. (2012) ."Increasing Cropping System Diversity Balances Productivity, Profitability and Environmental Health." PLoS ONE, 7,10, doi:10.1371/journal.pone.0047149.

Entz, M., Bullied, W.,Katepa-Mupondwa, F. (1995). Rotational benefits of forage crops in Canadian prairie cropping systems. *Journal of Production Agriculture* 8, 521-529.

Finney, D., Kaye, P. (2016). "Functional Diversity in Cover Crop Polycultures Increases Multifunctionality of an Agricultural System." Journal of Applied Ecology, 54, 2, 509–517., doi:10.1111/1365-2664.12765.

Han, Z., Walter, M. T. & Drinkwater, L. E. (2017) N2O emissions from grain cropping systems: a meta-analysis of the impacts of fertilizer-based and ecologically-based nutrient management strategies. Nutrient Cycling in Agroecosystems, 107, 335-355.

Garibaldi, L. et al. (2014) "From Research to Action: Enhancing Crop Yield through Wild Pollinators." Frontiers in Ecology and the Environment, 12, 8, 439–447., doi:10.1890/130330.

Isbell, F. et al. (2017) "Benefits of Increasing Plant Diversity in Sustainable Agroecosystems." Journal of Ecology, 105, 4, 871–879., doi:10.1111/1365-2745.12789.

King, A., Blesh, J. (2017) "Crop Rotations for Increased Soil Carbon: Perenniality as a Guiding Principle." Ecological Applications, 28, 1, 249–261., doi:10.1002/eap.1648.

Kremen, C., Miles, A. (2012). "Ecosystem Services in Biologically Diversified versus Conventional Farming Systems: Benefits, Externalities, and Trade-Offs." Ecology and Society, 17, 4, doi:10.5751/es-05035-170440.

Kremen, C. et al. (2007) "Pollination and Other Ecosystem Services Produced by Mobile Organisms: A Conceptual Framework for the Effects of Land-Use Change." Ecology Letters, 10, 4, 299–314., doi:10.1111/j.1461-0248.2007.01018.x.

Lee, KH., Jose, S. (2003) Soil respiration and microbial biomass in a pecan — cotton alley cropping system in Southern USA. *Agroforestry Systems* 58**,** 45–54 https://doi.org/10.1023/A:1025404019211

Lee, Isenhart, Schultz (2003) Sediment and nutrient removal in an established multi-species riparian buffer. *Journal of Soil and Water Conservation*. 58 (1) 1-8;

Liebman, M., Dyck, E. (1993). Crop rotation and intercropping strategies for weed management. *Ecological Applications* 3(1):92-122. http://dx.doi.org/10.2307/1941795

Lotter, D., Seidel, R., Liebhardt, W. (2003). The performance of organic and conventional cropping systems in an extreme climate year. *American Journal of Alternative Agriculture* 18(3):146-154. http://dx.doi.org/10.1079/AJAA200345

Meisinger, J.J. & Hargrove,W., Mikkelsen,R., Williams, J., Benson, V. (1991). Effects of cover crops on groundwater quality. Cover crops for clean water. Proc. conference, Jackson

Potts, S. G., B. A. Woodcock, S. P. M. Roberts, T. Tscheulin, E. S. Pilgrim, V. K. Brown, and J. R. Tallowin. (2009). Enhancing pollinator biodiversity in intensive grasslands. *Journal of Applied Ecology* 46(2):369-379. http://dx.doi. org/10.1111/j.1365-2664.2009.01609.x

Raseduzzaman, M., Jensen, E. (2017) "Does Intercropping Enhance Yield Stability in Arable Crop Production? A Meta-Analysis." European Journal of Agronomy, 91, 25–33., doi:10.1016/j.eja.2017.09.009.

Reiss, E., Drinkwater, L. (2017) "Cultivar Mixtures: A Meta-Analysis of the Effect of Intraspecific Diversity on Crop Yield." Ecological Applications, 28, 1, 62–77., doi:10.1002/eap.1629.

Robertson, G., Vitousek (2009) "Nitrogen in Agriculture: Balancing the Cost of an Essential Resource." Annual Review of Environment and Resources, 34,1, 97–125., doi:10.1146/annurev.environ.032108.105046.

Russelle, M. et al. (2007) "Reconsidering Integrated Crop-Livestock Systems in North America." Agronomy Journal, 99, 2, 325–334., doi:10.2134/agronj2006.0139.

Römkens, Plicht, Hassink (1999). *Soil organic matter dynamics after the conversion of arable land to pasture.* Biology and Fertility of Soils. 28. 10.1007/s003740050494.

Saam, H., Powell, M., Jackson-Smith, D., Bland, W., Posner, J (2005). Use of animal density to estimate manure nutrient recycling ability of Wisconsin dairy farms. Agricultural Systems. 84. 343-357. 0.1016/j.agsy.2004.06.020.

Sanderson, Matt A., et al. (2013) "Diversification and Ecosystem Services for Conservation Agriculture: Outcomes from Pastures and Integrated Crop–Livestock Systems." Renewable Agriculture and Food Systems, 28, 2 ,129–144., doi:10.1017/s1742170512000312.

Schipanski, M. E., Barbercheck, M., Douglas, M. R., Finney, D. M., Haider, K., Kaye, J. P., Kemanian, A. R., Mortensen, D. A., Ryan, M. R. & Tooker, J. (2014) A framework for evaluating ecosystem services provided by cover crops in agroecosystems. Agricultural Systems, 125, 12-22. doi:10.1016/j.agsy.2013.11.004.

Song, L., Zhang, D., Li, F., Fan, X., Ma, Q., Turner, N. (2010). Soil Water Availability Alters the Inter and Intra-Cultivar Competition of Three Spring Wheat Cultivars Bred in Different Eras. Journal of Agronomy and Crop Science - J AGRON CROP SCI. 196. 323-335. 10.1111/j.1439-037X.2010.00419.x.

Tamburini, Gi et al. (2020). "Agricultural Diversification Promotes Multiple Ecosystem Services without Compromising Yield." Science Advances, 6, 45, doi:10.1126/sciadv.aba1715.

Tonitto, C., David, M. B. & Drinkwater, L. E. (2006) Replacing bare fallows with cover crops in fertilizer-intensive cropping systems: a meta-analysis of crop yield and N dynamics. Agriculture, Ecosystems and Environment, 112, 58-72.

Udawatta, R., Krstansky, J. Henderson, G., Garrett, H. (2002). Agroforestry practices, runoff, and nutrient loss: A paired watershed comparison. Journal of environmental quality. 31. 1214-25

de Vallavieille-Pope C. (2004) Management of disease resistance diversity of cultivars of a species in single fields: controlling epidemics. C R Biol. 327(7):611-20. doi: 10.1016/j.crvi.2003.11.014. PMID: 15344811.

Zan, Claudia S, et al. (2001) “Carbon Sequestration in PERENNIAL BIOENERGY, Annual Corn and Uncultivated Systems in Southern Quebec.” Agriculture, Ecosystems & Environment, 86, 2, 135–144., doi:10.1016/s0167-8809(00)00273-5.

Zhu, Y., H. Chen, J. Fan, Y. Wang, Y. Li, J. Chen, J. X. Fan, S., Yang, L. Hu, and H. Leung. (2000). Genetic diversity and disease control in rice. *Nature* 406(6797):718-7