2008

The effects of farmer attitudes and farm management practices on soil quality: a study in Cherokee County, Iowa

Amber D. Anderson Mba
Iowa State University

The effects of farmer attitudes and farm management practices on soil quality: a study in Cherokee County, Iowa

by

Amber D. Anderson Mba

A thesis submitted to the graduate faculty

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Major: Sustainable Agriculture

Program of Study Committee:
Andrew Manu, Co-Major Professor
Cornelia Flora, Co-Major Professor
Jon Sandor
Dan Nordman

Iowa State University

Ames, Iowa

2008

Table of Contents

List of Tables

List of Figures

Abstract

This study seeks to relate farmer attitudes, perceptions, and management characteristics to field soil quality and laboratory fertility indicators. Farmer interviews were conducted to document recent practices on the farm as well as farmer attitudes about farming. To obtain soil quality measures, both the Natural Resource Conservation Service's field soil quality kit and laboratory tests were employed. Sites from the eastern half of Cherokee County, Iowa, were selected.

Key considerations of this study included farmer practices of renting versus owning land and organic or synthetic nitrogen application. Additional farmer data, including attitudes about farming, are used in this analysis.

In our study, farmers with longer farming experience had access to larger acreages. Also farmers with larger farms tended to adopt no till systems. When asked how they would change their operation if provided with unlimited resources, farmers who make decisions based upon simplicity and economics are more likely to continue their operation as is, while those who use experience, trial and error, as well as experimentation as their primary decision making tools are more likely to scale back their operations.

It was observed that ownership was not directly an influencing factor in shaping soil quality. However, some of the farmers’ traits and attributes led to management activities that significantly impacted selected soil quality and fertility indices. The use of organic and inorganic amendments had not led to significantly different potassium or phosphorus levels in the fields. Fields of farmers with large acreages had lower microbial respiration and higher pH. The no-till systems adopted by farmers with large acreages were associated with soils with higher bulk density. Farmers who viewed farming as only labor or management had fields with higher bulk densities and nitrate levels than those who viewed farming as a multifaceted profession. Additionally, farmers who enjoyed farming had fields with lower bulk densities than those who farmed simply to make a living.

Chapter 1: Introduction

General Introduction

Soils are a vital part of our every day lives. They are the base upon which we build our cities, grow our food, and obtain raw materials for production. Soil quality of the remaining farmland may be increasingly important, as less land is available for food production due to degradation or urban use. Future food production for an increasing population is dependant upon proper preservation of this resource. The quality of this natural resource, and forces that affect it, should therefore be of concern to all of us.

Soil quality, according to the United States Department of Agriculture, is “The capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation” (USDA-ARS-NRCS, 1999). This broad definition of soil quality encompasses the many benefits that healthy soils bring.

Human activities have had numerous effects on soil formation and quality. Human impacts include urban areas where large amounts of soil have been displaced for development purposes, and agricultural areas where the many processes of farming affect soils. Farmers have a direct effect on soil quality through their management of the land. Around the world, various soil disturbances occur through farming practices of tillage, fallow, and the addition of amendments.

As humans require more land for living space, less land will be available for agriculture. The quality of the remaining agricultural land is crucial for continued food production to supply a growing population. The issue of soil quality is especially relevant in Iowa due to the many acres that will be changing hands in the near future as well as the increasing cost of farmland.

Additionally, money for conservation from some sources is becoming more limited. If soil quality could be more easily correlated to farmer traits, money could be targeted to areas that provide the most environmental benefit. If simple to obtain characteristics, such as farmer age or acreage farmed, were found to have a significant impact on soil quality, money could be more easily targeted to watersheds containing those farmers. These more easily identifying characteristics would be significantly easier and cheaper to obtain than sampling all fields in the area or talking to all area farmers.

Approximately 90,000 farm operators in Iowa farm an average of 356 acres (USDA-NASS, 2007). The distribution ranges greatly from very small farms of a few acres or less to large farms with several thousand acres. The majority of this land is planted to two crops, corn and soybeans. In 2008, it is estimated that Iowa will produce 13.2 million acres of corn and 9.8 million acres of soybeans (Abendroth et al., 2008).

The soils in Iowa are relatively fertile and have favorable physical characteristics due to the predominant parent materials of loess and glacial till with low stone content. The native prairie vegetation produced soils of high organic matter content and good structure.

At various research stations around the United States, manure application has been found to decrease erosion, even if not applied yearly (Gilley and Risse, 2000). Additionally, manure applications have been found to increase corn grain and stover yields in Wisconsin, however, yearly variations in weather had a significant influence (Arriaga and Lowery, 2001). Manure has previously been viewed as a waste product of animal production. Excessive application, may lead to problems such as water pollution. With the large number of animals, especially the 18.9 million hogs estimated to be in the state in December of 2007, along with poultry and cattle populations, manure is widely available (USDA-NASS, 2007).

It is a common assumption that ownership will result in better care of any particular item. In this case, better use and care of the land would result in better soil quality on owned land. On the other hand, farmers may farm all their land the same way, regardless of ownership. This could lead to soil quality being based upon the individual farmer and their management practices. Previous studies have shown that perennials and certain legumes are significantly more likely to be grown on owned land while annuals are more likely to be grown on rented land, even if the lease agreement is for several years (Fraser, 2004). Ownership should therefore lead to less erosion and improved soil quality over time. Studies from other areas, including China, have found that investments, such as organic amendments and other land improvements are more likely to occur on land with security in tenure than in areas where redistribution is common (Jacoby et al. 2002). In Ethiopia, research has shown that 47% of farmers would make improvements if they had secure tenure of the land (Deininger and Jin, 2005). These improvements included conservation practices and long-term investments in the land quality.

Hypotheses

Due to the reasons discussed above, soil quality is anticipated to be enhanced on soils in fields farmed by their owners who apply manure. It is also anticipated that rented acres would exhibit the highest degree of soil degradation. In addition, it was thought that reasons for farming, farm practices, and farmers' views could influence land treatment and therefore its quality.

Purpose and Objectives

The purpose of this study was to assess various farmer and field attributes as well as farmer management practices and relate them to soil quality. The objectives were: (1) to carry out a survey to determine farm attributes including land ownership or lease, farmer management practices such as tillage systems, frequency and type of fertilizers applied, and ideas about the farming profession; (2) to assess field soil quality parameters; (3) to determine selected soil chemical parameters from field and laboratory tests; (4) to correlate farm and farmer attributes to soil quality and fertility indicators.

Chapter 2: Literature Review

Natural Resource Conservation Service Soil Quality Kit

The soil testing kit is designed so that a basic but holistic assessment of soil health could be more easily completed. Measurements for simple indicators of soil health are assessed in the field. This analysis can be completed more quickly in the field than a full laboratory analysis. Additionally, the soil is in place rather than being disturbed by transportation to a laboratory. The kit can be transported to areas that do not have access to laboratory facilities, such as rural areas. The NRCS's recommended soil quality kit was used in this assessment due to the ease of access for farmers. Many of the tests can be run with relatively inexpensive equipment. This access is important if farmers are to assess changes in soil quality on their own. Prior assessments of this particular in-field soil quality kit have found measurements of soil pH, nitrate, electrical conductivity, and gravimetric water content not to be significantly different from those measurements obtained in a laboratory (Liebig, 1996). Field soil microbial respiration was significantly higher than that obtained in a laboratory setting, likely due to the inclusion of plant respiration (Liebig, 1996). Tests included in the kit are as follows:

Soil Respiration: This test measures the level of microbial activity in the soil by the amount of carbon dioxide produced. Microbial activity is generally associated with a healthy soil. A diversity of microbes would lead to a soil more resilient to various changes in the field.

Soil Infiltration**:** Soil infiltration is a measure of how quickly water can enter the soil. A slow infiltration rate would result in more runoff in addition to the plants not being able to take full advantage of rainfall. While infiltration is affected by some inherent soil properties such as soil texture, management practices that lead to crust formation or compaction also negatively impacts water entry into the soil.

Soil bulk density: This test requires collecting a measured volume of soil, drying it, and weighing it. This ration of weight to volume is an indication of how dense the soil is. Measurements obtained may be an indication of compaction. When soil becomes compacted, it becomes harder for roots to form effective root area for uptake, growth, and anchoring of the plant. In the field, bulk density can be negatively affected by increased trips over a field, large equipment, or tillage while soil is too wet.

Electrical Conductivity: This test measures the amount of non-saline salts in the soil. Salts make water uptake more difficult for plants, resulting in decreased plant growth. Typically, this is not a problem in Iowa due to plenty of rainfall that leaches salts out of the soil.

pH: A pH value is a representation of the amount of acidity in the soil on a scale from 0 to 14. A value of 7 is considered neutral, while lower values indicate more acid conditions. Various nutrients are available at certain pH levels, but unavailable at others. \ Iowa soil pH values typically range from five to seven. In soils with high pH, iron or other deficiencies may occur, while values too low may result in lower than optimal plant growth due to nutrient unavailability and other related problems.

Soil Nitrate test: Nitrogen is an essential plant nutrient for growth. This test is a quick approximation of the amount of nitrogen available to the plant, but this same form is also the most vulnerable to loss from the soil. Nitrates can be easily leached or lost through volatilization if the soil becomes saturated.

Slake test*:* This tests the stability of the peds and how easily the soil forms a crust. Crust formation on the soil surface prohibits water from easily entering the soil, slows gas exchange, and inhibits seedling emergence. The stability of peds can be improved through organic additions. Assigned slake values for this kit range from 1 to 6 with 6 representing the most stable aggregates.

Land Tenure and Land Use

As of 2002, 59 percent of active farmland in Iowa is rented (Duffy, 2004). This is a significant increase over the 1982 value of 43 percent (Duffy, 2004). The consequence of having such a large percentage of rented farmland could be a large flow of cash away from the rural communities due to payments from farmers to absentee landowners living in other areas. This could be detrimental to the already suffering rural Iowa communities. Additionally, in 2002, 20% of Iowa farmland was owned by individuals living outside of the state (Duffy, 2004).

Soil Amendments

Although Iowa's soils are relatively fertile, amendments are added to maintain high crop yields. These include phosphorus (P), potassium (K), and nitrogen (N) containing products as well as lime to increase the pH of acidic soils. Nitrogen is normally a limiting nutrient for corn production. However, it can be a potential water pollutant, with potential human health problems resulting from high levels in drinking water (Wortmann et al, 2006). Therefore, N management is crucial.

For the 1999 growing season, 1.4 billion pounds of anhydrous ammonia was applied as a N source (Hanna et al, 2003). Other forms of N such as manure, urea, or liquid forms were also applied around the state. Unused N from these and other sources have resulted in excessive loss of N and high nitrate levels in ground water and water bodies.

Manure from the state's many animals can also be used as a source of N, P, K and other nutrients. Additionally, organic additions such as manure can improve various aspects of the soil's quality. With increasing costs of synthetic nitrogen sources like anhydrous ammonia, it will likely become more valuable as a fertilizer.

Iowa Farmer Profile

Individuals farming in Iowa are predominantly white and male (USDA-NASS, 2007). Approximately 99 percent of Iowa farm operators are white. Just over 93 percent of principle operators are male (USDA-NASS, 2007). Many of these operators come from families who have been farming for several generations, resulting in a strong tradition in the family. This tradition is strongly ingrained leading to maintenance of production practices. A strong connection seems to develop between farm families and land because it is commonly passed down through several generations.

Older individuals own and farm Iowa farmland. Results from a survey carried out in 2007 indicated the average farmer was 54 years of age (USDA-NASS, 2007). Additionally, almost half of Iowa's farmland is owned by individuals over the age of 65 (Duffy and Smith, 2002). It is fair to assume that large amounts of this land will be transferred to new ownership in the coming years. Therefore, policy can be shaped to encourage certain types of land tenure for the benefit of soil quality.

Iowa Farmland

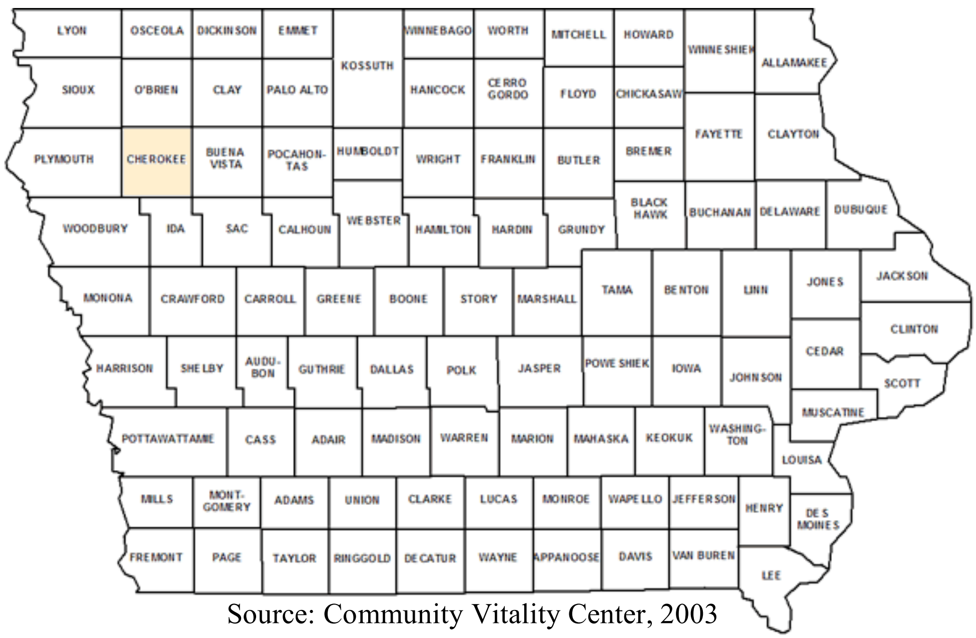
According to the USDA definition, a farm is any operation that sold or would have sold at least $1,000 worth of agricultural products in a normal year (USDA-ERS, 2008). However, the vast majority of corn and soybeans are produced on significantly larger farms than the average size. Among particular farmers in this study, the most common farm size was near 1,000 acres.

Iowa farmland has become increasingly valuable. Average land price in Iowa has increased from $1,857 to $3,908 per acre between 2000 and 2007 (Duffy and Smith, 2007). Specifically in Cherokee county, which includes the study area, average land price has increased from $3,581 per acre in 2006 to $4,466 per acre in 2007 (Duffy and Smith, 2007). With extraordinarily high commodity grain prices and a limited supply of land, these high prices will likely continue, at least for the short term.

Chapter 3: Materials and Methods

Study Area

Cherokee County, Iowa, in the northwest part of the state, was selected for the study. The county level was chosen as a study unit to eliminate some variability among soils, climate, and farmer factors, but still obtain soils and farmer information, which are generally available at the county level. Since this particular county has more strongly sloping land in the western half, the farmers selected farm in the eastern half.



Source: Community Vitality Center, 2003

Figure 1: Location of Study Area

Common soils in Cherokee County are in the Marcus-Primghar-Galva association. Galva soil series (Fine-silty, mixed, mesic Typic Hapludolls) is the most common, which covers over half of the county. The surface texture of this particular soil is silty clay loam and it is in land capability class IIe. This rating is due to the slope and erodibility of this particular soil. These soils are relatively fertile and may make soil quality differences more subtle and difficult to determine. Additionally, soil quality differences in these soils are not likely to be the determinant in crop success or failure.

Four groups of farmers were selected for this study (Table 1) and a total of 9 farmers and 25 fields were used (Table 2). All farmers interviewed belonged to at least two of the four designated field groups, but only one belonged to all four groups. The study consisted of three parts. First, a short farmer interview was carried out to obtain information about the farmer. Second, one field from each group per farmer was chosen for in-field tests, if farmed by the farmer. The USDA-NRCS soil quality kit was used to determine soil quality indicators on chosen fields. Third, samples from the top six inches of each field were taken to determine additional soil fertility indices.

Table 1: Description of groups of fields used in the study

Group	Management
1	Owned land that has manure applied regularly
2	Owned land that has not had manure regularly applied
3	Rented land that has manure applied regularly
4	Rented land that has not had manure regularly applied

Farmer Selection and Site Location

Participating farmers were chosen by randomization from a list of farmers obtained through a Freedom of Information Act request to the Cherokee County Extension office. The farmers were then contacted by phone to assess their interest in the study. An outline of the phone conversation can be found in Appendix A: Phone call outline. Out of contacted farmers, only two were not prepared to participate in the study. One indicated he did not want his soil tested and the second indicated he was too busy to participate. More farmers were willing to participate in the study, but farmers were needed who fell into at least two categories. Additionally, more willing participants owned land rather than renting. The number of fields sampled in each group can be found in Table 2. Specific fields sampled were claimed to have been under roughly the same management (rent/own; manure/no manure) for not less than five years. Additionally, all sites sampled within each field were mapped as 310B, a Galva soil map unit with two to five percent slope. Surface soils were hand textured at each location to ensure a similar surface texture of silty clay loam.

Many farmers fell easily into multiple field groups. A field close to their farm site with animals, for example, would receive regular manure applications. However, a farm located a few miles away would be less likely to receive manure due to the hassle of transport. However, if large manure application equipment was available, longer distances could be traveled for application. These fields would receive manure, but also could have detrimental soil effects from the large application equipment.

Farmers often rent fields to supplement their owned land due to the high price of land. A few of the farmers, specifically in group 3, rented land partially because they had excess manure to apply. Hog, cattle, and composted turkey manures were used as fertility sources among these farmers. Only one field had purchased manure applied rather than manure from the operation's animals. However, rates at which manures were applied are unknown, adding to complexity.

Table 2: Number of fields sampled per group

Group	Fields
1	8
2	7
3	5
4	5

Farmer Interview

Farmers were asked a series of 12 questions to obtain information on farm history, management, including tillage, fertilizer applications, crop rotations, and also to determine the farmers' philosophies on farming. The specific questions can be found in Appendix B.

In Situ Soil Quality Assessment

Each of the soil quality determinations was replicated within each field.

Infiltration

At each field site, an aluminum cylinder was inserted into the ground making sure the surface was minimally disturbed. The cylinder was measured at five different points around its circumference to determine the average height above ground. A predetermined volume of water, equivalent to 2.5 cm (1 inch) across the entire surface, was placed in the cylinder. To cause the least disturbance of the surface soil, all the water was poured on to plastic wrap, which was gradually removed to allow the water to go down. The amount of time it took for the water to infiltrate was recorded. The first inch of water filled the surface pores to bring the soils to approximately the same soil water content. A second inch of water was added using the same method. The second inch of water was used as an estimate of the infiltration rate.


SARAN
ORIGINAL

Microbial Respiration

The cylinder used for the previous infiltration study was closed with a plastic lid and left covered for thirty minutes. A needle was inserted into a septum of the plastic lid on the cylinder. A syringe was used to draw 500 ml of air from the headspace through a Draeger tube. The amount of CO_2 was determined colorimetrically. Soil temperature was recorded in order to adjust the readings to a constant temperature.

Bulk Density

At each field site, an aluminum tube 7.5 cm in diameter was driven into the ground. Five measurements around the internal edge were taken to determine the actual volume of soil removed. The ring was carefully removed from the soil. Excess soil was trimmed from the bottom of the tube. The soil was placed in a labeled sample bag. The sample typically contained five centimeters of surface soil. The samples were not taken from the center of the inter-row area as these areas could have been compacted during recent field operations. The entire sample bag with soil was weighed to determine field weight. An average weight of the bag was determined and subtracted from the total weight to obtain the soil weight.

A twenty-gram sub-sample was taken from each of the samples. This sample was oven dried at 105^{o}C, and weighed to determine the gravimetric moisture content. This moisture content was used to determine the oven dry weight of the entire sample. The dry weight was then divided by the soil volume to determine the bulk density.

EC, pH, Nitrate, and Phosphate

A 10 gram sample was placed in a cup and 10 ml of distilled water was added. The suspension was shaken for approximately 30 seconds. The electrical conductivity meter (Hanna Instruments, 2008) was calibrated and a reading was taken. After letting the sample sit for approximately 15 minutes, the pH reading was taken from a calibrated meter (Hanna Instruments, 2008). The sample was then filtered through filter paper into a second cup. Nitrate was colorimetrically determined using Hach Company nitrate water quality test strips (Hach Company, 2008). Phosphate levels in the solution were also determined colorimetrically using a test strip (Hach Company, 2008).

Slake

Eight peds were taken from each field and air-dried. Each was placed on a small screen and immersed in distilled water. Timing began when the ped entered the water and stopped when the ped had lost half of the original structure. If this did not occur quickly, every five minutes the screen was lifted and replaced ten times. At twenty minutes, the peds were assessed to determine what proportion of the original ped was intact.

Laboratory Analyses

All soil samples were first air dried and then ground to pass a 2 mm sieve.

pH

Soil pH was determined by adding 10 grams air dried ground soil to 10 ml of deionized water (Soil Survey Staff, 2004) This mixture was stirred for one minute, allowed to stand for thirty minutes, and then stirred again. A Fisher Scientific AR15 pH meter was used to obtain readings. The meter was standardized before testing, twice during testing, and again at the end of testing.

Nutrients

Calcium (Ca), phosphorus (P), potassium (K), and magnesium (Mg) contents of these soil samples were analyzed by the Iowa State University Soil and Plant Analysis Laboratory using a Mehlich III extraction (Sparks, 1996). Ten ml of Mehlich III solution was added to one gram of soil. The mixture was shaken for five minutes, after which the suspension was filtered (Warncke, D. and J. R. Brown, 1998). Concentrations of Ca, Mg, and K were determined using an ICP spectrometer. Potassium readings were obtained through atomic absorption. Phosphorus concentrations were determined by the ascorbic acid-molybdate reduction method (Warncke, D. and J. R. Brown, 1998). Total carbon and N were analyzed using dry combustion in a LECO TruSpec CN analyzer (LECO Corporation, 2005). From total carbon content, organic matter levels were obtained because no free calcium carbonate was detected in the testing zone.

Statistical Analyses

Non-numerical farmer response data were coded into numerical values to allow for statistical analyses between farmer response data and soil data obtained. Simple analysis of variance (ANOVA) was used to assess relationships between specific pairing of groups, observations, and farmer response codes. Analyses were done using SAS version 9.1 (SAS, 2005). Due to the complexity of the data and high variability, this simple analysis was the most appropriate. The Tukey-Kramer method for multiple comparisons was used to determine all pair wise comparisons and statistical significance of differences. Statistix 7.0 (Analytical Software, 2008) was used to determine correlation between the variables tested. The Pearson product-moment correlations were computed for continuous variables. Chi-square tables were used to test for independence in coded farmer responses.

Chapter 4: Results and Discussions

Farmer Survey

Among the selected farmers, farming experience ranged from sixteen to sixty years. The majority had been farming between twenty and thirty years. These farmers normally farmed alone or with a family member. Only one regularly hired help outside of family. The median acreage for this group of farmers was 1000 acres with the largest farm operating on approximately 3,000 acres. The smallest number of acres farmed was 450, but this farmer also helped with his family's larger operation.

Changes

During their years farming, many of the changes most evident to the farmers involved technology and changing cultural practices, such as decreased tillage. Especially noted was Global Positioning System (GPS)-related technology as well as the prevalence of genetically modified seed (GMO). All the surveyed farmers used some type of GMO seed and one farmer noted that "genetics are there whether you want it or not". He specifically wanted a single trait rather than a combination of multiple traits, which he said was not going to be available the following year. Combinations of genetically engineered traits are becoming the common seed type rather than a novelty. Additionally, changing plant genetics have other effects. Genetics to prevent stalk lodging combined with decreased tillage were cited by one farmer to slow decomposition of residue, leaving more 'trash' on the field for a longer period of time. In the past, the word trash was used to refer to plant residue, especially when tillage every fall was intended to completely bury all crop residues to ensure a better seedbed in the spring. Even though this tillage practice is rarely used today in Cherokee County, the term persists.

Decreased tillage was noted as another significant change. None of the surveyed farmers used moldboard plows, and some had gone to no-till during one or both years of their rotation. There was no particular pattern by age of those who adopted no-till. It generally seemed to be adopted by some farmers due to ease of spring planting, by only making one trip through the field rather than several for seedbed preparation and another trip for planting. As fuel prices rise, fuel savings are also a benefit from no-till. Those not adopting no-till in the area generally cite cooler or wetter soil conditions that lead to poor seedling emergence as well as more weed problems. Narrow rows and closer plant spacing were also pointed out as cultural changes that have occurred recently.

GPS technology was seen as a significant innovation. In particular, GPS technologies were used by some surveyed farmers to monitor yield during harvest in their combine. Additionally, a few farming operations can soil sample more extensively and apply fertilizer at a variable rate based upon test conditions. The variable rate applicators are not a very large portion of farmers in the study area. From this monitoring, farmers generally know where the most productive areas of their field are located.

Four farmers acknowledged biofuels, such as ethanol, and their impact as a recent change that has affected the farming arena. Locally, an ethanol facility is located in Holstein, Iowa, approximately 20 miles south of the town of Cherokee. Nationally in 2007, 2.1 billion bushels of corn were used for ethanol (Iowa Corn Promotion Board, 2008). However, the influence had not led any of the surveyed farmers to change their rotation to include more corn on either rented or owned land. The majority of these farmers considered converting more acres to corn a poor decision due to the increasing N costs, possible disease or insect infestations, and the likely parallel increase in soybean prices.

Three farmers pointed out the increasing rate at which the above changes are taking place. One individual noted that he still remembers the numbers of the corn hybrids he planted many times in his earlier years farming, but would not be able to tell me what varieties were in his field currently without looking them up. He reported he does not keep track of varieties any more because they change so rapidly.

Decision Making

Decisions made on the farm are influenced by a variety of different factors. Some sources from which farmers reported obtaining information included readings, other farmers, and agricultural supply dealers. This information was used for decision-making in combination with farmer experimentation or “trial and error” as well as simplicity and economics. Farmers judged success in this decision making based upon higher yields and ease of implementation. Economic benefit was judged as added gain in yield after accounting for money or time needed to achieve the benefit. Soil and water quality generally were not considered heavily in their decision-making. Soil properties are considered in some aspects of production. Farmers pick seed for their general soil type, for example, a variety that tolerates wetness for a low-lying field. Other soil qualities besides soil moisture and soil texture are not taken into consideration when picking varieties of seed to grow. This is likely because other soil properties are generally suitable for corn production in Iowa.

Attitudes

When asked what a farmer would do with their land if they had unlimited resources, the response was split. Six farmers said they would continue farming while three said they would rent out their land. Age was likely an influencing factor in this decision; one farmer noted that if I had asked him this same question in a few years, he would rent out his land rather than keep farming. Of those continuing to farm, two farmers would remove livestock from the farm, while one would remove his row crops, leaving only animals and pasture. Only one individual said that they would expand their operation. This is contrary to the current trend of expansion throughout most of Iowa, suggesting that at least these farmers did not see expansion of their acreage as a goal.

Farming Profession

The most common responses given as to why they farm were “I enjoy it” and “It’s what I know”. Farmers also liked the challenge that farming brings. An additional benefit noted by two farmers was the positive environment for raising a family. “Making a living” was the least mentioned as a reason for continuing to farm. Only one farmer indicated this was his primary reason for farming while another indicated it was a secondary reason for farming.

In describing their responsibilities as a farmer, four responded, “I do everything” or a similar response listing labor, management, marketing, food production, maintenance, and agronomist work. Simply put by one farmer, "I'm a jack of all trades". Three farmers responded that their job was simply labor or management. Food production was described as their profession as one farmer stated that "I feed people", and another responded that his job was to "produce food in the best possible way".

In Situ Soil Quality Parameters

Soil quality parameters were measured at two sites in every field. The following soil quality parameters were assessed.

Bulk Density

Bulk density is important in determining compaction in soils. As bulk densities increase in soils with normal mineralogy, plant root growth becomes more difficult and aeration decreases. Therefore, high bulk densities have negative impacts on crop growth and yield.

In this study, bulk density values obtained ranged from 0.87 to 1.27 g/cm^3 (Table 3). These values are lower than the typical values for the Galva soil series. Expected bulk density values for this soil range from 1.25 to 1.3 g/cm^3 (USDA-NRCS, 1989). According to the NRCS, good values for bulk density of a silty clay loam soil are below 1.40 g/cm^3 (USDA-ARS-NRCS, 1999). Many of the sampled fields had been recently tilled for seedbed preparation or weed removal. This tillage could have increased porosity within the soil.

Bulk density was positively correlated to carbon, N, and organic matter (Table 4). This result is contrary to expectation. Since soils high in organic matter generally have a low bulk density, we expected a negative association between these variables. However, in this particular study the possible soil compaction resulting from heavy machinery used to apply manure could negate the effect of organic matter on soil bulk density.

Table 3: Summary statistics of soil quality indices

Variable	Mean	Standard Deviation	Minimum	Median	Maximum
Bulk Density (g/cm3)	1.03	0.095	0.87	1.01	1.27
Infiltration (in/hr)	36.48	27.09	2.00	30.43	133.83*
Slake (rating)	4.1	0.9	2.8	4.0	5.8
Microbial Respiration (lbs CO_2/ac/day)	1649.8	541.8	726.0	1667.5	2930.0
Electrical Conductivity (mmhos)	0.34	0.33	0.05	0.27	2.29
Nitrate (ppm)	25.9	19.8	2.0	20.0	70.0
pH	6.1	0.5	4.7	6.1	7.1
Phosphate (ppm)	26.5	8.6	10.0	25.0	50.0

*Outlying value has been removed

Table 4: Significant correlation coefficients of soil quality indices

Variable	Variable	Correlation coefficient	P-Value
Microbial Respiration	Infiltration	0.42	0.0023
Infiltration	Slake	0.23	0.1025
Infiltration	Soil Moisture	0.01	0.9468
Slake	Nitrate	0.30	0.0337
Slake	pH	-0.30	0.0336
pH	Electrical Conductivity	-0.24	0.0961
pH	Nitrate	-0.65	<0.0001
Electrical Conductivity	Nitrate	0.55	<0.0001

Table 5: Summary statistics of soil quality by group

Variable	Mean	Standard Deviation	Minimum	Median	Maximum
Group 1					
Bulk Density (g/cm3)	1.05	0.11	0.87	1.03	1.27
Infiltration (in/hr)	32.15	20.41	2.00	32.97	67.04
Slake	4.1	0.9	3.0	4.1	5.8
Microbial Respiration (lbs CO_2/ac/day)	1552.9	547.6	726.0	1601.5	2466.0
Electrical Conductivity (mmhos)	0.47	0.55	0.10	0.30	2.29
Nitrate (ppm)	21	17	4	19	50
pH (field)	6.1	0.5	5.0	6.2	6.7
Phosphate (ppm)	30	9	10	30	45
Group 2					
Bulk Density (g/cm3)	1.01	0.08	0.90	1.00	1.15
Infiltration	47.48	39.30	2.00	32.13	133.83
Slake	3.7	0.7	2.8	3.8	5.3
Microbial Respiration(lbs CO_2/ac/day)	1794	598	896	1890	2931
Electrical Conductivity (mmhos)	0.21	0.14	0.05	0.17	0.51
Nitrate (ppm)	17	32	2	10	70
pH	6.4	0.4	5.7	6.6	7.1
Phosphate (ppm)	25	9	15	25	50

Table 5: Continued

Group 3					
Variable	**Mean**	**Standard Deviation**	**Minimum**	**Median**	**Maximum**
Bulk Density (g/cm3)	1.02	0.06	0.94	1.00	1.13
Infiltration (in/hr)	42.31	22.97	18.35	45.98	94.74
Slake	4.9	0.7	2.8	3.8	5.3
Microbial Respiration(lbs CO_2/ac/day)	1856	490	1129	1755	2660
Electrical Conductivity (mmhos)	0.36	0.14	0.19	0.36	0.58
Nitrate (ppm)	39	20	15	43	70
pH	5.8	0.6	4.7	5.8	6.5
Phosphate (ppm)	24	4	20	23	30
Group 4					
Bulk Density (g/cm3)	1.02	0.12	0.87	0.99	1.27
Infiltration (in/hr)	22.77	7.43	12.06	21.63	36.00
Slake	4.9	0.7	3.8	5.3	5.5
Microbial Respiration(lbs CO_2/ac/day)	1397	417	786	1404	2130
Electrical Conductivity (mmhos)	0.33	0.10	0.18	0.34	0.47
Nitrate (ppm)	32	16	10	33	60
pH	5.9	0.5	5.0	6.0	6.6
Phosphate (ppm)	26	10	12	25	40

Infiltration

Infiltration is a measure of the rate at which water enters the soil. Water entering too slowly results in higher amounts of runoff and possible erosion. Additionally, less water would be allowed into the soil for crop growth.

The infiltration rates of 2 to 133 in/hr obtained at the study sites, which range from moderately rapid to very rapid are significantly higher than would be expected (Table 6), possibly due to the difference between field conditions at time of sampling. Macropores possibly present in the field could have led to increased rates of infiltration. It is also possible the soils were not thoroughly saturated by the first inch of water leading to the high readings obtained. Relative differences are still valid, however, due to similar moisture contents among fields at sampling. Also, no significant correlation between moisture content and infiltration was found (Table 4).

Table 6: NRCS Infiltration Classes

Inches per Hour	Infiltration Class
>20	Very rapid
6-20	Rapid
2-6	Moderately rapid
0.6-2	Moderate
0.2-0.6	Moderately slow
0.06-0.2	Slow
0.0015-0.06	Very slow
<0.0015	Impermeable

*Table summarized from NRCS Soil quality kit guide, 1999

Significant relative differences in infiltration exist between owned land and rented land when no manure is applied, are shown in Figure 2 and Table 5. These Differences could be explained by the idea that larger equipment, generally used by farmers who farm more acres, and therefore often rent more, could have detrimental effects on the soil. However, these effects could be lessened by the organic contributions in group three.

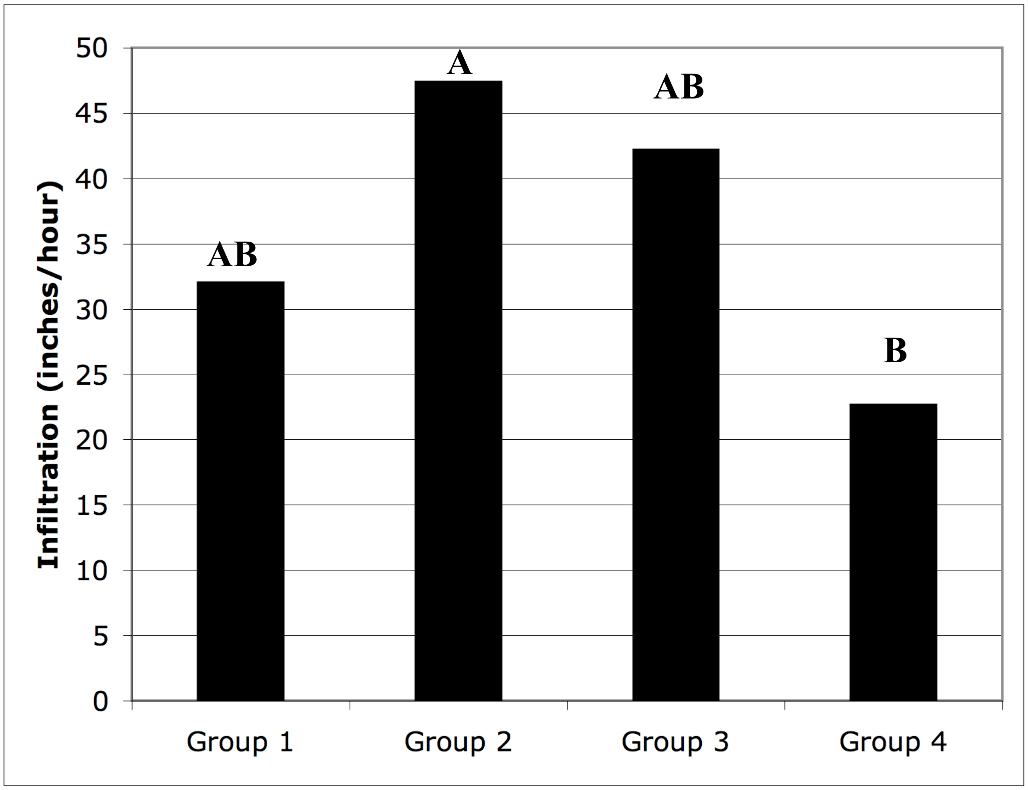


Figure 2: Infiltration rates as a function of group

Columns with the same letters are not significantly different ($p<0.05$)

Slake test

Aggregate stability is an important factor in holding soil particles in place and preventing crust formation. The slake test is a measure of this stability. In this study, the least stable aggregate took only sixteen seconds to lose half of its structural integrity, while many were still intact after the timing period. The average stability value was 4 on a scale of 1 to 6, with 6 being the most stable (Table 3). The result of 4 means 10 to 25 percent of the aggregate remained on the screen at the end of the test (USDA-ARS-NRCS, 1999).

Average slake ratings vary between 3.7 and 4.8 (Table 3). Group three has a significantly higher average slake rating than the other three groups (Figure 3). The higher rate of manure application in fields of farmers who rent and apply manure is a likely cause for the increase in aggregate stability.

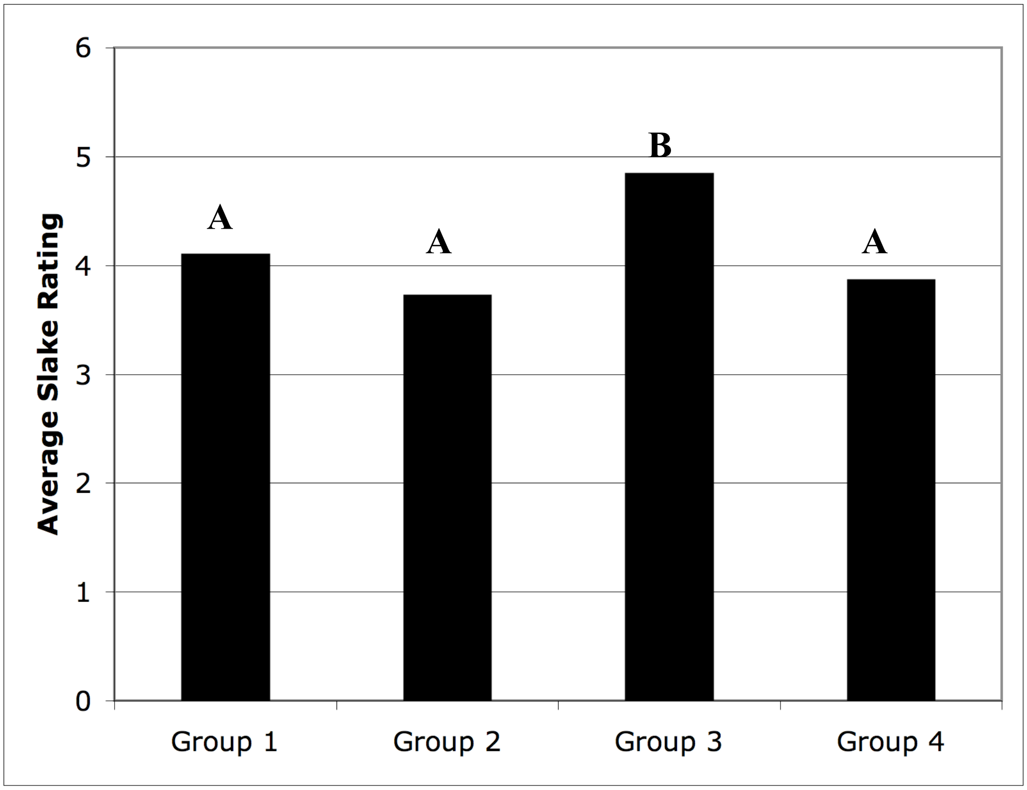


Figure 3: Aggregate stability as a function of group

Columns with the same letters are not significantly different ($p<0.05$)

Microbial Respiration

Microbial respiration is a reflection of the soil biota health. The more vibrant the community, the more carbon dioxide is released from the soil. Therefore, higher levels of carbon dioxide released from the soil would indicate a healthier system. Healthier microbial communities are less susceptible to domination by one pathogenic organism.

Microbial respiration in this study ranged from 726 to 2930 lbs CO_2/ac/day. These are relatively high values, indicating a strong microbial community. Microbial respiration is positively correlated to infiltration (Table 4). In order for microbial respiration to take place, ready exchange of gases must take place. Therefore, water would likely infiltrate faster into these many air-filled pores, leading to higher infiltration. There were no significant differences in microbial respiration between groups.

Electrical Conductivity

Electrical conductivity is a measure of salts in the soil system. Salts in the soil solution can make water uptake difficult for plants. The majority of the electrical conductivity (EC) values from this study are not in a range that is detrimental to plant growth. However, one field's values of 2.29 mmhos would qualify it as a slightly saline soil (Table 7). The fields with relatively high values were those that had large amounts of manure applied recently. This result is possibly due to the combination of high levels of manure and low rainfall during season of this study.

Table 7: NRCS Salinity classes

Electrical Conductivity (dS/m)	Salinity Class	Crop Response
0-0.98	Non saline	Negligible
0.98-1.71	Very slightly saline	Very sensitive crop yields restricted
1.71-3.16	Slightly saline	Most crop yields restricted
3.16-6.07	Moderately saline	Only tolerant crops yield satisfactory
>6.07	Strongly saline	Only very tolerant crops yield satisfactory

*Table summarized from the NRCS soil quality kit guide, 1999

Differences exist among EC values between groups as shown in Figure 4 and Table 5. Within owned land, the higher EC value within group one may be due to a few relatively high values from fields recently treated with manure and the lack of rainfall as discussed above. The second group would not have this problem because no manure has been recently applied to these fields. There were no significant differences in EC between groups three and four.

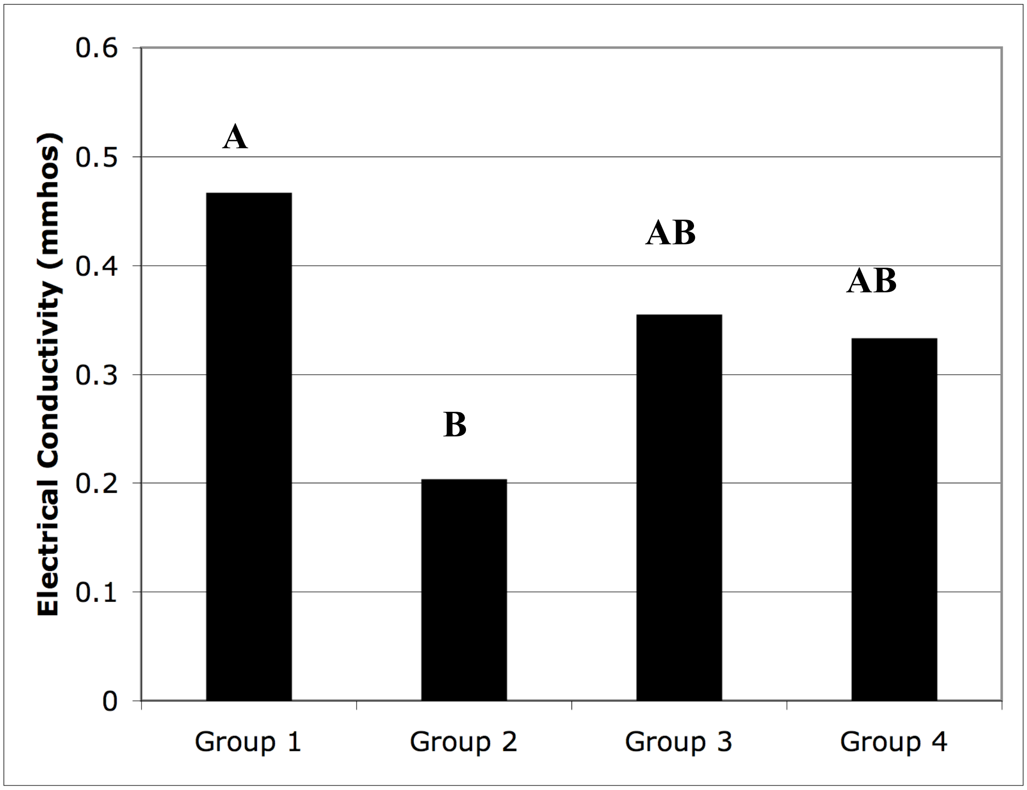


Figure 4: Electrical conductivity as a function of group

Columns with the same letters are not significantly different ($p<0.05$)

Nitrate

Nitrate is especially important as a plant nutrient because it is the most available form of N. Corn production requires large amounts of N for highest yields. Unfortunately, nitrate is easily lost from the system through volatilization if the field is submerged, or through leaching. Human health concerns result if nitrates contaminate drinking water.

Nitrate levels in these soils ranged from 2 to 70 ppm (Table 3). Testing took place over approximately a thirty-day period, ending at a time when the corn crop was near physiological maturity. At this time, N uptake should be minimal and ideally, soil nitrate levels should be low. In this study, nitrate levels of 60 ppm were found near the end of testing. This would likely indicate an over-fertilization of N. Residual N could possibly leach, causing contamination of ground water.

Rented land with manure applied had significantly higher levels of nitrate than either type of owned land (Figure 5 and Table 5). Application of larger amounts of manure on these rented fields may account for the higher nitrate content. Large numbers of livestock owned by some of these farmers might necessitate renting additional land for proper manure disposal. All farmers renting land also owned land.

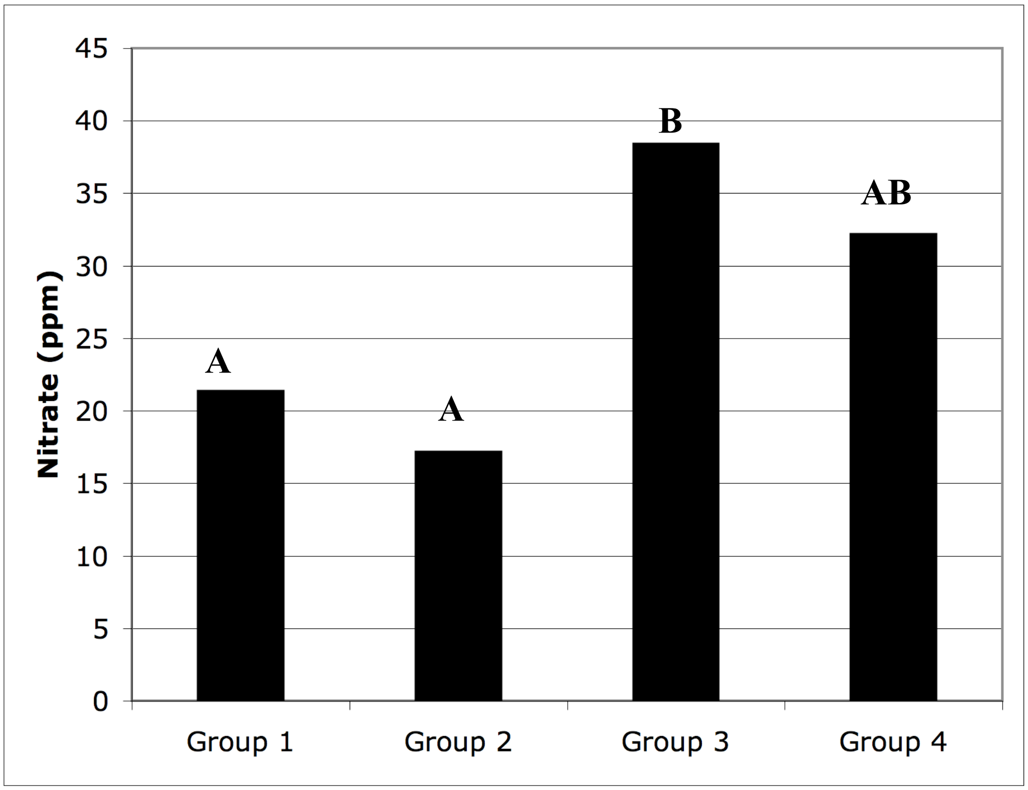


Figure 5: Nitrate levels as a function of group

Columns with the same letters are not significantly different ($p<0.05$)

pH

Values for pH are a measure of acidity or alkalinity in the soil. Many plant nutrients have pH ranges in which they are most available for plant uptake. Different crops also prefer varying ranges. Generally, pH values near 6.5 are considered favorable for crop growth.

According to the Cherokee County Soil Survey for the Galva soil series, the normal pH range for the topsoil is slightly higher than the 4.7 to 7.1 pH values that were measured in our study. Expected pH values range from 5.6 to 7.3 (USDA-NRCS, 1989). This lower pH is likely due to farming modifications such as the effect of N application.

The lower pH values in rented land as compared to owned land without manure, as shown in Figure 6, could be partially explained by ownership. Since lime is not fully reactive in its first year, the benefits are realized over several growing seasons. Renters, who are generally only guaranteed to be farming the land for one year, may not want to make that investment to correct low pH soils. Farmer responses support this idea, but this is likely dependent upon the landlord. In the discussion, one farmer struggled with his landlord to split the cost of a lime application that was needed. Longer rent contracts could alleviate this problem assuring the farmer of multiple seasons over which to spread the lime application costs.

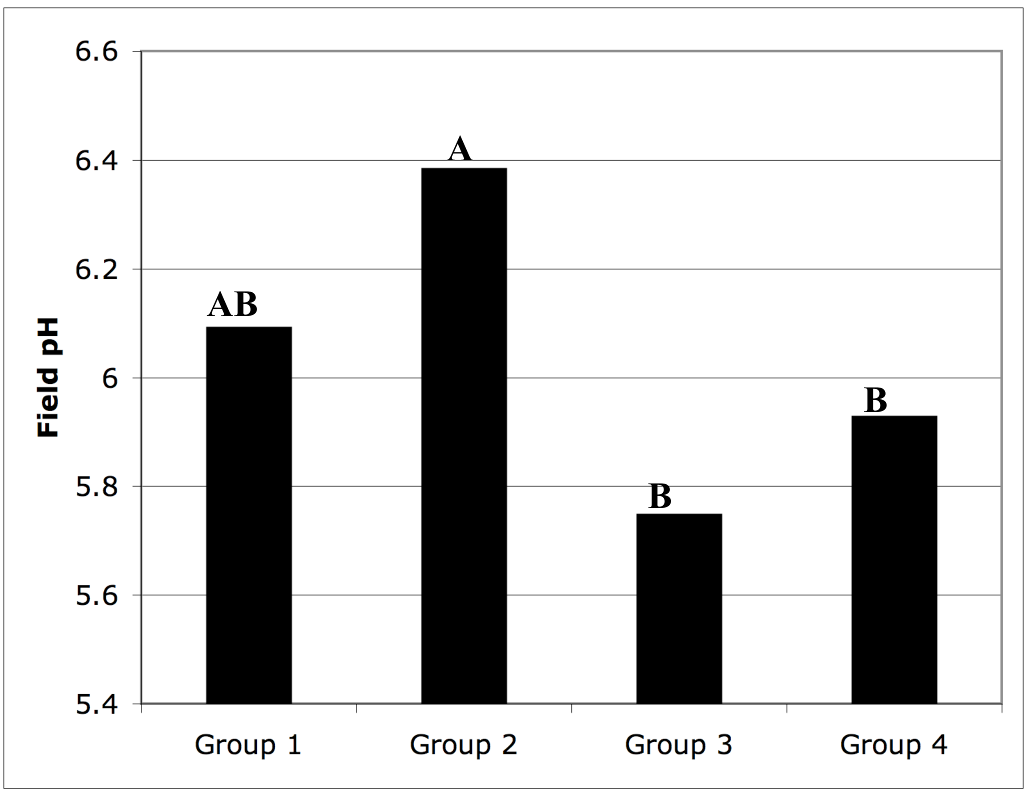


Figure 6: pH as a function of group

Columns with the same letters are not significantly different ($p<0.05$)

Laboratory Results

Calcium and Magnesium

Calcium and Mg are not generally deficient for crop production in Iowa. These soils are relatively young and unleached. Calcium is generally applied in the form of agricultural lime to increase soil pH rather than supply crop nutrient needs. Magnesium, in varying amounts, may also be in this applied lime as dolomite. Additionally, Mg can be contained in manure that has been applied to many of these fields.

Calcium ranged from 172 to 463 ppm (194-509 g/m3) at the study sites (Table 8). Lower levels of Mg were obtained, ranging from 32 to 66 ppm (33-79 g/m3). Our data shows no significant difference among groups in Ca levels. Magnesium levels, on the other hand, are significantly higher within group two than in group one (Figure 7 and Table 10).

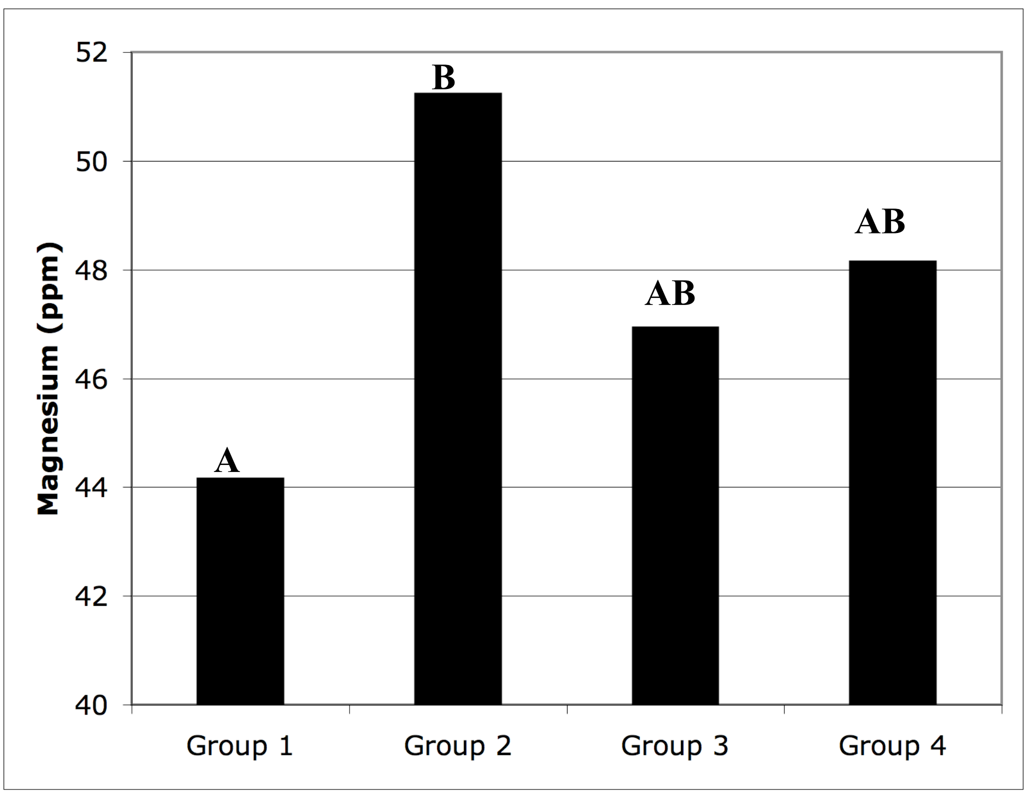


Figure 7: Magnesium contents as a function of group

Columns with the same letters are not significantly different ($p<0.05$)

Table 8: Summary statistics of of laboratory variables

Variable	Mean	Standard Deviation	Minimum	Median	Maximum
Calcium (ppm)	323.7	52.1	172.0	328.3	462.9
Magnesium (ppm)	47.5	7.4	31.7	46.6	65.6
Nitrogen (%)	0.236	0.021	0.186	0.239	0.293
Organic Matter (%)	5.59	0.52	4.39	5.59	6.83
pH	6.32	0.62	4.78	6.40	7.47
Phosphorus (ppm)	9.16	5.58	1.96	8.16	27.60
Potassium (ppm)	31.40	9.52	19.55	28.77	55.90

Table 9: Correlation coefficients of laboratory results

Variable	Variable	Correlation Coefficient	P-Value
pH	Calcium	0.64	<0.0001
pH	Magnesium	0.63	<0.0001
Organic Matter	Calcium	0.32	0.0254
Organic Matter	Magnesium	0.33	0.0191
Organic Matter	Nitrogen	0.43	0.0018
Organic Matter	Potassium	0.28	0.0523
Calcium	Magnesium	0.40	0.0039
Calcium	Nitrogen	0.36	0.0251
Calcium	Phosphorus	0.25	0.0771
Phosphorus	Potassium	0.79	<0.0001

Table 10: Summary statistics of laboratory parameters by group

Variable	Mean	Standard Deviation	Minimum	Median	Maximum
Group 1					
Calcium (ppm)	326.86	64.38	215.10	329.10	462.90
Magnesium (ppm)	44.18	3.51	38.24	44.39	50.40
Nitrogen (%)	0.2324	0.0260	0.1947	0.2307	0.2933
Organic Matter (%)	5.34	0.55	4.39	5.40	6.16
pH (lab)	6.34	0.57	5.12	6.44	7.13
Phosphorus (ppm)	10.11	6.78	1.96	9.97	22.10
Potassium (ppm)	29.14	10.30	20.39	25.10	52.50
Group 2					
Calcium (ppm)	330.81	33.59	266.40	319.95	384.70
Magnesium (ppm)	51.26	6.91	42.37	49.54	65.60
Nitrogen (%)	0.2306	0.0202	0.1860	0.2323	0.2612
Organic Matter (%)	5.55	0.40	4.83	5.57	6.17
pH	6.46	0.63	5.57	6.39	7.47
Phosphorus (ppm)	7.20	4.20	2.14	7.27	14.10
Potassium (ppm)	31.29	11.67	19.55	28.72	55.90
Group 3					
Calcium (ppm)	303.33	62.74	172.00	325.35	346.20
Magnesium (ppm)	46.96	8.86	31.72	47.55	57.10
Nitrogen (%)	0.2447	0.0106	0.2216	0.2437	0.257
Organic Matter	5.73	0.47	4.65	5.795	6.22
pH	6.092	0.76	4.78	6.295	7.20
Phosphorus (ppm)	9.19	3.54	4.44	9.30	13.60
Potassium (ppm)	33.67	4.83	25.69	34.62	39.90
Group 4					
Calcium (ppm)	328.85	41.530	263.60	331.40	339.30
Magnesium (ppm)	48.17	9.31	35.87	46.59	64.90
Nitrogen (%)	0.2427	0.0164	0.2235	0.2415	0.2723
Organic Matter	5.76	0.58	4.91	5.56	6.83
pH	6.30	0.57	5.41	6.30	7.17
Phosphorus (ppm)	10.37	6.74	2.74	8.09	27.60
Potassium (ppm)	32.90	8.88	21.53	30.89	49.05

Nitrogen

Nitrogen is an important nutrient for plant growth. The laboratory results include all N in the soil. Nitrogen can also be held in organic forms such as organic matter in addition to nitrate as discussed previously. Total N in the soils tested ranged from 0.19 to 0.29

percent (1780-3333) (Table 8). No significant differences existed between groups (Table 10).

Organic Matter

Organic matter has positive affects on the soil. It generally increases soil nutrient and water holding capacity, increases aeration, decreases bulk density, and leads to more stable aggregates. Organic matter contents in these soils ranged from 4.39 to 6.83% (39159-79904 g/cm^3) with a mean of 5.56% (Table 8). These are typical for Iowa farmland, which would indicate minimal amounts of erosion. Specifically, Galva soils typically contain 3 to 4 percent organic matter (Soil Survey Staff, 1979). This organic enrichment may be due to a long-term history of manure additions and the prairie vegetation under which these soils formed. Long-term history of these sites is unknown, so it cannot be specifically accounted for.

Organic matter contents are positively correlated with many of the nutrients including Ca, Mg, N, and K as given in Table 9. The cation exchange sites present on the organic matter can hold Ca, Mg, and K in the soil while N is a building block of organic matter. Therefore, these relationships would be expected.

Significant differences in organic matter are shown in Figure 8. These results are contrary to expected values. However, long-term histories of these sites are not known and these relationships could reflect the effect of long-term management. Previous farmers, rather than current practices, could have added organic residues that would lead to increased organic matter levels.

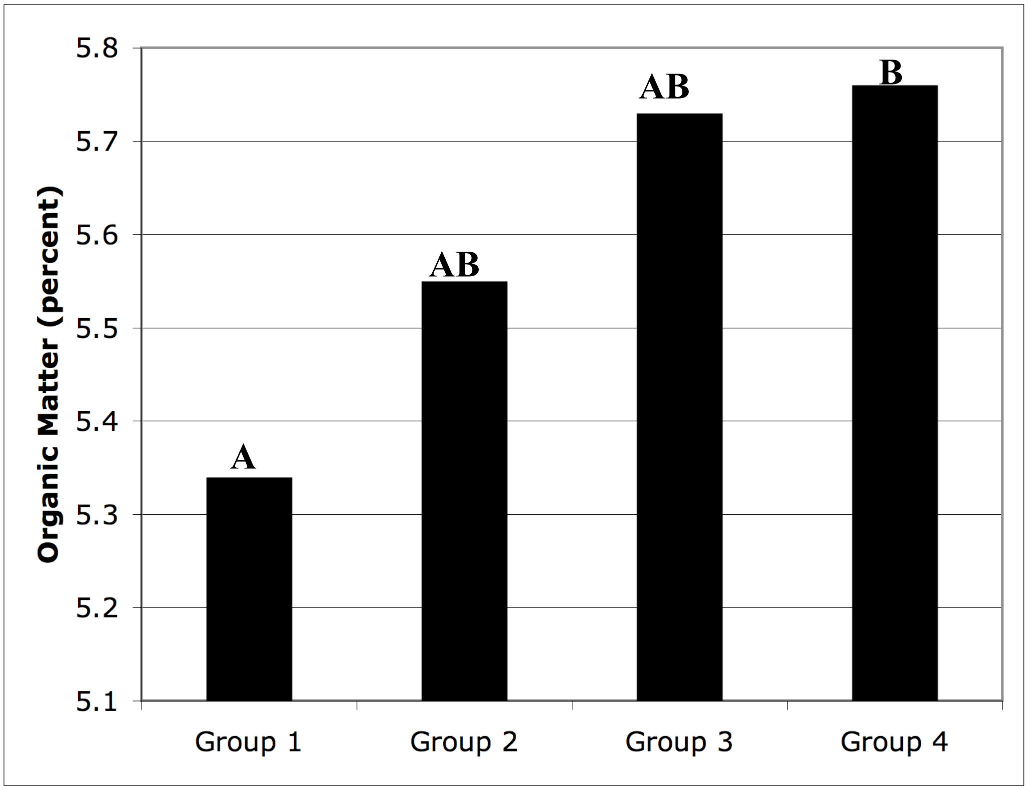


Figure 8: Organic matter as a function of group

Columns with the same letters are not significantly different ($p<0.05$)

pH

The pH values determined in the laboratory were similar to those obtained using the soil quality kit, with the laboratory mean value being 0.2 units higher (Table 8 and Figure 10). Most of the observations fall within the expected Galva soil series range of 5.6 to 7.3, but a few fell below this range (USDA-NRCS, 1989). Variation from this range can be explained by the discussion of soil quality kit pH. As expected, pH values are positively correlated to both Ca and Mg levels in the soil (Table 9). Relationships among groups were similar, however, due to the probability level used to assess significance ($p<0.05$), there were no significant differences between groups among pH values determined in the lab (Table 10).

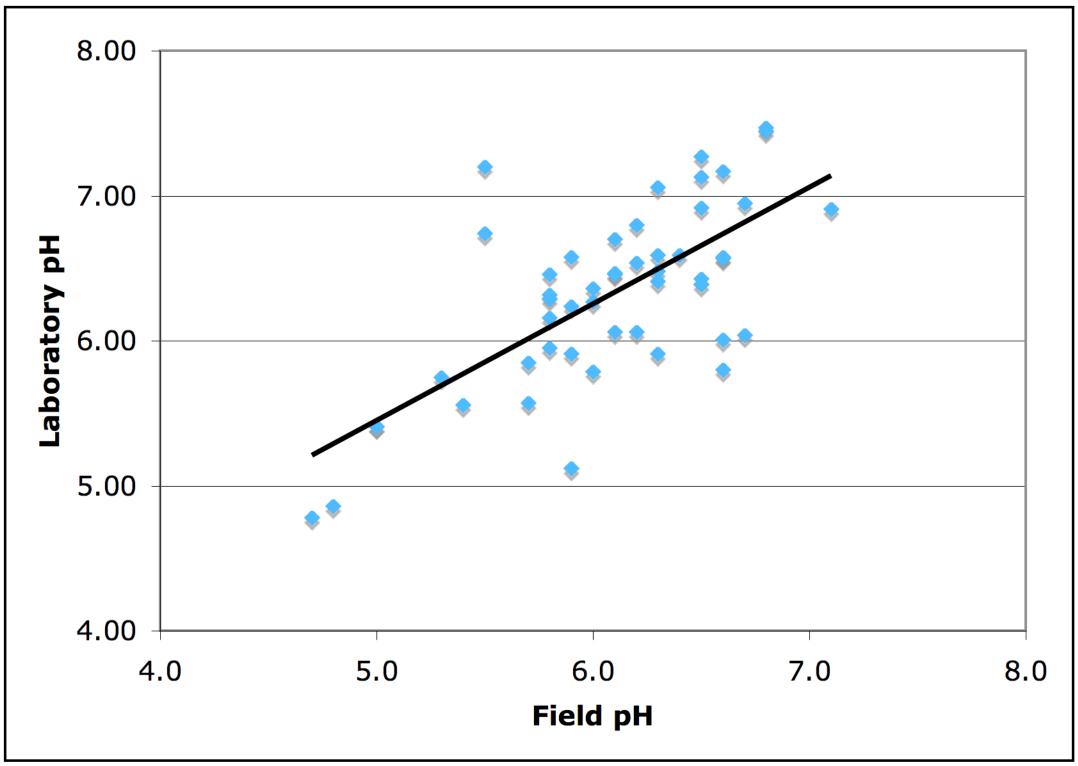


Figure 9: Comparison of pH values from the field and laboratory

Phosphorus

Phosphorus levels obtained from the Mehlich III laboratory extraction are shown in Table 8. The values ranged from 2 to 28 ppm (2-24 g/m^3) with a mean of 9 ppm. According to Iowa State soil testing laboratory, the mean value would fall into the 'low' soil test category, meaning application of fertilizer should be designed to exceed crop removal rates in order to increase soil nutrient levels (Iowa State University Extension PM 1688, 2002). Subsoils of Galva soils generally have very low available p, requiring slightly more p be applied for crop production (USDA-NRCS, 1989).

Phosphorus values are highly correlated to K levels in the field (Table 9). This could be due to the common practice of applying both phosphorus and K in a single trip across the field, either in manure or a commercially applied non-manure source. In this area, Diammonium phosphate (DAP) or another phosphorus source and a K source are applied at the same time. No significant differences existed in phosphorus levels between groups (Table 10).

Potassium

Potassium values ranged from 20 to 56 ppm (18-55 g/m^3) with a mean of 31 ppm. This mean value, combined with the expected low or very low subsurface K in a Galva soil, would put the soils in the 'very low' soil testing category (Iowa State University Extension PM 1688, 2002; NRCS 1989).

The relatively low Mehlich III values could be due to common nutrient management practices. Farmers' first priority in nutrient management and application is N. Therefore, P and K levels applied may be based upon budget concerns rather than plant needs. These results could therefore reflect years of this type of management in which more emphasis is placed on N application than to P and K.

Relationships between farmer attributes and soil information

To allow for statistical analysis of the entire dataset, farmer information was coded. Responses and corresponding codes can be found in Table 11. Full questions can be found in Appendix B: Farmer Interview Questions. After coding, simple Pearson correlation coefficients were determined between continuous variables from farmer responses and soil parameters. Significant correlations are given in Table 12. Coded variables were tested for independence using a Chi-squared test.

Table 11: Coded farmer responses

Question	Code 1	Code 2	Code 3
Decision-making?	Research or Experience	Easiest or Economics	
Unlimited resources?	Rent out land	Scale back or remove animals	Keep the same operation
Reason for farming?	Enjoy it or Good Environment	Enjoy and Know	Know or Make a Living
Definition of farming?	Management, Labor, or Marketing	"Jack of all Trades", food production, or agronomist	
Majority Nitrogen Source	Anhydrous Ammonia, Urea, or liquid	Manure	
Tillage Type	Conservation tillage	Includes No-till	

Table 12: Summary of correlation coefficients between farmer responses and soil parameters

Variable	Variable	Correlation Coefficient	p-value
Acreage	Calcium	0.29	0.0396
Acreage	Magnesium	0.51	0.0001
Acreage	Microbial Respiration	-0.40	0.0041
Acreage	Nitrate	-0.34	0.0165
Acreage	pH	0.33	0.0198
Acreage	Potassium	-0.24	0.0969
Acreage	Years Farming	0.40	0.0038
Years Farming	Magnesium	0.25	0.0792
Years Farming	Nitrate	-0.27	0.0607
Years Farming	pH	0.36	0.0111
Years Farming	Total Nitrogen	-0.34	0.0161

Acreage

Number of acres farmed was correlated to several soil indicators, one of these being microbial respiration. Manure, which generally has a positive effect on microbial respiration, would be spread more thinly over larger acreages, which could explain the negative correlation between acreage and microbial respiration.

Farmers with larger acreages were more likely to continue their farming operation in the current capacity than those with smaller land areas. These farmers might have a more favorable financial situation than those with smaller acreages and therefore, have a more favorable outlook on farming.

Number of years farming is positively correlated to acreage (Table 12). This would likely be due to accumulation of land over time. Current high land values would not allow a young farmer to purchase large amounts of land at the start of their farming career. Additionally, a reputation as a good farmer would not have been established yet, limiting access to rental land.

Decision Making

When asked how decisions were made regarding farming practices, responses generally fell into one of two categories. First, five farmers responded that farming decisions were made based on experience, experimentation, or research. Four indicated that decisions were made based more heavily on simplicity of the practice being adopted as well as economics.

Potassium levels were lower in the fields belonging to farmers who based their decisions on simplicity and economics (Figure 10). This group may be less likely to perform routine soil tests. They may also be slower to make the investment of time and money to supply required soil amendments.

Farmers who indicated they made decisions based simply upon what was the easiest were more likely to continue their operation as it currently exists, even if more resources became available to them (Table 13). This may be because they have simplified their management to the minimal required input, making the farm operation less demanding.

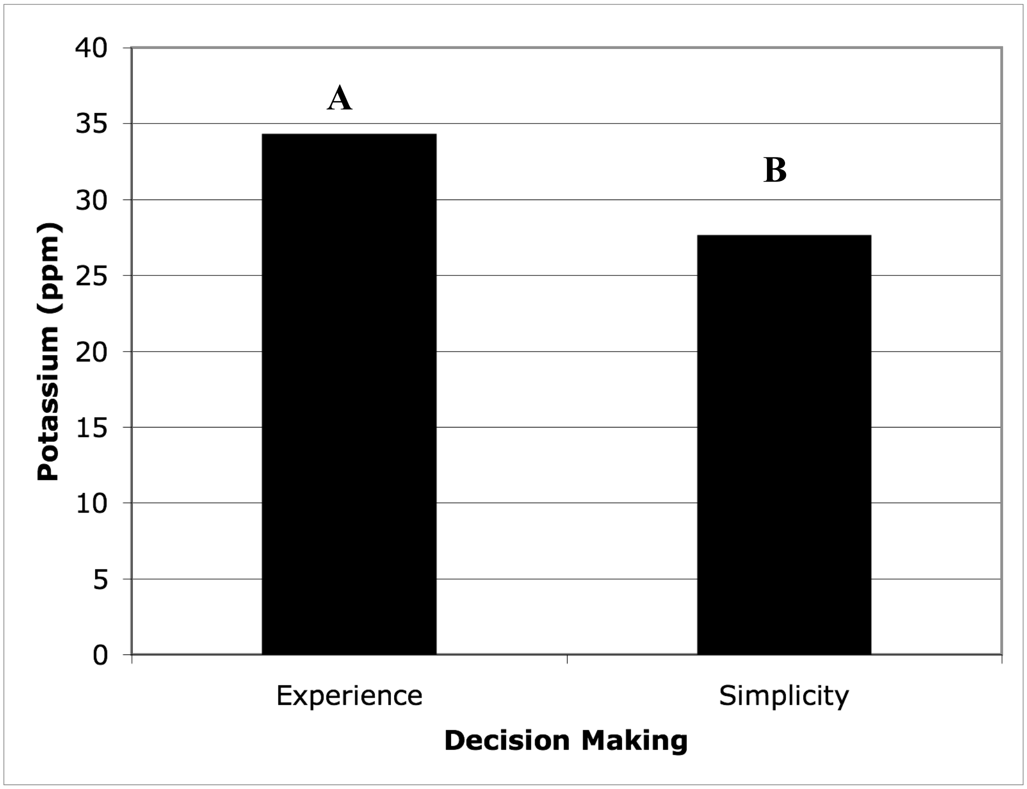


Figure 10: Potassium levels by decision making response

Columns with the same letters are not significantly different (p<0.05)

Table 13: Contingency table of decision making and unlimited resources

	Unlimited Resources			
	Codes	1 (Rent out land)	2 (Scale back)	3 (Continue)
Decision Making	1 (Experience)	Observed: 2 Expected: 1.11 Cell Chi-Sq: 0.71	Observed: 3 Expected: 2.22 Cell Chi-Sq: 0.27	Observed: 0 Expected: 1.67 Cell Chi-Sq: 1.67
	2 (Easiest/ Economics)	Observed: 0 Expected 0.89 Cell Chi-Sq: 0.89	Observed: 1 Expected: 1.78 Cell Chi-Sq: 0.34	Observed: 3 Expected: 1.33 Cell Chi-Sq: 2.08

Overall Chi-Square: 5.96 p-value: 0.0507

Definition of Farming

Farmers were asked to describe their job as a farmer. Responses given fell roughly into two categories. As indicated above, some farmers indicated that they were simply labor, management, or responsible for marketing of farm products. Additional farmers said they had more diverse roles, described by some as “I do it all” or “I’m a jack of all trades”. Farmers who gave the multifaceted response had soils with significantly lower bulk density in their fields compared to those who considered their responsibility as just labor or management (Figure 11). Additionally, the labor and management response was correlated to higher levels of nitrate (Figure 12).

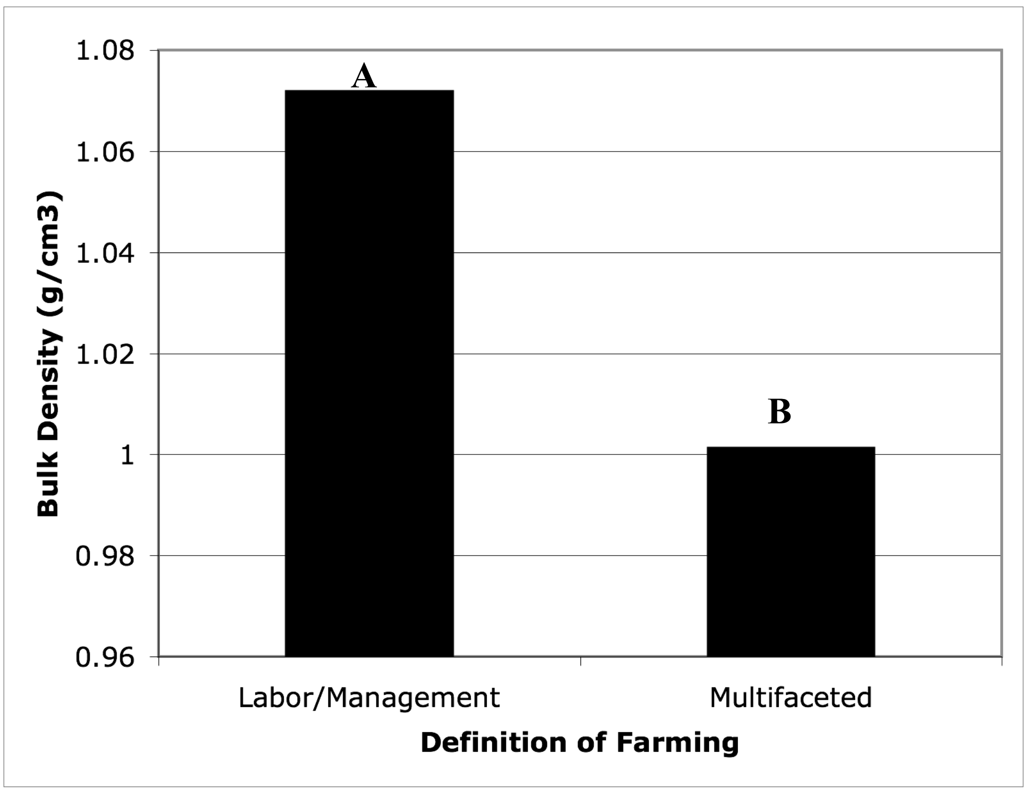


Figure 11: Relationship between definitions of the farming profession and bulk density of soils in farmers’ fields

Columns with the same letters are not significantly different ($p<0.05$)

Figure 12: Nitrate levels by definition of farming

Columns with the same letters are not significantly different ($p<0.05$)

Reason for Farming

Farmers were asked why they farm. Responses given were grouped into three categories. Three individuals reported to farm simply because they enjoy it. Two farmers indicated that they farm because this is what they were brought up with and know, but also enjoy what they do. Four reported that they farm because it is what they know and/or they farm to make a living. This group did not indicate that they enjoy the profession.

Responses to this question were highly related to the farmer's definition of farming (Table 14). Those who responded that their job was multifaceted, rather than business-based, were more likely to say they farm because they enjoy it. Those who farm because they enjoyed it were more likely to make decisions based upon experience rather than economics or simplicity (Table 15). Additionally, fields belonging to farmers responding that they farm because they enjoy farming had soils with significantly lower bulk densities compared to soils in fields of farmers who consider farming only as a profession they know or they farm to make a living (Figure 13).

Table 14: Contingency table of reason for farming and definition of farming

Definition of Farming	Reason for Farming			
	Codes	1 (Enjoy it)	2 (Know and enjoy)	3 (Know/make a living)
	1 (Labor/ Management)	Observed: 0 Expected: 1.00 Cell Chi-Sq: 1.00	Observed: 0 Expected: 0.67 Cell Chi-Sq: 0.67	Observed: 3 Expected: 1.33 Cell Chi-Sq: 2.08
	2 (Multifaceted)	Observed: 3 Expected: 2.0 Cell Chi-Sq: 0.50	Observed: 2 Expected: 1.33 Cell Chi-Sq: 0.33	Observed: 1 Expected: 2.67 Cell Chi-Sq: 1.04

Overall Chi-Square: 5.63 p-value: 0.0601

Table 15: Contingency table of reason for farming and decision making

Decision Making	Reason for Farming			
	Codes	1 (Enjoy it)	2 (Know and enjoy)	3 (Know/make a living)
	1 (Experience)	Observed: 3 Expected: 1.67 Cell Chi-Sq: 1.07	Observed: 0 Expected: 1.11 Cell Chi-Sq: 1.11	Observed: 2 Expected: 2.22 Cell Chi-Sq: 0.02
	2 (Easiest/ Economics)	Observed: 0 Expected: 1.33 Cell Chi-Sq: 1.33	Observed: 2 Expected: 0.89 Cell Chi-Sq: 1.39	Observed: 2 Expected: 1.78 Cell Chi-Sq: 0.03

Overall Chi-Square: 4.95 p-value: 0.0842

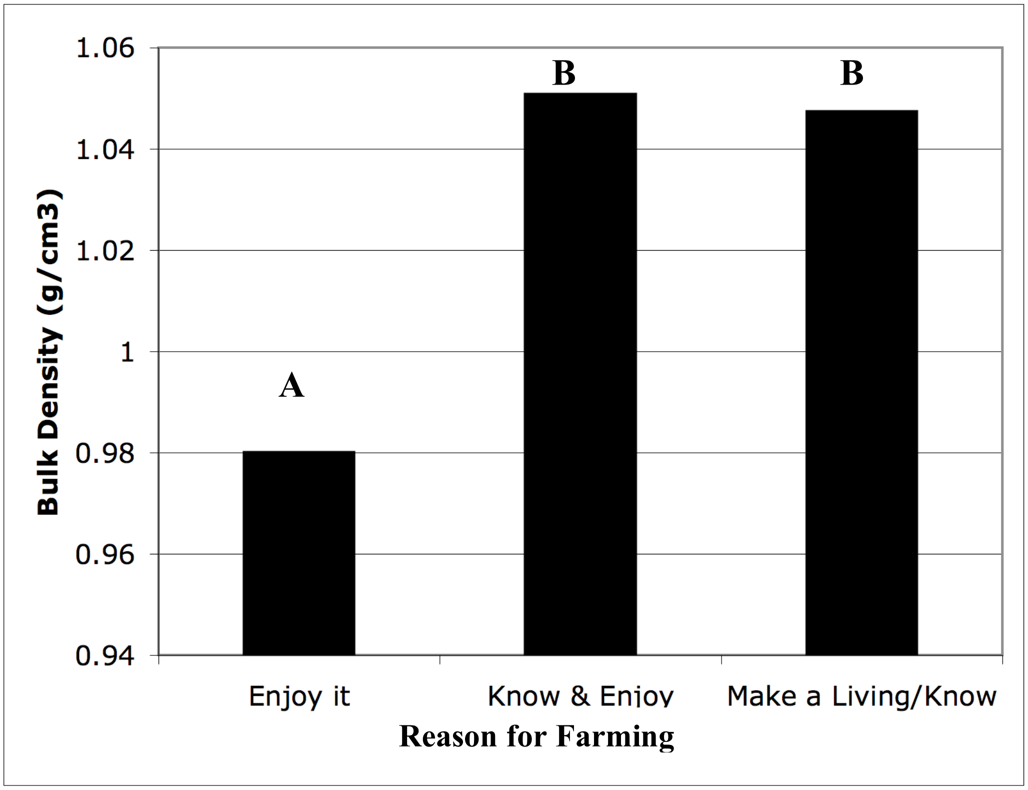


Figure 13: Relationship between reasons for farming and bulk density of soils in farmers' fields

Columns with the same letters are not significantly different ($p<0.05$)

Tillage Type

Tillage practices were divided into (1) a system including no-till (one or both years of the rotation), or (2) a system in which no-till was not used at any time. Tillage systems that included no-till had soils with significantly higher bulk densities (Figure 14). However, none of the obtained field values from either system would be considered to be root-limiting values. No-till fields do not have frequent tillage to increase porosity and aeration. Over time, this could lead to higher levels of organic matter. Increased porosity and aeration are likely to lead to soils with low bulk densities. Farmers who had larger acreages were increasingly more likely to practice no-till in their fields (Figure 15). This is likely due to necessity, as more acreage can be conveniently managed with the decreased operations associated with the no-till system. No-till can offer a way to decrease trips across each field, saving time, fuel, and wear on farm equipment. With continual increasing of acres per farm, we would expect increasing bulk density due to more adoption of no-till systems.

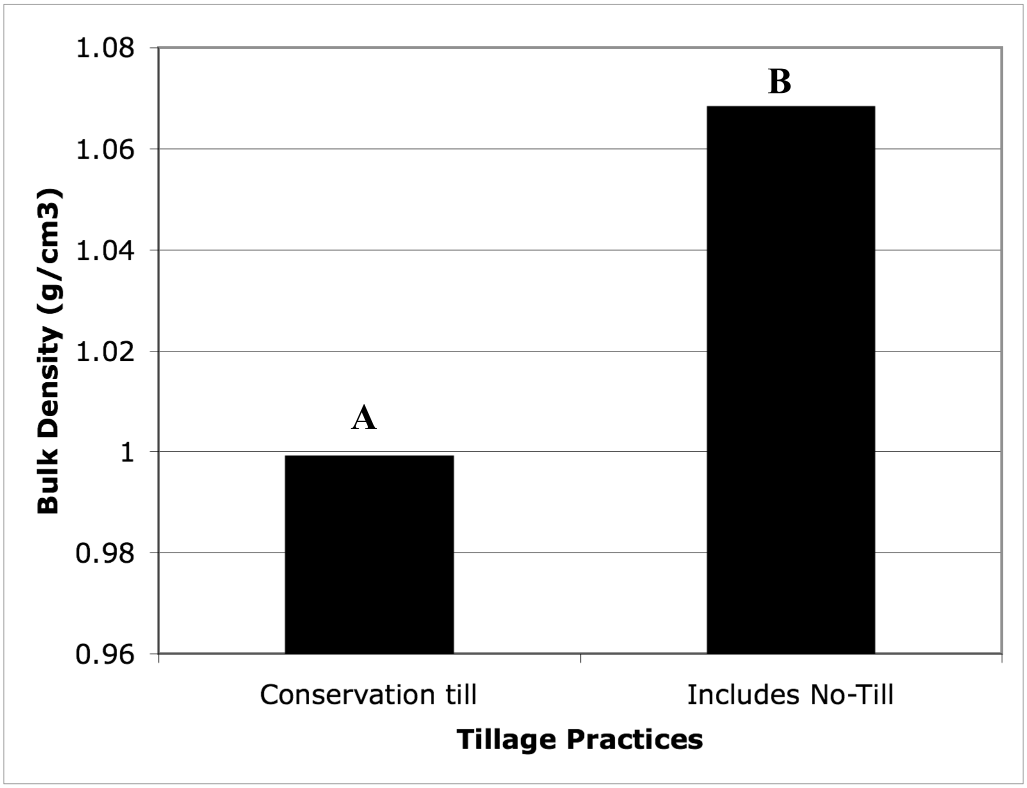


Figure 14: Relationship between type of tillage and bulk density of soils in farmers' fields

Columns with the same letters are not significantly different ($p<0.05$)

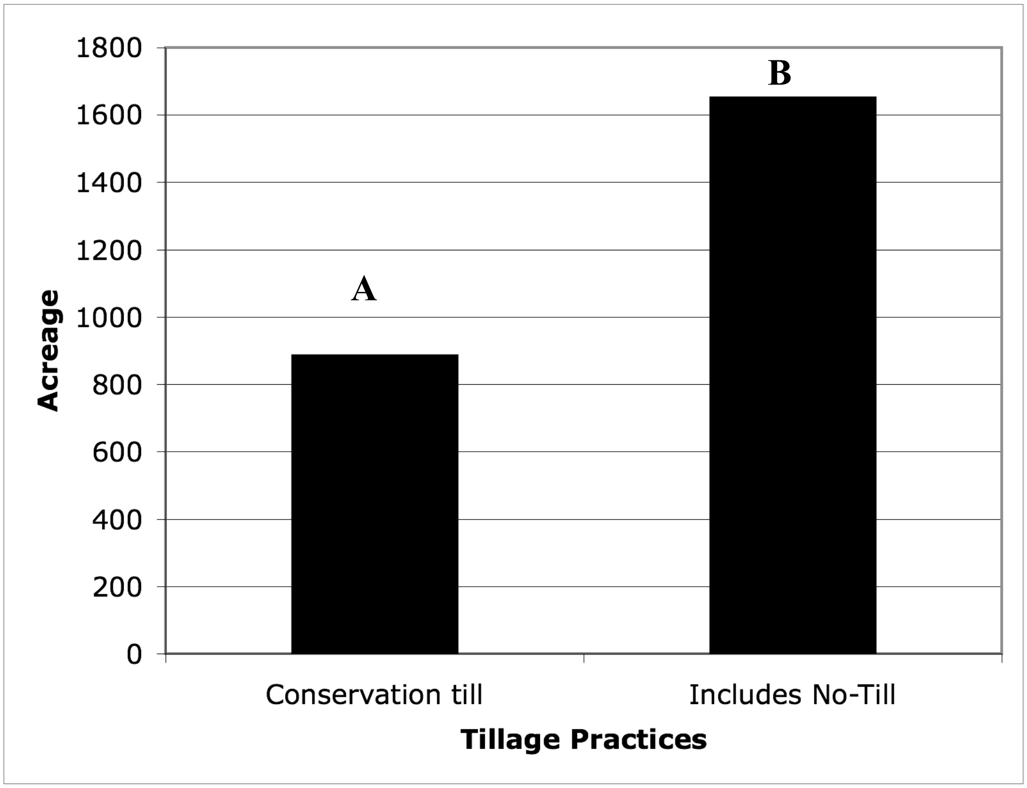


Figure 15: Relationship between tillage practices used by farmers and the number of acres farmed.

Columns with the same letters are not significantly different ($p<0.05$)

Unlimited Resources:

When asked what farmers would do with their land if they had unlimited resources such as money, land, or labor, responses ranged from renting out the land, scaling back their farming operation, or not making significant changes to their current management. Farmers who would continue their operation had lower K levels than those who would rent out their land (Figure 17). Phosphorus levels among farmers who would rent out their land were higher than those who would scale back their operation (Figure 16). Larger farmers tended to respond that they would continue their operation as it currently stands, and these same large farmers had less available manure. Phosphorus and K are found in relatively high concentrations in manure, leading to higher soil test values when manure is applied.

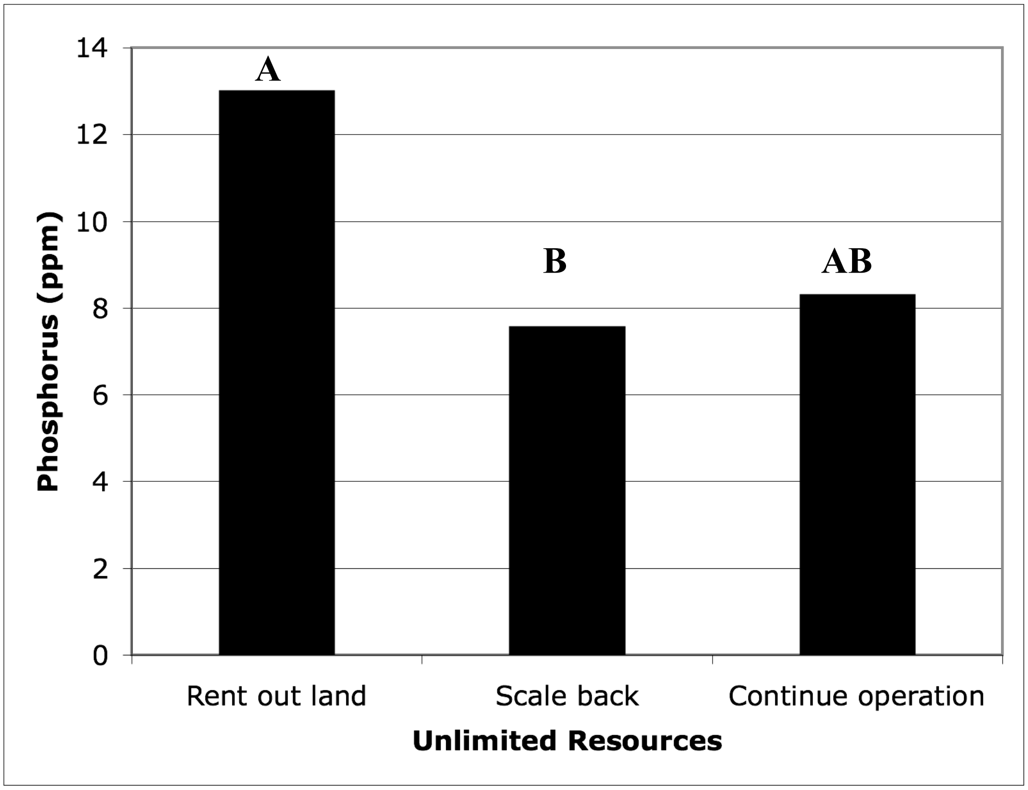


Figure 16: Phosphorus levels by farmer response to unlimited resources

Columns with the same letters are not significantly different ($p<0.05$)

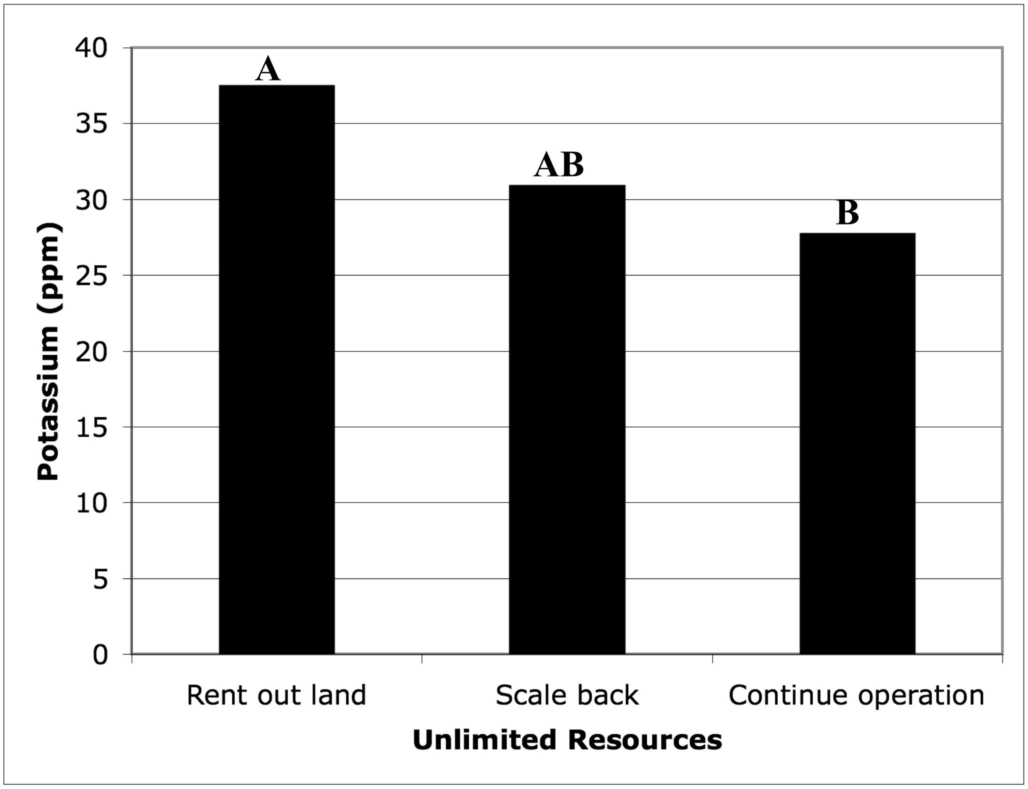


Figure 17: Potassium levels by farmer response to unlimited resources

Columns with the same letters are not significantly different ($p<0.05$)

Years Farming

The number of years a farmer has been farming was recorded. Both total N and nitrate levels are negatively correlated to years farming (Table 12). This could be a result of experienced farmers are not over-fertilizing, or have not adjusted their N application for more updated yield goals.

Chapter 5: General Discussion and Conclusions

The general purpose of this study was to relate soil quality to management and other farmer characteristics. It was found that certain characteristics are significantly related to soil quality. It was also observed that ownership had less of a direct effect on soil quality than expected.

Iowa soil is generally high in quality. High microbial respiration, relatively low bulk density, and generally favorable pH and nutrient levels would support this. Differences in these parameters could mean higher or lower yields, but would not generally lead to complete crop failure.

Overall, acreage farmed had significant impacts on decisions farmers make due to a limited time available per acre. These decision, in turn, impact soil quality. The impact of acreage was more extensive than expected. These results, relating an easy to obtain value, such as acres farmed, with soil parameters could be useful in larger scale modeling. In that situation, soil quality data may be extremely difficult to obtain, however acres farmed could be used to partially estimate other parameters.

Challenges

Extreme variability of soils as well as farmer management makes drawing definite conclusions more challenging. Fields in this study were said to have been under the same management for five years, but previous history is unknown. Rates at which manure was applied varied and were not known, so could not be used as a factor in this study. Very little previous research relating soil quality to farmer attributes makes the study more complex.

Overall, farmers currently have many constraints upon them that do not allow for ideal management at all times. Timing of field operations, especially during wet seasons, can be difficult. This difficulty is compounded by an increase in acres farmed.

Further Research

Due to high levels of variability, a larger number of field sites would be beneficial. More farmers could also help strengthen relationships between soil quality and farmer responses. Additionally, I would like to investigate how various trends persist or change as one crosses cultural boundaries.

References

Abendroth, Lori, Palle Pedersen, and Roger Elmore. 2008. Iowa State University Extention. http://www.extension.iastate.edu/CropNews/2008/0409AbendElmorePedersen.htm Accessed 6/08

Analytical Software. 2008. Statistix 8. Tallahassee, Fl. www.statistix.com.

Arriaga, F. J. and B. Lowery. 2001. Effects of Erosion and Manure Applications on Corn Production. In: D.E. Stott, R.H. Mohtar, and G.C. Steinhardt (eds). 2001. Sustaining the Global Farm. Proceedings of the 10th International Soil Conservation Organization meetings. May 24-29, 1999. West Lafayette, Indiana.

Community Vitality Center. 2003. Iowa Transfer of Wealth. http://www.cvcia.org/content/wealth.transfer/index.html. Accessed 6/08.

Deininger, Klaus, and Songquing Jin. 2005. Tenure security and land-related investment: Evidence from Ethiopia. European Economic Review: 50(5) 1245-1277.

Duffy, Mike and Darnell Smith. 2007. Iowa State University Extension PM 1825. Ames, IA.

Duffy, Mike. 2004. Trends in Iowa Farmland Ownership. Iowa State University Extension. http://www.extension.iastate.edu/agdm/articles/duffy/DuffyOct04.htm Accessed 5/08.

Fraser, Evan D. G. 2004. Land Tenure and Agricultural Management: Soil Conservation on Rented and Owned Fields in Southwest British Columbia. Agricultural and Human Values 21: 73-79.

Gilley, J.E. and L.M. Risse. 2000. Runoff and Soil Loss as Affected by the Application of Manure. Journal of the American Society of Agricultural Engineers: 43(6): 1583-1588.

Iowa Corn Promotion Board. 2008. "How our crops were used in 2007" online. Accesed 7/08 http://www.iowacorn.org/cornuse/cornuse_1.html

A General Guide for Crop Nutrients and Lime Requirements in Iowa. 2002. Iowa State University Extension Publication PM 1688. Ames, Iowa.

Hanna Instruments, 2008. Woonsocket, RI. www.hannainst.com

Hanna, H. Mark, Tom S. Colvin, Michael L. White, and James L. Baker. 2003. Reducing anhydrous ammonia application by optimizing distribution. Leopold Center for Sustainable Agriculture. Competitive Grant Report 00-34. Iowa State University. Ames, Iowa.

Hach Company, 2008. Loveland, CO. www.hach.com.

Jacoby, Hanan G., Guo Li, and Scott Rozelle. 2002. Hazards of Expropriation: Tenure Insecurity and Investment in Rural China. American Economic Review 92(5): 1420-1447.

LECO TruSpec CHN analyzer. LECO Corporation. 2005. St. Joseph, MI.

Liebig, Mark A., John W. Doran, and John C. Gardner. 1996. Evaluation of a Field Test Kit for Measuring Selected Soil Quality Indicators. Agron J. 88:683-686.

SAS Institute, Inc. 2005. SAS 9.1. Cary, NC. http://www.sas.com/.

Soil Survey Staff, 1979. Official Series Description for the Galva Series. Author, Washington, D.C.

Soil Survey Staff. 2004. Soil survey laboratory methods manual. Soil Survey Investigations Rep. No. 42, ver 4.0. U.S. Gov. Print Office, Washington DC. p. 213-215.

Sparks, D.L. (ed) 1996. Methods of Soil Analysis Part 3: Chemical Methods. Soil Science Society of America. Madison, Wisconsin. (Book Series 5)

U.S. Department of Agriculture, Agricultural Research Service, and Natural Resource Conservation Service. 1999. Soil Quality Kit Guide. http://soils.usdsa/gov/sqi/assessment/test_kit.html

USDA-ERS. 2008. "Farm Income: Partitioning the Definition of a Farm". Accessed 6/08. http://www.ers.usda.gov/data/farmincome/Sizedefinition.htm

USDA-NASS. 2007. Iowa State Agriculture Overview-2007. http://www.nass.usda.gov/Statistics_by_State/Ag_Overview/AgOverview_IA.pdf Accessed 5/08

USDA. 1989. Survey of Cherokee County, Iowa.

Warncke, D. and J.R. Brown. 1998. Potassium and Other Basic Cations. North Central Region Research Publication #221. Missouri Agriculture Experiment Station, Columbia, MO.

Wortmann, Charles, Mahdi Al-Kaisi, Matt Helmers, John Sawyer, Daniel Devlin, Charles Barden, Peter Scharf, Richard Ferguson, William Kranz, Charles Shapiro, Roy Spalding, David Tarkalson, John Holz, Dennis Francis, and Jim Schepers. 2006. Nitrogen Management for Water Quality Protection in the Midwest. University of Nebraska Extension Publication RP189. Lincoln, Nebraska.

Appendix A: Phone call outline

Hello N., my name is Amber Anderson. I'm a graduate student at Iowa State in Agronomy and Sustainable Agriculture. I wondered if you would be willing to participate in a study about soil quality that I would like to do in Cherokee County.

Response: If negative, thank the farmer for their time.

If affirmative, continue to explain:
The study would consist of a short interview with you. Then I would test for several soil characteristics in a chosen field and then take soil samples back to the laboratory for a few analyses. Your identity will not be revealed in the analysis or results. If you would like, I can share your field results with you when I complete the analyses.

If still interested:
Two of the characteristics I am looking at are land ownership (owned or rented) and if manure or synthetic nitrogen is applied. Which of these fields do you have?
What is the most convenient time for us to meet?
Contact information was exchanged, the farmer was thanked for their willingness to participate in the study.

Appendix B: Farmer Interview Questions

1) How long have you been farming?

2) Have you noticed any changes since you started farming? What are they?

3) Will you tell me about how many acres you farm?

4) Farming practices:

   a) Tillage type:

   b) Fertilizer types:

   c) Crop Rotation:

   d) Main Chemicals used:

5) How do you make those decisions?

6) If you had unlimited resources (money, labor, land, etc) would you change anything? What?

7) Why do you farm?

8) How would you describe is your job as a farmer?

9) How would you describe your soils?

10) What is your average yield in area to be sampled?

Acknowledgements

I would like to thank my major professor, Andrew Manu, for his enthusiasm, assistance, as well as many hours of proofreading and discussion. I also appreciate the introduction to teaching that he offered, though it may have taken much encouragement and prodding. I would also like to thank Cornelia Flora, my co-major professor, for her unique perspective and contributions to this project. I am grateful to Jon Sandor for his input, as well as offering the unique learning opportunities that the soil judging team has provided over the years. Thanks also to my final committee member, Dan Nordman, for his statistical advice and patience.

I would like to thank Amy Norton for her encouragement, advice, and constant picture taking. Also, thanks to Al Hasselman for his help and encouragement and to Gretchen Zdorkowski for her inspiration and patient guidance.

I would like to thank my family: Abigail and Ashley for many hours of help in the field; Nathan for listening and bouncing around agricultural ideas; Mom for her proofreading and support; and Dad for his support and the seed of my interest in agriculture. Finally, I would like to thank my husband Mark for his continuous patience, encouragement, and proofreading.

I am appreciative to all of the farmers in Cherokee County who were so willing to participate and share information for the study with me and also to all those who have inspired me over the years, leading me on this path.