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Analysis of the Barriers and Opportunities for the Use of Compost in Agriculture

White Paper

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I. Introduction

The Illinois Soil, Water, Food & Composting Summit of November 2017 (funded by Food:Land:Opportunity) was designed to "bust silos" and advance collaboration on various sustainability topics. Successfully, it provided a broad context regarding how we in Illinois can advance development of a local, sustainable food shed; maintain and expand our soil health to support Illinois' agricultural economy; protect our waterways from hypoxia caused largely by synthetic agricultural fertilizer and nitrate runoff; recover wasted food for higher use; and grow Illinois business sectors such as composting and specialty crops for local consumption while protecting our natural resources. The issue of protecting natural resources is at the forefront of the discussion, which includes building long-term soil health, protecting water quality, and finding solutions related to food and agriculture problems – all of which are economically viable and environmentally sustainable. Understanding how these issues, their causes and potential solutions intersect provides a foundation for the discussion within this paper.

The more specific purpose of this white paper within this broader discussion is to look at strategies that are employed to address nutrient loss reduction, water quality, and soil health, in addition to examining the viability of the use of compost on mid and large-scale farms and any related challenges. It will not *directly* delve into the multiple issues related to building a local, sustainable food shed for (based on an increase in small to mid-sized farms that produce food for Illinois consumption) – a vital mission but outside the scope of this paper. **This paper will explore the viability of compost as a medium for building soil health and reducing nutrient runoff and the related impacts caused by mid and large-scale farms, as well as to understand the circumstances that are advancing or impeding the use of compost in agriculture.**

The environmental benefits of compost are well-documented (and will be discussed within this paper in greater depth) and include reducing soil erosion, building soil nutrients, retaining water, sequestering carbon, reducing pesticide use, and enabling the growth of healthy, sustainably-raised food. Questions that remain, however, include: a) whether compost can be a cost-effective and viable option for large-scale agriculture; b) what its place is among various other strategies to reduce/eliminate the use of chemicals in farming and to protect water quality and human health; c) what the economic potential is for a robust composting industry in Illinois that potentially incorporates large-scale agricultural use of compost in addition to small-scale agriculture, urban agriculture, landscaping, and other applications; and d) what technologies and case studies are available that could make the use of compost and its ecological benefits more widespread in Illinois.

Lastly, this paper will discuss the current efforts among state agencies, farmers, and environmental groups to reduce nutrient runoff and loss that degrades water quality, threatens drinking water, and creates aquatic dead zones. It will investigate which of these strategies solely solve the immediate issue of nutrient loss and which take additional steps toward building long-term soil health, protecting water quality and reducing greenhouse gas emissions that contribute to climate change.

II. Overview of the Issues

Soil Health and Depletion

According to the U.S. Department of Agriculture, erosion losses total more than 2 billion tons each year in the United States. Erosion impedes plant growth by removing beneficial nutrients and organic matter, which are essential to fertile soil. Reduced plant growth and plant residue decreases soil cover, further worsening and perpetuating the erosion process (Spiegel, 2010). The danger in this process is that it can be imperceptible and eventually lead to infertile land void of topsoil. Since farming began, most agricultural soils have lost 30% to 75% of their original soil organic carbon. Every year, valuable hectares of cropland are abandoned after becoming unproductive due to erosion, which depletes cropland soil at a rate much faster than soil formation (10.8 annual tons per hectare versus 0.5 to 1 annual tons per hectare), leaving land barren and unable to produce food in the future (Lal et al., 2007).

Illinois has some of the most fertile soil in the world thanks to natural prairie and minerals left by prehistoric glaciers. Unfortunately, the introduction of modern agriculture techniques (stripping the land for agriculture and tilling) has translated into massive soil loss. In 2015, roughly one-fifth of Illinois' farmland lost more soil than it generated according to the Illinois Department of Agriculture. This has created lower-yielding crops and damage to waterways and the natural environment. A recent survey found that 7% of Illinois farmland has twice the amount of soil loss considered "above tolerable," and 12% has between one and two times the tolerable soil loss level, which is the highest it has been since at least 2006. Soil Scientist Roger Windhorn from the Department of Agriculture advises that Illinois will not "hit bedrock" in the near term with current soil loss rates. However, erosion does mean lower yields on farms and lower yields for farmers who come into ownership of the land years later (Keating, 2016).

Erosion also leads to reduced water quality downstream. Phosphorus fertilizers cling to soil particles and wash into water sources. The sediment often settles at the bottom of a waterway and, in some cases, the sun can bake the phosphorus and cause an algal bloom. Many of these blooms make the water harmful for human consumption and recreation (Keating, 2006). Soil conservationists, farmers and environmentalists agree that over the next several decades erosion could convert farmland into infertile ground, but they disagree on the best possible strategy. Eroded topsoil carried into our waterways contains toxic chemicals and fertilizers which reduces water quality in catchment areas and has a negative impact on aquatic life. This issue is not unique to Illinois. In neighboring Iowa, agronomist Rick Cruse's research indicates that 5 tons per acre of soil is lost annually due to erosion, and the average loss of 6.8 inches of topsoil from erosion causes an average of 10 bushels per acre yield loss (Cruse, 2016).

In addition to erosion, other aspects of agriculture negatively affect soil quality. These impacts include compaction, loss of soil structure, nutrient degradation, and increase in soil salinity. Nutrient loss is the removal of nutrients without replenishment. Human-induced depletion occurs due to to over-cultivation, insufficient inputs of replacement nutrients, and poor soil management practices (Tan et al., 2005). Nutrient depletion can result in crop yield reduction and production loss, and consequently a potential loss in earnings. "We still continue to harvest more nutrients than we replace in soil," says Land Institute scientist Jerry Glover (Qiu, 2014). "If a country is extracting oil, people worry about what will happen if the oil runs out. But they don't seem to worry about what will happen if we run out of soil." Chemical fertilizers are not sufficient replacements for the nutrients present in the complex networks within the soil. Fertilizers are "not a full health package," stated Glover (Qiu, 2014).

Water Quality

Jason Weller, former Chief for the Natural Resources Conservation Service, stated that 78% of U.S. waterways are rated poor or fair for sustaining biological life (Adams, 2015). An example of one of the biggest and well-known problem areas, the Mississippi River leading to the Gulf of Mexico, has seen concentrations of nitrogen increase by 44% between 1976 and 2014. Excess nitrogen presents three challenges to the Mississippi River including human health risks, maintaining healthy development of aquatic life, and its contribution to the Gulf of Mexico's "dead zone" which is now the size of the state of New Jersey (Moss & Scheer, 2011). In 2008, the U.S. EPA Mississippi River/Gulf of Mexico Hypoxia Task Force developed an action plan that requires states in the Mississippi River Basin to reduce nitrogen and phosphorus loading to rivers by 45% in order to reverse the growing "dead zone", which is characterized by nutrient-fed algal blooms that deplete oxygen in the Gulf. Excessive nitrogen from agricultural chemical fertilizers and wastewater treatment practices are the primary causes of the problem. Excessive phosphorus and nitrogen levels contribute to eutrophication (over-fertilization of water) which causes hypoxia (depletion of oxygen in water) (Rabalais, 2011).

As excerpted from Edwin Ongley's 1996 Food and Agriculture Organization report, the symptoms and impacts of eutrophication include:

- Increase in production of phytoplankton, attached algae, and macrophytes
- Shift in habitat characteristics due to change in assemblage of aquatic plants
- Replacement of desirable fish by less desirable species
- Production of toxins by certain algae
- Increasing operating expenses of public water supplies, including taste and odor problems, especially during periods of algal blooms
- Deoxygenation of water, especially after collapse of algal blooms, usually resulting in fish kills.
- Infilling and clogging of irrigation canals with aquatic weeds
- Loss of recreational use of water due to slime, weed infestation, and noxious odor from decaying algae
- Impediments to navigation due to dense weed growth
- Economic loss due to change in fish species, fish kills, etc.

Lake Erie/Toledo, OH

In 2014, Lake Erie reported a dramatic increase in phosphorus causing a spike in dense algae growth near the surface of the water, known as eutrophication. The increase in phosphorus and other nutrients was a direct result from nutrient runoffs from fertilized farms, cattle feedlots, and leaky septic systems. In this case, the algae grew directly above the city's water intake pipe and contained microcystin, a poisonous toxin. The increase in water toxicity posed a serious health risk for 11 million lakeside residents who use and drink Lake Erie's water, severely damaged commercial fishing, and increased the number of summertime bans on swimming and other forms of recreation. Approximately 500,000 Toledo residents went without potable drinking water as a result, leading Chicago Mayor Rahm Emanuel to convene a meeting of Great Lakes mayors to address the issue. Since that summer, Congress has funded a Great Lakes Restoration Initiative to create wetlands and teach farmers to reduce fertilizer use and runoff (Wines, 2014).

For nitrogen alone, Illinois and Iowa generate over 28% of the nitrogen reaching the Gulf of Mexico but have only 9% of the watershed (Heffernan et al., 2010). Illinois is the largest contributor to the overall nutrient loss problem, containing 74,300 farms and livestock operations that depend on phosphorus and nitrogen to

support the state's $19 billion agriculture industry. These dead zones harm drinking water sources; make people and/or animals swimming in the water sick; prevent recreational opportunities; and diminish property values. The Illinois Nutrient Loss Reduction Strategy outlines multiple strategies to address the problem, including capping the amount of phosphorus treatment plants are permitted to release, changing agricultural practices, and taking additional measures to capture nutrient runoff before it reaches Illinois rivers (Illinois Waste Water Resources Center, 2016).

Carbon Release and Climate Change

Though soil is the second largest carbon sink on the planet, it is often neglected (European Environment Agency, 2015). Historically, land-use conversion and soil cultivation are responsible for about one-third of greenhouse gases (GHGs) in the atmosphere (Ongley, 1996). According to recent research from Stanford University, the "Soil contains three times more carbon than the atmosphere. Some of that carbon remains trapped underground through chemical reactions with minerals. However, most is in the form of decomposing plant and animal matter, which microorganisms break down to create energy and CO_2 – the equivalent of our eating and breathing" (Than, 2017). Moreover, according to a report by the European Environment Agency (2015):

> "On farmland, ploughing the soil is known to accelerate decomposition and mineralization of organic matter. In order to keep carbon and nutrients in the soil, researchers suggest reducing tillage, farming with complex crop rotations, using so-called 'cover crops' and leaving crop residues on the surface of the soil. Leaving crop residue on the surface before and during planting operations can help to protect against the risk of soil erosion. Such protection is essential given that it can take thousands of years to form just a few centimeters of soil. Reduced tillage involves less breaking and turning of the soil, helping to retain carbon in the soil. Similarly, because organic agriculture uses manure, it can rebuild the soil's organic carbon deep below the surface. Organic agriculture has the benefit of curtailing greenhouse gases because it does not use chemical fertilizers. The UN Food and Agriculture Organization calculates that CO_2 emissions per hectare of organic agriculture systems are 48% to 66% lower than in conventional systems."

III. Benefits of Compost

The issues of nutrient runoff and loss, degradation of water quality linked largely to the use of synthetic agricultural fertilizers, and declining soil quality are facing farmers and those concerned about protecting natural resources across the Midwest and Illinois. Compost has been shown to increase soil health, retain and conserve water, sequester carbon, increase crop yields and reduce the need for the use of synthetic chemical fertilizers. Numerous studies demonstrating the superior capacity of compost to build soil organic matter, increase nutrients and manage nutrients effectively for plants have been conducted, and some are referenced in later sections within this report. One research project, Digestate and Compost in Agriculture, was conducted in 2010 over a minimum of three growing seasons (with some extended year trials) in Wales, Scotland and England using rigorous scientific methodologies. The findings concluded that compost and food-based digestate (the material remaining after the anaerobic digestion of a biodegradable feedstock) can increase yields while maintaining crop quality and safety and can increase soil organic matter – in some cases by 20-25% – more than bagged fertilizers. Retention of organic matter with the use of compost was almost double that of farmyard manure. The study concluded that in addition to increased crop yields and build-up of organic matter and nutrients in soil, the use of compost also allowed for improved financial returns via reductions in costs from fuel and manufactured fertilizer (Waste and Resources Action Programme, 2016).

Compost Reduces Soil Erosion and Improves Soil Structure

Amending soil with compost is an effective strategy that increases its ability to retain water and reduce erosion. Humus, a key material in compost, functions as the "glue" that binds soil together and makes it more resistant to erosion. The more organic material present, the more resistant to erosion the soil will be. The organic matter in compost is important because it feeds billions of crucial microorganisms. The microbial process results in effective stormwater infiltration, drainage, and moisture-holding capacity and provides a strong, stable soil structure conducive to strong crop growth. These passageways and a higher bulk density allow plant roots to establish and expand. Compost also increases soil fertility by "controlling pH levels and increasing buffering capacity against pH change" (Bell & Platt, 2014). Research shows that certain organisms found in compost protect against soil-borne diseases and plant pathogens, which protects agricultural crops (Illinois Food Scrap Coalition, 2015).

Compost Improves Water Retention and Reduces Irrigation Needs

The high organic matter content in compost (40-60%) increases water infiltration rates and the soil's ability to retain water; this water retention is vital for crop growth. Soil organisms create pore spaces for air and water, increasing permeability and storage capacity. This allows rainwater that would otherwise be lost to evaporation or runoff to remain within and replenish soil ecosystems. Research indicates that compost has a higher absorption and storage capacity than other common agricultural soil amendments, including raw manure, commercial fertilizer and anhydrous ammonia. Compost's ability to capture rainfall also reduces the need to treat stormwater runoff at water treatment facilities, consequently saving money (Illinois Food Scrap Coalition, 2015).

Compost Reduces Synthetic Chemical Needs and Protects Watersheds

Amending soil with compost creates a controlled, slow release of phosphorus, potassium, sulfur and other micronutrients, satisfying crop requirements for plant growth and survival. Nutrients from synthetic agricultural chemicals, on the other hand, feed massive algal blooms, which decompose and consume most of the available oxygen in the water and leave worms, clams and other bottom-dwelling sea life to suffocate. Additionally, improving water retention with compost can prevent dangerous pollutants in stormwater runoff from reaching surface water resources that crops may absorb. Compost also minimizes soil erosion and runoff, converts nitrogen into a more stable and less mobile form, and serves as a filter and sponge for stormwater and agricultural runoff (Illinois Food Scrap Coalition, 2015).

Compost Reduces Greenhouse Gas Emissions

Compost supports greenhouse gas emissions reductions by reducing the volume of biodegradable materials that end up in landfills and create methane, naturally sequestering carbon, and providing feedstock for biogas development. Landfills are struggling to capture the methane that they release, and food scraps are a large contribution to their methane release. By using food scraps for compost, agricultural facilities can divert much of this food scrap waste from the landfill and deplete one source of methane emissions. The top 3.2 feet of the world's soil stores more than 3 times the amount of carbon held in the atmosphere. There is widespread scientific agreement that compost increases carbon sequestration and reduces the overall release of greenhouse gases into the atmosphere (Walker et al., 2006).

Compost as an Economic Driver

A study and report conducted by the Institute for Local Self Reliance measures job creation linked to landfill operations, incinerators, and compost facilities and concluded that composting generates more jobs than landfilling (2 to 1) and incineration (4 to 1). In addition, composting creates an increase in the number of jobs related to end product compost sales, and preserving the life of landfills through reduced-use will save state of Illinois taxpayers expensive siting and landfill development costs. Lastly, in 1999 Illinois tax payers doled out $55 million to clean up 32 improperly closed landfills – an expense that would certainly decrease with less use pressure on current landfills (Skumatz et al., 2016).

In 2017, Skumatz Economic Research Associates (SERA) completed a FLO-funded Economic Impact and Market Study Report making the economic case for developing a viable food scrap composting industry in Illinois that would contribute to the development of the state's local food economy. The economic analysis was designed to estimate the various statewide economic impacts of policies aimed at bolstering organics collection and processing. SERA analyzed three scenario levels (low, moderate, and aggressive), which assumed that food scrap collection and processing increased to 35%, 65%, and 85% of Illinois organics stock. These levels represented thresholds for program and policy portfolios, including thresholds for an enforced and non-enforced material ban. According to Skumatz et al. data, **if Illinois can achieve the mid-point 65% organics diversion goal, this will create**:

- 3,185 Jobs paying an average salary of $50k annually,
- $290 million in economic output for the state annually,
- $10.5 million in local and state tax revenue annually,
- Over 2 million tons of diversion away from landfills annually, and
- Over 800k MTCO2e in GHG emissions reduction annually

IV. Illinois Nutrient Loss Reduction Strategy

Against the backdrop of the benefits of compost, Illinois and Midwest farmers are confronting the major issue of nutrient loss. In this section, we will look at the primary strategies currently implemented as part of Illinois' Nutrient Loss Reduction Strategy, while noting that the use of compost is not among those strategies.

Following the 2008 Gulf Hypoxia Action Plan, which asked the 12 Mississippi River Basin states to devise a plan to reduce their nitrogen and phosphorus runoff into the Gulf of Mexico, the Illinois EPA developed the Illinois Nutrient Loss Reduction Strategy (NLRS). A Policy Working Group comprised of "representatives from local, state and federal agencies, the agricultural industry, nonprofit organizations as well as scientists, academics, and wastewater treatment professionals" developed the Illinois NLRS, mirroring its framework on the U.S. EPA's 2011 state recommendations (Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, 2008).

The NLRS deliberately focuses on reducing the *loss* of nutrients through runoff, as opposed to reducing or eliminating the use of synthetic nitrogen fertilizers or phosphorus that scientists have determined are the cause of eutrophication and hypoxia.

According to the Illinois EPA (2015), the NLRS has 6 key strategic components:

- *Extends ongoing regulatory and voluntary efforts:* The strategy describes a comprehensive suite of best management practices for reducing loads from wastewater treatment plants and urban and agricultural runoff.
- *Identifies priority watersheds for nutrient loss reduction efforts:* Recommended practices target the state's most critical watersheds and are based on the latest science and best-available technology.
- *Establishes the Nutrient Monitoring Council to coordinate water quality monitoring efforts by government agencies, universities, non-profits, and industry*
- *Creates the Nutrient Science Advisory Committee to develop numeric nutrient criteria for Illinois waters:* This committee will evaluate all available research, data, and methodologies and recommend a credible approach.
- *Identifies strategies for improving collaboration among government, non-profits, and industry:* This includes formation of an Agriculture Water Quality Partnership Forum to steer outreach and education efforts to help farmers address nutrient loss and an Urban Stormwater Working Group to coordinate and improve stormwater programs and education.
- *Defines a process for regular review and revision by the Policy Working Group, as well as for measuring progress and reporting to the public.*

Best Management Practices

Illinois' Nutrient Loss Reduction Strategy (NLRS) characterizes best management practices (BMPs) for agriculture into three categories: in-field, edge-of-field, and land use changes. The NLRS included BMPs that have been proven to reduce nutrient losses in peer-reviewed, published research. Those practices are noted below with an asterisk. Additional BMPs that can be utilized by farmers in Illinois, many of which are being tested in ongoing research, are also included (IEPA, 2015).

In Field

- Nitrogen management*
- Cover crops*
- Reduced tillage*

Edge-of-Field

- Buffers*
- Saturated buffers
- Woodchip bioreactors*
- Wetlands*
- Drainage water management
- Streambank stabilization

Land Use Changes

- Perennial/energy crops*

Illinois Farm Bureau Nutrient Stewardship Grants

The Illinois Farm Bureau's (IFB) Nutrient Stewardship Grant Program funds Illinois farm-based projects designed to reduce nutrient loss and increase environmental stewardship practices among Illinois Farmers. In December 2018, the IFB awarded 18 projects across Illinois a total of $100,000 to implement a variety of programs. These incorporated education; testing and implementation of practices to reduce nutrient runoff in waterways; nitrogen management; nutrient loss demonstration plots; water sampling/testing; use of manure and cover crops; fertilizer application rates; recycling of drainage water; learning roundtables on cover crops; woodchip bioreactors; saturated buffers and soil testing (Shipman, 2017).

V. Soil Health Partnership

Another initiative that has farmers analyzing and changing their practices with potential benefits to soil health, productivity and water quality protection is the Soil Health Partnership (SHP):

> "Founded in 2014, the Soil Health Partnership (SHP) is an initiative of the National Corn Growers Association that is testing conservation practices on farms using plots from 20 acres to 80 acres in size….Most are corn and soybean operations, though several also have wheat in rotation, grow seed crops or have livestock or dairies…The program receives financial support from Monsanto, NCGA, USDA's Natural Resources Conservation Service, The Walton Family Foundation, General Mills and the Midwest Row Crop Collaborative. It receives technical support from the Environmental Defense Fund and The Nature Conservancy" (Birt, 2017).

SHP project is testing about 1,000 acres in the states of Missouri, Minnesota, Nebraska, North Dakota, South Dakota, Illinois, Ohio, Wisconsin and Michigan with one satellite location in Maryland, with farm sizes varying from 300 acres to more than 10,000 acres. Using provided data platforms and methods from SHP, participating farmers gather data on their farms to better characterize their business performance outcomes throughout the duration of the program (Muehling, 2018).

According to their website, the goal of the SHP is to "measure and communicate the economic and environmental benefits of different soil management strategies and to provide a set of regionally specific, data-driven recommendations that farmers can use to improve the productivity and sustainability of their farms" (SHP, 2014).

The Soil Health Partnership's key strategies are:

- Recruit a **network of farmers** that will showcase to other farmers innovative soil management practices including reduced tillage, cover crops and nutrient management
- Establish **research protocols** to measure the connection between soil practices and soil health
- Publish **findings and recommendations** that highlight the economic and environmental benefits of healthy soil
- Support **networking and technical assistance** that help decision-making that leads to soil health sustainability and economic viability (SHP, 2014)

The Soil Health Partnership develops case studies, excerpts of which are included below from their Farmer Profiles webpage to provide information on the strategies that farmers are employing:

Terry Bachtold

Terry Bachtold of Strawn, Illinois, has been farming his entire life with cattle, hogs and an annual rotation of oats, soybeans, corn and hay. He sees cover crops as a return to "the old ways" through a shorter term, similar rotation system. Plus, they are a way to naturally increase organic matter. “We have come a long way in technology as far as nutrient management, but I think the next leap forward is going to be improving soil through practices like cover crops and no-till,” says Bachtold. “Organic matter is basically what holds the soil together. If you don’t have organic matter, you’re not going to raise a crop.” Bachtold is also interested in cover crops because of their ability to suppress weeds and hold nitrogen for the next crop year. He’s hopeful this means he can reduce commercial application of nitrogen, but only time—and research with the Soil Health Partnership—will tell.

David and Chase Brown

David Brown and son Chase farm more than 4,000 acres in central Illinois. They grow corn, soybeans and wheat, plus forages and hay for their cattle. The Browns want to see the evidence for themselves: Are cover crops really going to deliver on the promise of increased yields and improved soils health? By joining the Soil Health Partnership, they believe the answer is yes—and have put their own fields in Decatur, IL, to the test. “’You can’t open any farming publication today without seeing the ‘cover crop’ buzzword,” says Chase Brown. “We keep hearing all of these claims: Yield bumps! Sequester nitrogen! More organic matter! As part of the Soil Health Partnership, we’re ready and excited to prove it for ourselves.”

Dave Moose

The Moose Farm is a 1400-acre row crop operation with soybeans and corn. Dave Moose started farming with his father in 1976, but he did not get into cover crops until 2011. Moose has been no-till on his farm since 1985 and added cover crops as a way to provide additional organic matter into the soil that he wasn’t seeing from no-till alone. His cover crops include cereal rye and crimson clover, with occasion rapeseed and tillage radishes if the season allows. The benefits of no-till and cover crops are obvious on his Illinois farm: more worms, more organic matter, and better soil retention. Still, he wants to see quantifiable research that will clearly spell out the pros and cons for every farmer interested in pursuing these practices. Moose kneels down in the black Illinois dirt and gently pulls up a tiny green plant. The plant’s thin tap root extends deep into the soil, making him smile in satisfaction. “See that? The tap root is already nearly 12 inches long. It will grow to be another one or two feet down in the soil,” he says. “It provides a nice environment for worms and creates channels for water to go down deep in the soil. “I don’t have to rip up the soil for this to happen. Plus, these plants hold nutrients and transfer them into the soil later on." Moose elaborates: “I think there’s going to be more rules and regulations headed our way, and they will target how our practices impact the watershed. We need to get ahead of these regulations and show what we can do.”

Tim Seifert

Tim Seifert grows 3,000 acres of corn and soybeans. He began strip-till in 1979 (tilling only the part of the land that produces crops), and today that remains his main focus on most of his farm. He likes how it allows him to put nutrients deep in the soil, exactly where his crops need them. Seifert asserts that it is up to him to be a good steward of the soil, even if it means adopting practices that add more work to an already tough job. “We have to take care of the soil,” he says. “Sometimes that may not be easy, but farming has never been easy. We need it to be healthy for the next generation.” Seifert participates in the program by collecting data on test plots with the help of field managers and their agronomists. Those test plots include cover crops, nutrient management and conservation tillage. He became concerned with runoff and nutrient management 25 years ago and joined the area Soil & Water District. Over the years, they focused on the importance of the waterways and agriculture’s impact on them. Cover crops caught his attention as another way to prevent nitrates from migrating through the soil. “It’s important that we use cover crops, not only to increase the tilth

of our soil, but also to preserve the nutrients and things we have in the soil," says Seifert. "If this cover crop system will allow us to continue to use nitrogen to better our crops alongside a plan to protect the environment—that will be huge."

Cover crops have not come without challenges on the Seifert farm. Time is limited during the harvest—the key time to plant cover crops. Knowing when to plant, what variety to put down and when the weather is right are all challenges during what is unquestionably the busiest and most important time of the agricultural year. The challenges continue in the spring with timing the cover crop termination advance of planting. "I am ready to see if cover crops will help keep nitrogen out of the waterways and instead in our soil."

Tim Smith

Living in the Boone River Watershed, Tim Smith had heard about high levels of nitrates found in stream water and wondered why. "I always thought I was doing everything pretty good in terms of nitrogen stewardship, but it turned out I had room for improvement," Smith says. He began planting cereal rye as a winter cover crop at first on just 300 acres. Planted in late August or early September in his standing crops, the deeply rooted rye helps absorb the nitrate left behind from his corn and soybean crops. He kills the rye in spring before he plants corn, but leaves the plant residue in the field to help build organic matter as it slowly decomposes over the summer. The slow decomposition of rye residue and mineralization of organic matter in turn release nitrogen back into the new crop over time. "I did some biomass sampling and found 30 pounds of nitrogen in the rye," Smith says. "That was my first realization that these crops have value. At the time, 30 pounds of nitrogen was worth 50 cents a pound, or about $15 an acre." The financial incentives may have started Tim Smith on his journey to these new methods, but he quickly realized even more compelling reasons. A combination of switching to strip-till (with similar benefits to no-till) and cover crops has improved the overall profile of his soil. Smith points out that in heavy rain, a cover crop will greatly mitigate soil erosion. He also says it is a "no-brainer" for cattle farmers, who can let their animals graze on the cover crop or harvest the forage for feed.

Smith says because of each growing season's unpredictability, he has not really changed his nitrogen applications. Rather, the change is seen in the cover crops that store excess nitrogen that might otherwise be lost to leaching. Today, he plants cover crops on 550 out of his 800 acres. "My goal is long-term sustainability," he says. "Losing precious soil is not sustainable. If we keep eroding the good soils, we'll be down to nothing. It's important to remind farmers of this. A lot of farmers think they don't have erosion, but in heavy rains, every drop has the potential to take soil with it. Some farmers don't like change, but farming practices are always evolving."

VI. Case Studies from the Field

To gain a better understanding of the use of composting in relation to other practices for building soil health and protecting water quality, we'll examine case studies of large, mid-sized and small farms locally and outside of Illinois that are employing various strategies to address these issues. The examples of large-scale farms using compost come from outside of Illinois, underscoring the reality that the use of compost on large-scale farms in Illinois is not commonly practiced. These examples are intended to highlight the actual practices of different types of farms within and outside of Illinois, and shed light on the impetus for using compost or the barriers preventing its broader use.

Large-Scale Sustainable Farms

Vilicus Farms

Doug and Anna Crabtree launched Vilicus Farms in 2009 when they acquired 1,280 acres of Northern Great Plains prairie in Montana. Doug and Anna "recognized the emerging opportunities in the organic market and began drafting their vision of a model organic farm that would push the boundaries of conservation and sustainability" (Vilicus Farms, 2015). "Over 26% of the farm is in non-crop conservation and habitat. Vilicus Farms' cropping system allows for [them] to farm alongside nature's systems and to mirror its processes for sustainable food production…Organic production isn't just growing food without chemical inputs. It's a system that requires improving soil, water and associated resources while producing safe and healthy food for a growing population of informed consumers (Vilicus Farms, 2015).

The core strategies employed on Vilicus Farms to build nutrients in the soil, reduce erosion and protect water quality include: a) 5-7-year crop rotations (small grains; lentils; broad leaf, flax, buckwheat; etc.); b) cover cropping with vetch; c) the integration of manure from a neighbor's farm which they work into the soil; and d) the use of 20-30-foot native grass/plant conservation buffers that divide their 240-foot-wide cultivation strips. According to Anna, their conservation goals coincide with their ambitions to design a farming system with little or no artificial inputs. Their system is also designed to withstand the impacts of the vastly changing and varying climate in their region and to protect against heavy reliance on one type of crop that could be susceptible to severe weather damage. Access to free manure in addition to reintegrating "green manure" from cover crops eliminates the need for purchasing and spreading compost. In her regional community of farmers, compost is not readily available and they are not aware of any similarly sized operations that use compost (Vilicus Farms, 2015).

Joseph Phelps Winery

Joseph Phelps Winery began implementing sustainable practices in its vineyards in 1974. Since then, Wine Spector Magazine selected Joseph Phelps Winery's flagship wine Insignia as 2005 Wine of the Year, demonstrating that sustainable agriculture can be "fruitful and contribute to the production of world-class wines" (CalRecycle, 2014).

"Winemakers manage their vineyards to cultivate particular characteristics, including flavors and aromas unique to their soils and climate, sometimes known as 'terroir.' For Sarah Black, viticulturist, tending the vineyards and managing 600 tons of organic waste material each year and applying its compost for soil restoration is a full-circle labor of love for the land and the wine. Black operates a compost facility at the Joseph Phelps Vineyards winery in Napa, [CA]" (CalRecycle, 2014).

Located Napa Valley's eastern slopes, the winery "spreads across 120 acres including a compost site that sits among mustards, poppies, daisies, soaring blue oak trees, and other native species that provide a habitat for birds and a host of beneficial insects…Feedstock for compost includes manure from an organic dairy, wood chips, and grape seeds, skins, and stems (sometimes called pomace)" left over from the winemaking process (CalRecycle, 2014). "After building a windrow, the pile is turned and aerated. The windrow is about 100 feet long and 7 feet high. [Black] makes sure to meet the 'time and temperature' requirements that kill weed seeds and pathogens. The windrow reaches temperatures up to — sometimes exceeding — 150 degrees Fahrenheit,

more than hot enough to comply with the standards for pathogen reduction established by California regulations" (CalRecycle, 2014).

All the compost, typically 3 to 5 tons per acre, is applied onsite in the fall and tilled in 4 to 6 inches deep between vine rows. Following application, Black seeds cover crops (e.g. rye, brome, clovers) to "maintain soil integrity and fix nitrogen" (CalRecycle, 2014).

Photo source: CalRecycle, 2014

For Joseph Phelps Winery, using compost is about "creating site specific conditions in the soil, and keeping the vines just so, in order to produce the particular grape quality… Compost benefits these vineyards by enhancing water-holding capacity and reducing the potential for erosion" (CalRecycle, 2014). Black states, "Too much moisture, and you can get fungus. Grape vines want a low nutrient condition and not too much moisture at the surface so the roots can get deep. You don't want to coddle these plants, you have to stress them a bit in order to get the vines to produce a grape that is suitable to wine-making" (CalRecycle, 2014). She further explains that, composting "helps build organic matter in soils, and overall healthy plants is what we are striving to maintain…Using compost in combination with cover crops enhances soil life and this helps create an environment for healthy plants" (CalRecycle, 2014).

Earthbound Farm: Compost Use in Large-Scale Production of Salad Greens

Photo source: CalRecycle, 2013

Earthbound Farm, one of the nation's largest producers of fresh and organic fruits and vegetables, is a big proponent of the use of compost in its salad greens production. Michael Brautovich, Earthbound Farms Senior Manager for Quality, has five watchwords when it comes to purchasing compost for Earthbound Farm: "quality, safe, consistent, mature, organic" (CalRecycle 2013). "We are looking for compost free of chemical, physical, and biological contaminants," says Brautovich (CalRecycle, 2013).

Across its Arizona, California, and Northern Mexico farms, Earthbound Farm applies 3 to 10 tons per acre of compost to their 30,000 acres of organically grown produce. Earthbound Farm prioritizes risk management whether they are purchasing compost from permitted California facilities or making it on one of their 150 affiliated farms,…All compost supplied to Earthbound Farm must have third-party certification. The third-party authority works with the composter to review process-water testing, feedstock separation, temperatures, curing procedures, and overall sanitation. Oftentimes, finished product is covered to keep out birds. When the product is delivered to one of Earthbound's fields, it is tilled in right away and is never allowed to sit" (CalRecycle, 2013).

The U.S. Compost Council's Test Methods for the Examination of Composting and Compost provides detailed standards, contamination parameters, and testing procedures to "verify the physical, chemical, and biological condition of composting feedstocks" (U.S. Composting Council, 2001). Earthbound has adopted these methods to promote zero contamination on their farms. Beyond zero contamination, Gina Bella Colfer, an Earthbound agronomist, tracks certain indicators to promote compost maturity, which is essential for usable compost. For example, Colfer strives to keep "pH between 6.5 and 8.5, a carbon-to-nitrogen ratio less than 17:1, zero or minimal ammonia and nitrate, and zero nitrite" in addition to maintaining seedling germination rates at or above 90% (CalRecycle, 2013).

Brautovich stated that, "all compost applications are either done at the end of the cropping season or very, very early" (CalRecycle, 2013). Earthbound applies compost before seeding two of its flagship products, baby spinach and tiny lettuce, which have 30-day growing cycles. To reduce fuel usage and soil compaction, Earthbound also mixes in organic materials such sulfate of potash and gypsum to its custom compost blend (CalRecycle, 2013).

Additionally, Earthbound carefully considers the microbial diversity of its compost. In the past, they contracted with a laboratory that would break down the types of microbes in the compost, but finding a sufficient laboratory replacement has been difficult since that laboratory has closed. As of 2013, Earthbound has been using a lab that reveals the total number of active bacteria and fungi (CalRecycle, 2013).

Photo source: CalRecycle, 2013

Earthbound also sorts out physical contaminants through a small sifting screen, which will catch anything larger than a quarter of an inch. Because Earthbound is entirely organic, biosolids and animal material are not viable compost options. ***Food waste is also not possible because they risk too many contaminants***. Instead, "Clean Green" urban green wastes, dairy manure, agricultural wastes, and the cotton gin plant residues are all utilized. Earthbound's San Juan Bautista packing plan delivers all vegetable material to facilities for compost or to feed cattle (CalRecycle, 2013).

Brautovich and Colfer agree that composting has had many benefits. For example, compost builds "soil organic matter over time," which is essential to maintaining their organic farm (CalRecycle, 2013). Brautovich and Cofler also cite the increased microbial diversity and water-holding capacity of their soil, which increase crop resistance and water savings (CalRecycle, 2013).

Marin Carbon Project: Compost Use on California Rangeland

In response to the rising threat of climate change, the Marin Carbon Project (MCP) seeks to "enhance carbon sequestration in rangeland, agricultural, and forest soils through applied research, demonstration and implementation in Marin County" (Marin Carbon Project, 2018). The Marin Carbon Project is performing a long-term experiment testing the effect of using large quantities of compost on forage in California rangeland. Preliminary results point to substantial improvements in forage quantity and quality, native perennial grass growth, and carbon sequestration benefits. The project's vision is for "landowners and land managers of Marin's agricultural ecosystems to serve as

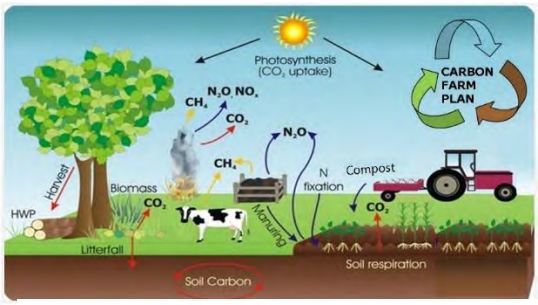

Photo source:
Intergovernmental Panel on Climate Change (IPCC)

stewards of soil health and to undertake carbon farming in a manner that can improve on-farm productivity and viability, enhance ecosystem functions, and reverse climate change" (Marin Carbon Project [MCP], 2013). According to the Marin Carbon Project (2018), "as much as one-third of the surplus CO_2" is released into the atmosphere through common land and agricultural practices such as grazing, tilling, or driving tractors. Despite these CO_2 releases, soils can store carbon for decades or centuries via soil carbon sequestration.

MCP engages in Carbon Farming, which improves the rate of carbon sequestration and conversion to organic material in the soil. In 2013, it launched a soil carbon program across 3 farms in Western Marin County (Stemple Creek Ranch, Straus Dairy, and Corda Ranch). Currently, MCP is working on "securing the policy and economic supports necessary to support adoption of carbon-beneficial practices at scale in Marin County" (Conservation in a Changing Climate, 2016).

Photo source: MarinCarbonProject.org

MCP performed "extensive baseline soil sampling and a full rangeland assessment to identify appropriate application sites" (MCP, 2018). Once MCP determined the appropriate compost cites, it applied nearly 4,000 cubic yards of compost across its 3 ranches, totaling almost 100 acres (MCP, 2018). MCP's Implementation Task Force worked with these farms and the local Natural Resources Conservation Service (NRCS) to "identify a suite of farm management practices to complement compost application in a manner that builds soil carbon and soil health and improves productivity" (CalRecycle, 2018).

Each of the 3 farms has developed a comprehensive Carbon Farm Plan (CFP), including "known climate-beneficial practices such as windbreaks, riparian and range management improvements, and grass, plant and tree establishment" (CalRecycle, 2018). The Stemple Creek Ranch, Straus Dairy and Corda Ranch CFPs are written and are now in implementation stage. In the coming years, the Marin Carbon Project expects to help produce at least 20 more CFPs for farms in Marin County (National Resource Conservation Service California, n.d.).

Small and Mid-Sized Sustainable Farms

Mint Creek Farm

According to Harry Carr, a founder of Mint Creek Farm, it "raises premium, grass-fed meats for the Chicago area. We are a family farm, grazing our livestock on Certified Organic central Illinois pasture. We produce grass-fed lamb, grass-fed beef, pastured pork, and pasture-raised goat. In addition to our pastured livestock, we raise pastured poultry, including duck, chicken, and turkey" (Good Food Accelerator, 2014). Mint Creek Farm sells at a variety of farmers' markets in Chicagoland. It uses a manure/hay/straw compost that it produces onsite on 220 acres; the compost heaps are turned, aged and spread with a manure spreader/small tractor operation or spread naturally through rotational grazing. Mint Creek Farm faces no obstacles to creating and using compost and sees its use as essential to holistic farming and good soil fertility. Composting for Mint Creek Farm has economic advantages and provides tremendous environmental and quality of product benefits according to its owners (Mint Creek Farm, 2017).

Angelic Organics

Founded by farmer John Peterson in Caledonia, IL, Angelic Organics is known as the "granddaddy" of small-scale Community Supported Agriculture (CSA) in Illinois, providing households with weekly boxes of fresh, seasonal, and organic produce and herbs since the 1990s. Dedicated to sustainable, organic and biodynamic farming, Angelic uses compost on 60 acres of vegetables and 120 acres of permanent pasture and hay ground. Despite intensely working the ground through vegetable production, Angelic has doubled its soil's organic matter and productivity over the past 15 years through the use of compost and cover cropping. It mainly uses compost made on the farm consisting of ruminant manures, straw and soil. The compost is spread with a manure spreader on the vegetable plots, and it is spread naturally through livestock rotations.

Tom Spaulding, director of the Angelic Organics CSA Learning Center, asserts that there are no barriers to using compost at Angelic and that it is a great source of fertility with greater capacity to fix nitrogen and mitigate climate change. According to him, Angelic Organics is a good representation of many small farms that are committed to a holistic approach to farming, for which the use of compost is an integral and necessary component. The holistic approach focuses on building nutrients from within the farm; seeing the farm as a living organism; combining a mix of animals, grains and produce; using materials wisely; and creating diverse life within soils. Spaulding believes one of the challenges farmers face with using compost is a mindset focused more on short-term nutrient needs rather than building soil biology for long-term soil health. He also cites the lack of Illinois compost that has consistent quality designed for use in agriculture as another major obstacle. When Angelic does purchase compost, it tries various local brands but eventually returns to using Vermont Compost due to its consistency in quality. Lastly, Spaulding cites that the loss of Illinois dairy farms and readily available manure has impacted on-farm composting, though it may provide market opportunities for the purchase and use of quality compost (Angelic Organics, 2015).

Springdale Farm

Run by Peter and Bernadette Seely for over 20 years, Springdale Farm produces approximately 35 different crops including an assortment of leafy greens, root vegetables, garlic, onions, leeks, squash, watermelons, strawberries, and a variety of herbs. Today their CSA has about 700 members, and in addition to the produce they are able to harvest from their own fields, the Seelys also work with over a half-dozen other sustainable growers who also contribute fruits and vegetables to filling their CSA boxes. Although the farm, located about 2 hours north of Chicago near Plymouth, WI, is not certified organic, Springdale operates sustainably and yields organic crops through crop rotation, planting cover crops, and applying compost. Peter Seely prefers to make his own compost by mixing a variety of manures with straw, leaves, and corn and cabbage residues. He also purchases compost as needed from a Racine, WI producer and uses about 10-40 tons per acre. Implementing environmentally sound practices, such as using compost, is crucial to upholding the farm's core values (Springdale Farm, 2008).

VII. Opportunities and Barriers to Composting on Farms

Despite increasing awareness of the benefits of compost, significant barriers exist that are preventing greater use of compost within large and mid-scale farming operations. This section will examine a few of the most significant studies that have been conducted around the issue of why compost is not used more frequently among many farmers, and in addition to barriers will discuss potential solutions for more wide-spread use of compost in mid and large-scale agriculture.

Flanders, Belgium Study

Studies on the use of compost on farms are not plentiful. Ergo, this paper will draw from findings made in a 2016 study conducted in Flanders, Belgium, that complement U.S.-based farmer interviews we have

conducted, interviews with commercial composting facilities, and other case studies related to the use of compost as a strategy for building soil nutrients and mitigating water quality pollution (Viaene et al., 2015).

Despite consensus on the numerous benefits on compost use on farms, the Flanders study reveals that compost is rarely used in intensive agriculture, especially in regions with high manure surpluses. The Flanders study found limited compost use despite farmers' recognition of the benefits; multiple barriers to compost use in agriculture; and determined the most common barriers to be either financial, institutional or informational. The study also makes recommendations to overcome these barriers, which may shed light on considerations for Illinois (Viaene et al., 2015).

The Flanders study, and many other studies found through research for this white paper, overwhelmingly determine that compost contains large amounts of organic matter and adds a higher volume of Soil Organic Content than do applications of mineral fertilizers, chemical fertilizers and slurry. Multiple studies have offered science-based data supporting claims that nutrients in compost are gradually released; compost reduces the amount of leaching into waterways because they are fixed in the microbial soil mass; and that compost adds biological diversity, sequesters water and carbon, and increases crop yields. The Flanders study concluded that most farmers interviewed acknowledged the multiple positive effects of compost on soil quality (Viaene et al., 2015).

Despite this recognition by farmers in the study, the Flanders interviews confirmed that only a minority of farmers apply compost – only 6.6% of the farmers on an average of 10% of their land, and only 11% said they intended to use compost in the future (Viaene et al., 2015).

Barriers to Using Compost

The barriers to compost articulated in the Flanders study include: a) **complex regulations** in Belgium regarding the use of compost; b) the **surplus of manure** and availability of manure at no cost as a provider of nutrients, and the social connection between farmers who have excess manure and those who receive it; c) **availability and transportation** of compost related to lack of supply, uncertainty of product availability when it is needed, costs to transport, and difficulty of finding contractor to transport and spread compost; d) **quality of compost** and the perception of the risk of weeds and diseases, and uncertainty about quality and what type of product they are actually getting; e) **lack of knowledge** and experience with using compost, including that extension services and other educational sources for farmers do not incorporate the use of compost in trainings and materials and that there are very few peers who can provide learning opportunities; and f) the **ownership vs. leasing** issue and the nature of compost as a solution with short-term costs yielding long-term economic and environmental benefits that farmers who lease land may not realize after the fact (Viaene et al., 2015).

Recommendations

The authors of the Flanders study presented long-term recommendations to address the barriers to the use of compost in agriculture in Flanders, Belgium. Some of the recommendations included **outsourcing on-farm compost production** to alleviate the need for farmers to buy expensive equipment and reduce the time commitment and knowledge needed for them if they were doing it themselves; **financial incentives** from the government to encourage on-farm composting; **simplifying the regulations** for on-farm composting; creating specific certification and **quality assurance** labels related to compost for agricultural use; and **engaging extension services** trusted by farmers to educate them about the use and creation of compost (Viaene et al., 2015).

Illinois and Florida Studies

A study conducted in 2006 by Paul Walker from Illinois State University and colleagues from the University of Illinois and Texas State University was designed to determine and evaluate potential paying markets for compost using Illinois as a model. 746 surveys were returned, with the greatest interest in composting coming from commercial tree growers, nurseries and greenhouses; landscape contractors; and lawn care operations. Conventional commodity farmers, vegetable and fruit growers, and livestock farmers all did not emerge as sectors with interest. Despite studies on the benefits of compost (Ozores-Hampton et al. 2001; Sikora and Szmidt, 2001; He et al., 2001; Hardy and Sivasithamparam, 1991; Scheuerell and Mahaffee, 2002; Chaney et al., 2001; Sterrett et al., 1996; Brown et al., 1998; and numerous other recent studies), the majority of respondents did not indicate that the replacement of chemical fertilizers and greater seed germination were primary reasons for using compost. Walker et al. and other studies (Glenn 1999; Naylor and Girenes 2002; Rosen et al 1993) suggested that because compost facilities in Illinois have been designed primarily to divert material from landfills, the mindset of manufacturing a marketable product may not always exist (Goldstein 2001) – thus limiting interest in using compost by many sectors including agriculture (Walker et al., 2006).

In a study conducted by Monica Ozores-Hampton (2001), a compost researcher at the University of Florida, findings indicated that many farmers in South Florida are not using compost because of the high cost of purchasing, transporting and spreading – despite the great need for nutrients in soil that have high sand content. The study cited that the necessary equipment (tractors, turners, spreaders) for making and using compost was cost-prohibitive despite the realization that synthetic fertilizers were not long-term effective at building soil nutrients. The lack of large-scale compost spreaders was also cited as a problem.

St. Louis Composting

Patrick Geraty founded St. Louis Composting, a composting facility, in 1992. It has 6 composting facilities, which process approximately 600,000 cubic yards of material each year, totaling more than one-third of St. Louis County's combined yard waste. "In addition to composting yard trimmings gathered by the area's major waste haulers, [St. Louis Composting] receives material collected from landscapers and homeowners…St. Louis Composting is based in Valley Park, Mo. It is home to a 26-acre composting facility which carries a full line of Seal of Testing Assurance- certified compost, topsoil and soil blends plus a variety of mulches" (St. Louis Composting, 2018). Sara Ryan Koziatek, Marketing Coordinator of St. Louis Composting and Vice President of the Illinois Food Scrap Coalition, states that St. Louis Composting has virtually no market with farmers despite an interest in selling to farmers.

Organix Recycling

Organix Recycling is the largest nationwide collector of food waste in the USA and presently services 38 states with full collection and services Walmart stores in all of the continental United States and Puerto Rico. Last year, Organix Recycling collected and recycled over 500,000 tons of food waste and 150,000 tons of green waste. According to Jim Cowhey, Chief Strategy Officer for Organix Recycling, less than 5% of the company's compost sales reach the agriculture sector.

Abundant Biology, LLC

Abundant Biology, LLC is a commercial composting operation based in Fairfield, IA. It started in 2016 on an 800-acre certified organic grain farm targeting mid-to-large scale commercial grain farmers among other clients. Mallory Krieger, Director of Business Development for the relatively new venture, is surprised by the lack of conversation around the use of compost on farms in professional conferences. Krieger cites multiple examples, such as the recent Practical Farmers of Iowa Conference, where the term "compost" is hardly mentioned let alone a topic of discussion. Through anecdotal conversations, Krieger hears skepticism from conventional farmers about the ability of compost to "do all that it promises" and that it will actually work.

Other barriers, according to Krieger, include the perception that composting is expensive (and the reality of higher up-front costs related to transport), the lack of geographic proximity of a high-quality compost product, and a preference among farmers to use cover cropping to build soil nutrients despite the greater capacity of compost to build nutrients in the soil and provide multiple other cost-saving and environmental benefits. She also cites that some farmers who experimented with products marketed as "compost" (but were using industrial waste products loaded with salts and heavy metals) did not experience positive results and were turned off to compost as a result. Krieger asserts that not all compost is true compost, and greater education about what is true compost needs to occur. Lastly, improved farmer education and refinement of the economics around compost should lead to increased use of compost in the agricultural sector.

Western Washington State Farm Study

Over the past several years, the Snohomish Conservation District has been partnering with Washington State University Snohomish County Extension on the Compost Outreach Project. With more than 13 commercial composting facilities and more than 900,000 tons of food scraps and yard trimmings composted annually, Western Washington is at the forefront of organic materials recovery. Although compost is available on a large scale, agricultural markets make up less than 5% of the total compost market in Washington State. The Washington State University (WSU) Compost Outreach Project is working to evaluate the benefits of compost on local crops and address the challenges faced when using compost.

While farmers are consistently seeking sources of organic matter, in 2015, 81% of farmer respondents (35 out of 43 WSU Compost Trials Participants) had not used food scrap and yard trimming compost prior to participating in the trials. Local compost producers – Bailey Compost, Cedar Grove Composting and Lenz Enterprises – have donated over 4,500 tons of compost to the project since 2011 with the goal of expanding its use in agriculture. Correspondence and focus groups with farmers in Snohomish and King counties revealed challenges to using compost; the most significant barriers to using more in agriculture are compost price, compost spreading (time and equipment), and lack of information.

At Carleton Farm, research trials evaluated the effect of cumulative multiyear compost applications. In 2012, two years of compost application (approximately 20 dry tons per acre) increased pumpkin yield by 28%. In 2013, sweet corn ear weight increased by 24% after three years of compost application (rate of application approximately 15 dry tons per acre). In 2014, no additional compost was applied and the three previous years of application resulted in a 35% increase in cucumber yield. In 2014, at Darrell Hagerty Farms, a light application rate (6.5 dry tons per acre) of registered organic compost increased organic green bean yield by 19%. Beet seed at Williams Farm showed a 21% increase in yield with 20 dry tons per acre application. Each of these results was statistically significant. There were 49 demonstration trials in 2015, and while the drought in 2015 posed significant challenges, farmers reported that compost improved crop production in 68% of the trials (out of 47 trial crops). 55% of farmers found compost increased soil water retention; Christmas tree farmers have observed improved tree growth and health; a farmer using compost on sweet peppers reported larger and more productive plants; blueberry plants have thrived in rows mulched with compost; and compost consistently has shown positive crop yield and health results on pumpkins. However, several participants reported the compost had no noticeable effect.

Farmers continually pinpointed price, spreading (equipment and time), delivery, plastic contamination, and lack of information as challenges to using compost. In response, educational workshops and presentations have aimed to increase farmer knowledge of when and how to use compost, and an ongoing dialog between composters and farmers is shaping a mutually beneficial relationship. Conservation districts continue to enhance their focus on compost education, targeting farmers and landowners. Snohomish and King County Solid Waste Divisions, with support from Waste Management, continue to develop and expand the agricultural

end use market to ensure the success of the local composting industry and the continued availability of compost for use on local farms. The Compost Outreach Project has achieved notable success and worked with 73 farmers since 2011. In 2015, 62% (23 out of 37 participating farmers) reported they are motivated to use compost and nine farmers purchased loads of compost outside of the program in 2014 and 2015 (Collins, Harness, & Brady, 2016)

VIII. Final Summary

The Issues

Though barriers to using compost in agriculture exist, opportunities to increase the use of compost are worth exploring given the multiple environmental benefits that the use of compost generates. For conventional farmers looking to rebuild soil nutrients, reduce nutrient loss, and protect water ways, the current menu of practices in Illinois (through Illinois Farm Bureau grants and with farmers linked to the Soil Health Partnership) are focused on cover cropping, crop rotation and low or no-till farming in addition to multiple strategies listed previously that focus specifically on nutrient loss reduction. While these practices reflect a giant leap forward and are critical to long-term, sustainable agriculture, this paper has attempted to explore barriers and solutions related to the use of compost in agriculture as a complement to other sustainable agriculture practices. The lack of discussion around compost in agriculture at professional conferences and through extension services may be symptomatic of other barriers to the use of compost. It also presents an opportunity for increased education about the multi-faceted, long-term benefits of compost.

Access to free manure even among sustainable farmers, in addition to folding ”green manure” from cover crops into the soil, currently competes with the price of purchasing and spreading compost. Free manure and cover cropping are more cost-effective methods for many farmers than buying or producing compost and applying it, despite knowledge about the superior benefits of compost.

Some small- to mid-sized farms producing food for local consumption incorporate the use of compost they make on the farm or purchase into their farming practices as part of a broader holistic approach to sustainable, organic, and biodynamic farming. For these farmers, using compost is a given, and in some Illinois cases, they supplement on-farm compost production with purchasing quality out-of-state compost when there is a lack of available quality compost suitable for agriculture.

Food-waste amended compost is viewed by some farmers as risky because of the real or perceived level of contaminants. Some have tried products labeled as compost that did not perform, turning them off to compost entirely. Similarly, for some farmers there is doubt as to whether compost can do all that it promises. Many farmers in the studies referenced in this white paper see the multiple benefits of compost but still prefer to use other practices to build nutrients. Some studies indicate that the most commonly expressed obstacles to using compost – despite knowing the superior performance benefits of compost – include price, compost spreading (time/equipment) and a lack of information.

For some farmers, barriers to using compost also include the reality of higher transportation costs due to the lack of geographical proximity of compost to their farm and a preference to use cover cropping.

Moving Forward

Recognizing the challenges impeding the use of compost in agriculture, the opportunities to increase the use of compost will need to address: a) the quality and availability of compost locally; b) cost-competitiveness related to purchasing price, transport and application; and c) compost education including its benefits, how to access and apply compost, and how to make compost onsite.

Testing locally on farms and sharing those results with farmers in Illinois could support more use of Illinois-grown compost. With Illinois' significant problem the Mississippi River nutrient overload issues, there seems to be an opportunity to explore the effectiveness of compost in holding onto nutrients in comparison with other nutrient loss reduction strategies being deployed.

Within the state, it seems that even among sustainable farmers who incorporate the use of compost as part of a holistic farming approach that having quality Illinois compost *purposefully made for agricultural use* would provide them with a local compost supply to supplement what they would otherwise make onsite. In regard to price, it seems that greater supply within closer proximity of farmers would support more favorable price points. The lack of supply plus long transportation and other related costs must be overcome if farmers are going to see compost as a viable long-term solution for building soil health and increasing farm productivity. Some newly developing composts may offer solutions related to pricing and ease of application, and the push nationally to advocate for Seal of Testing Assurance (STA) compost could address quality and reliability concerns.

If quality and pricing are addressed, then education about compost may have more traction with farmers who could then factor in the long-term soil health and other environmental benefits of compost and potentially see them as outweighing the short-term costs – and ultimately as a strategy that complements other sound agricultural practices that build healthy soils, protect water quality, and support greater crop quality and yields.

Appendix A: Acknowledgements

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Appendix B: Glossary

Algae bloom: the rapid increase in the population of algae in an aquatic ecosystem as a result of the presence of excess nutrients (particularly phosphorus and nitrogen) in high concentrations in a body of water. The overpopulation of algae in an ecosystem leads to competition for resource and often results in the loss of many other aquatic species due to oxygen loss.

Anaerobic digestion: a series of biological processes in which microorganisms break down biodegradable material in the absence of oxygen.

Biogas: the gaseous emissions from anaerobic degradation of organic matter. Biogas technology recovers this gas for use as fuel for direct heating, mechanical power, electrical generation and other uses.

Carbon sequestration: an artificial or natural (occurring in the form of carbon sinks such as oceans, forests, or soils) process by which carbon dioxide is removed from the atmosphere and stored in solid or liquid form.

Carbon sink: an artificial or natural reservoir (oceans, forests, soils) that absorbs carbon from the atmosphere, effectively offsetting greenhouse gases.

Compost: a mixture of various decaying organic waste substances, such as food scraps, dead leaves, or manure used as soil fertilizer.

Cover crop: a crop grown for the protection and enrichment of the soil.

Erosion: the act in which rock and sediment is worn away, often by water, wind, or other natural agents.

Eutrophication: excessive richness of nutrients in a lake or other body of water, frequently due to runoff from the land, which causes a dense growth of plant life and death of animal life from lack of oxygen.

Food scrap composting: the process of decomposition and recycling of organic matter derived from food waste, to be turned into a high-quality soil amendment.

Humus: the dark organic material in soils, produced by the decomposition of vegetable or animal matter and essential to the fertility of the earth.

Hypoxia: oxygen depletion; an environmental phenomenon where the concentration of dissolved oxygen in water decreases to a level that can no longer support living aquatic organisms. Hypoxia in the northern Gulf of Mexico is defined as a concentration of dissolved oxygen less than 2 mg/L (2 ppm).

Leaching: the loss of water-soluble material or plant nutrients from a substance, such as soil or rock, through the percolation of water.

No-till: a way of growing crops or pasture from year to year without disturbing the soil through tillage.

Pre-consumer food scraps: food waste generated during the manufacturing and production of food prior to the item being sold in shops or served to consumers that can result from overproduction, spoilage, faults in food preparation, or products not meeting the demands of food retailers (due to size and aesthetics).

Saturated buffer: a vegetated buffer near a water system in which the water table is artificially raised by diverting much of the water from a subsurface drainage system along the buffer to reduce nitrate loading to surface water via enhanced denitrification.

Soil organic carbon (SOC): the amount of carbon stored in the soil is a component of soil organic matter; basis of soil fertility.

Streambank stabilization: a vegetative, structural or combination treatment of streams designed to stabilize the stream and reduce erosion.

Strip-till: an agricultural system that uses minimum tillage, combining the soil drying and warming benefits of conventional tillage with the soil-protecting advantages of no-till by disturbing only the portion of the soil that is to contain the seed row.

Tillage: the agricultural preparation of soil by mechanical agitation of various types, such as digging, stirring, and overturning.

Topsoil: the fertile, uppermost layer of soil (usually the top 2 to 8 inches) that has the highest concentration of organic matter and microorganisms and is the site of most of earth's biological soil activity.

Woodchip bioreactor: subsurface trenches filled with a carbon source, mainly wood chips, through which water is allowed to flow just before leaving the drain to enter a surface water body.

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