DIFFERENCES IN TILLAGE INTENSITY
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Abstract

A group of four undergraduate Geography students at the University of Wisconsin – Madison looked into agricultural practices and tillage intensity in the Oregon, Wisconsin area. First, they were curious as to specifically how agricultural practices affected tillage intensity and why farmers chose to implement said agricultural practices. Second, they were curious as to what sort of practices were utilized in the study area and whether any sort of spatial relationships existed between the adoption of said agricultural practices and various variables—such as slope, size of field, distance to water bodies and water ways, and distance to town. It was discovered that most farmers practice roughly the same tillage practices with regards to the crop type planted. Generally (for the major cash crops of the area), soybean fields are left un-tilled after harvest and corn fields are plowed by moldboard plow. All farmers practice some sort of tilling of the soil, none use purely "no-till" agriculture. Since tillage practices are so universal per crop type in this area, it is speculated that crop rotation is the major way tillage intensity is controlled for in this area. Upon comparing the locations of fields classified by current crop type (classified as either a "high intensity tillage crop" or a "low intensity tillage crop") to slope data, the researchers found that there appears to be a relationship between the two. It is speculated that farmers tend to plant high intensity crops more often when fields are located on flatter ground, and low intensity crops when fields are on steeper ground. More research is necessary to confirm these results or to identify other existing relationships, et cetera.

Introduction

The Wisconsin landscape is largely defined by vast farmland, and a large variety of agricultural techniques employed by many different farmers. The advantages and disadvantages of various tilling strategies has been the focus of agricultural studies pertaining to environmental health, crop yields, and economics. We believe that the distribution of these different tillage practices can be better understood through the identification and analysis of critical geographic variables. In this report, we analyze the distribution of tilling techniques in the Oregon, Wisconsin area and attempt to determine the geographic conditions that influence the strategies of farmers.

In our study area, we found that tillage practices do not vary tremendously, and farmers utilize similar tillage techniques for a given crop type. We believe that these observed crop rotations are generally adjusted in order to account for different tillage intensity requirements of the land. Through analysis of the area, we have determined that slope is a probable indicator of tillage decisions in this area.

Literature Review

Background:

There is a wide gradation of tillage practices used in crop production in the Midwest, and techniques are usually defined by the intensity and frequency of field plowing. While there is no “black and white” separation of tilling strategies, conventional tilling and conservation tilling are two terms associated with different strategies with opposing advantages and drawbacks.

Conventional Tilling—

Conventional tilling refers to a host of traditional farming methods where the soil is turned over in order to loosen the soil, and mix in fertilizer and plant residue. Previous studies have indicated that these traditional plowing techniques leave the resulting landscape more susceptible to erosion (Phillips & Young 1973: 42). Tilling is also considered an effective solution for weed management in crop fields, thus greatly reducing and often eliminating the need for herbicide applications (Sprague et al 1986: 50-54). Common tilling techniques include moldboard plowing, chisel plowing, as well as disc plowing. Moldboard plowing is considered the most intense form of plowing as the blade cuts between 9.5 and 15.7 inches into the soil surface in order to turn over and loosen the soil, leaving no crop residue on the surface (de Alba 2001: 335). Chisel plowing is a more adjustable form of tilling where more crop residue is left on the surface and the soil is not disturbed at as deep of levels. Disc plowing is another less intensive plowing technique that breaks up soil in order to prepare a seed bed (Duiker et al 2003).

Conservation Tilling—

Conservation tilling is another general term that refers to a wide range of approaches that attempt to reduce or eliminate soil disturbance while preparing a seed bed for crop growth. The most extreme method is no-till farming, where no tillage occurs and the soil surface is disturbed minimally by drilling seeds directly into the ground. This strategy has become increasingly popular as multiple studies have claimed no-till reduces erosion, and increases water retention in the soil. Studies have also claimed no-till provides an economic advantage by reducing the costs of labor, fuel, irrigation, and machinery costs. A significant drawback that is commonly associated with this method is the necessity of excessive herbicide use to control weed growth. Conservation tillage also includes minimal tillage methods where either a chisel or disk plow is used to break up only the top most layers of soil and preserve much of the surface crop residue.

These methods are growing increasingly more popular, especially in areas of increased slope (Lal 1997: 223).

Previous Studies—

Many studies have tangentially studied the adoption of tillage practices, by examining a variable or pattern that influences farming decision. Such studies include erosion, slope, soil, economic, and cultural analyses as they relate to tillage practices (Knowler & Bradshaw 2007: 25). One study by Knowler and Bradshaw attempted to reveal one synthesized explanation for why farmers chose to adopt conservation agricultural practices over conventional farming practices (2007: 27). This study, which considers 167 distinct variables, fails to find a single universal explanation; however, suggests that a variable related to "social capital" can serve as a primary indicator of a farmer's adoption of tillage practice (Knowler & Bradshaw 2007: 27-45). While this study highlights important variables that will need to be considered in our own research, we believe the scope of their analysis is too broad to effectively explore this issue. While their study analyzed factors driving tillage decisions at a global scale, we hope to narrow the scope of our research and explore important local variability that influences tillage practices.

Another study by Prokopy et al which examines the distribution of tillage practices, looks at 55 different studies spanning over the previous 25 years (2008: 300). In this study, a variety of variables was considered and each was separately tested for correlation (positive or negative) with the adoption of agricultural Best Management Practices (BMPs). BMPs are practices designed to conserve tillage, and limit erosion and sedimentation in water bodies. This study identified education level, capital, income, farm/ field size, access to information, attitude toward environmental concerns, environmental awareness, utilization of social networks, and age as the variables most critical to BMP, yet Prokopy et al also claimed that in their "synthesis effort, the results are clearly inconclusive about what factors consistently determine BMP adoption" (2008: 308). Additionally, they claim that utilizing different statistical analysis methods had a negligible effect on the results for this data set (Prokopy et al 2008: 300). Unfortunately, this study appears to have many elements of subjectivity and ambiguity, and also seems to identify variables that seem impossible to operationalize. This study, however, did provide important variables for us to consider in our research.

Site Selection:

Geographic research questions add a level of complexity to the sampling process because they incorporate spatial variability. The challenge of obtaining a representative sample of a target population is summarized by Jensen & Shumway in *Sampling Our World*, "One of the most challenging facets of geographic research concerns the issue of how best to represent different aspects of the world" (2010: 78). In addition, time limits, available funding, and resources influence how all researchers choose to sample their target study area.

There are two main categories of sampling: probability and non-probability sampling. "The essential difference between the two methods is that in probability sampling, every component has an equal (or known) opportunity of being selected, whereas in non-probability sampling every item does not" (Jensen & Shumway 2010: 81). Our research lends itself to the non-probability method because of our relatively small sample area. By sampling only fields around Oregon, Wisconsin, our findings will not necessarily represent the norm across all farm fields of the Midwest or even Wisconsin (Jensen & Shumway 2010: 81).

Sampling, by nature, has multiple sources of error, the most common sources being inherent and operational (Jensen & Shumway 2010: 88). Inherent errors involve errors with the actual data collection. These types of errors could deal with the lack of representativeness, introduction of bias from the researchers, from the limited sample size, and from the original assumptions made as to how to collect the data. Operational errors deal with poorly calibrated machines or tools that are used in the field or in laboratory settings. We are more concerned with inherent errors through our qualitative observations. It is important that we be aware of such limitations, make necessary adjustments, and be willing to accept what we cannot change in our research project.

Landscape Observations:

As landscape observations are essential to understanding the distribution of tillage practices, we have referred to several studies to form a baseline data collection process. In a tillage evaluation study in Rock County, PA, soil management teams separated fields based on tillage intensity. The categories from more intense to less intense tillage were: Moldboard, Disc 2x, Chisel/Disk, Chisel, and No-till (Duiker et al 2003). Although this study examines crop yields rather than the adoption of tillage practice, it provided a quality classification system to utilize while observing and mapping fields.

Interviews:

A portion of our primary data collection for the project involved acquiring anecdotal information through interviews with local farmers. We chose to use interviews over surveys because interviews can offer greater depth and understanding. In her chapter from *Research Methods in Geography*, Anna J. Secor comments on the usefulness of interviews; she explains, “We may need to talk to people if we are trying to learn about things that we cannot observe for ourselves…” (Secor 2010: 195).

Surveys perhaps would have been useful for inferential statistics concerning the larger population (Secor 2010: 196), but with such a small sample population, we were concerned about the possibility of having too low a response rate from our target audience to have significant findings. Mailed and e-mailed surveys tend to gather very low response rates (Secor 2010: 197). Plus, our initial thoughts were that interviews would be more beneficial because farmers might be more willing to talk with us in person at their farms. The farmers were the “experts” (Secor 2010: 203) on tillage practices and it was our goal to learn from their knowledge and experiences so as to assess why certain tillage practices exist along Highway 138.

Recruitment of interview participants proved to be more difficult than our group had anticipated. In retrospect, more preliminary planning and gathering of names of farmers to interview would have been beneficial. Secor mentions that there are two common techniques used to assemble an interview population. One technique is called the “snowball technique”. She defines it as sampling by finding an entry point and making contact with some members of the group (Secor 2010: 201). Initially this method was not feasible because no one in our group had connections/ contacts who were farmers in our study area. However, in an indirect way, we did revert to this technique because we talked with people along Highway 138 who were able to give us names of farmers whom they knew. The second technique that Secor describes is the “on site recruiting technique”, where one simply approaches people and asks for a moment of their time to answer a few questions (Secor 2010: 201).

Soil Analysis:

Variables for Soil Quality—

Soil consists of many different qualities and variables that create countless different types and varieties of soil. Soil texture, soil structure, and soil chemistry are just three broad categories of factors that go into defining what soil can be present in certain areas. Unfortunately, there are many specific variables that influence soil variance and not all of these variables can be tested, especially in one analysis. For this research, the question that needs to be considered is what is important for agricultural soils and which of these qualities makes a good soil? A soil is considered healthy agriculturally if it has the ability to provide goods for all life and allow for "benefit when the soil's natural productivity is managed in a sustainable way" (Sullivan 2004: 2). Soil of good quality also has the potential to increase productivity, fend off foreign contaminants, and keep a good relationship between organisms and the environment they live in (Doran & Parkin 1994: 5).

Of the qualities that determine soil quality, one key component is the ability for the soil to aggregate. Aggregation is the process of soil particles clumping together. Through aggregation, a soil is better able to allow for water and air to dissipate into and through the soil, allow more water to be stored, and prevent crusting of the surface of the soil (Sullivan 2004: 8). Crusting is detrimental to soil quality as it allows for greater amounts of runoff erosion as well as prevents the soil from "breathing" and intake of necessary elements for quality soil (Sullivan 2004: 9).

Another component that will be examined is the texture of soil. Soil texture is dependent on the percentages of three particles: sand, silt and clay; different percentages lead to different types and quality of soils. Clay particles are the most vital particle for quality agricultural land. Clay has a lot of surface area to allow for bondage to other particles as well as being the only particle that has the ability to sustain a sufficient amount of plant nutrients (Sullivan 2004: 2). The texture of soil that is present at the sites will be an important variable for analysis of the quality of soil for agricultural purposes, as well as to see if there is any degradation to the land as a result of certain practices.

The chemical make-up of soils is a very important component to the effectiveness of soils. Organic matter is crucial for effective agricultural soil as it contains necessary nutrients for plants and organisms to intermingle and survive. Organic matter, the layer of soil containing organisms as well as decomposing material from the surface, consists of 2 to 5% of soil volume (Sullivan 2004: 2). Through the decomposition of material of soil organisms, organic material puts nutrients back into the soil for future use (Sullivan 2004: 7). A difference in organic matter content seen throughout the different agricultural practices may reveal the consequences of certain tillage strategies.

Soil color is also a characteristic of soil that varies depending on the quality of the soil. Color can be a determinant of soil erosion. As the soil is eroded away down a hill or any slope, the soil color changes as the material is displaced. In a study by Lindstrom et al, they found through calculating the erosion loss of soil in a field that they could “easily account for the presence of observed lighter colored soil” (1992: 243). As stated earlier, the key to good soil is to have a good amount of organic matter; organic matter, when integrated with soil, forms a dark O horizon in the soil. The change in soil color is primarily associated with a loss of the O horizon and other upper layers of soil which are key to good agricultural fields.

Seed Floatation—

One additional area of emphasis to help determine the quality of the soil will be an analysis of the amount of seeds present in soil. Using the seed flotation test technique has been utilized as a test that boasts quality results (Mesgaran et al 2007: 1). Seed flotation has been used for a wide variety of biological research in different settings (Elsey-Quirk et al 2009: 2) (Lopez 2001: 2). For our purposes of this research, a fast and accurate process is needed to be utilized for laboratory analysis due to time and financial constraints. This technique is useful as it is a fairly quick process for separation of seeds (Mesgaran et al 2007: 2). Seed flotation also has been proven to yield comparative results of accuracy to other methods of seed separation (Mesgaran et al 2007: 2). Through this process, samples of soil from the field would be taken and test the number of seeds to float would be counted as a measure of the presence of weeds in the site's soil. In many instances, this solution is a chemical solution (Mesgaran et al 2007: 2), with the exact solution depending on what is being examined. The process can call for different solutions to test for the flotation abilities of different seeds (Elsey-Quirk et al 2009: 2).

GIS Analysis:

Using a geographic information system (GIS) is a powerful way to analyze spatial data. Using GIS allowed us to perform spatial analysis using both secondary data sources and our own samples and observations (Goodchild 2010: 376-377). Our objective with GIS analysis was to seek correlations between observed land-use practices in our study area and selected GIS data layers.

The selection of data layers for our study area depended on what we considered to be potentially influential on tillage practices. To gather an idea of what sort of data is relevant to tillage practices, we had to consult the scientific literature and use our own intuition. In "No-Tillage and Surface-Tillage Agriculture" the studies of a group of experts suggest tillage practices should be determined based on a variety of site characteristics including slope, erosion hazards, mulch cover, and soil texture and drainage properties (Sprague et al 1986: 50-54). Agriculture and Agri-food Canada (AAFC) funded the publication "Best Management Practices: Field Crop Production" in which a suitability rating for tillage practices is developed based on yield potential, need for erosion control and relative ease of management of the tillage system on that soil (Gasser 1993). A similar suitability rating system has been adopted by the Ohio

Department of Natural Resources in their efforts to improve erosion control (Lohrer 2010). While these studies fail to address cultural and economic factors that influence tillage decisions, they provided a good baseline for environmental factors to be included in our GIS analysis.

Remote Sensing Data—

The science of remote sensing helped our group find a viable study area and helped us digitize the fields in our study area. Remote sensing (Jensen 2007: 4) is the acquisition of data about an object without touching it. Remote sensing images can be aerial photographs taken from low flying planes, or satellite images taken from satellites orbiting the Earth's atmosphere. The science of remote sensing offers numerous benefits to researchers; one in particular is that images can be obtained systematically over very large geographic areas rather than just single-point observations (Stow 2010: 156).

Methodology

Variable Selection:

The number of variables we consider in this study was inevitably limited by time and resources. Of particular interest to us in this research are physical characteristics of the field such as tillage intensity, field size, crop type, slope, erosion, soil health, and weed presence. Cultural and social variables are also of importance in this analysis such as field ownership status, length of ownership term, and labor force.

Site Selection:

Under ideal circumstances, we would sample farm fields within our study site using the probability sampling techniques of stratified random or systematic sampling as to reduce researcher bias in site selections and to give us a more representative sample. However, we have chosen to use the non-probability sampling method of purposive or judgment sampling.

Purposive or judgment sampling allows for us to assume that what we are sampling is representative (Jensen & Shumway 2010: 81).

While we are not able to examine a very large and randomly selected sample, we were able to designate Highway 138 between Stoughton and Oregon, WI as a representative transect of agricultural fields (Figure 2). This site was accepted based on a minimum set of requirements including soil type variation, available ownership data, and a variety of tilling techniques. A preliminary observation of the study area revealed an obvious variation in field size, terrain, and tillage intensities. Plat books and digital parcel data were also available for this area and provided us with complete ownership and parcel size information. Also, we found preliminary evidence through soil survey maps, of three different soil types throughout our sample. Through the use of satellite imagery we were able to analyze the relative size and position of our fields of interest, and count fifty-seven fields within our sample. Another determining factor in the selection of this location was its accessibility and convenience, as this stretch of Highway 138 is a short drive from the UW-Madison Campus.

Landscape Observations:

The initial landscape observations consisted of a twofold classification process. First, each field was classified based on tillage intensity. As a classification scheme we used the Duiker et al study as a model and simplified the categories to: moldboard plow (most intense), chisel/disk (medium intensity), and minimal till/untilled (least intense) (Figure 1). While there were many fields that were untilled at this point of the season (November) with significant crop residue cover, it is important to note that none of the fields in our study area were continuous no-till fields. The second classification was made based on the type of crop being grown or most recently grown on the field. This was important for examining correlation between crop type and tillage intensity. For each of the fifty-seven fields in our study area, these two classifications were made, plotted on a map, and a picture was taken for later reference and analysis. As quality assurance measures for our classifications, we compared our photographs to other tillage images from various sources, verified our classifications in farmer interviews, and reclassified in early December to control for any change in tillage before the ground froze.

Interviews:

Our interview questions and privacy statement (see Table 3) were initially drafted and brought before our peers in a focus group meeting during class. We gained valuable input through this dialogue and made necessary modifications to our original set of questions. The interviews were made of ten questions, and were designed to take roughly twenty minutes to complete (Secor 2010: 198). The interview process involved one member of our group dictating the questions to the farmer while two members recorded the responses. The set of questions made prior to the interviews was a guide to follow, but additional questions were also asked through informal conversation. Please note that the questions were somewhat geared toward looking at the extreme ends of tillage practices, “full-till” and “no-till.” Some of the questions were centered on specific farm fields.

Our initial strategy for compiling an interview population was on site recruiting, but our strategy had to be modified due to a lack of success. Our actual interview population was compiled using both methods. The entire interview process was basically completed in two steps. The first step entailed talking with business and home owners within our study area to get leads for possible interview contacts. The second step was to follow up with those we thought to be the best interview candidates. We interviewed just two farmers, one who had clearly used a moldboard plow recently on the field in question (Farmer 1), and one who appeared to have not used any plow on the field in question for some time (Farmer 2). Please see Table 4 (for Farmer 1) and Table 5 (for Farmer 2), which each contain the final version of our interview questions along with the corresponding responses. From these farmers, we also received permission to collect soil samples (for soil analysis, discussed later on). In addition to the formal interviews conducted, we also gathered a couple brief statements from other farmers. Participants were thanked, invited to our public symposium, and provided a copy of our final paper (Gartner 2010).

Soil Analysis:

Soil Sampling—

Sampling fields for the purpose of performing soil analysis is much the same as sampling any other kind of population. One problem with regards to soil sampling is that an innumerable number of soil samples could be taken (it involves a very, very large population). Pennock et al note this—"even a single 10 ha field contains about 100,000 1 m^2 soil pits or 1 x 10^7 10 cm^2 cores, and sampling the entire population would be more of an unnatural obsession than a scientific objective" (2008: 1).

In general, "The goal of sampling is to produce a sample that is representative of the target population" (Pennock et al 2008: 4). The exact goal of soil sampling can change from application to application. Sampling may be geared toward finding what the average soil in a field is like (as we are), or toward mapping the variations in a field (Pennock et al 2008: 12). The exact purpose determines the population needed for the experiment, and thus the sampling design to be utilized. Another issue surrounding soil sampling is the fact that certain fields are less homogenous than others and thus require more sampling to arrive at a semi-accurate representative average.

Our soil collection consisted of ten samples from four different fields. We sampled from a corn, winter wheat, tobacco, and soybean field in order to examine soil variability related to crop type. We are not so much interested in mapping the soil variations, but rather, are interested in finding an average value for each field sampled. One fortunate coincidence is that we will be sampling in fall after the growing season, which is supposed to be the best time to sample soil. Sampling in the fall is beneficial because the temperature becomes low enough, below 10ºC, after which nutrients levels are expected not to change.

Soil Structure—

We utilized surrounding soil to test and determine the aggregation of the soil in the field to see how the soil particles stick to each other to form distinctive shapes in the soil. A shovel was used to take a scoop of soil and displace it on the surface by letting the soil fall off the shovel. Once on the ground, the natural clumping of the soil was examined and recorded. The structure of the soil aggregates was determined by comparing the observations with a soil structure table which depicted the general types of soil structure (Birkeland 1999: 12). Through determining the structure of the soil, we were able to determine, at a relative scale, how easily liquids and gases are able to penetrate/move through the soil. This measure of breathability gave us a possible factor of soil that is influenced by the agricultural practice utilized in the field. We were also be able to see general trends in clumping techniques in each agricultural technique and compared the results to previous knowledge on aggregation of soil particles (Bronick and Lal 2005: 6).

Soil Texture—

For soil texture, we followed a generic ribbon test that looks at what percentages of sand, silt and clay are present in the soil sample. The test first examines the ability of the soil to clump together. Though this first step is closely related to structure of soil, it looks to see if the soil is completely sand, which does not clump, or a combination of the three particle types. If the soil clumped together, a ribbon was formed by hand and the length of the ribbon, before it breaking by its own weight, was recorded. The length of the ribbon determined certain amounts of particles in the soil because the different amounts of soil particles allow for the different strengths of the particles to adhere to one another to form a longer ribbon. After determining the length of the ribbon, a part of the ribbon (a pinch of soil) was saturated to see how the soil particles feel to the touch. Depending on whether the particles felt gritty, smooth, or neither, a soil texture was determined. If at any point of the test the step failed, there was a specific soil texture assigned. An example of this is the sand example stated above. Generally, the more amounts of silt and clay, the finer particles, the better the soil is for agricultural use (Bronick and Lal 2005: 8).The soil textural triangle was then utilized to familiarize ourselves with the approximate amounts of sand, silt and clay in the soil texture found and determine whether this is a factor that is affected by tillage practices. (Birkeland 1999: 10).

Organic Matter—

The only laboratory analysis that we completed was called the Total Carbon (TC) Procedure. In the field, our group obtained soil samples from each farm field that we visited. Soil samples used for this test were be taken by shovel at the randomly selected location within the site. The TC procedure can be summarized into three basic steps: pre-weigh, heat, and post-weigh. Prior to any analysis with our soil samples, we measured and record their weights. Next we used a high temperature commercial furnace to dry the soil samples to burn off all carbon present in the soil samples. The recommended temperature range is 900 to 1000° Celsius for resistance ovens and between 1300 to 1500° Celsius for induction ovens (Schumacher 2002: 13); however, we used a 550° muffle furnace with less than optimal heat. The heating process took about one hour. Finally, when the soil samples cooled, we weighed the soil samples a second time. The difference between the preheated soil samples to the heated soil told us how much carbon was present (Singer and Janitzky 1986: 33).

Soil Color—

Soil color is a good qualitative measure of the quality of soil in a particular field. Through field observations, photographs from the roadside were taken to organize the fields in the study area as well as confirm the crop type and agricultural practice used on each field. With these photographs, soil color was determined through comparing the soil color in the photos to the Munsell color book. Once the color was determined for a field, it was recorded and later used as part of GIS analysis for classification of the fields.

Seed Flotation—

Seed flotation is a simple test that allows for organic matter and seeds to separate from the rest of the soil. In our test, about 75 mL of soil was utilized from each sample site. The soil that was collected was of shallow depth (several cm's) so that the most amount of seeds and organic material can be collected as possible. Once the samples were collected and labeled to their appropriate site location, one sample was placed into a large container. Water was added into the container to completely saturate the soil. This complete saturation allowed for the breakdown of the particles of the soil so that seeds and other organic material were easily separated. After the water was added to the container, the container was shaken up to help separate the seeds and organic material from the soil particles. The soil particles separated overnight so that the soil settled down to the bottom of the container. After the allotted time, the seeds and organic material were floating on top of the water. We then counted the number of seeds that floated to the top. This process was repeated for each sample that was collected. Once all the seeds were counted in each sample, an average for each site was made. These average numbers were compared to the amounts of seeds seen in each site to see if there was a significant change in seed amounts between the different agricultural techniques practiced on the fields. These values were compared to the general idea that less intensely tilled fields contain more weed seeds than intensely tilled fields (Cardina and Sparrow 1996: 48).

GIS Analysis:

Our goal for spatial analysis was to find trends or phenomena that could be presented geographically by employing cartographic techniques. To employ any kind of GIS analysis, we first had to create a dataset of our own to use within ArcGIS. To do this, first, we utilized remotely sensed images of the study area to digitize the field polygons. Second, we assigned attribute data to the fields. To see a table with this data, see Table 1. Fields were assigned photograph numbers, crop types, tillage statuses, soil colors, areas in acres, et cetera.

Ultimately, we ended up selecting slope data as the primary landscape feature to compare our data too. A slope raster layer was created via converting a ten meter digital elevation model (DEM) (USGS Seamless Server) in Arc, using Spatial Analyst. Another layer that our data was matched with was a water bodies and water ways layer. We also imported a land parcel layer () which was at one point used to find addresses and names of farmers/ land owners. We ourselves used a GPS to mark soil sample locations—which were then brought into Arc as points, although they did not benefit our analysis much.

Results

Landscape Observations and Classification:

After classifying our fields and verifying through quality assurance measures, we determined that our study site contained thirty one fields that were not tilled at the end of the season, four that were recently tilled with a chisel or disc, and twenty two fields that were recently tilled with a moldboard plow. For crop type, the classifications we made in order of prevalence were: corn, soybean, hay, clover, winter wheat, tobacco, and pumpkin. Due to the small samples in the latter categories, we condensed clover, winter wheat, tobacco, and pumpkin into one category we labeled “other”.

In order to detect correlation between our tillage intensity and crop type classifications, we produced two correlation matrices; one with raw totals, and the other with percentages (Table 2). With these matrices we were able to detect some patterns with crop rotations as they relate to tillage practices in the area. Over thirty percent of the fields in our study area were intensely tilled corn fields, making that the predominant agricultural activity in the study area. Fifty-six percent of corn fields in this area have been recently plowed with a moldboard plow, making it by far the most intensely tilled crop in the area. Soybean fields, however, were left untilled for the majority of instances, while those that had been tilled were mostly plowed minimally with a chisel or disc. Fields of “other” classification were about fifty percent moldboard plowed and none of these fields were plowed with a method of reduced intensity.

Interviews:

We did learn a few interesting things from our interview responses. Farmer 1 told us how farmers need to follow federal recommendations, best management practices for their fields to obtain subsidies. Also, he told us about the Conservation Reserve Program (CRP) and how through the program, farmers are paid subsidies from the government to keep highly erodible portions of their land fallow. In terms of erosion prevention, it is a win-win situation because farmers can continue to bring in income while helping to maintain the integrity of the local landscape. Farmer 1 also told us that general knowledge about erosion has expanded over the years, and that many new techniques have been created and implemented to reduce water and wind erosion since the infamous Dust Bowl—such as contour plowing, and allowing tree lines to grow between fields. Also notable, he mentioned how although corn has a lower market price than soybeans currently, it is subsidized by the government for ethanol production, thus, many farmers opt to grow corn instead of soybeans. In summary, Farmer 1 in many ways emphasized the economic motivations involved in tillage practice and crop regime selection. But he also emphasized how farmers these days are very conscientious of erosion problems associated with farming, even if they choose to use moldboard plowing.

Farmer 2 classified the field our questions were aimed at as "minimal-till." When asked if he has tried to use no-till techniques on that field before, he responded that he has tried but has never been able to make it successfully "work." One complication to reducing tillage that was discussed is the increased weed presence associated with it; in particular, he noted having troubles with weeds in the field mentioned earlier. He was able to inform us that for the most part, no one in the area was using no-till agriculture. Again, we do not have the data to back these statements completely, but they did seem to hold true at least in our small study area.

A local organic farmer was of the opinion that no-till agriculture was not much better in terms of erosion prevention (at least in this area) than forms of conventional farming that involve tillage. He also seemed to think that herbicide application requirements for no-till farming were too substantial to justify its practice. This opinion may be reflective of the expected objection an organic farmer would have toward herbicides, but his opinions on no-till are nonetheless interesting. In brief, he seemed to think no-till farming was a bad idea.

Another (primarily corn) farmer (of 34 years) who farms along Highway 138 in addition to a number of other places, indicated that the advantages and disadvantages between till and no-till are not "cut and dry." According to him, using till would theoretically be the best for crop growing (and weed prevention), if it were not for erosion and nutrient loss. He personally has practiced a variety of tillage practices—no-till (not along Highway 138), "shallow-till," and full-till. He has seen nearly every combination of results imaginable—for example, he has seen both till and no-till fields experience erosion problems (or not), and both till and no-till fields experience great yields (or not). In his opinion, the number one factor to consider with regards to deciding which tillage practice to use is soil type—which he says can vary on any given field. All in all, this farmer seemed to have mixed feelings when it came to tillage practices.

Soil Analysis:

An interesting array of results was seen after performing the tests in regards to the several key soil characteristics emphasized in the experiment (Table 6). It was seen that soil texture as well as soil structure was very similar throughout each sample. This result suggests that using a certain agricultural practice does not affect these aspects of soil quality and should not be a factor as to what practice is used on a particular field.

After calculating the organic matter content of each sample and averaging it out, there was a slight change in organic matter content between the different practices used in each field. The field that had the greatest amount of organic matter was the field that practiced minimal till and progressively decreased in amount as the tillage practice used on the field increased in intensity. Though the most amount of organic matter was found in the tobacco field that we tested, there was only one sample tested in the field and an average was not able to be made. This finding that there is more organic matter in less intensely tilled fields is not surprising as the smaller amounts of field surface is turned over, the greater amount of organic material will be collected on the top of the field and would be decomposed and integrated into the upper layer of the soil.

A similar result was found through the seed flotation test. After the average of each field was made, the seed count for the minimal tilled field was drastically higher than any other. This provides evidence that through less tillage activity on the surface of fields, the higher the ability for weeds to be present. By tilling the fields less intensively and not turning over more of the soil, weed seeds are able to become present through the lack of change of soil profile; with the lack of change of the soil, seeds are able to take hold in the soil and become more prominent throughout the field.

GIS Analysis:

When we compared the current or most recent tillage status of the fields to the slope, we found a very slight relationship. More often than not, moldboard plowed fields were in flatter areas, while un-tilled or lightly tilled fields were in steeper slope areas. But this relationship was slight, and when it was realized that currently un-tilled corn fields would be tilled before any new crop was planted (likely the next spring), any consideration that our research's results indicated a relationship between the current tillage status and the slope was abandoned. However, there may indeed be a relationship, but further research would need to be conducted to confirm. Please see Figure 4 for a map.

We also compared the current or most recent crop type to the slope (classified as either tillage intense or not tillage intense), we again found a relationship. This time, we found a stronger correlation. It appears that tillage intense crops tend to be planted on flatter ground, while not so tillage intense crops tend to be planted on steeper ground. Of course, multiple years worth of data would need to be collected to confirm such a finding. But, it is likely that current or recent crop types are somewhat indicative of the crop rotations utilized. If so, one could claim that tillage intensity is in fact higher in low slope areas and lower in high slope ones. Please see Figure 5 for a map.

Next, when applicable, soil color classifications for the fields were mapped against the slope. Please see Figure 3 for a map. As expected browner/ lighter soils were found more often in higher slope areas, where as blacker/ darker soils were found more often in lower slope areas. Perhaps soil erosion (and organic matter loss) is higher in high slope areas and farmers need to be more conscientious of this with regards to tillage practice in these areas. And perhaps they are. However, the relationship between soil color and slope was a weak one. Further, there are numerous potential flaws with assuming our findings were significant. First, although soil color is often useful for identifying how much O-horizon or A-horizon is on the surface, it is not the only soil attribute that should be looked at. Second, even supposing the browner soil color associated with higher slopes was related to A-horizon exposure, there is no way or knowing (based on our research) whether that exposure is the result of tilling or some natural phenomenon (or whether the natural phenomenon influenced the tilling practice or the tillage process influenced the soil). Third, many of the fields that were identified as browner or lighter were ones with exposed soil coming from the work of a chisel plow. Chisel plows can dig quite deep into the ground, and might potentially bring up more A-horizon than a moldboard. Lastly, most of the fields we identified did not even have substantial enough exposed soil quantities to justify classifying by color.

Another finding made through the use of GIS was that the five largest fields were currently either un-tilled or only lightly tilled. Beyond the first five fields, no pattern seemed to exist. More research (in a larger study area) would need to be conducted to determine if this is significant. Please see Figure 6 for a map.

The distances of the fields to water bodies and water ways were also compared. No relationship seemed to exist between distance to water and tillage intensity or practice. Likewise, no relationship seemed to exist between distance to town and tillage intensity or practice.

Future Research

A major problem we experienced with our research design is that it did not provide any way to accurately learn the history of tillage practices on a given farm field. The "history" of the land cannot be learned simply by looking at a snapshot in time (which our landscape observations were). Adding a survey to our design could prove most useful for handling this problem.

Another strategy would be to make this study a longitudinal study of at least a five year duration—so crop rotations and tillage practices could be better understood. Perhaps the landscape conditions could simply be documented each year, right after the first planting of the season as well as a little before the first typical snowfall. Also notable, landscape observations intended solely for noting the affects of different tillage practices (perhaps erosion or weed presence) could also be conducted.

Site Selection:

With more time and resources, it would be useful to expand our site to include a larger number of fields in a larger area. This would help capture more variance in tillage strategies, and perhaps reveal trends that were not apparent with our reduced sample. Ideally, a more comprehensive research project would examine closer to 500 fields randomly selected throughout Dane County.

Landscape Observations:

Ideally landscape observations in a future research project would take place over the course of several years. This way complete crop rotation practices can be accounted for and classifications of fields would be more specific with less error. With a more thorough understanding of crop management practices in place at each field, it would be possible to assign each field a classification based on the Soil Tillage Intensity Ranking (STIR) developed by the Natural Resources Conservation Service. STIR ranks the tillage intensity of specific fields based on crop rotations, speed of tillage equipment, tillage type, depth of tillage operation, and percent of soil surface area disturbed. The rankings range from 0 to 200, with lower scores indicating less intense tillage (NRCS 2008).

Interviews:

With only two interviews, both from the same small geographic area (Highway 138 between Oregon and Stoughton), it is difficult to make any definitive assumptions or conclusions about tillage practices in the Oregon, Wisconsin area If we were to continue our research we would definitely want to conduct more interviews. Additionally, we would like to involve other interview questions so as to look at other possibly meaningful variables. In conjunction with conducting more interviews, we would consider conducting surveys as well because of their ability to derive quantifiable and statistically meaningful results, and simply for the reason that they are easier for farmers to complete. Taking time for full-fledged interviews may not be feasible for a farmer’s schedule while a survey is less intrusive, quicker to complete, and easily returnable through the mail or by e-mail. If we encompassed a larger sample area, we definitely would want to incorporate surveys into our research design so as to more thoroughly sample the population.

Soil Analysis:

Through the limited amount of time and finance for this project, a lot of the techniques and processes utilized were used to get the most meaningful results in the shortest amount of time possible. To continue for this project, one may utilize more samples for a more accurate measure across the study area and within a site. Ideally for this project, several fields of each tillage practice would have been sampled to obtain a better average for a particular tillage practice as well as to see if there is a better trend amongst the different practices. We also would have taken a control sample from a non-farm field so we had a neutral field for seed counts and organic matter content for a comparison for the agricultural fields.

GIS Analysis:

As mentioned earlier, the geographic extent of the area in question could be enlarged so as to draw possibly more powerful/ universal conclusions. Perhaps added variability would provide more insight or strengthen our recent findings. For example, perhaps GIS analysis of areas of more slope variation would strengthen our finding that slope is related to tillage intensity. Perhaps no-till fields (one of the extremes) could also somehow be included into the study area. In general, additional variables could be tested for. One way would be via the utilization of additional data layers during GIS analysis. For example, use of a NRCS soil type layer (which we actually have already imported) (SSURGO) has the potential to be very enlightening for our research.

Remote Sensing—

Remote sensing technologies could provide another avenue for future research concerning the monitoring of tillage practices in the study area. With the aid of historical images, tillage intensity patterns might be able to be identified. With enough expertise, we could perhaps be able to study additional variables; for example, we could perhaps see trends concerning water content/ saturation of the soil in the fields (Schneider, 2009).

But remote sensing has its limitations. Jensen (2007: 8) notes one limitation is that the science of remote sensing is often oversold as a replacement for other data collection methods. Remote sensing images aid in research but should not be used exclusively as a visual representation of a study site. Field data and observations and accurate maps of a study are also critical to accurately assess a study site. Relying solely upon remote sensing techniques should be avoided. Douglas Stow mentions that using only remote sensing can lead to "false information or artifacts being introduced whether in data collections, image processing, or in image interpretation" (2010: 156).

One research group used remote sensing techniques to remotely sense tillage practices in north central Montana. They found two limitations while using remotely sensed images in their research. One was that crop canopies often made it difficult to determine accurately the tillage regimes used by the farmers. The second limitation was the sheer size of their study area made for high variability in their results (Bricklemyer et al 2006: 215).

Douglas Stow points out another potential major problem with depending upon remote sensing data: "students should not harbor unrealistic expectations when it comes to obtaining imagery to meet specific needs. Often, it will not be possible to locate images that are freely available in the public domain for exactly the time(s) and location(s) of interest" (Stow 2010:

160). We discovered this problem ourselves. Free, downloadable remote sensing data is hard to come by. Free data that is available often does not provide enough pixel resolution to obtain highly detailed information. Lastly, it can be a challenge to find images for the time of year needed.

Conclusion

We sought to find out how conventional farming tillage practices (with regards to tillage intensity—type, depth, and frequency of plowing) are distributed in the Oregon, Wisconsin area (along Highway 138 between Oregon and Stoughton) and what factors are behind those distribution patterns. To begin, we found that in a sense, there is not a large degree of variation in tillage practices for our study area. For example, most all the farmers till with moldboard plow after harvesting a corn crop, and most all do not plow at all (or plow only lightly with chisel plow or disc harrow) after harvesting a soybean crop. In other words, in this area, the crop type seems to be the major determinant of how a farmer will till, if at all. But, tillage intensity can nonetheless vary from farm to farm through differences in crop rotations; crop rotations allow farmers to control tillage intensity. A crop rotation favoring soybean years will be less tillage intense than a crop rotation that favors corn years for example. If trying to minimize tillage, a farmer might even opt to grow hay or leave a field fallow (as set aside CRP land).

But assuming all this is true, we only know how farmers control tillage intensity, not why they do or do not. Decisions concerning how intensely to till the soil (perhaps through a specific crop regime) seem to be influenced by several factors. In our interviews, we highlighted economics, understandings of erosion, and concerns over weeds to be major factors considered in the decision making process. It must be noted that often nowadays, it appears that through the use of subsidies (which provide economic motivation), the government to some extent seems to ensure that ecological concerns are addressed.

Assuming the farmer takes into account these ecological concerns and the limitations of the land, we should expect to see a variation in tillage practices and intensity based on the variation of the land. Of course, the land is likely to have multiple attributes impacting the level of tillage intensity the land can handle. Further, the attributes the farmer recognizes as being the most indicative of what the land can handle might not be quite correct. Nonetheless, comparison of agricultural practices to various land attributes can (often) allow one to identify causal or correlational relationships in the form of spatial patterns. We found that there seems to be a relationship between slope and tillage intensity. In general, tillage intensity (defined by current crop type's tillage intensity) seems to be greater when in flatter areas, while it tends to be lesser in steeper areas. We also found that size of field might also be related to tillage practice used. Perhaps for some unidentified economical reason, farmers are more likely to use less intense tillage practices or plant crops requiring less intense tillage when fields are relatively large (relative to the field sizes in our study area).

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Appendix

Table 1. Dataset pertaining to Farm Fields

Field ID Number	Photo Number(s)	Area of Field in Acres	Current/ Most Recent Tillage Status	Assigned Tillage Intensity for Tillage Practice	Current/ Most Recent Crop Type	Assigned Tillage Intensity for Crop Type	Soil Color according to Munsell 10 YR	Assigned Color Rank (1 = Most Black, 5 = Least Black)
1	1	37.1498	un-tilled	Least Intensity (Un-tilled)	corn	More Intense Tillage	NA	NA
2	2	13.2078	un-tilled	Least Intensity (Un-tilled)	soybean	Less Intense Tillage	NA	NA
3	3	45.8630	disc/ chisel	Medium Intensity (Lightly Tilled)	soybean	Less Intense Tillage	3/3	5
4	4	2.3447	un-tilled	Least Intensity (Un-tilled)	hay	Less Intense Tillage	NA	NA
5	5	12.4757	un-tilled	Least Intensity (Un-tilled)	corn	More Intense Tillage	NA	NA
6	6	6.2779	un-tilled	Least Intensity (Un-tilled)	corn	More Intense Tillage	NA	NA
7	7a, 7b	56.0387	partially moldboard	Highest Intensity (Greatly Tilled)	corn	More Intense Tillage	2/1	1
8	NA	8.9274	moldboard	Highest Intensity (Greatly Tilled)	corn	More Intense Tillage	NA	NA
9	9a, 9b	35.2376	moldboard	Highest Intensity (Greatly Tilled)	corn	More Intense Tillage	2/2	2
10	10	126.2020	un-tilled	Least Intensity (Un-tilled)	corn	More Intense Tillage	NA	NA
11	11	3.7360	moldboard	Highest Intensity (Greatly Tilled)	corn	More Intense Tillage	2/2	2
12	12	5.2174	un-tilled	Least Intensity (Un-tilled)	corn	More Intense Tillage	NA	NA
13	13	11.3100	moldboard	Highest Intensity (Greatly Tilled)	corn	More Intense Tillage	2/2	2
14	14	75.4372	moldboard	Highest Intensity (Greatly Tilled)	corn	More Intense Tillage	2/2	2
15	15	47.9642	moldboard	Highest Intensity (Greatly	corn	More Intense Tillage	2/2	2

				Tilled)				
16	16	19.2182	un-tilled	Least Intensity (Un-tilled)	corn	More Intense Tillage	NA	NA
17	17a, 17b, 17c	16.4629	partially disc/ chisel	Medium Intensity (Lightly Tilled)	soybean	Less Intense Tillage	2/2	2
18	18	8.7771	un-tilled	Least Intensity (Un-tilled)	soybean	Less Intense Tillage	NA	NA
19	19	63.8828	partially moldboard	Highest Intensity (Greatly Tilled)	soybean	Less Intense Tillage	3/1	3
20	NA	1.1568	moldboard	Highest Intensity (Greatly Tilled)	tobacco	More Intense Tillage	NA	NA
21	NA	2.0201	moldboard	Highest Intensity (Greatly Tilled)	corn	More Intense Tillage	NA	NA
22	22	23.3809	moldboard	Highest Intensity (Greatly Tilled)	corn	More Intense Tillage	2/2	2
23	23	34.6000	moldboard	Highest Intensity (Greatly Tilled)	corn	More Intense Tillage	2/2	2
24	24	16.3860	un-tilled	Least Intensity (Un-tilled)	hay	Less Intense Tillage	3/3	4
25	25	5.4420	un-tilled	Least Intensity (Un-tilled)	corn	More Intense Tillage	NA	NA
26	26	33.5179	un-tilled	Least Intensity (Un-tilled)	clover	Less Intense Tillage	NA	NA
27	27	12.1902	un-tilled	Least Intensity (Un-tilled)	hay	Less Intense Tillage	NA	NA
28	28	7.5439	partially moldboard	Highest Intensity (Greatly Tilled)	corn	More Intense Tillage	NA	NA
29	29	24.1607	partially moldboard	Highest Intensity (Greatly Tilled)	corn	More Intense Tillage	NA	NA
30	30	22.1624	un-tilled	Least Intensity (Un-tilled)	fallow	Less Intense Tillage	NA	NA
31	31	26.3903	un-tilled	Least Intensity (Un-tilled)	clover	Less Intense Tillage	NA	NA
32	32	39.1373	un-tilled	Least Intensity (Un-tilled)	corn	More Intense Tillage	NA	NA
33	33	1.2026	moldboard	Highest Intensity (Greatly Tilled)	pumpkin	More Intense Tillage	NA	NA
34	34	76.6805	un-tilled	Least	soybean	Less Intense	NA	NA

				Intensity (Un-tilled)		Tillage		
35	35	77.2582	un-tilled	Least Intensity (Un-tilled)	winter wheat	Less Intense Tillage	NA	NA
36	36	1.2217	un-tilled	Least Intensity (Un-tilled)	corn	More Intense Tillage	NA	NA
37	37	26.5719	partially disc/ chisel	Medium Intensity (Lightly Tilled)	corn	More Intense Tillage	NA	NA
38	NA	3.5106	un-tilled	Least Intensity (Un-tilled)	hay	Less Intense Tillage	NA	NA
39	39	6.3781	un-tilled	Least Intensity (Un-tilled)	hay	Less Intense Tillage	NA	NA
40	NA	1.2897	un-tilled	Least Intensity (Un-tilled)	hay	Less Intense Tillage	NA	NA
41	41	2.4978	moldboard	Highest Intensity (Greatly Tilled)	winter wheat	Less Intense Tillage	NA	NA
42	42	55.8987	moldboard	Highest Intensity (Greatly Tilled)	soy	Less Intense Tillage	3/3	4
43	43	46.5269	un-tilled	Least Intensity (Un-tilled)	corn	More Intense Tillage	NA	NA
44	44	153.3608	un-tilled	Least Intensity (Un-tilled)	soybean	Less Intense Tillage	NA	NA
45	45	1.4905	un-tilled	Least Intensity (Un-tilled)	fallow	Less Intense Tillage	NA	NA
46	46	12.1519	un-tilled	Least Intensity (Un-tilled)	hay	Less Intense Tillage	NA	NA
47	47	32.3255	un-tilled	Least Intensity (Un-tilled)	soybean	Less Intense Tillage	NA	NA
48	48	86.6190	disc/ chisel	Medium Intensity (Lightly Tilled)	soybean	Less Intense Tillage	4/3	5
49	49	23.8661	un-tilled	Least Intensity (Un-tilled)	hay	Less Intense Tillage	NA	NA
50	50	20.6639	un-tilled	Least Intensity (Un-tilled)	hay	Less Intense Tillage	NA	NA
51	51	3.7549	un-tilled	Least Intensity (Un-tilled)	corn	More Intense Tillage	NA	NA
52	52	7.0707	un-tilled	Least Intensity (Un-tilled)	corn	More Intense Tillage	NA	NA
53	53	15.4062	moldboard	Highest Intensity (Greatly Tilled)	corn	More Intense Tillage	2/1	1
54	54	15.0876	moldboard	Highest	corn	More	2/1	1

				Intensity (Greatly Tilled)		Intense Tillage		
55	55	60.7694	moldboard	Highest Intensity (Greatly Tilled)	corn	More Intense Tillage	2/1	1
56	NA	15.7457	moldboard	Highest Intensity (Greatly Tilled)	corn	More Intense Tillage	NA	NA
57	57a, 57b	21.4602	moldboard	Highest Intensity (Greatly Tilled)	corn	More Intense Tillage	2/2	2

Table 2. Correlation between Crop Type and Tillage Intensity

	Un-tilled	Chisel or Disc	Moldboard	Total
Corn	12	1	17	30
Soybean	5	3	1	9
Hay	9	0	0	9
Other	5	0	4	9
Total	31	4	22	57

	Un-tilled	Chisel or Disc	Moldboard	Total
Corn	21%	2%	30%	53%
Soybean	9%	5%	2%	16%
Hay	16%	0%	0%	16%
Other	9%	0%	7%	16%
Total	55%	7%	39%	100%

Table 3. Privacy Statement

Privacy Statement

Dear potential participating farmer,

We are students at UW-Madison, conducting research for our senior year geography department colloquium research project. Our project documents both the distribution of tillage practices in Oregon, Wisconsin, and attempts to find the many reasons that farmers choose one set of tillage practices over another. We are asking your permission to collect 4 soil samples from one of your farm fields plus 1 control sample from an adjacent non-farmed area, each approximately 2 cups (60 grams) in size, so that we may test for basic soil fertility (N, P, K) and perform weed seed bank analyses. We also have a short interview.

Your privacy is very important to us. We will not collect any personal information without your written consent. We can assign you an alias (e.g. Farmer One) if you so desire. The soil analyses and interview responses will be used in our research and our presentation only. Your participation is entirely voluntary. You may refuse to answer any question. We are not using any electronic recording devices during the interview.

Thank you once again. Your participation is greatly appreciated! If you would like an electronic copy of our paper, or to attend a free public symposium in mid-December on the University of Wisconsin-Madison campus, please contact us at:

Robert Sommers	email: xxxxxxxxxxxx.xxx	xxx-xxx-xxxx (cell)
Andrew Wilson	email: xxxxxxxxxxxx.xxx	xxx-xxx-xxxx (cell)
Kolin Erickson	email: xxxxxxxxxxxx.xxx	xxx-xxx-xxxx (cell)
Corey Barnes	email: xxxxxxxxxxxx.xxx	xxx-xxx-xxxx (cell)

Table 4. Interview Responses from Farmer 1

1) How long have you been farming this property? • **6 years**
2) What was the total number of acres on your farm this past year planted in crops, placed in conservation reserve, or devoted to other agricultural uses (pasture, permaculture, etc.)? • **2 acres**
3) How would you characterize your farm's ownership: (1) full owners, who own all the land they operate; (2) part owners, who own some and rent the remainder of their land; or (3) tenants, who rent all of their land or work on shares for others? • **Full owners**
4) Can you describe the labor force that operates your farm (e.g. is it primarily made of family members? how many laborers are part-time or seasonal? how many are full-time)? • **Family, part-time basis**
5) Can you describe your general crop rotation for the field in question? • **Row crops, with rotation of alfalfa, hay, pumpkin patch** • **Do this for weed and pest control**
6) How would you describe the primary tillage practices used for your major annual crops: (1) till (moldboard plow); (2) minimum tillage (chisel plow, disc); or (3) no-till? • **Every third year, chisel plow to break up the soil compaction** • **Use moldboard plow, good consistency for the spring planting season**
7) In terms of the prevalence and severity of weeds, can you highlight any concerns you have about your current set of tillage practices? • **Quack grass, velvet leaf are a challenge** • **No herbicides used**
8) In terms of soil erosion and soil fertility, can you highlight any concerns you have about your current set of tillage practices? • **Contour plow** • **Have some issues with rill and gulley erosion** • **Tolerable soil loss** • **Fertility issues because of nitrogen loss/ drain**
9) What are your herbicide application requirements and what are your fertilizer/ manure application requirements? • **No herbicides used** • **Use manure from their farm animals** • **Starter fertilizer, 40-10-10 (NPK)**
10) Why do you practice the tillage practice that you do (till, minimum tillage, or no-till)? • **Knowledge, learned practices that work well**
Extra) • **Knowledge about tilling has greatly improved since the Dust Bowl** • **CPR land subsidized** • **Best management practices need to be followed to receive subsidies** • **Corn subsidized for ethanol production**

Table 5. Interview Responses from Farmer 2

1) How long have you been farming this property? • **25 years**
2) What was the total number of acres on your farm this past year planted in crops, placed in conservation reserve, or devoted to other agricultural uses (pasture, permaculture, etc.)? • **82.3 acres**
3) How would you characterize your farm's ownership: (1) full owners, who own all the land they operate; (2) part owners, who own some and rent the remainder of their land; or (3) tenants, who rent all of their land or work on shares for others? • **Tenant**
4) Can you describe the labor force that operates your farm (e.g. is it primarily made of family members? how many laborers are part-time or seasonal? how many are full-time)? • **Farmer 2 is the labor force, full-time**
5) Can you describe your general crop rotation for the field in question? • **Corn, soybeans, winter wheat**
6) How would you describe the primary tillage practices used for your major annual crops: (1) till (moldboard plow); (2) minimum tillage (chisel plow, disc); or (3) no-till? • **Minimum tillage practices**
7) In terms of the prevalence and severity of weeds, can you highlight any concerns you have about your current set of tillage practices? • **Thistle grass, cockle burr, pokeweed**
8) In terms of soil erosion and soil fertility, can you highlight any concerns you have about your current set of tillage practices? • **Decent soil fertility** • **Small amounts of erosion—one big wet hole present**
9) What are your herbicide application requirements and what are your fertilizer/ manure application requirements? • **Wheat 2-40** • **Round Up spray for soybeans** • **Liberty Corn spray** • **No manure or fertilizers used**
10) Why do you practice the tillage practice that you do (till, minimum tillage, or no-till)? • **Cannot make no-till work**
Extra) • **No one practices no-till in that area now** • **Soybean fields are not tilled after harvest, the following crop is planted directly in** • **Corn is always tilled** • **Hay seeds are usually sprayed in with fertilizer—hay still involves some till** • **Clover is usually tilled in (and can be left in, or not)**

Table 6. Soil Analysis Results *SA denotes Sub-Angular

Soil Sample #	Structure	Texture	Organic Matter (g)	Seed Count
1	destroyed	silty clay loam	0.394	48
2	destroyed	clay loam	0.274	47
3	SA Blocky	clay loam	0.553	34
4	SA Blocky	silty clay loam	0.389	12
5	SA Blocky	silty clay loam	0.351	10
6	SA Blocky	silty clay loam	0.291	7
7	SA Blocky	clay loam	0.491	5
8	SA Blocky	clay loam	0.187	11
9	SA Blocky	silty clay loam	0.355	12
10	SA Blocky	silty clay loam	0.454	24
Field #	**Soil Samples Included**	**Crop Present**	**Field OM Ave (g)**	**Field Seed Count Ave.**
1	1 - 4	Winter Wheat	0.403	35.25
2	5, 6	Soybean	0.321	8.50
3	7	Tobacco	0.491	5
4	8 - 10	Corn	0.332	15.67

Table 7. Exposed Soil Color vs. Tillage Intensity (defined by Crop Type)

	High Intensity Tillage Crops	Low Intensity Tillage Crops	Total
Black	12	1	13
Brown	0	5	5
Total	12	6	18

	High Intensity Tillage Crops	Low Intensity Tillage Crops	Total
Black	66%	6%	72%
Brown	0%	28%	28%
Total	66%	34%	100%

Figure 1. Tillage Classifications

Moldboard Plow

Chisel Plow or Disc Harrow

Un-tilled

Figure 2. Study Area

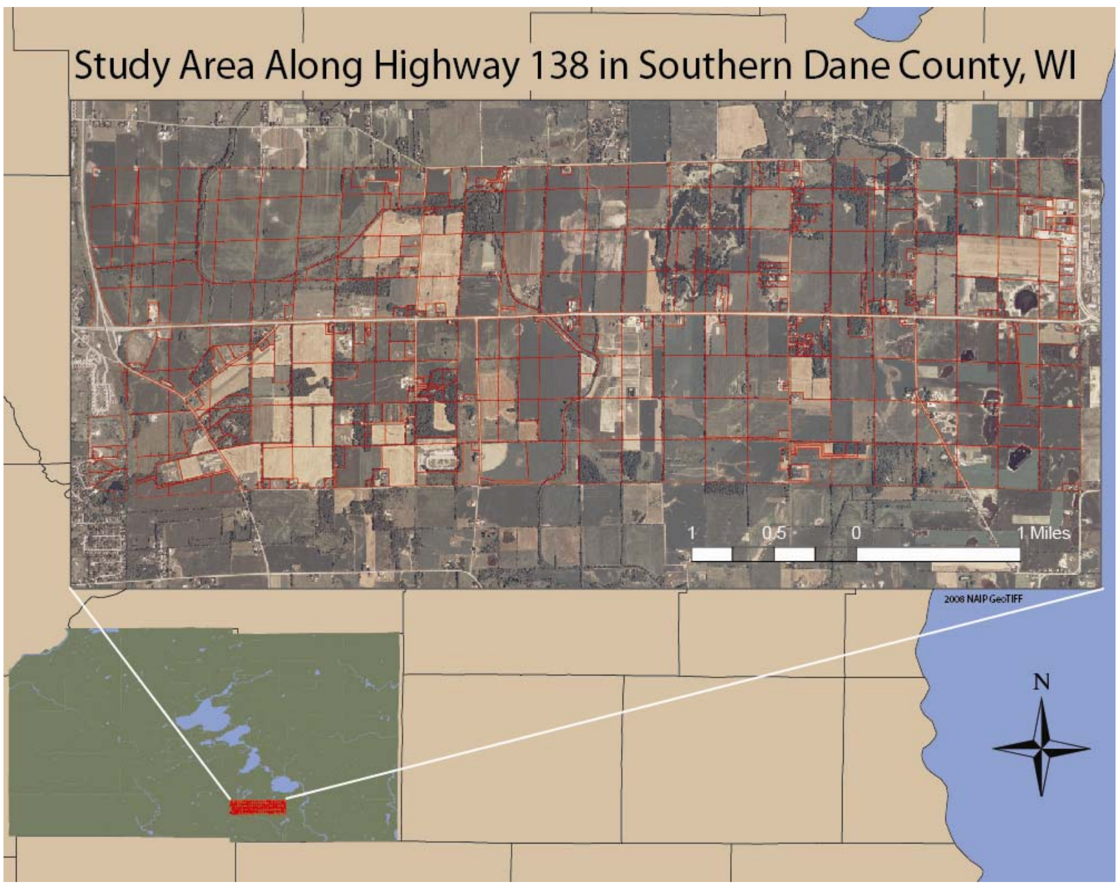

Figure 3. Map of Exposed Soil Color and Slope

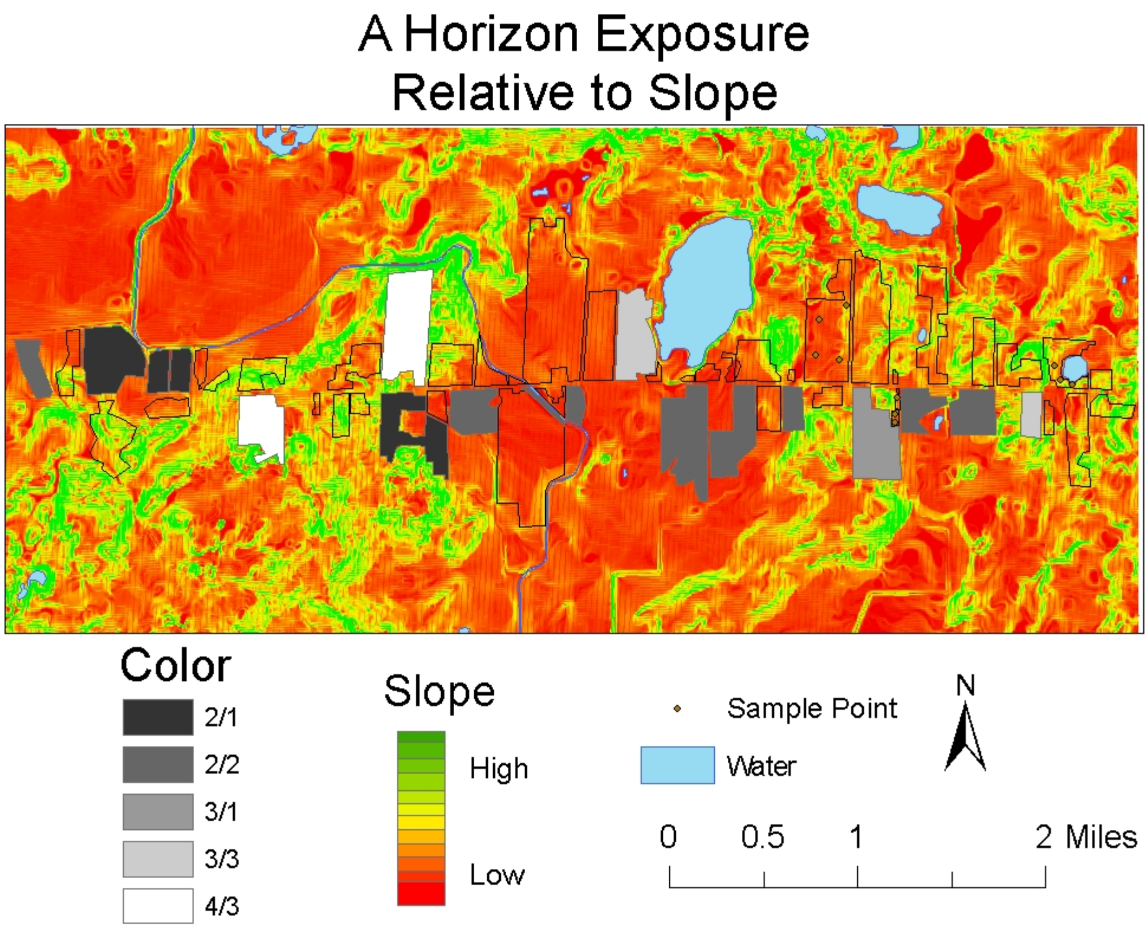

Figure 4. Map of Current Tillage Status and Slope

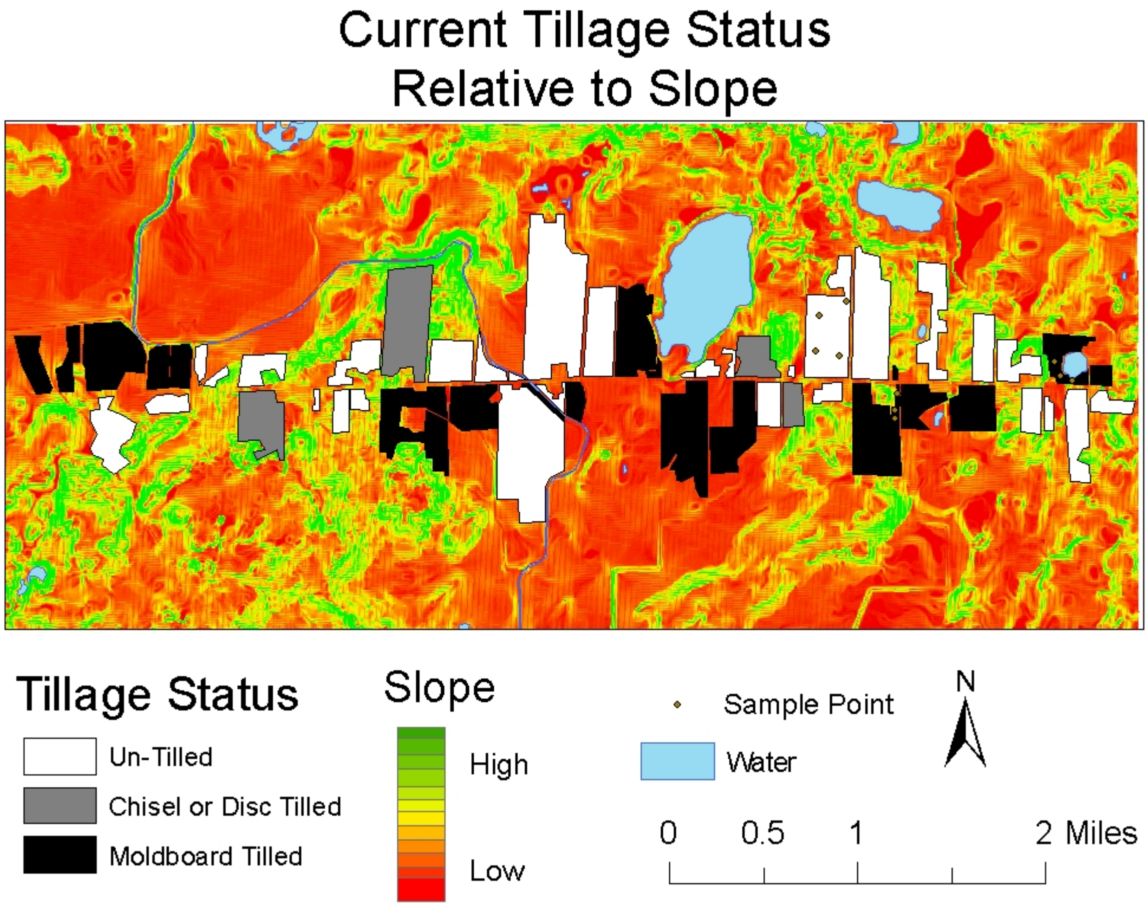

Figure 5. Map of Current Crop Type and Slope

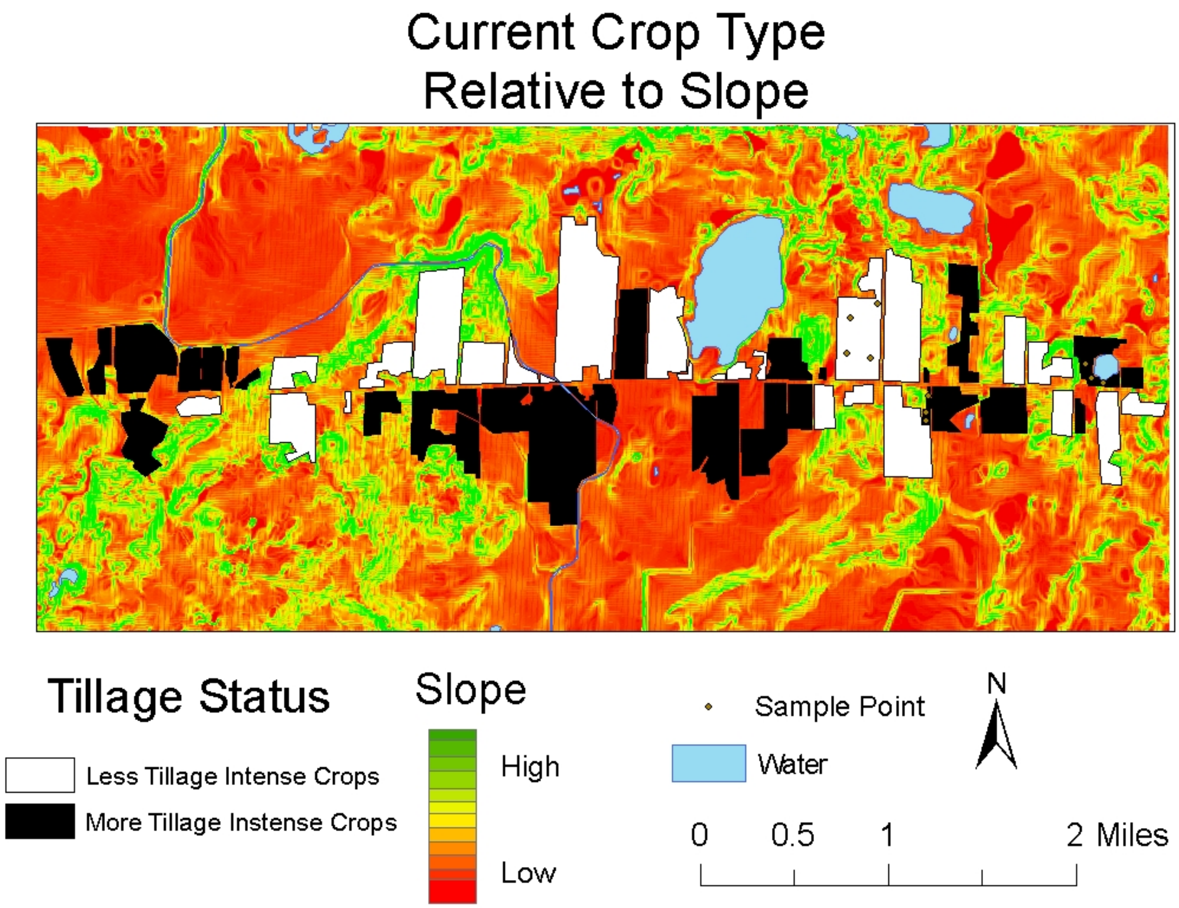

Figure 6. Map of Five Biggest Fields