INSTITUTE FOR ENERGY AND
ENVIRONMENTAL RESEARCH
*Democratizing science to protect
health and the environment*

An Economic and Agronomic Analysis of Transitional and Organic Cropping Systems

prepared for

Institute for Energy and Environmental Research

by

Zimmer Ag Consulting

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Foreword

The Institute for Energy and Environmental Research (IEER) commissioned this report on a transition to regenerative organic row crop production from conventional row crop production as part of its exploration of the business case for regenerative agricultural practices. IEER is the lead organization for developing the business case in the Million Acre Challenge collaborative, which consists of six non-governmental organizations seeking to advance healthy soils practices on a million Maryland acres of agricultural land by 2030. The suite of healthy soils practices in this context is the usual one aimed at minimizing soil disturbance to the extent possible, keeping the soil covered, keeping a living root system for the whole year, increasing crop diversity and maximizing soil biological diversity, and, where possible, integrating livestock. In addition, there is the broader goal of improving the health of the ecosystem(s) in which farms are located. The entire state of Maryland, with the exception of its western tip (the western part of Garrett County), is located in the Chesapeake Bay watershed.

There are three aspects to developing a business case for adopting regenerative practices:

1. An assessment of the net changes in costs of adopting healthy soils practices, such as planting cover crops, composting, changing chemical inputs (types and quantities), creating riparian buffers and other perennial plantings, and changes in labor and equipment costs associated with using a no-till or low-till approach to planting and weed management.
2. An estimation of the net changes in benefits, such as yield changes, price changes per unit output, improved yield resilience over time, and availability of public incentives that would offset or more than offset the added costs.
3. Transition period costs, such as those associated with purchase of added machinery and learning new approaches to cultivation and soil, pest, and fertility management.

There are case studies available that estimate net changes in costs and benefits for limited sets of healthy soils practices, notably cover crops and no-till/low-till. However, data on transition costs and risks are scarce. A complication is that inherent differences in soil quality may also contribute to risks and outcomes. Moreover, these costs and risks can be expected to vary from farm to farm and from one region to another, even for the same crops. In addition, except for special *ad hoc* arrangements, there is no assured crop price premium for investing in healthy soils practices unless they are accompanied by a transition to organic production, where a market price premium is generally assured because the market recognizes organic food as being of higher quality. That was one of the main reasons that IEER commissioned this report.

IEER is exploring a variety of approaches to covering transition costs and risks and improving farm profits and economic resilience at the same time. Adoption of combined solar electricity production with some types of farming (such as grazing sheep) is one example. This paper explores a transition from conventional commodity crop farming to organic production that also uses regenerative practices as another possible avenue to promoting healthy soils and making that compatible with farm profitability and economic resilience

Healthy soils practices are no less needed on farms involved in conventional row crop production that may not see a path to a transition to the certified organic agriculture. Specific situations of farms vary a great deal; location brings its strengths and weaknesses. Specifically, Maryland’s Eastern Shore is the economic center of the state’s agricultural production both for row crops and its chicken industry. But the advantages of location also bring their own challenges. Many farms, notably on the Lower Eastern Shore, face the problem of high phosphorous loading due to long-term application of chicken litter. In addition, some parts of that same area are also affected by increasing salt water intrusion and sea-level rise – a topic of active research by the College of Agriculture & Natural Resources of the University of Maryland. This is a very challenging context in which to develop a business case for regenerative practices. That is why IEER is exploring several avenues, including examining the economics of adopting suites of healthy soils practices short of organic production, a transition to regenerative organic agriculture, greater diversification of crops, dual-use solar (as mentioned above), and the policies and incentives that could allow a range of transitions suited to different circumstances.

The (relatively) assured profitability after a transition to regenerative organic commodity crop production makes it less complex to demonstrate that specific business case. Yet, the challenges in Maryland are significant even for that transition (as discussed briefly in Chapter IX of this report).

IEER retained Zimmer Ag to do this report because it is led by one of the leading practitioners of the art of biological farming, Gary Zimmer; indeed, he literally wrote the book with that title. He and his firm, Zimmer Ag, have also been helping farmers around the country to transition to biological farming. They are also familiar with the particularities that apply to farming in Maryland, including on the Eastern Shore. The Maryland-specific exploration is limited in this report however, due to the limitations of available resources for commissioning this study. We agreed that Zimmer Ag would rely on data already in its archives. This latter aspect is reflected in the scope of work for the study; the core of that scope is reproduced at the end of this Foreword.

Given their experience and expertise, I felt that Leilani Zimmer-Durand and Gary Zimmer of Zimmer Ag were in an excellent position to produce a report to examine the issues relating to the promotion of healthy soils and organic agriculture at the same time.

I was introduced to Gary by Ellen Polishuk, who has been working with IEER on examining the same transition – except in her case, we have been working on regenerative organic vegetable farming. Thank you Ellen. In addition to Ellen, Amanda Cather, the director of the Million Acre Challenge, and Lisa Garfield of Future Harvest and lead of the Science Working Group of the Million Acre Challenge, participated in the conversations we had with Leilani and Gary throughout the study process. All three, in addition to myself, provided comments to Leilani and Gary on a draft of this report.

As is normal IEER practice, the authors were asked to take careful note of the comments but, being responsible for the contents, were free to take them into account in revising their report as they saw fit.

I want to thank Leilani and Gary for this excellent report; I have learned a lot from it. I want to thank Ellen, Amanda, and Lisa for their input and advice during the production of this study and also for their reviews of the draft report. I also want to thank Niamh Shortt, Field School Director, Future Harvest, who shared her insights into the barriers to a transition to regenerative organic agriculture in Maryland. Finally, I want to thank the Town Creek Foundation, which funded the Million Acre Challenge as one of the last six grants it made as it closed its doors at the end of 2018.

Extract from the Scope of Work for this study:

"The overall research goal is to document the costs and benefits of a transition from industrial corn-soy-wheat farming to regenerative organic agriculture, possibly with a greater diversity of crops. Zimmer Ag would provide data and analysis collected from farms that have actually made the transition (including parcels of Otter Creek Farm) in the areas listed below. No new data would be generated. Data exist in archives of Midwestern BioAg ; they would be recovered from there and suitably compiled:

1. The practices during the transition and the time period involved.
2. Costs of the various aspects of the transition.
3. The baseline economic analysis – crops, yields, costs, prices.
4. Post-transition farm economics.
5. If there are data from Maryland, and/or the Eastern Shore (VA, MD, DE)they would be included.
6. There would be a commentary, with quantitative comments if possible, on the relationship of the farms analyzed to the conditions on the Eastern Shore.
7. A commentary on the role of greater crop diversity in the transition. (No need to do new work if such analysis already exists.)
8. Observations on infrastructure and marketing needed to support a widespread transition in Maryland (or the Eastern Shore more broadly)."

End of extract

Arjun Makhijani
President, Institute for Energy and Environmental Research

Executive Summary

Farming practices in the United States over the past 50 years have generally been focused on producing high volumes of crops at a low price, without much concern for soil or water quality. That focus is starting to shift as the side effects of large scale commodity farming are becoming more problematic. Issues such as nutrient runoff into waterways, soil loss due to erosion, and a loss of soil organic matter and soil water holding capacity are major problems facing farmers and communities today.

One way of addressing these challenges is through adoption of regenerative farming practices. Regenerative practices include practices like cover cropping, adding more crops to the rotation, maintaining soil structure through appropriate tillage practices and not over-tilling, applying crop nutrients in lower quantities and from sources that are less immediately soluble, and using fewer agricultural chemicals. It is possible to add regenerative practices to any farming system, but there is not a direct path to increased profit from them. The best way for farmers to realize a greater financial return for adopting these types of regenerative practices is to transition their farm to organic.

Transitioning to organic farming is a cost and a risk to the farmer, particularly during the 36-month period where the crops are sold at conventional prices, but organic farming practices must be followed. This paper examines several different agronomic approaches to transitioning to organic and the costs associated with each. Six different successful organic farm examples are then highlighted, five in the Midwest and one on Maryland's Eastern Shore. By looking at both theoretical and actual examples of organic farming practices, a picture is drawn of what it takes for an organic farmer to be profitable.

While the crops grown on the example farms vary, all the farms follow regenerative practices and yield close to their county average for conventional crops. There is a common belief that organic farms always yield lower than conventional farms, but that does not hold true when regenerative practices are followed. It also helps to have education programs in place for new organic farmers. Organic farming is a different system of farming, and requires a different mindset and different skills. Farmers who take advantage of some of the many organic farming education programs available and work with mentors are much more likely to be successful and have better quality, higher yielding crops.

While organic farming is currently the most profitable way for farmers to adopt regenerative practices, it is not the only way. Farmers can also take advantage of programs like EQIP that pay farmers a per-acre fee for growing cover crops. Some farmers will add regenerative practices to their farms knowing there are long-term benefits for soil health and sustainability, but for other farmers having financial incentives in place are key. If farmers understand how to add these practices and have cost offsets in place for things like cover crop seed, more farmers will adopt regenerative practices leading to more positive outcomes for the climate and more long term resiliency for farms.

I. Introduction

The purpose of this report is to examine regenerative, organic farming practices along with transition to organic and post-transition farm economics. The data in this report is primarily from Midwestern farm examples, and will be compared to conditions on Maryland's Eastern Shore.

Farming organically is currently the best way for a farmer to increase their revenue from adding regenerative practices to their farming system. Organic farming is far from the only way to improve soil health, water quality, crop health and environmental outcomes from farming, but it does offer the best added margin for farmers who are adopting these regenerative practices. Organic crop prices fluctuate from year to year just as conventional prices do, and just like with conventional farming there is both cost of production risk and market risk. The price differential between an organic crop and a conventional crop does not follow any specific pattern, meaning some years organic farmers will get twice as much for their crop over conventional prices, while other years it may be as low as 20% more. However, for a good farmer the added cost of production for following the National Organic Program rules for farming is only slightly higher than conventional, making this a very profitable farming system for a skilled organic farmer.

For this report, practices and economics from six different farms were used as a baseline for generating the data on row crop transition to organic. Five of the farms were in the Midwest, and one was in Maryland. All of the farmers grew corn and cover crops and at least one other crop, but the crop rotations and crops planted varied. Some of the farms have been organic for many years, while others transitioned more recently. In addition to corn and beans, some of the farms grew rye, some grew mixed cover crops, and some grew wheat. What these farms all have in common is that they are all successful and profitable organic farms.

The six points covered in this paper include:

1. The practices during the 36-month transition to organic, including fertility practices, crop rotations, tillage and weed control.
2. Costs of the various aspects of the transition and the baseline economic analysis – crops, yields, costs, prices.
3. Post-transition farm economics, including cost of production, expected yields and expected crop prices.
4. A qualitative analysis of the relationship of the farms analyzed to the conditions on the Eastern Shore.
5. A commentary on the role of greater crop diversity in the transition.
6. Observations on infrastructure and marketing needed to support a widespread transition in Maryland's Eastern Shore.

i. Practices during the 36 month transition to organic production.

The 36-month period during transition to organic crop production is a time farmers can use to build fertility and gain skills that will set them up for the greatest chance of success and profit during their first year of organic production. For most crop farmers, the 36-month transition period begins in the late summer or early fall, when they apply their last input that is restricted or prohibited by the National Organic Program (NOP) guidelines. They then have two crop years of transition, during which they are following all of the organic practices but have a lower yield at conventional prices that is used as the baseline for crop insurance purposes, and most likely sell their crop at conventional prices. Some farmers are able to get a transitional premium, but those markets aren't large so not all farmers can capture that premium. After the 2nd crop year of transition, the farmer is able to harvest the 3rd crop year as organic, as long as it is harvested at least 36 months after the date of the last non-NOP compliant input.

II. Fertility practices

Because the philosophy behind organic farming is to use the health of the soil to build a healthy crop that does not need chemical fertilizers or pesticides, successful organic farming starts with the soil. Plants have a natural ability to defend themselves from pests and to produce bountiful yields if the building blocks to do so are in place. Plant genetics is a piece of this, but equally important is having an abundance of plant-available nutrients in a biologically active and well-structured soil.

Building soil health starts with taking a soil report, looking at the balance of minerals, and applying soil correctives to address imbalances of nutrients, particularly calcium, magnesium and potassium. Adding soil correctives can be a major investment for a farm, but it is one that will pay off in the long run, as balanced nutrients lead to healthier biology and better soil structure as well as better nutrient availability. The other piece of a soil corrective program is using plants to build soil health by planting a mixed species cover crop. Different types of plants have different root structures and support a different suite of microorganisms, so adding plant diversity builds soil health which leads to more successful organic crop production.

When it comes to fertilizing the organic crop, the National Organic Program rules limit what fertilizers can be used to those that are naturally derived. In practical terms, this means most organic farmers look to manure as a good source of the nitrogen, phosphorus and potassium needed to grow a healthy crop. There is a lot of available manure in the U.S. as sources from both conventionally and organically raised animals can be used, but logistics are a problem as most manure sources are wet and difficult to haul long distances. Chicken litter is the exception, as it is a drier manure and can be transported and applied more easily than other manure sources. While chicken litter is a good source of crop nutrients, applying a large amount year after year cause problems with excess nutrients. For example, a pretty typical analysis for chicken litter is 5% nitrogen, 4% phosphorus, 3% potassium and 7% calcium. If 2000 lbs/acre is applied, this will supply 100 lbs/acre nitrogen to meet most of the needs of an organic corn crop, but will also supply 80 lbs/acre of phosphorus, 60 lbs/acre of potassium and 140 lbs/acre of calcium. Over time, the levels of those nutrients will rise in the soil and can cause issues with nutrient imbalances, and can also lead to water quality problems if there is soil runoff and phosphorus gets into the waterways.

Many organic farmers use manure as a primary nutrient source and supplement with other mined dry fertilizers like rock phosphate, potassium sulfate or calcium sulfate. Healthy organic crops also need micronutrients, which are found in very small quantities in most manure sources. Therefore, organic farmers will often apply a dry micronutrient blend when their soil tests show deficiencies.

i. Crop rotations

Crop rotation during transition to organic varies by farm, but there are several cropping practices that are known to set the farm up for success with fertility and low weed pressure once the farm is certified organic. The first is soil building through a focus on cover crops during transition. The cover crops can be used solely for soil building or paired with an early harvest small grain like wheat or rye so the crop is off early enough to plant and establish a healthy cover crop before winter. The second is using hay during the transition. A high quality alfalfa hay is harvested multiple times during the growing season, which does not allow weeds to go to seed and reduces the weed seed bank during transition. In addition, if the hay has a large percentage of alfalfa, the deep roots and nitrogen fixing capability of the alfalfa will build soil health during transition. It is important to note that harvesting hay does remove a lot of nutrients so it is essential to apply enough manure or fertilizer to compensate for that removal of nutrients from the hay crop.

Many farmers will transition to organic by maintaining a row crop rotation, but switching to organic-approved methods and inputs. While this can work for transitioning, it does not set the farm up for success as an organic farm. It's important to have that focus on soil health and organic management so that when the crop can be certified organic, it's a high quality, high yielding crop that will provide a good financial return to the farm.

ii. Tillage

Using sound tillage practices is another key practice for building soil health. In conventional farming, there is a lot of emphasis on no till as a way to build soil health, but no till is a chemical-dependent method of farming and therefore very difficult to pivot into an organic system. Shallow incorporating residues is a better method of terminating cover crops than using herbicides, and it can be used by both conventional and organic farmers. Tillage often is vilified as destroying soils, but it is important to recognize that not all tillage is the same. Aggressive tillage will harm soils, but shallow incorporating a cover crop where the tillage tool always stays more shallow than the size of the cover crop won't destroy soils.

At Gary Zimmer's farm, Otter Creek Organic Farm, the Lemkin Disc is the main tool used to terminate cover crops and chop up residues. After the first pass with a Lemkin, a second pass is done with a vertical tillage machine, such as the Kuhn-Krause. At planting there are still some residue clumps on the soil, so the planter has row cleaners on it to ensure good soil to seed contact. This method works extremely well for killing the cover crop and capturing the nutrients and carbon from those plants, releasing them into the soil where they can be utilized by microbes and ultimately the cash crop.

It's also important to use tillage as a tool to maintain good soil structure. In farming it's not possible to avoid driving on wet soils 100% of the time, so when compaction does occur an in-line ripper can be used to break up compaction and create areas where water can infiltrate, and roots can penetrate deeper into the soil.

The ideal tillage practices will vary from farm to farm. There is no one ideal way to manage tillage that works equally well on all farms. Differences in soil type, terrain cropping system and climate all impact what types of tillage work best. The key take-away on how to implement good tillage practices on an organic farm is to focus on being a good soil manager. Are you doing what it takes to have loose, crumbly, rich soils that support roots and an abundance of soil life?

iii. Weed control

Effective weed control in organic farming is one of the most difficult aspects to master, and poor weed control is often the biggest factor that separates organic from conventional yields. For someone new to organic farming, there is a learning curve to being successful at mechanical weed control, and new organic farmers can benefit greatly from education and mentoring to help them choose the right tools, determine the best timing, and set the machinery correctly to best kill weeds without damaging their crops.

Weed control for transitional farms growing row crops is the same as for organic farms. The farmer needs to select the right tools that are the right size for the farm to be used at the best time for the crops being grown. Weed control on organic crop farms usually consists of two early passes with a rotary hoe, and two later cultivator passes. The rotary hoe is a very effective tool for killing small weeds before the crop is up, or when the crop is still very small. It can be driven quickly across the field and will do minimal damage to a young corn or bean crop if it's used at the right growth stage. If the crop is too big or the rotary hoe goes too deep, it can damage the crop, so farmer education is a big component of effectively using this tool. Once the crop is larger, a cultivator is used to kill weeds between the rows and to throw dirt into the rows to cover up as many weeds as possible. A Buffalo-type cultivator is a commonly used and very effective weed control tool for organic row crops. Having cut away discs, large sweeps and row shields is essential to making a cultivator effective. Depending on whether their fields are hilly, or whether or not rocks or high residues are an issue, farmers will also often use an Einbock or Lilleston rolling cultivator to control weeds in their row crops. Learning how to set and then pull the cultivator to maximize weed control without damaging the crop takes time and skill. It's very easy to accidentally cultivate out large sections of the crop causing a reduction in yield. New GPS guidance systems for cultivators are helping to make cultivating easier and more precise, but they are expensive and only a financially viable solution for larger farms.

If weeds do get out of control, for example if it's too wet to cultivate during the ideal window when the crop is bigger than the weeds, a flame weeder can be used to burn the weeds in the row. As with all organic weed control, it takes farmer skill to use this tool effectively. There are also a couple of organically-approved weed control chemicals on the market. They work similarly to conventional herbicides, however they are quite expensive, costing around $60 to $120/acre. The current available organic herbicides are non-selective, meaning they will kill your crop as well as your weeds if they come into contact with the plants. The best use of these organic herbicides is to spot-kill problematic weeds like thistles or giant ragweed to keep them from going to seed and creating an even bigger problem for the next growing season.

III. Cost of transition, and baseline economic analysis of organic farming

The cost of transitioning to organic production varies widely based on a number of agronomic baseline practices, including the current equipment owned by the farm, whether the land is rented or owned, the condition of the soil, and the farmer's understanding of how to implement organic farming practices.

Once transition to organic begins, the farmer must follow all of the National Organic Program (NOP) guidelines for organic production, but cannot label and sell their product as organic until 36 months after the last non-NOP approved input is used. There are some options available for selling the crop as 'transitional' for a premium above conventional prices, but those markets are limited so for the purposes of this model it is assumed the transition year crops will be sold at conventional prices but grown using organic practices at organic prices. It is also assumed the transition period will cover two cropping years, and that the third year the crop will be sold as organic.

The following model looks at four different ways of transitioning to an organic crop rotation on a farm in northern Illinois. The model data is an amalgamation of economic information from several different organic farms in Illinois, along with Iowa State data on organic cropping costs.[1] All of the soil conditions, equipment costs, weed and pest control practices and land costs (for rented land) are the same in each model. Two of the models use hay as their transition crop, while the other two use corn and soybeans. All of the models move to a row crop rotation that includes corn and soybeans, with one of the models including wheat in the rotation. For the model that has a two-year corn, one year soybeans rotation, it is assumed that the farm will plant a cover crop after corn to meet the organic requirements of growing at least three different types of plants (this is a very common rotation used on organic farms in Illinois). It is also assumed that the farms will need to increase their baseline fertility in order to increase plant and soil health and be successful at organic farming, therefore a 2-year soil corrective is included as a 'transition soil building expense'. The amount of soil correctives needed to balance a soil are highly variable, ranging from nothing on a rich, highly mineralized soil to $1200/acre on a run-down soil that's very low in nutrients. The model assumes $450/acre over 2 years is very typical for an average to above-average soil.

[1] Iowa State Extension, 2016

Model Transitional Rotations with Costs:

	Model 1	Model 2	Model 3	Model 4
Transition year 1	Hay year 1	Hay year 1	Corn	Corn
Transition year 2	Hay year 2	Hay year 2	Corn	Soybeans
Organic year 1	Corn	Corn	Soybeans	Corn
Organic year 2	Soybeans	Soybeans	Corn	Soybeans
Organic year 3	Wheat	Corn	Corn	Corn
Net Revenue Estimates (per acre)				
Transition year 1	($174)	($174)	($106)	($106)
Transition year 2	$75	$75	($192)	($187)
Organic year 1	$850	$850	$697	$850
Organic year 2	$697	$697	$850	$697
Organic year 3	($202)	$850	$595	$850
Estimated transition soil building expense (per acre):				
transition year 1	$225	$225	$225	$225
transition year 2	$225	$225	$225	$225
Operations return per acre during 2 crop year transition to organic period:				
	($549)	**($549)**	**($748)**	**($743)**
Averaged Annual Revenue over 2 years' transition and 3 years organic production:				
	$249	**$460**	**$279**	**$421**

Based on the model data, the most profitable way to transition is to grow hay. Transitioning to organic nearly always involves a loss in revenue, and the operations return during the 2 year transition is indeed negative in all four models. However, the two models using hay lose less money during transition. What does not show up on the model however, is that the farms growing hay during transition are also in better condition for growing an organic crop their first year. Growing hay reduces the weed seed bank, and also builds available nitrogen in the soil, setting up good conditions for a very successful organic corn crop the first year of organic production. The downside to growing hay during transition is that it removes a lot of minerals and organic matter from the soil. Harvest is also highly weather dependent, and the markets are very variable. The model assumes steady markets at moderate prices, and 4 cuttings of hay each year during transition.

When the farms are then in their organic row crop production years, corn is always going to be the most profitable crop. However, corn cannot be grown continuously, both for agronomic reasons and because the organic guidelines require at least three different crops be grown. Growing corn on corn generally results in a yield reduction the 2nd corn year, particularly on organic farms where nitrogen starts to be depleted in the soils. In the model, a 30% yield reduction the 2nd corn year is assumed based on data from Otter Creek Organic Farm.

In the model, costs for cover crops each year are included, with rye being the predominant cover crop grown as it is possible to plant it after corn or soybean harvest in the fall. Wheat is not a profitable crop in the organic rotation, but because it is harvested early in the season, a mixed cover crop that includes legumes can be grown after wheat, which builds soil health and organic matter. It is not possible to capture these variables in the model, but although the rotation that includes wheat looks to be the least profitable, in fact that farm will likely have higher yields of corn after the wheat/cover crop year than following soybeans or corn.

The model was built upon detailed agronomic data, based both on the University of Illinois Crop Budgets data for 2020[2] and on experiential and anecdotal data from the hundreds of organic farmers that have worked with Gary Zimmer and Leilani Zimmer-Durand over the last 15 years.

For the corn crop, the following is the budget detail for the conventional and organic crops. It is assumed the organic corn yields will be 85% of the conventional yield. This number is based on yield reductions generally observed in organic due to weed control, planting later, and a lack of continuous nitrogen availability.

	Conventional Corn		**Organic Corn**
Yield	225		191.25
Price	$ 4.50		$ 9.50
Revenue	$ 1,013		$ 1,817
ARC/PLC	$ 30		$ -
Crop Insurance Proceeds	$ -		$ -
Gross Revenue	**$ 1,043**		**$ 1,817**
Expenses:			
Fertilizer	$ 125		$ 200
Crop Protection Chemicals	$ 60		$ -
Seed	$ 112		$ 80
Cover Crop Seed	$ -		$ 20
Drying	$ 15		$ 15
Storage	$ 10		$ 10
Crop Insurance	$ 23		$ 23
Total Direct Costs	**$ 345**		**$ 348**
Machine hire/lease	$ 26		$ 39
Utilities	$ 6		$ 9
Machine repair	$ 27		$ 27
Fuel and Oil	$ 17		$ 25

[2] Crop Budgets Illinois 2020

	Conventional Corn		Organic Corn
Light Vehicle	$ 2		$ 3
Machinery Depreciation	$ 58		$ 65
Total Power Costs	**$ 136**		**$ 168**
Hired Labor	$ 23		$ 23.00
Unique Organic Labor			$ 20.00
Building Repair and rent	$ 9		$ 9
Building Depreciation	$ 17		$ 17
Insurance	$ 10		$ 10
Misc.	$ 9		$ 9
Interest (non-land)	$ 26		$ 26
Total Overhead Costs	**$ 94**		**$ 114**
Certification and Records			$ 5
Amortized Soil Corrective Costs			$ 50
Total Unique Organic Costs			**$ 55**
Total Non-Land Costs	$ 575		$ 670
Operator Return (non-Land)	**$ 468**		**$ 1,147**
Average Cash Rent	$ 297		$ 297
Operator Return Including Rent	**$ 171**		**$ 850**

The following assumptions are built into this model data:

- Organic yield and prices based on 2020 markets and data from organic farmers
- Fertilizer prices exclude cost of soil correctives
- No government payments for cover crops or conservation practices were utilized
- Crop protection is assumed to be zero for organic farms that have healthy soils, but this can be varied in the model
- Seed costs are based on current advertised prices as of 2021 for both conventional and organic seed
- Unique organic labor is mainly hand weeding and other additional weed control
- Costs are based on a 400 acre farm, which maximizes machinery efficiency

The model includes a 50% higher cost for machinery hire/lease for the organic rotation. This is based on the additional costs of mechanical weed control. Organic farms can use the same planting and harvesting equipment as a conventional farm, but will have additional equipment that is used for weed control. Typically, this equipment would include the following:

1. Rotary hoe or tine weeder, cost approximately $12,000 for a 12 row piece of equipment.

2. High speed disc or rotavator (for a smaller farm) to terminate cover crops. A 12 foot rotavator costs $15,000, but a larger farm would need to spend $50,000 for a large rotator or high speed disc like a 20 feet Kuhn/Krause or similar.
3. Aeration tool, such as an in-line ripper. Many conventional farms also have this piece of equipment, but not always. The average cost is $25,000.
4. Cultivator. There are many different types, but commonly used ones include Buffalo, Einbock, or a Lilleston rolling cultivator. Each would cost around $40,000 for a brand new 12 row model.
5. A tool for planting cover crops, which a conventional farm may already have. A grain drill or spinner is needed, with the grain drill costing about $35,000 for a 12 row.
6. Some organic farmers also like to use a weed burner to kill in-row weeds. These cost around $12,000 for a 12 row burner.

For the soybean crop, the following is the budget detail for the conventional and organic crops. It is assumed the organic soybean yield will be 80% of the conventional soybean yield. This is based on later planting dates and the difficulty of controlling weeds in soybeans.

	Conventional Soybeans		**Organic Soybeans**
Yield	65		52
Price	$ 10.50		$ 27.50
Revenue	$ 683		$ 1,430
ARC/PLC	$ 30		$ -
Crop Insurance Proceeds	$ -		$ -
Gross Revenue	**$ 713**		**$ 1,430**
Expenses:			
Fertilizer	$ 31		$ 60
Crop Protection Chemicals	$ 36		$ -
Seed	$ 73		$ 50
Cover Crop Seed	$ -		$ 20
Drying	$ 1		$ 1
Storage	$ 4		$ 5
Crop Insurance	$ 15		$ 15
Total Direct Costs	**$ 160**		**$ 151**
Machine hire/lease	$ 22		$ 33
Utilities	$ 5		$ 5
Machine repair	$ 23		$ 23
Fuel and Oil	$ 14		$ 18
Light Vehicle	$ 2		$ 3
Machinery Depreciation	$ 56		$ 64

	Conventional Soybeans		Organic Soybeans
Total Power Costs	**$ 122**		**$ 145**
Hired Labor	$ 20		$ 20.00
Unique Organic Labor			$ 30.00
Building Repair and rent	$ 4		$ 4
Building Depreciation	$ 8		$ 8
Insurance	$ 7		$ 7
Misc	$ 9		$ 9
Interest (non-land)	$ 22		$ 22
Total Overhead Costs	**$ 70**		**$ 100**
Certification and Records			$ 5
Amortized Soil Corrective Costs			$ 50
Total Unique Organic Costs			**$ 55**
Total Non-Land Costs	$ 352		$ 436
Operator Return (non-Land)	**$ 361**		**$ 994**
Average Cash Rent	$ 297		$ 297
Operator Return Including Rent	**$ 64**		**$ 697**

The assumptions for the soybean model, along with the equipment scalar, are the same as those used for the corn model, above.

For the wheat crop, the following is the budget detail for the conventional and organic crops. It is assumed the wheat yield will be 80% of the conventional yield. For the wheat model, only a 10% increase in equipment expense is assumed. That's because winter wheat does not require weed control as it's planted in fall and comes back in spring, shading out most weeds early in the season.

	Conventional Wheat		Organic Wheat
Yield	85		68
Price	$ 5.00		$ 8.50
Revenue	$ 425		$ 578
ARC/PLC	$ 30		$ -
Crop Insurance Proceeds	$ -		$ -
Gross Revenue	**$ 455**		**$ 578**
Expenses:			

	Conventional Wheat		Organic Wheat
Fertilizer	$ 76		$ 120
Crop Protection Chemicals	$ 27		$ -
Seed	$ 50		$ 50
Cover Crop Seed	$ -		$ 50
Drying	$ 1		$ 1
Storage	$ 1		$ 1
Crop Insurance	$ 9		$ 9
Total Direct Costs	**$ 164**		**$ 231**
Machine hire/lease	$ 18		$ 20
Utilities	$ 7		$ 8
Machine repair	$ 33		$ 33
Fuel and Oil	$ 20		$ 22
Light Vehicle	$ 2		$ 2
Machinery Depreciation	$ 49		$ 54
Total Power Costs	**$ 129**		**$ 139**
Hired Labor	$ 18		$ 36.00
Unique Organic Labor			$ 5.00
Building Repair and rent	$ 3		$ 3
Building Depreciation	$ 7		$ 7
Insurance	$ 5		$ 5
Misc	$ 9		$ 9
Interest (non-land)	$ 14		$ 14
Total Overhead Costs	**$ 56**		**$ 79**
Certification and Records			$ 5
Amortized Soil Corrective Costs			$ 50
Total Unique Organic Costs			**$ 55**
Total Non-Land Costs	$ 349		$ 488
Operator Return (non-Land)	**$ 106**		**$ 90**
Average Cash Rent	$ 297		$ 297
Operator Return Including Rent	**$ (191)**		**$ (207)**

For the hay crop, the following is the budget detail for the transition to organic year 1 and year 2 hay crop. It is assumed the hay will yield 4 tons the first year, which is planting year, and 6 tons the second year once it's established and the farmer can get at least 4 good cuttings. Because the hay is a transition crop, it is sold at conventional prices for high quality hay.

	Transitional hay year 1		Transitional hay year 2
Yield (tons)	4		6
Price per ton	$ 150.00		$ 150.00
Revenue	$ 600		$ 900
ARC/PLC	$ -		$ -
Crop Insurance Proceeds	$ -		$ -
Gross Revenue	**$ 600**		**$ 900**
Expenses:			
Fertilizer	$ 100		$ 150
Crop Protection Chemicals	$ -		$ -
Seed	$ 65		$ 65
Cover Crop Seed	$ -		$ -
Drying	$ -		$ -
Storage	$ 5		$ 5
Crop Insurance	$ 9		$ -
Total Direct Costs	**$ 179**		**$ 220**
Machine hire/lease	$ 19		$ 27
Utilities	$ 4		$ 6
Machine repair	$ 35		$ 35
Fuel and Oil	$ 40		$ 40
Light Vehicle	$ 1		$ 2
Machinery Depreciation	$ 100		$ 100
Total Power Costs	**$ 200**		**$ 210**
Hired Labor	$ 38.00		$ 38.00
Unique Organic Labor	$ -		$ -
Building Repair and rent	$ 5		$ 5
Building Depreciation	$ 15		$ 15
Insurance	$ 11		$ 11
Misc	$ 10		$ 10
Interest (non-land)	$ 19		$ 19
Total Overhead Costs	**$ 98**		**$ 98**
Certification and Records	$ 20		$ 20

	Transitional hay year 1		Transitional hay year 2
Amortized Soil Corrective Costs	$ -		$ -
Total Unique Organic Costs	**$ 20**		**$ 20**
Total Non-Land Costs	$ 477		$ 528
Operator Return (non-Land)	**$ 124**		**$ 372**
Average Cash Rent	$ 297		$ 297
Operator Return Including Rent	**$ (174)**		**$ 75**

Costs of transition: The cost of transitioning from conventional farming practices to organic varies greatly depending on the starting condition of the soil, the type of soil, current farming practices, and how the farm is managed during transition. While it's possible to go from conventional row crop farming to organic simply by stopping any non-organic approved practices and keeping everything else the same (tillage, crop rotation, fertility amounts --just switching sources), that rarely leads to a successful organic operation. To transition to successful and profitable organic farming, the focus needs to be on soil quality. Each farm is different, but farming practices need to be implemented in order to improve the chemical, physical and biological properties of the soil. The farmer needs to take soil tests and apply soil correctives in order to balance the soil minerals. Mixed species cover crops should be planted and managed in order to maximize biology and soil structure. Weeds are a huge problem in organic farming, so during transition it's very important for the farmer to focus on practices that reduce the weed seed bank to set the farm up for success. The farmer needs to be educated in how to manage the soil for soil health and quality and needs to learn how to use mechanical weed control methods.

The cost of implementing these practices varies widely. For example, if there is an affordable manure source close by, it makes nutrient management for the organic crops much easier. It's difficult to go from using conventional nitrogen sources to all organic without having an affordable manure source. It's also difficult to manage organic crops using manure without overloading the soil on phosphorus and potentially also calcium if laying hen manure is used.

It's also difficult to match conventional yields growing grasses (corn or wheat for example) on sandy soils. Sandy soils have a very limited capacity to build organic matter, and without organic matter it's difficult to get available nitrogen to the crop. This limits yields and makes organic farming more difficult and costly. The same can be true in heavy clay soils that don't dry out easily, leading to a very limited opportunity to cultivate for weed control without causing compaction. It's also costly to take a run-down, depleted soil and transition it to organic. If the soil mineral levels are very low, such as phosphorus levels in the single digit ppm's and potassium levels below 100 ppm, a lot of nutrients need to be added to rebalance those minerals. Adding a large volume of nutrients can be very costly, and limits yields until those nutrient levels are adequate.

It's very difficult to capture an 'average' cost of transitioning to organic production. Every farm is different, and every farm operator is different in their skill level and approach. While the above model tries to show a pretty typical transition scenario in the Midwest, it does assume the farmer is skilled at weed control, and that the soil is in relatively good condition and needs only minimal soil correctives. This will be true in many cases, but certainly not all.

i. A note on yields in organic compared to conventional crops

In the above models, a yield reduction for the organic crops was assumed. This is because organic crops typically yield less than conventional crops, primarily due to weed control issues, not enough nitrogen, and a lack of skilled organic farm managers. The conventional wisdom is that you can always tell an organic field when driving down the road because it's full of weeds, but in practice this isn't always true. In fact, many organic farmers have yields that are comparable to or higher than their conventional neighbors. This is true at Otter Creek Organic Farm, where they have abundant manure sources nearby and very skilled farmers who focus on soil health and are adept at weed management. The more skilled the organic farm operator, the better the farm yields and the greater the farm profitability.

A comprehensive meta-analysis of organic crop yield studies conducted by Ponisio et al. in 2017 found that organic yields are not substantially lower than conventional yields when the farm follows an enhanced crop rotation and is run by a skilled operator. The study conducted a reanalysis of 115 prior studies on conventional vs organic crops and found that average organic yields were 19.2% lower than conventional across all crops and farmers and all counties. However, that yield difference dropped to just 8% when the farmers employed better management practices, such as incorporating more plant diversity through intercropping or planting a more diverse crop rotation. In addition, the Ponisio paper found that investment in organic cropping practices and organic crop genetics has the potential to further reduce the yield difference between conventional and organic crops.[3]

The numbers used in this report for organic yields are based on data collected by Gary Zimmer and Leilani Zimmer Durand from the farms they've worked with over the last 15 years, and from Gary's experience on his own farm in southwestern Wisconsin. While organic yields do tend to be slightly lower than conventional yields in most cases, a 15% to 25% yield difference is the range that was observed most often.

IV. Post-transition farm economics

The cost of production and profitability of organic farms will vary based on many of the same factors that make transition to organic successful or problematic. To best capture some of the variability found in different organic farms, six scenarios from successful organic farms are presented below. Five of the farms are in the Midwest, and one is in Maryland. The data presented is an average of several fields' production costs, yields and economic return to operator in either one or two growing seasons.

Crop insurance is a big part of farming economics in the U.S. The majority of American farmers take advantage of government subsidized crop insurance in order to minimize their risk and ensure stable returns to the farm each year. In the past few years, the crop insurance program offered to organic farmers has expanded and made this program more attractive to organic farmers, who tend to grow a wider variety of crops and who also have a different yield expectation and different markets than conventional farmers. Because of the major role crop insurance plays in farming, a discussion and

[3] Ponisio et al., 2017

example of crop insurance for an organic farm is included at the end of this section. However, crop insurance is not factored in to the baseline economics of each of the below farm examples.

i. Southern Michigan Farm Example

The following table is an example of a typical crop year at an organic farm in southern Michigan. The farmer plants corn, wheat and soybeans, and yields are close to but often slightly below county averages. Weather conditions and weed control in the spring make a big difference in the success of the crops. This year happened to be a wet spring where the fields with heavier soils had poorer weed control, and thus the corn yields were below county averages because it wasn't possible to cultivate in time to control all of the weeds. The soybeans were planted on a sandier field so it was easier to cultivate and thus the beans yielded well.

Category	**Cost per acre for corn**	**Cost per acre for wheat**	**Cost per acre for soybeans**	**Notes:**
Crop Seed	$79	$44	$73	
Cover crop seed	$10.50	--	--	Cover crop planted before corn
Fertilizer	$180	$105	$0	Includes chicken litter and a blended dry fertilizer
Crop protection	$43	$23	$14	Crop protection includes organic insect control
Labor and Equipment	$90	$60	$90	
Harvest	$95	$95	$95	Includes drying and trucking
Land Rent	$200	$200	$200	
TOTAL:	$697.50	$527	$472	
	Yields and income per acre for corn	**Yields and income per acre for wheat**	**Yields and income per acre for soybeans**	
Yields:	137 bu/acre	74 bu/acre	57 bu/acre	
County average yields:	173.7	93	52.8	
Contracted price	$8.20	$14.50	$29.00	Soybean price was unusually high
Crop income:	$1123.40	$1073	$1653.00	
Operator return:	$425.90	$546.00	$1181.00	

ii. Wisconsin Farm Example

The Wisconsin farm example is Gary Zimmer's own farm, Otter Creek Organic Farm. It is a 1,500 acre organic farm that grows a mix of grain corn, seed corn, alfalfa/forages, cover crops, and rye. The farm has been in production since 1992, and until last year had a small dairy with 175 cows.

Because this is a large farm composed of many small fields, in order to get a good snapshot of farm productivity the summary data in the tables is an average of several fields across one growing season. The tables include costs per acre for the cover crops in the fall before corn, and the corn planting year. Corn is the farm's most profitable crop, and also where most of the fertilizer costs are focused. On non-corn years, the fertility spend is lower but the other costs remain similar.

In addition to rotating corn with alfalfa, on some fields the rotation is rye/cover crop one year and corn the following year. The rye is not a profitable crop for the farm, but the rye seed provides some return to the farm and because it is harvested in July, a soil-building mixed species cover crop can be planted and become established after the rye is harvested. This helps to keep the weed seed bank low because the rye is harvested and the field mowed before most weed species can go to seed. This rotation builds soil health while also setting the farm up for very high productivity on its most profitable crop, organic corn.

The economics of hay production are not included in this model because all of the hay is used on-farm to feed livestock.

Category	**Cost per acre for corn**	**Cost per acre for rye**	**Notes:**
Crop Seed	$90	$18	
Cover crop seed	$30	--	The cover crop is planted after rye harvest, but is budgeted to the corn year
Fertilizer	$90	$0	Fertilizer includes chicken litter from a nearby laying hen operation, plus sulfur and trace minerals as needed
Crop protection	$0	$0	
Labor and Equipment	$95	$75	Planting plus two tillage passes only for the rye.
Harvest	$90	$90	Includes drying and trucking
Land Rent	$150	$150	
TOTAL:	$545	$333	
	Yields and income per acre for corn	**Yields and income per acre for rye**	

Yields:	175 bu/acre	40 bu/acre	
County average yields:	186.7	N/A	
Contracted price:	$9.00	$10.00	Rye seed is saved for on-farm used as a cover, sold as cleaned seed, or used for milling.
Crop income:	$1575	$400	
Operator return:	$1030	$67	

iii. Southeastern Minnesota farm example

The farm in southeastern Minnesota is a 425 acre organic farm with a small dairy operation where they milk 80 cows. The farmer grows corn, soybeans, hay, and some barley or oats. The farm transitioned to organic in 2015. Their fertility program consists of manure from the farm, plus liquid starters and dry potassium blends to keep potassium levels adequate, particularly on fields that don't get much manure. In order to get a good representation of costs and yields, the data presented here is averaged across several fields from two growing seasons.

Category	Cost per acre for corn	Cost per acre for soybeans	Cost per acre for hay	Notes:
Crop Seed	$90	$60	$75	
Cover crop seed	$0	$0	$0	
Fertilizer	$225	$60	$50	Hay fields received dairy manure and calcium fertilizer only
Crop protection	$0	$25	$0	
Labor and Equipment	$95	$95	$100	
Harvest	$90	$90	$200	Includes drying and trucking
Land Rent	--	--	--	The farm is owned, so there is no land rent
TOTAL:	$500	$330	$425	
	Yields and income per acre for corn	**Yields and income per acre for soybeans**	**Yields and income per acre for hay**	
Yields:	178 bu/acre	63.5 bu/acre	6.5 tons	
County average yields:	186	59	4 tons	

Contracted price:	$8.00	$25	--	All hay was utilized on farm for feed
Crop income:	$1924	$1587.50	--	
Operator return:	$1424	$1257.50	*return is as part of milk check	

iv. Eastern Nebraska farm example

This data is a summary from three farms located in Eastern Nebraska, just west of Omaha. The farm's main crops are organic alfalfa, organic corn and organic soybeans. All of the corn acres receive manure, either from nearby beef feedlots or from poultry litter. An organic insecticide to control insect pests, particularly on the alfalfa and also often on the soybeans. Soil conditions vary from field to field, with some fields higher in fertility (mainly those near manure sources) and some fields with very low fertility, and with soil type varying from heavy clay to lighter loams. The data below is an average of several fields in one growing season.

Category	Cost per acre for corn	Cost per acre for soybeans	Cost per acre for established alfalfa	Notes
Seed	$80	$50	$25	Alfalfa is planted once every 3 years and seed costs are amortized over that time
Fertilizer	$200	$25	$75	
Crop protection	$0	$25	$25	Insect pests are a problem on pure alfalfa, so NOP approved insecticides are applied
Labor and Equipment	$125	$125	$33	Fields are prepped and planted once every 3 years, and field time is amortized over 3 years
Harvest and storage	$100	$95	$275	Harvest costs are yield dependent, especially with alfalfa
Land Rent	$225	$225	$225	
TOTAL costs:	$730	$545	$658	
	Yields and income per acre for corn	**Yields and income per acre for soybeans**	**Yields and income per acre for hay**	
Yields	135 bu/acre	40 bu/acre	6 tons	
County average yields	174	48.4	5 tons	

Contracted Price	$9.50	$34	$240/ton	
TOTAL income:	$1282.50	$1360	$1440	Soybean prices are unusually high this year
Operator return:	$552.50	$815	$782	

v. Iowa farm example

This is a 300 acre farm in east central Iowa where they grow corn, soybeans, oats and forages. The farm has been organic since 1978, and they milk 130 cows so use dairy manure for much of their fertility. The farm has naturally very rich, high organic matter soils and produces high yielding crops.

This farm has been in the family for many years in an area of the country where land prices and land rents are high. If the farmer was renting land rather than farming an owned piece of land, the farm economics would be quite different. Current land rents in the area run about $250/acre.

Category	Cost per acre for corn	Cost per acre for soybeans	Cost per acre for established alfalfa	Notes
Seed	$80	$50	$20	Hay seed cost amortized over 4 years of rotation
Fertilizer	$20	$30	$75	Hay fields get manure and some calcium. Corn fields get 3000 gal/acre dairy manure.
Crop protection	$0	$0	$0	
Labor and Equipment	$125	$125	$33	Planting and tillage cost for hay amortized over 4 years of rotation
Harvest and storage	$100	$95	$275	
Land Rent	$0	$0	$0	The farm is owned so there is no rent cost
TOTAL costs:	$325	$300	$403	
	Yields and income per acre for corn	**Yields and income per acre for soybeans**	**Yields and income per acre for hay**	
Yields	175 bu/acre	60 bu/acre	4.5 tons	
County average yields	189	56.5	3.6 tons	
Contracted Price	$9	$24	--	Alfalfa all used on farm for dairy feed

TOTAL income:	$1575	$1440		
Operator return:	$1250	$1140	*return is as part of the milk check	

vi. Maryland Farm Example

The farm is in the Chesapeake Bay watershed, in northern Maryland. The farm has been organic for over 20 years. Soils on the farm are sandy, which makes it difficult to build organic matter. Without high organic matter levels, it's more difficult to maintain enough available nutrients in the soil throughout the growing season to grow a high yielding crop, especially corn. Nitrogen has to be applied more than once, and it's difficult to find organic sources that can give the crop the needed in-season boost to maintain robust growth.

The farm grows a suite of cover crops each year. Due to the long growing season, it's possible to plant a mixed cover crop after corn or soybean harvest, or even to plant soybeans after winter wheat is harvested, practices that don't work in the shorter growing season of the Midwest.

This farmer was not able to share detailed economics, but did share yield data:

- Corn: 130 bushels/acre
- Soybeans: 35 bushels/acre
- Hay: 4 tons/acre

At this year's crop prices, the returns would be:

- Corn: $1235/acre
- Soybeans: $1120/acre
- Hay: $800/acre

V. Role of crop insurance in organic farm economics

This report is not designed to be an analysis of crop insurance, but any discussion of farm economics in the United States today needs to at least touch on government support for farming, which in the current era comes in large part from subsidized crop insurance. Government subsidized crop insurance plays a role in the economic viability of most farms in the U.S. Through government subsidies, the cost of buying crop insurance is low for the farmer, and crop insurance payments effectively ensure farm income doesn't fall below a certain level (depending upon the level of insurance purchased by the farmer). For organic farmers, until recently crop insurance was rarely a good fit. It required the use of either 5 years of baseline yield data or county average organic yields, neither of which was available for many organic farms, and only covered a few crop types. In the last couple of years the insurance options for organic farmers have improved, and now many organic farms take advantage of this program.

At Otter Creek Organic Farm, they recently started purchasing crop insurance for their organic crops. This past spring the farm took advantage of their insurance. The weather was initially quite warm then got very cold, and several fields of corn were damaged by a late frost. The fields had to be replanted, and crop insurance paid the cost of replanting the corn. For Otter Creek, using county average yields for organic farms doesn't work because there are too few organic farms in the county to establish that baseline yield data needed for insurance payments. Instead, Otter Creek uses their own 5-year crop history to establish baseline yields for insurance purposes. In order for this to work, a farm needs to have well organized and verified yield records that can be used to set their baseline yields for insurance purposes.

The following table compares Multi-Peril Crop Insurance (MPCI) for a conventional, transitioning, and organic farm. MPCI is designed to cover a single crop, so best fits farms with a simple crop rotation (such as corn/beans) and can cover both yield loss and revenue loss. Whole Farm Revenue Protection (WFRP) is a popular insurance option with diverse farms or farms that direct market their products since it insures based on whole farm performance rather than a single crop. Otter Creek uses WFRP because the farm grows seed corn and rye in addition to field corn, and it's more difficult to insure those specialty crops with the single-crop MPCI program. When it comes to comparing insurance options between farms, it's difficult given how customizable this program is for each farm, but the below table gives a very broad-brush example of how it could work.

	Conventional insurance	**Transition to organic insurance**	**Organic Insurance**
Example level of coverage for each crop (MPCI)	85%	85%	85%
Example level for whole farm revenue	Up to $8.5M in revenue for specialty crops, locally marketed, or diverse crops	Up to $8.5M in revenue for specialty crops, locally marketed, or diverse crops	Up to $8.5M in revenue for specialty crops, locally marketed, or diverse crops
How yield and price are set	5 year farm crop history, or baseline yield (county avg), and current commodity prices	Organic baseline yield (which is 65% of conventional), and contracted price for crop	5 year farm crop history, organic baseline yield (county avg or 65% of conventional), and contracted price
Baseline yield and crop payment	Conventional price is $4.00/bu, county avg yield is 200 bushels	Have a transitional contract for $5.50/bu, no yield history but organic yields are set at 130 bu/acre	Organic price is $9.00/bu, have yield history avg of 170 bu/acre
Guaranteed revenue (at 85% coverage)	$680/acre	$607.75/acre	$1300.50/acre
Actual revenue after 50% loss due to weather or drop in prices	$400/acre	$357.50/acre	$765/acre
Crop Insurance Payment	$280/acre	$250.25/acre	$535.50/acre

Given a similar weather event or drop in prices causing the same percentage damage to an organic, transitional and conventional farm, the organic farm can get more insurance per acre, but this is dependent upon market prices and the farm's historical yield averages for the crop. Once that baseline is established for an insurable crop, MPCI supports the organic revenue loss in a similar way to how it supports a conventional revenue loss. However, in order for farmers to get crop insurance they need to follow USDA defined 'best management practices'. In theory this ensures the farmer isn't taking unnecessary risk that would result in a yield loss triggering an insurance payment. In practice, this means farmers are often denied insurance for changing management practices to more regenerative ones, such as adding more crops to their rotation, or for planting novel types of cover crops.

In fact, recent research has shown that crop insurance is having an adverse effect on farmer adoption of regenerative farming practices. A statistical analysis of farmer participation in crop insurance and yield variability found that variations in crop yields due to higher temperatures rose when more farmers had crop insurance.[4] This suggests that farmers are not adopting climate mitigation farming practices, such as planting cover crops, and are instead accepting the risk of yield loss due to climate change because crop insurance covers that risk. Whatever the underlying reasons behind this trend, it is clear from this and the 'best management practices' rule for getting crop insurance, that changes in this policy need to be made to encourage and support farmers in the use of regenerative farming practices.

VI. The role of markets

Organic farming is a lot more work and requires more knowledge than conventional farming, so farmers generally aren't going to transition to organic unless there is a strong profit motive. The knowledge of new practices required, need for additional equipment, lack of supply infrastructure, need to access new markets and increased paperwork for certification are all hurdles to overcome in making the decision to transition to organic. Unfortunately, in the current economic climate where conventional crop prices are high and organic prices are low it's difficult to make the economic case that organic farming is a good business decision. This will eventually change, and once organic prices rise and conventional prices drop, more farmers will look to transition to organic again. But this see-saw between prices and the number of farmers getting into organic will continue.

Farming in the United States today is not a free market system, as government programs strongly influence both profitability and practices in farming. Farmers who adopt regenerative practices without growing organic crops do not get paid a premium for their crops. Though there are government programs available, like EQIP, that provide financial support for growing cover crops, it's often not enough to cover the cost of the seed, planting, and termination of the crop. Farmers who currently grow cover crops tend to be more educated and experienced about the practice.[5] There is a learning curve to adopting these types of practices and it requires education for farmers to see the financial benefits, which are often long-term. It's difficult to envision a future where more farmers use organic and/or regenerative farming methods without more government support for those practices, or a change in how conventional farming is supported.

[4] Wang, Rejesus, and Aglasan 2021
[5] SARE, 2020

VII. Discussion of the relationship of farm examples used here and conditions on Maryland's Eastern Shore

The farm examples used in this report are primarily from the Midwest, where some things, like soil conditions, climate, and cropping cycles are different from those used on Maryland's Eastern Shore. Other things, like soil health practices, markets, and organic farming principles and best practices are the same.

Farmers on Maryland's Eastern Shore currently do not have much incentive to go organic because conventional corn is $6.50/bu and organic corn is under $10/bu (mid-July 2021). That price difference is not enough to make up for the additional management required in organic farming, or enough to make up yield differences between organic and conventional corn. On the Eastern Shore, the soil is quite sandy, making it difficult to build organic matter and thus nutrient holding capacity and nitrogen cycling. This means that while the conventional farmers can split apply commercial nitrogen and get 200 bu/acre of corn, organic farmers have to use natural sources that don't last the whole growing season and a good organic farm will get around 130 bu/acre of corn. However, because of the longer growing season, double cropping of wheat and soybeans is common, making this part of the rotation more profitable because there are two cash crops in one growing season.

Cover cropping is very common among both organic and conventional farms on Maryland's Eastern Shore because of government support for growing cover crops. It's common for farmers to fly on rye, clovers and other legumes, and brassicas and other forbs in late summer. The government subsidies for cover crops make this practice appealing to most farmers, and open up more opportunities to use innovative planting practices. No-till is strongly advocated and much of the soil in the region is heavily compacted; however it's difficult for farmers to break up compaction using a straight no-till system. Organic farmers integrate more diverse tillage practices into their crop management, but still face issues with breaking up compaction on the easily compacted, sandy soils.

Manure management is also a big issue on the Lower Shore. There are a lot of poultry raised in this region, particularly on the southern end of the Eastern Shore. All the chicken manure has resulted in too much phosphorus in the soil, and right now the government is paying farmers to truck manure to the northern part of the Eastern Shore where the soils are less overloaded with nutrients and it's still possible to spread manure without causing nutrient loading issues. This can be an issue for organic farmers who rely on manures to feed their crops, because when the soil P levels are too high and manure is no longer an option it becomes very expensive to fertilize crops. Organic-approved nitrogen fertilizers from sources other than manure can cost 10 times more than manure or than conventional nitrogen sources. This becomes a hurdle and a deterrent to organic farming in the region.

VIII. Role of crop diversity in transition

Crop diversity is a key piece of any regenerative farm, whether organic or conventional. There is a lot to be gained by adding more types of plants to a farming system through growing cover crops or growing 3 or more types of crops in the crop rotation. Many pests, for example, prey on a relatively narrow range of species, so increasing plant diversity can break pest and disease cycles. Growing a wide range of plant species can also increase soil life diversity because different types of microbes prefer different types of plants,[6] meaning that above ground diversity builds below ground diversity. Another benefit of increasing plant diversity is that different types of plants access nutrients other than those the crop will pull up, so planting cover crops and working them into the soil can increase the amount and variety of plant-available nutrients. Planting a cover crop with a mix of different species from different functional groups can also improve soil structure because different types of plants have deeper or denser roots systems, which will help keep channels in the soil open to allow water infiltration and air movement.

Increasing plant diversity results in a wider variety of soil life and insects, and as a result no one disease or crop pest can take over. If you're planting a corn/beans rotation with no variation and no cover crops, you have neither a diversity of residues nor a diversity of soil life. Without diversity it's difficult to stop a particular pest from taking over, and usually requires pesticides or fungicides to reduce the pest population. Plant diversity is the key that can break those pest and disease cycles. Because each type of plant uses different minerals and has a different suite of symbiotic microbes, a diverse cover drop puts different minerals back in the ground as it breaks down and this feeds a variety of soil life, improving the entire biological system.

Planting a diversity of crops also builds organic matter. This is something that pretty much any organic farmer can tell you from experience, and the McDaniel et al. meta-analysis of 122 studies conducted in 2014 backed up this observation. [7] By adding more crops to a rotation, both organic C and N went up in soils, and that rate of increase more than doubled when a diverse cover crop was planted. This is in part due to the fact that different types of plants play different roles in N and C cycling, especially when they're managed differently. For example, a young, green rye crop that is incorporated into the soil before the crop is planted will break down quickly, releasing nutrients and feeding soil bacteria which in turn enhances more nutrient cycling. However, if that same rye cover crop is left to grow to where it's mature and turning brown, it will break down slowly in the soil when it's worked in or mowed, tying up nitrogen as it slowly decomposes. Decomposition will be led by fungi not bacteria when the plant is more mature and lignified, and while this may slow nutrient cycling it speeds the process of building organic matter.

i. Organic farming builds organic matter

This example is from fields at Otter Creek Organic Farm. This section of the farm was first purchased in 1991, and for the following 16 years soil tests were taken from the top six inches of each field and tracked to measure how nutrient and organic matter levels changed. On Field 3, organic matter levels improved, when on Field 4 they decreased slightly. These changes in organic matter are related to how the fields were farmed between 1991 and 2007. (Note that no phosphorus levels were included on these tests because the soil tests were taken as part of a long-term soil potassium study.)

[6] Tiemann et al., 2015
[7] McDaniel, Tiemann, and Grandy 2014

FIELD 3									
	OM	CEC	%K	%Mg	%Ca	pH	K ppm	Mg ppm	Ca ppm
1991	1.98	11.22	2.90	32.13	64.98	7.2	128.50	433.50	1456.83
1998	2.33	9.57	2.47	28.93	68.57	7.1	92.67	333.67	1305.67
2003	2.30	10.30	2.10	25.60	71.30	7.0	83.00	317.00	1460.00
2007	2.60	9.90	1.50	22.50	75.10	7.2	57.00	267.00	1497.00
FIELD 4									
	OM	CEC	%K	%Mg	%Ca	pH	K ppm	Mg ppm	Ca ppm
1991	2.37	11.73	3.23	32.30	64.43	7.2	150.00	456.33	1515.00
1998	2.30	11.00	3.80	29.20	67.00	7.3	162.00	384.00	1469.00
2003	2.30	10.60	2.40	27.80	69.00	7.3	101.00	353.00	1469.00
2007	2.10	9.90	2.50	23.70	72.90	7.2	98.00	282.00	1439.00

During this sixteen-year time span, the farm was milking 300 cows and growing all their own feed on 600 acres of crop land. This meant that hay was harvested 4 times a year, corn silage was chopped, and all wheat or corn stalks were removed for bedding, leaving no complex carbons on or in the soil. Manure was returned to the land, which on some fields (such as Field 3) did result in an increase to organic matter over time. On other fields (such as Field 4) organic matter levels did not increase.

The farm has now switched production methods to a system that leaves more complex carbons on the soil and is building organic matter. In the new production system, the majority of the acres are in a rye/corn rotation. Cover crops are grown on every acre every year, and rye and corn stalks are left on the field to decompose and build organic matter. With this rotation there is also less tillage, as rye is planted in the fall and comes back early in the spring when it outcompetes weeds. This new rotation was just started two years ago so there isn't any data from these fields. However, based on what has been observed on other farms where the focus is on building organic matter by leaving corn stalks on the ground and letting some of the cover crops get more mature, it is expected that organic matter levels will increase by 40% or more over the next 5 years under the new crop rotation.

ii. Regenerative farming and soil health and resiliency

Using biological/regenerative farming practices adds resiliency, especially in bad crop years. Healthy soils hold more water, helping to ameliorate both drought and flooding and leading to healthier crops in adverse weather conditions. The 2012 drought in the Midwest was a very good example of how some farms fared better than others in the dry conditions. In the 2012 drought, Otter Creek Organic Farm averaged 112 bu/acre organic corn when the county average was 87.7 bu/acre that year for conventional corn. Unfortunately, no comprehensive study was done on how the drought impacted soil health and water holding capacity, in part because it's so difficult to predict a drought year. But several other farms following regenerative practices also vastly outyielded the neighboring farms during this drought. A south-central Wisconsin biological farmer that has been following biological farming methods for over 10 years averaged 185 bushels/acre conventional corn, when the county average corn yield was 140 bushels/acre. Another farm, further east in Wisconsin, yielded 145 bushels/acre on their organic corn, when the county average that year was only 140 bushels for conventional corn.

TEST	Fall 1993	Fall 1995	Fall 2001	Summer 05	Summer 07	Fall 2012	Summer 2015
CEC	8.9	8.8	10.3	10.7	11.2	14.3	10.9
O.M.	1.9	1.9	2.0	2.4	2.4	3.1	2.7
P1	22	45	55	63	68	55	67
P2	37	84	96	173	140	102	117
K	2.2%	2.9%	1.96%	3.4%	3.5%	2.4%	4.1
Mg	32.6%	27.9%	22.7%	22.7%	24.6%	20.9%	23
Ca	65.1%	69.2%	72.9%	72.9%	70.9%	75.8%	71.5
K	78	99	81	141	153	133	173
Mg	355	295	271	292	331	359	301
Ca	1180	1125	1506	1550	1584	2176	1557
pH	6.9	7.2	6.9	7.3	7.3	7.7	6.9

These examples show how building soil health helps build crop health and crop resiliency. Some research, such as those done by Dr. Rattan Lal of Ohio State University on building resilience in global food systems through building and maintaining soil health, does make a connection between soil health and crop health,[8] but more work needs to be done in this area. There is very little work done on the connection been biologically farmed soils, resilience to climate extremes, and higher yields such as what the farmers saw on their biologically farmed soils during the drought of 2012.

Building soil health is the key tenet of regenerative farming, but there is no agreement on the best way to go about this. In conventional farming, there is a lot of emphasis on no-till as a way to build soil health. Unfortunately no-till is a chemical-dependent method of farming and therefore very difficult to

[8] Maas et al. 2017; Lal 2015

adopt in an organic system. A corn/bean no-till system will not regenerate soils. There is too much bare ground in that system, leading to surface crusting, and the crop residues left behind stay on top of the ground where they oxidize rather than becoming fungal food and turning into stable soil carbon. Row crops also have shallow root systems, so a farming system that only uses corn, beans and no-till never builds deep roots.

To build healthy soils, it's essential to grow a mix of different species with different rooting depths. Deep roots is where most of the carbon sequestration in soils takes place, and that is why rye as a cover crop is so valuable. It has a large, deep root mass that pulls a lot of carbon down into the soil. It's also important to leave a blanket of residues on top to protect the soil. This protects the soil from rain drops and prevents a crust from forming which would limit gas exchange between the soil and the air. Regenerating soils is about setting up conditions that allow the soil biology to be fed and to flourish. This means adding the right minerals, planting a variety of types of crops and cover crops to build diversity in the soil, and using the right type of tillage at the right time to loosen soils without damaging them. Strip tillage is a better method of tillage that builds soils in the root zone, but also leaves the area between the rows untouched, so soil aggregates remain intact and soil life can thrive.

IX. Observations on infrastructure and marketing needed to support transition in Maryland and Eastern Shore

A lack of infrastructure on Maryland's Eastern Shore is a major hurdle to successful and profitable organic farming. The Eastern Shore has a lack of dedicated organic grain storage and grain processors that can work with the many small organic farms in the region.

According to Niamh Shortt of Future Harvest, there is only one mill dedicated to organic grains in the region, and it will only take grain that has been dried.[9] This requires the farmer to have a grain drier and storage on farm, which is a large expense and a hurdle that makes profitability more difficult, especially for smaller organic growers. Conventional growers don't face this same obstacle, as local coops will take wet grain and dry and store it on site. It's also more difficult to transport grains to market for organic growers. While the large conventional grain buyers will pick up truckloads of harvested grains on farm, the organic growers need to get the grain to a mill themselves, necessitating either owning trucks or contracting with local truckers who are willing to follow the clean out protocols required for transporting organic grains.

Another hurdle commonly found on Maryland's Eastern Shore is the need for irrigation. Contracts with organic buyers often require the grower to have irrigation, which is expensive to install and maintain. It is also often difficult to find contracts for organic grains in general. Connecting to buyers and markets for organic growers is not easy, especially in comparison to the conventional markets which are large, regionally distributed, and easy to join. A lot more time and effort has to be spent by the organic farmer to find good markets for their crops.

The current market conditions make transitioning to organic production less financially attractive than in the last few years. Ratan As of fall of 2021, conventional crop prices are high, and organic prices are

[9] Shortt 2021, personal communication for this and the next paragraph.

relatively low (with the exception of organic soybeans). It's also difficult to grow comparable yields to conventional on Maryland's Eastern Shore due to the light soils and difficulty building organic matter. In order to incentivize farmers to take on the risk and expense of the 36-month transition period, organic prices need to be high enough that the farmer will realize more profit from their organic crops.

X. Conclusions

To achieve the goals of healthier soils, better nutrient management and less runoff, regenerative farming practices need to be widely adopted. This includes cover crops, but also should include a whole-farm system that improves soil health and environmental outcomes. Achieving the goals of healthier soils needs to be a systems approach that includes building diverse soil biology, adopting tillage practices that build soil structure, and careful nutrient use, especially nitrogen.

Organic farming is one method to achieve these goals that also provides the farmer with a greater financial return for their crops. Organic isn't the only way to incentivize farmers to adopt regenerative farming practices, but currently it is the only method that directly provides a higher market return. While adding regenerative practices builds resiliency and sustainability which results in better soil health, better crop health and better long term sustainability of the farm, those benefits are harder to directly quantify.

One of the challenges with regenerative farming is that the NRCS promotes no-till universally, even when it's not the best system for the local soil. Unless the soil has good structure that can be maintained under a no-till system, other tillage options need to be considered as well. No-till fits some soils and not others, and there need to be more studies done on runoff under various tillage systems combined with cover cropping systems to show what works best to build soil health. It's very difficult to practice no-till on organic farms, yet many organic farms have healthy soil structure with little runoff. More research is needed showing the connection between a variety of regenerative farming practices and soil quality and nutrient loss.

Monitoring and assessment of outcomes where cover crops are grown is essential. Just paying farmers to plant cover crops doesn't mean those cover crops are achieving the goals of building soil health and retaining more nutrients. There are many different ways to manage cover crops, and working with farmers to help them be successful at establishing cover crops, terminating them at the right time, and managing them so they enhance yield and soil quality is key. Farmer education programs are starting to become more widespread, and the Million Acre Challenge team will be one piece of this key component of making regenerative farming practices successful. Once farmers see and understand the advantages of regenerative practices, they will adopt them not just because of the current financial incentives, but because it really works for their farm.

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