What will it take to restore organic matter to Iowa's soils?

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Scope of Work

What will it take to restore organic matter to Iowa's soils?

Iowa has some of the most organic-rich agricultural soils in the world, contributing to both high productivity and strong resiliency. However, these soils have only about 50-70% of their original organic matter and many current agricultural practices are conducive to further organic matter loss. Efforts have been made to begin restoration of organic matter, the most extreme among these being the reconstruction of native prairie. A recent comparison of soil organic matter in reconstructed prairie to corn-based systems not only failed to show any increase in soil organic matter in the prairie soil, but a simulation of the systems over 50 years showed that both systems continuously lost soil organic matter. While current soil organic matter decomposition theory supports these results, mathematical modeling plays a strong role in the simulation.

Each decomposition model is based upon a different hypothesis of decomposition, which in turn is based upon sets of experiments. The simulation previously mentioned is based upon just one hypothesis of decomposition. We propose running the same simulation situation with 55 of the most common decomposition models to test the results and examine the factors that may lead to different outcomes. We then propose using the same models to determine a value for organic matter input which results in an increase in soil organic matter in Iowa soils.

The diversity of decomposition hypotheses comes from many different experiments, all of which share flaws brought about by manipulating soil, a medium which acts very differently when disturbed. These experiments have all examined the three biggest factors controlling decomposition: temperature, moisture, and organic matter carbon and nitrogen content. We propose to examine these same factors, but in undisturbed soil. We will terminate subplots of prairie, creating a belowground pool of dead roots to function as organic matter, and then track the decomposition of this organic matter over three years. The results of this experiment will be incorporated in the previously used models.

The results of the modeling and the measurements will be used to create an interactive, online tool where the user can manipulate temperature, moisture, organic matter quality, organic matter amount, and initial soil organic matter amount to see how these factors change the soil organic matter amount over time. This engaging format is meant to instill a better understanding of how soil organic matter dynamics work. Results of the study will also be published in farming and scientific publications. The most important outcome of the project will be recognition of how temporary Iowa's soil organic matter is and how difficult it will be to restore it. This will lead to a greater desire for preservation and begin a difficult dialogue on a potential future with soils lower in soil organic matter.

Background

A soil's best defense against abrupt environmental changes such as drought, flood, compaction, and nutrient deficiency is high organic matter content. Association of organic matter with soil minerals promotes the formation of aggregates, providing soil structure for air and water exchange. The absorption ability of soil organic matter (SOM) regulates the retention and availability of soil water. SOM is also the primary source of nitrogen (N), phosphorus (P) and sulfur (S) and its decomposition and capacity for cation exchange controls nutrient availability (Horwath 2008). High levels of SOM in Iowa soils has made it one of the most resilient and productive regions in the world. However, erosion and tillage-induced increases in microbial metabolism of SOM has resulted in the loss of 30-50% of Iowa's native SOM (David 2009). There are many strategies aimed at restoring SOM in Iowa. However, our fundamental understanding of SOM dynamics is inadequate for designing agricultural systems that will contribute to SOM levels. This proposed project aims to expand our basic understanding of organic matter in Iowa soils to enable us to pursue worthwhile practices that increase or maintain SOM levels or adapt to inevitable SOM loss.

Soil organic matter is derived from dead plant matter, so it is intuitive that adding more plant matter to a system will increase the amount of organic matter in the soil. However, soil systems do not always work as human intuition would have. It is entirely possible to add plant material to a soil and not only lose the plant matter, but lose SOM that was previously there, resulting in a total net loss of SOM. Since we aim to expand our understanding of SOM in Iowa, it is useful to review this current understanding of the potential fate of plant matter in Iowa soil. Much of Iowa's soil developed under productive tallgrass prairie wetlands and has remnant levels of high organic matter and high carbon (C) levels (SOM is ~ 58% C). There are two important concepts related to organic matter decomposition and stabilization in high-C soils – C saturation and substrate- and rhizosphere-induced priming.

Carbon saturation recognizes that there is a limit to how much C a soil can hold in a stable form (Six et al 2002, von Lutzow et al. 2008, Stewart et al. 2008). Carbon can be stabilized in the soil by forming an association within the mineral matrix. For example, within the structure of clay there may be an attraction site to C and once C associates with this site, it is unavailable to any processes that may result in the loss of the C. This is known as chemical protection. On a slightly larger scale, C in the soil may become trapped within the formation of aggregates and be effectively unavailable for decomposition. This is known as physical protection. In soils which are C-saturated, there are no remaining attraction sites for chemical protection and no remaining aggregate spaces for physical protection. This environment incapable of C protection is the setting for organic matter entering Iowa soils.

What, exactly, does organic matter need to be protected from? Microbes metabolize organic matter for growth and energy. Carbon that is not incorporated into microbial structure is lost to the atmosphere as carbon dioxide (CO_2). Carbon that is incorporated into microbial structure or used in microbial enzymes eventually becomes available to be metabolized by other microbes in the absence of physicochemical protection (Castellano et al. 2015, Cotrufo et al. 2013). In an environment with a constant amount of inputs, organic matter reaches a steady state where the amount of organic matter lost is equal to the amount of organic matter gained and the microbial population stays relatively stable. When a steady state environment receives a flush of new inputs, such as increased plant material, the microbial population grows and becomes more active. When the initial new inputs are no longer able to support this bigger and more active population, the microbes may mine older SOM reserves to support themselves. This microbial stimulation and resulting net C loss is known as priming (Cheng et al. 2014).

Case Study

An illustrative example of C saturation and priming in Iowa soils can be found in our previous study on C inputs at the Comparison of Biofuel Systems (COBS) project near Ames, IA. Our earlier work explored increasing C in Iowa soils through corn-soybean rotations, continuous corn with and without a winter cover crop, and reconstructed prairie with and without nitrogen (N) fertilizer. These systems had very different amounts of root mass, but showed no difference in soil C after six years and simulations of the systems over 50 years showed that all systems were gradually losing C (Dietzel 2014). This experiment is also relevant because it is the site of work planned in this proposal.

The COBS site is dominated by Nicollet loam and Webster silty clay loam soils, both of which have high organic matter contents (~5%). The experiment was established in 2008 and root mass was measured after the first hard frost every year. Immediate differences in root inputs between the annual row-crop systems and perennial prairie systems were found and these differences increased over time as perennial root systems became more established (Figure 1).

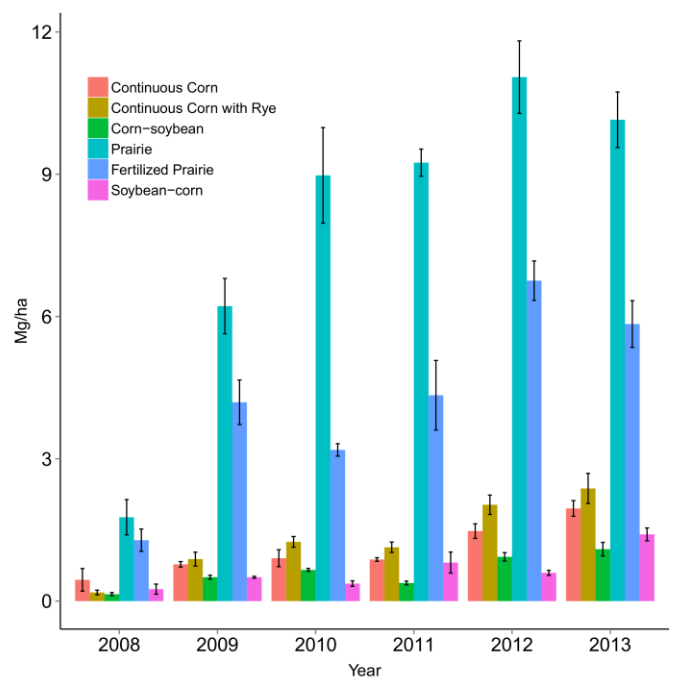

Figure 1. Root pool mass to a 1 meter depth. Error bars and parentheses in table denote one standard error of the mean. Different letters in the table denote significant differences between treatments within years.

Further support that prairies would lead to increases in SOM was seen in the distribution of root placement in the soil profile (Figure 2). By 2013, prairies had more root mass at a 60-100 cm depth than the row-crop systems had near the surface. Placement of C at depth led to expectations that the C would stay there because lower temperatures and less oxygen are less conducive to decomposition.

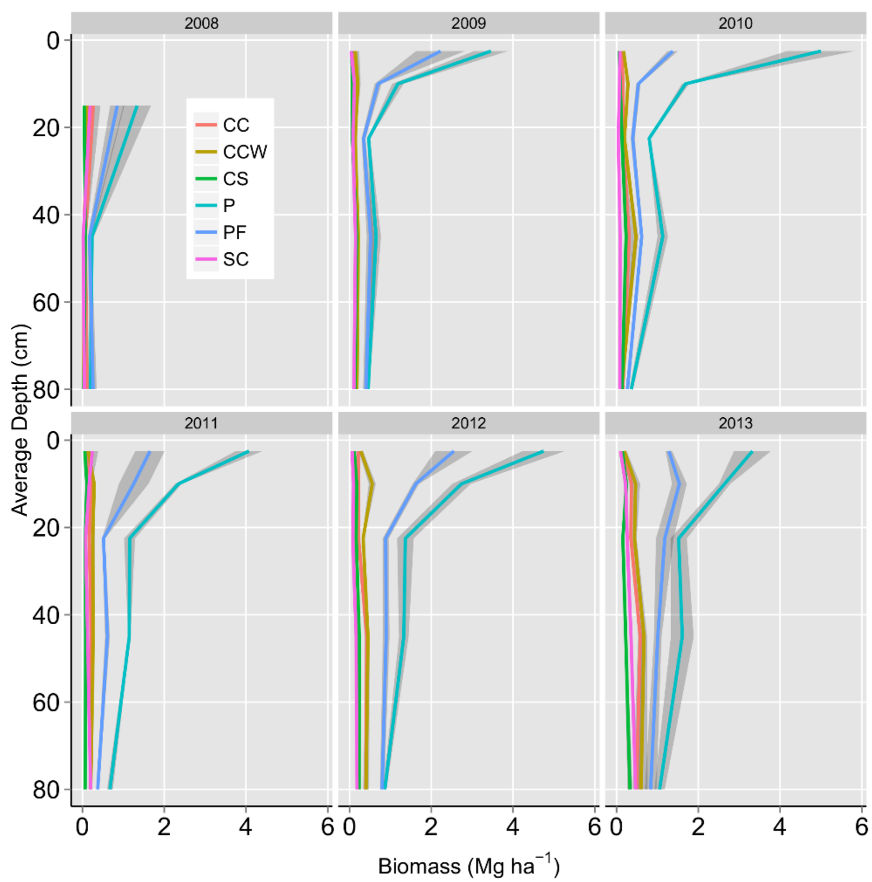

Figure 2. Root pool mass in each depth increment of each year. Data is plotted at the midpoint of each depth increment 0-5 cm is 2.5 cm, 5-15 cm is 10 cm, 15-30 cm is 22.5 cm, 30-60 cm is 45 cm and 60-100 cm is 80 cm. Treatments are continuous corn (CC), continuous corn with winter cover crop (CCW), corn-soybean rotation (CS), soybean-corn rotation (SC), fertilized prairie (PF), and unfertilized prairie (P). Shading represents one standard error of the mean.

After six years, it was found that prairie, especially if not fertilized, contributed much more mass belowground than row-cropped systems. It is common for perennial plants to have more root mass if not fertilized because these plants need to reach further to obtain nutrients for growth (Dietzel 2015a, Hunt and Nicholls 1986). Unfertilized prairies placed ~6.5 x more C belowground than row-crop systems and fertilized prairies placed ~3.5 x more C belowground than row-crop systems. While these differences are impressive, as long as C is in the root C pool, it cannot be used for other purposes such as cation exchange capacity, water retention, better aggregation, microbial substrate, or a source of plant growth-inducing compounds. Therefore, we also looked for evidence of increased C in the soil.

Despite differences in the amount of roots pool mass gained belowground, there was no evidence of an increase in soil organic C. Permanganate oxidizable carbon (POXC) represents a pool of C that has been found to be responsive to management changes on short-term time scales (Culman et al. 2012). We measured POXC and found differences between depths, but no differences between treatments (Fig. 3). We also compared total organic carbon (TOC) from measurements made in 2008 and measurements made in 2013 and found no differences over time or between treatments (Fig. 4). This lack of differences may be explained by the difficulty of adding C to C-saturated soils with large microbial populations which are likely stimulated by new root additions.

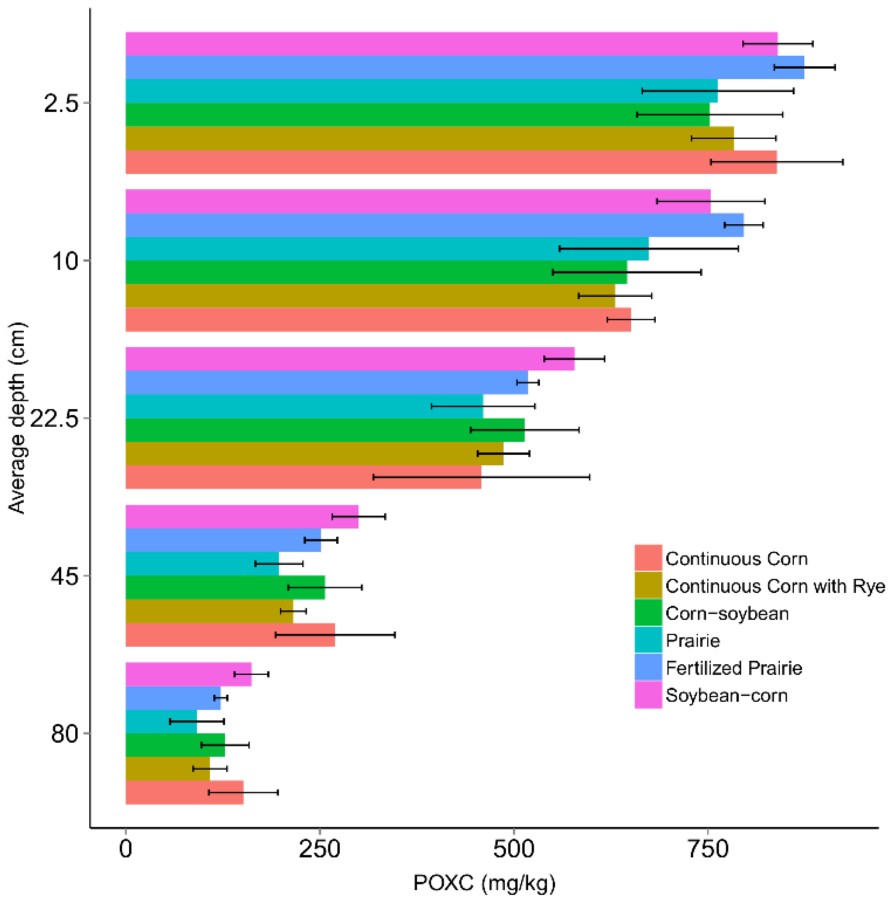

Figure 3. POXC measurements for each depth increment in 2012 displayed by midpoint of the increment, 2.5 is 0-5 cm, 10 is 5-15 cm, 22.5 is 15-30 cm, 45 is 30-60 cm, 80 is 60-100 cm. Error bars and parentheses are one standard error of the mean.

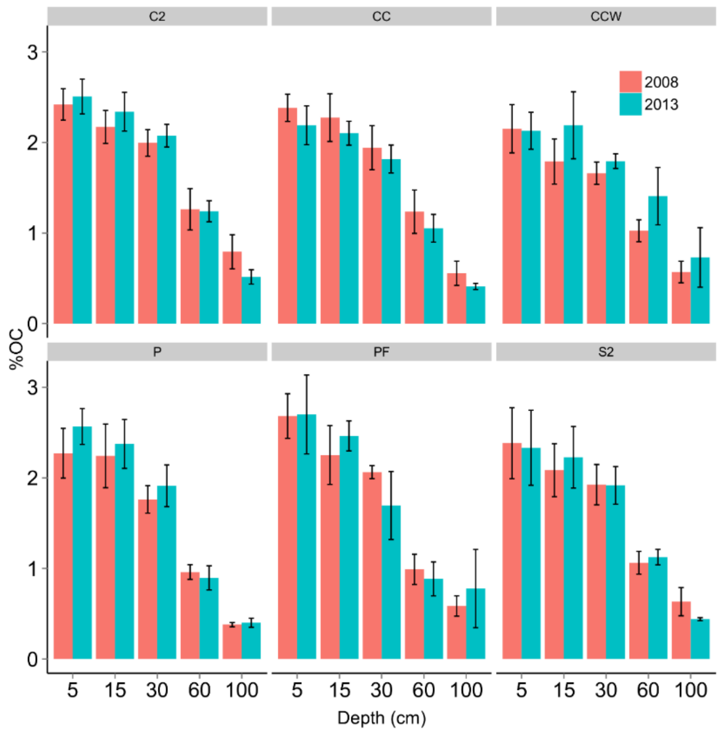

Figure 4. Total organic carbon (TOC) in each depth increment in 2008 and 2013. 5 is 0-5 cm, 15 is 5-15 cm, 30 is 15-30 cm, 60 is 30-60 cm, and 100 is 60-100 cm. Treatments are continuous corn (CC), continuous corn with winter cover crop (CCW), corn-soybean rotation (CS), soybean-corn rotation (SC), fertilized prairie (PF), and unfertilized prairie (P).

Planting prairies and not finding increases in SOM is surprising because, afterall, it was prairies which created the SOM-rich soils Iowa has today. However, there is a major difference in the soil conditions now compared to historical soils. The COBS experiment, like much of Iowa, has tile drainage. This means that the soil rarely experiences water saturation. Saturation greatly inhibits decomposition and leads to the accumulation of organic material. Tile drainage keeps soils at a more optimum moisture for decomposition and the loss of organic matter. While Iowa soils developed under prairie wetlands, they now persist in more aerated conditions.

Another possibility is that any change in soil C was too small to be measured against the large background of soil C already present and that more time is needed to find measureable differences. To address the possibility of needing more time, we turned to simulation modeling. We used the cropping systems APSIM modeling platform (Holzworth et al. 2014, Keating et al. 2003) to simulate corn- and prairie-based systems. An abundance of data from six years of the experiment were used for an elaborate model calibration which resulted in very good simulation of several components of the system, including biomass and yields at harvest, in-season corn biomass dynamics, rye plant N concentration, soil temperature, soil water, subsurface drainage, CO_2 emissions, and spring soil NO_3-N (Dietzel 2015b). We then used predicted daily weather data from 20 different global climate change models to run the simulations for 50 years. After 50 years, all cropping systems, including both prairie systems, lost soil C.

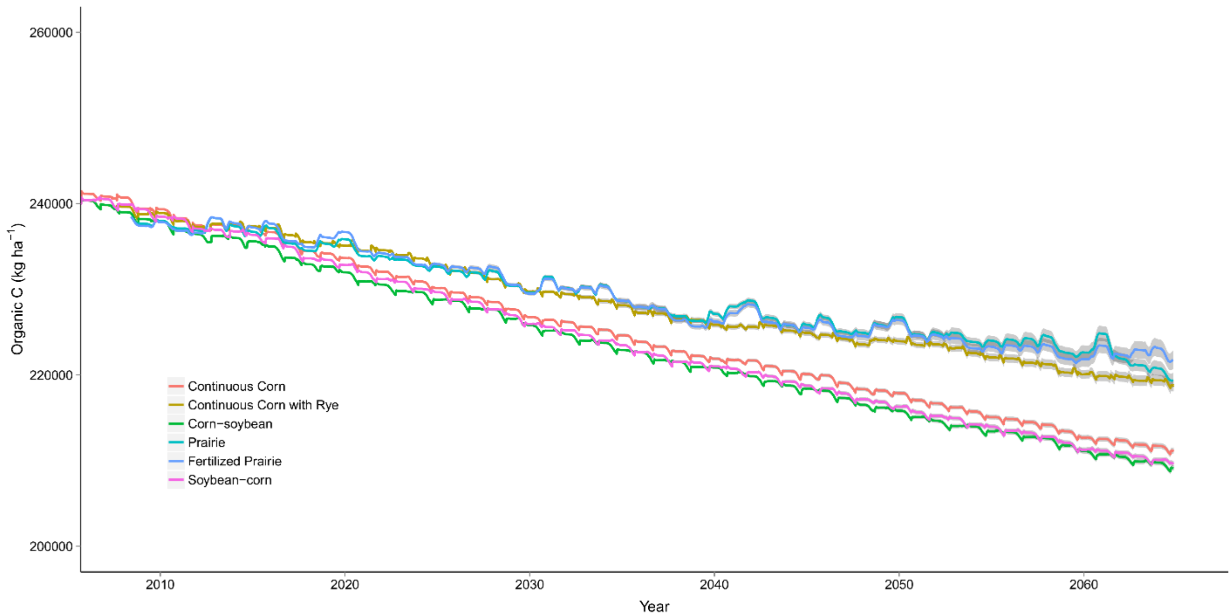

Figure 5.

Modeling Decomposition

Mechanistic hypotheses such as C saturation and priming are helpful in understanding what may be happening to C in a system, but modeling also allows us to examine decomposition mathematically. In the most basic form, the change of organic matter over time is equal to the inputs minus the outputs. The output of organic matter is the pool of existing organic matter multiplied by the rate of decomposition. As an equation, this is

$$\frac{dSOM}{dt} = I - (k * SOM) \qquad \text{Equation 1}$$

where SOM is soil organic matter, t is time, I is inputs and k is the rate of decomposition (Sierra et al. 2012). By this logic, when a soil has a lot of SOM, the losses are large and the inputs must be very large to overcome any loss. To put this in perspective, after six years at COBS, unfertilized prairie added about 4 Mg of C to the soil as roots. This number is insignificant compared to the 240,000 Mg ha^{-1} of C that was already present in the soil. Using the simple equation 1, even a loss of 0.01% per year would equal a loss of 240 Mgha-1. The rate of decomposition, k, would need to be 0.000016 to avoid SOM loss. Soils which begin with lower SOM content have much lower SOM rates and therefore require lower inputs to increase SOM.

Equation 1 represents the most basic hypothesis of changes in SOM. Hypotheses, and their corresponding equations, of how SOM changes over time quickly get more complicated as factors are added that account for the effect of temperature, moisture, and the composition of the material being decomposed (most often reflected by how much C in relation to how much N is in the material). Another factor influencing theoretical SOM decomposition is how many pools of SOM are represented in the equation. Soil organic matter pools are conceptual fractions of SOM which differ in how quickly they decompose. Any given model has a very labile pool wherein the SOM decomposes in a matter of days, an inert SOM matter pool which practically never decomposes, and one to nine pools in between these two with a corresponding rate of decomposition (Sierra et al. 2012). Mathematically, decomposition equations can quickly become complex and their structure can be based on a wide range of hypotheses on how SOM is lost. APSIM contains only one equation which simulates decomposition (Archontoulis et al. *in press*, Probert et al. 1998). This begs the question: **Do different equations of SOM loss support the finding of continuous SOM in corn- and prairie-based cropping systems?** The mathematical framework also allows us to test a range of input values and go on to ask: **How much organic matter needs to be added to high-C Iowa soils to result in an increase in SOM?**

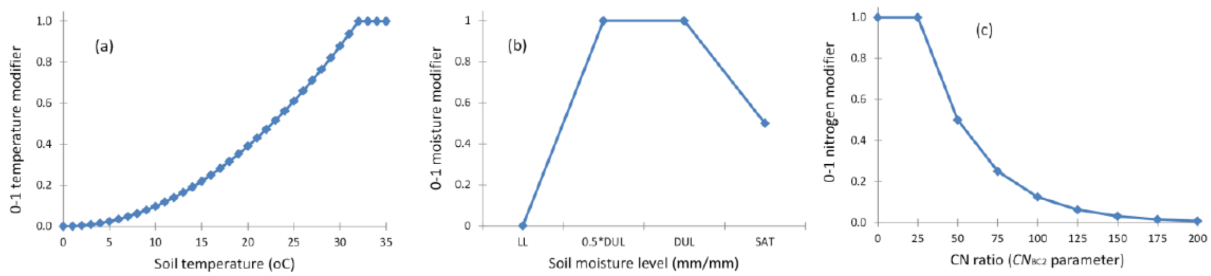

Figure 6. Temperature (a), moisture (b), and C:N ratio modifiers used by APSIM to adjust decomposition based on the environment. A value of 1 means no effect and a very low value (e.g. 0.01) means decomposition is inhibited (from Archontoulis et al. *in press*).

Decomposition increases as temperature increases, occurs optimally when it is neither too dry nor too wet, and decreases as the amount of organic matter C increases relative to organic matter N (C:N ratio increases)(Fig 6). While these basic concepts are agreed upon, the influence of each component and the interaction of the three are debated, leading to the multitude of decomposition equations. A lack of agreement is due to large in part to a lack of confidence in decomposition experiments. Most decomposition experiments share the same inherent weaknesses by being unable to accurately represent how decomposition occurs in the field (Cahill et al. 2009). Most decomposition relationships have been observed in one of two ways; 1) plant-free soil is brought into the lab, temperature/moisture/C:N ratio is manipulated and the amount of decomposition that occurs is measured as CO_2 or; 2) organic matter is bunched together in mesh bags and buried in the field, then removed and weighed to determine how much mass was lost. The first method neglects the natural conditions that occur in the field and the second captures field conditions, but uses organic matter that is unnaturally clumped and lacks contact with the soil. The COBS experiment provides the opportunity to set up a decomposition experiment that will avoid the problems introduced by manipulated environments. This opportunity will allow us to ask a basic question that has always lacked methodology for a sufficient answer: **How do temperature, moisture, organic matter C:N ratio, and relationships among these factors affect decomposition rates of OM *in the soil***?

Objectives and Strategies

The questions highlighted above surrounding SOM loss in high-C Iowa soils lead to three related objectives, the first two are theoretical, the third addresses theory through field-based experiment.

Objective 1. Determine if multiple established decomposition hypotheses support the continuous loss of SOM in high-C Iowa soils.

Strategy

Different decomposition equations can be found throughout soil and cropping systems models, such as APSIM. In the past, comparisons of the equations required the user to have knowledge of and access to all of these models. Fortunately, a package within R software (SoilR) was recently created to allow the use of equations from several of the most popularly used models to be implemented based on one set of inputs from the user (Sierra et al. 2012). Eleven different temperature functions and five different moisture functions are available and can be combined for a total of 55 possible temperature/moisture relationships. Models and their sources can be seen in Table 1 (from Sierra et al. 2012). Our strategy would be to use input parameters from the COBS experiment to run SoilR for fifty years and compare the results of changes in SOM found by other models to those found in APSIM.

Table 1. Functions implemented in SOILR to represent the effects of temperature T, and moisture W on decomposition rates.

$f(x)$	Terms	Function name	Source
$f(T) =$			
$Q_{10}^{(T-10)/10}$	T: mean temperature	`fT.Q10`	
$\frac{47.9}{1+\exp(\frac{106}{T+18.3})}$	T: monthly temperature (°C)	`fT.RothC`	Jenkinson et al. (1990)
$\left(\frac{T_{max}-T}{T_{max}-T_{opt}}\right)^{0.2} \exp\left(\frac{0.2}{2.63}\left(1-\left(\frac{T_{max}-T}{T_{max}-T_{opt}}\right)^{2.63}\right)\right)$	T, T_{max} T_{opt}: monthly average, maximum, and optimal temperature	`fT.Century1`	Burke et al. (2003)
$3.439 \exp\left(\frac{0.2}{2.63}\left(1-\left(\frac{T_{max}-T}{T_{max}-T_{opt}}\right)^{2.63}\right)\left(\frac{T_{max}-T}{T_{max}-T_{opt}}\right)^{0.2}\right)$	T, T_{max} T_{opt}: monthly average, maximum, and optimal temperature	`fT.Century2`	Adair et al. (2008)
$0.8 \exp(0.095 T_s)$	T_s: Soil temperature	`fT.Daycent1`	Kelly et al. (2000)
$0.56 + (1.46 \arctan(\pi 0.0309(T_s - 15.7)))/\pi$	T_s: Soil temperature	`fT.Daycent2`	Parton et al. (2001); Grosso et al. (2005)
$0.198 + 0.036T$	T: monthly temperature	`fT.linear`	Adair et al. (2008)
$\exp\left(308.56\left(\frac{1}{56.02} - \frac{1}{(T+273)-227.13}\right)\right)$	T: monthly temperature	`fT.LandT`	Lloyd and Taylor (1994)
$\exp(-3.764 + 0.204T(1-0.5T/36.9))$	T: mean temperature	`fT.KB`	Kirschbaum (1995)
$\exp((\ln(Q_{10})/10)(T-20))$	T: mean temperature. Q_{10}: temperature coefficient	`fT.Demeter`	Foley (2011)
$\exp(-(T/(T_{opt}+T_{lag}))^{T_{shape}}) Q_{10}^{(T-10)/10}$	T, T_{max} T_{opt}: monthly average, maximum, and optimal temperature	`fT.Standcarb`	Harmon and Domingo (2001)
$f(W) =$			
$\frac{1}{1+30\exp(-8.5W)}$	$W = P/\mathrm{PET}$, P: monthly precipitation, PET: monthly potential evapotranspiration	`fW.Century`	Parton et al. (2001); Adair et al. (2008)
$\left(\frac{W-b}{a-b}\right)^{d((b-a)/(a-c))}\left(\frac{W-c}{a-c}\right)^{d}$	W: water filled pore space. a, b, c, d: empirical coefficients	`fW.Daycent1`	Kelly et al. (2000)
$5(0.287) + (\arctan(\pi 0.009(RWC - 17.47))/\pi)$	W: volumetric water content	`fW.Daycent2`	Grosso et al. (2005)
$0.25 + 0.75(M/M_{sat})$	M: soil moisture. M_{sat}: saturated soil mositure	`fW.Demeter`	Foley (2011)
$(1-\exp(-(3/M_{min})(M+a)))^{b} \exp(-(M/(M_{max}+c))^{d})$	M, M_{min}, M_{max}: average, minimum and maximum moisture content in litter pool. a, b, c, d: empirical coefficients	`fW.Standcarb`	Harmon and Domingo (2001)

Objective 2. Determine how much organic matter needs to be added to high-SOM Iowa soils to overcome SOM loss.

Strategy
Once the SoilR framework is established, a range of organic matter input amounts can be tested to find the average input amount that results in a gain of SOM among the models available within SoilR.

Objective 3. Determine how temperature, moisture, and organic matter C:N ratio and the relationship among these three affect decomposition rates in the soil.

Strategy
Over the past eight years, COBS prairie treatments have placed a considerable amount of organic matter in the soil, but as mentioned, this is in the form of roots. Roots do not officially become organic matter until they are dead and available for decomposition. We propose to terminate small areas of the COBS prairies, thus creating available organic matter in the soil profile, and then track the decomposition of this organic matter to a one meter depth over three years. We also propose to do this in the continuous corn treatment which has a smaller, but consistent input of roots. This approach will eliminate many of the problems common to laboratory- or litter bag-based approaches because the organic matter is placed naturally in the soil, which creates optimum contact with the soil, and the organic matter will experience natural field conditions.

Although treatments do not differ greatly in temperature, examining decomposition across the soil profile will provide the temperature gradient needed to elucidate temperature relationships as soil temperature is greater at the surface and declines with depth during the summer. Soil moisture also differs with depth, although the relationship is less straightforward. Finally, the three treatments – unfertilized prairie, fertilized prairie, and continuous corn all have roots with different C:N ratios. Unfertilized prairie has an average C:N ratio of 150, fertilized prairie has an average C:N ratio of 85, and corn roots have an average C:N ratio of 25. If each one meter core is divided into six subsections based on depth, we will have 18 unique temperature/moisture/C:N ratio combinations over which to track decomposition.

Treatments within COBS are arranged as 30 x 60 m plots with each treatment replicated 4 times in a spatially balanced design. In the past, little variability has been found in root mass within treatments (Figs. 1 & 2). Traditionally, four cores have been taken within each plot, but statistical power analysis has shown that within-plot variability was small enough that the same results would have been found with only two cores per plot. We propose terminating two 2m x 2m areas within each plot and taking three 6.4 cm diameter x 100 cm long cores within each of these subplots to determine the initial mass present in 2016. We will then take three more cores in each subplot a year later in 2017 and again in 2018. Each year we will wash the soil from the organic matter and weigh the remaining organic matter. The difference in organic matter mass from one year to the next will represent how much organic matter decomposes over a year.

COBS is equipped with sensors which record soil moisture and temperature at five depths down to 50 cm every 30 minutes. Temperature and moisture will be modeled down to 100 cm and these data will be use to determine temperature and moisture relationships. Carbon and nitrogen concentrations will be measured in the initial organic matter measurement to determine differences in C:N ratios. The effect of each variable on decomposition and the interactions of the variables will be quantified using statistical non-linear mixed effects models and multivariate analysis. These analyses will determine how much each decomposition factor affects decomposition rate and the ability to examine all three at the same time may lead to new decomposition equations which include the interaction of temperature and moisture with C:N ratio.

Empirical data and its analysis will be used to support or refute the 55 decomposition hypotheses tested through modeling. This will allow us to know which decomposition model is most appropriate for Iowa, lending confidence to predictions of where Iowa SOM is heading and informing us of how much OM needs to be added to the soil to make a positive difference.

Results

The relationship between the inputs and activities described and the intended results is shown in Figure 7 and described below.

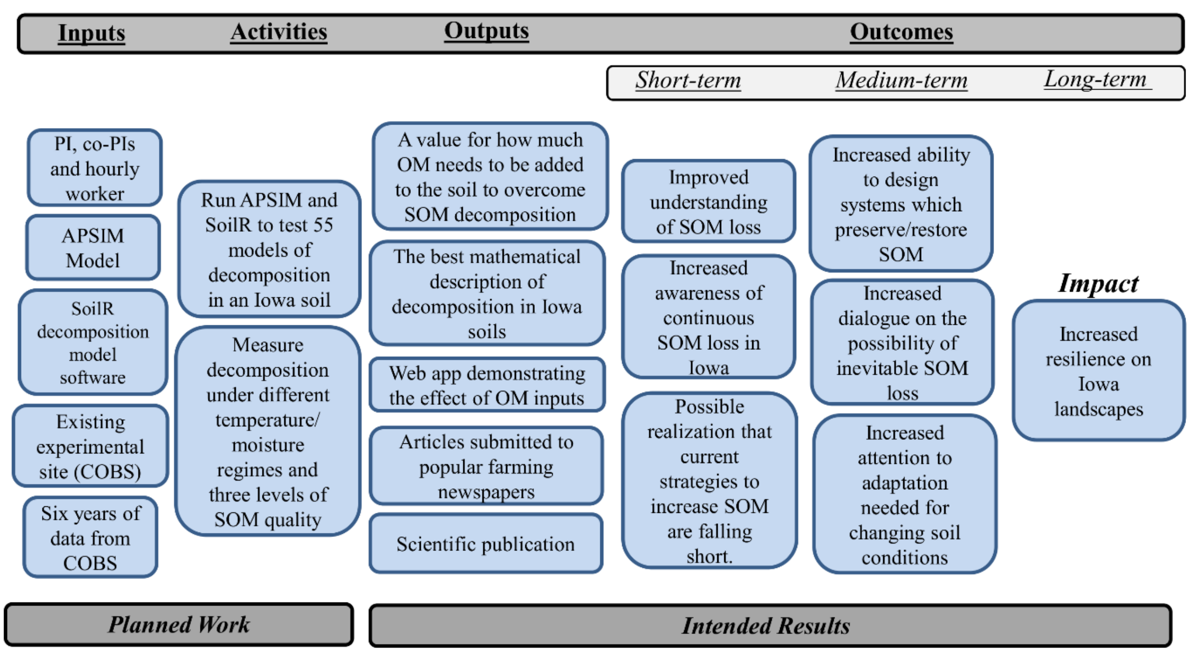

Figure 7. Logic model depicting the plan and results for this proposal.

Outputs

Achieving the objectives previously listed will result in a diversity of outputs. The most straightforward of these outputs is a value for how much organic matter needs to be added to a high-SOM Iowa soil to overcome the SOM lost by decomposition. This number will be easy to interpret when compared to values that people are familiar with such as how much plant mass is produced by a cornfield, cover crop, or prairie over the course of a year. This will be a way to gauge if current practices are falling short of the amount of plant matter needed to maintain SOM levels.

Another valuable output will be the best mathematical description of decomposition in high-SOM Iowa soils determined through the testing done in SoilR. This description will help in the understanding of what conditions lead to the greatest loss of SOM and will enhance the worth of knowing a target amount of plant matter by also understanding which practices will create conditions which are not favorable to decomposition. The most accurate decomposition model will allow us to confidently predict future changes in SOM. A new decomposition model could easily be incorporated in APSIM, allowing the simulation of decomposition based on different management or climate scenarios.

The amount of new organic matter required and the dynamic relationships of temperature, moisture, and organic matter composition will be best communicated to the public through an interactive, online visualization tool. People are more likely to think about information if they actively work with what they see. We plan to build a tool where users can adjust temperature, moisture, organic matter amount and C:N ratio, and initial SOM content and watch as a graph of decomposition over time changes. As a user attempts to create conditions in which SOM increases, they will begin to understand which controls are the most important factors in SOM decomposition. An advantage to this online format is that the information is easily shared and distributed through listserves and social networks. A previous interactive tool we have created can be found at http://agron.iastate.edu/CroppingSystemsTools/soybean-decisions.html .

We would also plan to submit articles describing the results of the work to Iowa Farmer Today and Wallaces Farmer and direct readers to the online visualizations. Iowa Farmer Today has 93,760 subscriptions alone and Wallaces Farmer is also popularly read. These journals are a good way to reach people who work in agriculture, but do not necessarily read scientific publications. It is expected that these articles would stimulate conversations about organic matter outside of academia and may also directly influence management decisions.

We would also plan to submit a manuscript to a scientific publication so that others in the field may benefit from the work and continue to advance the basic SOM science. The continuous loss of SOM despite regular inputs has been mentioned in the literature, but has never been highlighted. Calling attention to this potential phenomenon will encourage others to reexamine their data and run experiments to check decomposition hypotheses.

Outcomes
The most powerful outcome from this work may be the realization of how ephemeral are the rich Iowa soils that are so often taken for granted. While many are aware that Iowa soils have lost much of their organic matter, most assume that this problem can eventually be fixed by reducing tillage, planting cover crops, or reconstructing prairies. Alarming people of the difficulty of restoring organic matter should lead to increased awareness of fragility of SOM and increase efforts of SOM preservation.

In the short-term, outcomes will happen on the individual level as readers and web app users gain a better appreciation for SOM dynamics. Realizations and understanding will eventually grow to increased dialogues about the possibility of SOM loss and the implications for Iowa. People who recognize the importance of SOM will begin to pursue strategies that may reduce the rate of SOM loss, while others may pursue strategies that adapt to soils which are gradually losing SOM. On the medium-term scale, we may see effects on farmers as they fall into one of these two parties. Practices such as corn stover removal may be reduced and practices such as cover cropping may be increased by those wishing to attempt SOM preservation. For farmers who begin to experience the interaction of poorer soils less able to buffer climate variability and increased flood and drought predicted in the variable climate, diversification outside of corn- and soybean-based systems may be necessary to maintain a resilient farming system. These changes in practices may be desirable, but if the results of this study support strong continuous SOM loss in tile-drained high-SOM, soil management may have little effect. In this case, the most important outcome from this work would be taking the first step towards recognizing this previously misunderstood problem and encouraging a community towards finding solutions to ultimately create a more resilient landscape in Iowa.

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Partners

We have no official partners on this project, but the work will occur on the COBS experiment which co-PI Liebman is involved in and is maintained through other funding sources.

Timeline

Setting up and running SoilR will begin immediately after funding starts in 2016. It is estimated that the first results from the modeling will be available after an equivalence of two months full time, which will most likely be 6 months 1/3 time due to commitments to other projects. Another 6 months at 1/3 time during the second year will be used to build the online tool based on the modeling results.

Subplots in the prairie treatments will be terminated and initial organic matter samples will be taken in spring 2016 and subsequent organic matter samples will be taken in spring 2017 and spring 2018. Subplots in the corn treatment will be created when corn is at peak biomass in mid-summer and subsequent samples will be taken in these subplots the following two summers.

During the end of the second year of funding, enough data will have been collected to incorporate the results into the SoilR model and the online tool. By the third year of funding, most SoilR and online tool work will be running smoothly and incorporation of the final analysis of field data will be incorporated. During the third year, another 6 months at 1/3 time will contribute to the creation of farming and scientific publications and project evaluation.

Evaluation

Evaluation is an important step in assessing the impact of work. Our evaluation will target audiences that are expected to use the online tool, but may also be exposed to farming and scientific publications. We will distribute a short survey focused on organic matter decomposition in Iowa soils via the same means the online tool will be promoted – through listserves, social media, and as a note in the farming publications. This survey will test both perceptions on how SOM in Iowa decomposes and how often the reader discusses SOM. In the third year, we will again distribute the same survey by the same means and compare the changes in perceptions and frequency of SOM discussion to determine if the online tool was used and if it changed the attitudes of those who used it.