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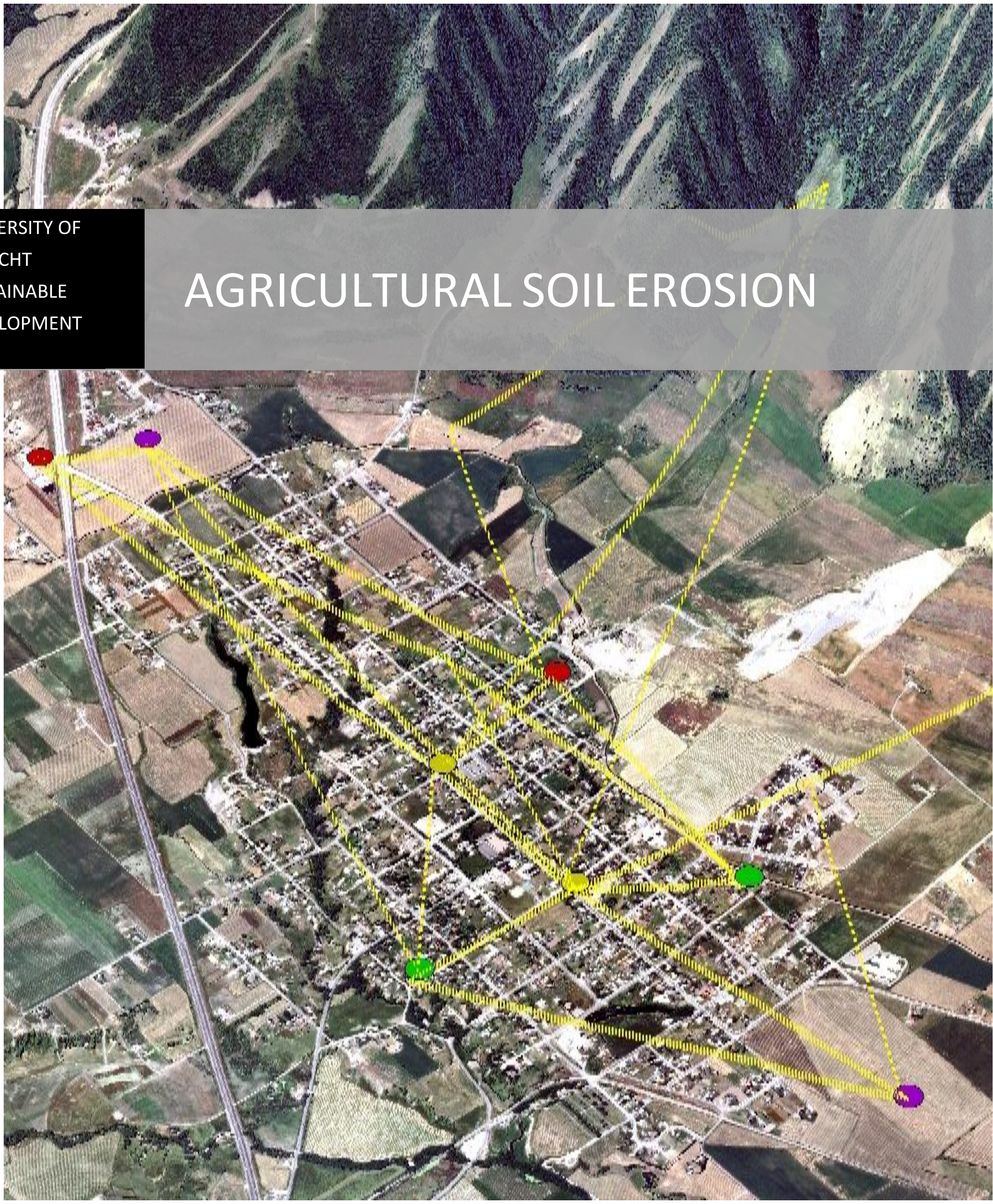

UNIVERSITY OF UTRECHT SUSTAINABLE DEVELOPMENT EPM

AGRICULTURAL SOIL EROSION

Master Thesis by Aaron Eckert

A Social Network Analysis on the Initiatives in Preventing Agricultural Soil Erosion

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Acknowledgement

This research project provided a great opportunity for me to meet a vast group of scientist, researchers and concerned citizens that dearly care about the sustainability of our planet. It is a great pleasure to thank those individuals who have made this project possible and supported me over the length of my study by providing the necessary tools and expanding my knowledge.

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Lastly, I would like to dedicate this work to my family, who have always kept faith in me and have really allowed for this thesis to become possible. Over the course of this work, my wife, Kathleen, gave birth to my beautiful daughter Pangaea, who reinforced the importance of leaving a sustainable world, one that would be worth to live in for generations to come.

Abstract

In the 1980's, the United Nations funded the Global Assessment of Human Induced Soil Degradation, which presented to the world the effects that soil erosion is having on our planet. Nearly 25 years later, environmental problems regarding soil erosion are still misrepresented within our society. Topics such as global climate change and biodiversity are spotlighted throughout the media, while erosion remains a distant threat.

In order to research this vast topic, which affects every location on the planet, a geographic information systems (GIS) analysis, in conjunction with a social network study has been used. This has been performed with the aim to identify the physical and social conditions among two counties within the State of Utah, USA, which aid towards a better agricultural management practices. This study shows the interconnectivity levels within the two studied social networks and its effects on efficient soil conservation practices.

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LIST OF ABBREVIATIONS

BMP – Best Management Practice

CRP - Conservation Reserve Program

FSA – Farm Service Agency

GIS – Geographic Information Systems

GLASOD - Global Assessment of Human-Induced Soil Degradation

LiDAR - Light Detection and Ranging

MDG - Millennium Development Goals

NAIP – National Agriculture Imagery Program

RUSLE - Revised Universal Soil Loss Equation Model

SARE - Sustainable Agriculture Research and Education

SNA – Social Network Analysis

UNEP - United Nation Environmental Program

USDA – US Department of Agriculture

USGS - US Geodetic Survey

USU- Utah State University

Chapter 1: Introduction

1.1 Agricultural Soil Erosion

The sustainability of agricultural practices reflect the decisions of cultures and societies, as food production and soil erosion are directly interconnected towards the sustainability of our current way of life. To begin this thesis, two quotes from the World Resource Institute are used to illustrate exactly how important sustainable agriculture practices are needed within our contemporary society.

> *Most high-quality agricultural land is already in production, and the environmental costs of converting remaining forest, grassland, and wetland habitats to cropland are well recognized. Even if such lands were converted to agricultural uses, much of the remaining soil is less productive and more fragile; thus, its contribution to future world food production would likely be limited.* (World Resources Institute, 1999)

> *One analysis of global soil erosion estimates that, depending on the region, topsoil is currently being lost 16 to 300 times faster than it can be replaced. Soil-making processes are notoriously slow, requiring from 200 to 1,000 years to form 2.5 centimeters of topsoil under normal agricultural conditions.* (World Resources Institute, 1999)

The consequences that soil erosion have on our geophysical and social environments are no new concepts to human societies, as humans have agriculturally exploited the land in order to provide for our tomorrow. Social scientist and author of "The Collapse", Jared Diamond, has given great insight to how agriculture practices have allowed for both the success and failures of societies. For example, the development of traditional agricultural practices in the Middle Eastern Fertile Crescent aided to the rise of a societal structure, which allowed human societies to shift from hunter-gathers communities to an agricultural mindset. Unfortunately, these new means of their success could have been the reason for their demise, as soil salinization and soil erosion left the once fertile soil to a barren wasteland (Diamond, 1997). Moreover, these problems still today threaten agricultural practices worldwide and with the global populations surpassing seven billion inhabitants, (United Nations, 2011) food demands are higher than ever. This is well illustrated in Donella Meadows' book *Limits to Growth*, where it is mentioned that in 1950 the worldwide corn production was 131 million metric tons per year, compared to the year 2000 production levels, which reached close to 600 million metric tons annually (Meadows 2000, p8). This phenomenon is not only reflecting corn production, but is also the same trend in other food products, such as wheat and rice (Meadows, 2000 p 8). Figure 1.1 demonstrates the effects on a natural resource, through the process of an overshoot and collapse scenario. In this diagram, the "resources" represent the stock of fertile soil, as food production increases the level of soil productivity begins to decline, especially as erosion events remove needed topsoil for production. One of the most interesting factors in this diagram, is the point at which environmental pollution begins to peak. It can be noted that after the resources are significantly eroded, it is required to put more energy into the system to maintain the current production levels. Regardless, as the forecast shows on Figure 1.1, the stock will continue to decline unless there are fundamental changes implemented for the usage of the resources.

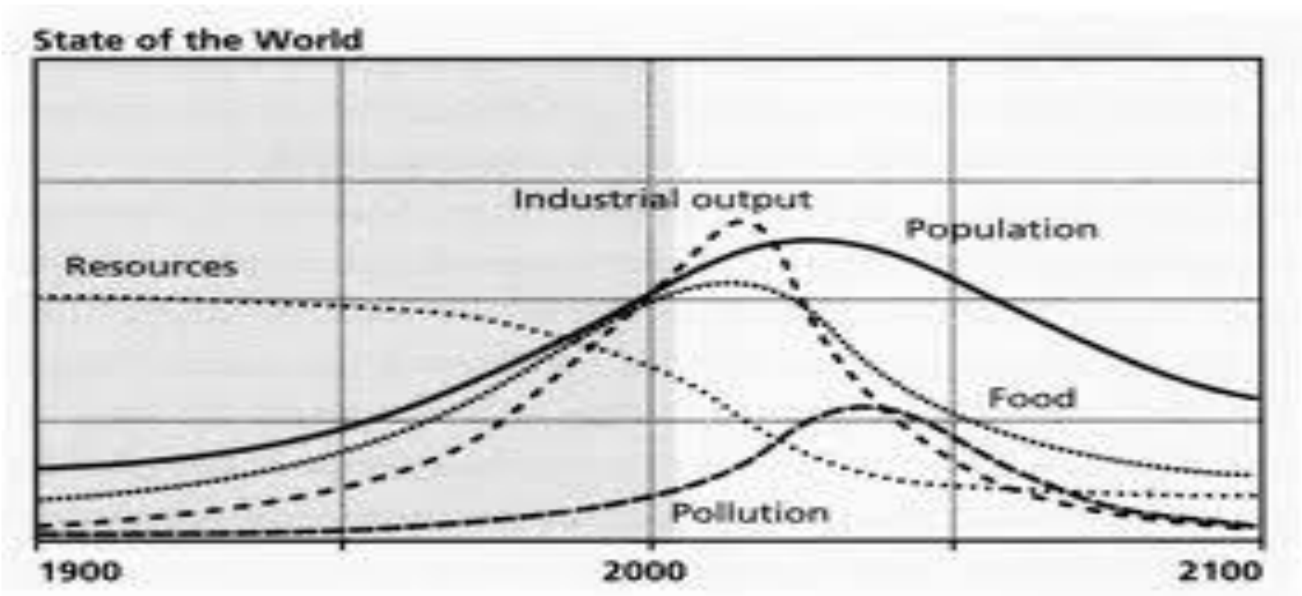


Figure1. 1 Overshoot and Collapse of Systems

(Meadows 2000, p169)

1.2 Research Goal and Objectives

The objective of this research is to analyze the farmers' network and the impact that the network's structure has on their land management practices. The identification of these networks and their characteristics provides the necessary tools to pinpoint areas concerning the development and dissemination of the knowledge towards Best Management Practices (BMP), as well as, their ability to self organize and to develop collective decision making processes. In order to reflect on the network development, this report addresses the work of

Sandström and Rova, as they stated that "*network structures can represent the decisions, interactions and consequences of individuals in managing resources*" (Sandström, 2010 p.529).

To analyze the research objectives in this report, the following research question was developed:

Under which conditions do the networks found within the research areas develop solutions towards preventing agricultural soil erosion and preventing onsite and offsite externalities?

The research question was evaluated by using both: theoretical and empirical research, in order to explore two agricultural communities, which have been identified through a Geographical Information Systems (GIS) erosion model. The following sub questions were used to develop a hypothesis in analyzing the central research question.

1. What are the policies affecting agricultural soil erosion within the State of Utah?

2. What areas in the State of Utah have a high probability of agricultural soil erosion?

3. What are the underlying networks of stakeholders found within the study area?

4. What is the structure and characteristics of the network throughout the study area?

5. What is the Network Closure of actors within the study area?

6. What is the Network Heterogeneity among actors within the study area?

7. To what extents have the networks of actors proven to be able to develop solutions for soil erosion management?

Throughout this project two study areas were cross examined by comparing their similarities and differences addressing agricultural soil erosion. The network structure within both areas and its impact on the farmers' land management practices were analyzed in order to evaluate the internal validity of this research. This project concludes by providing recommendations towards the improvement of the network structures in aiding to the mitigation of agricultural soil erosion and suggestions towards possible future researches.

1.3 The Structure of this Thesis

This thesis was broken into three sections: Introduction and Literature Review, Methodology & Research, and the Discussion of the Results.

Section 1, consisting of chapters 1-3 that begins to formulate an understanding of the importance of preventing agricultural soil erosion in the sustainability arena. This section introduces the literature review and begins to develop the conceptual framework and methodology for this project. Within this section, sub-research question 1 is answered in determining the conservation policies that have been developed in preventing agricultural soil erosion.

Section 2, composed by chapters 4-5, deals with the Methodology & Research part of the study. Chapter 4 presents a geographic information systems (GIS) model indicating two counties with the highest amount of agricultural soil erosion statewide. This GIS analysis was used to identify a random selection of actors that own agricultural lands with a high probability of soil erosion. Chapter 5 present the empirical data from the field work in order to analyze the remaining research questions evaluating the network structures. Within this section, sub-research questions 2-7 are answered, leading up the final section of this report.

The final section on the Discussion of the Results, formulates an analysis that evaluates the data collected through a comparative case study between the two individual network systems. This comparative case study answered the main research question. The end results were used to reflect recommendations of network structures in preventing agricultural soil erosion.

Chapter 2: Literature Review – Background

2.1 Introduction

One of the most proclaimed and recorded environmental disasters spotlighting unsustainable agricultural practices were the events in the American Great Plain States during the 1930s. These agricultural lands, located throughout the central region of the USA, provided farmers with some of the world's most fertile topsoil, abundant growing capacity, and wealth. In aiding to their production, a technological shift towards motorized farming equipment increased their yields drastically; therefore allowing farmers to maximize the profits of their lands. Alas, drought in combination with overexploitation of these fertile lands provided a scenario for the perfect storm. The once "Bread Basket" of the USA was physically transformed to the "Dust Bowl" as extensive soil erosion plagued this region for decades to come. By looking back throughout history, the signs that soil erosion needed to be addressed were there, as they are today, especially as farmers around the globe are producing more to feed the increasing demand of society. According to David Pimentel, professor of ecology at Cornell University, "soil erosion is second only to population growth as the biggest environmental problem the world faces." (Cornell University, 2006) As mainstream media and environmental groups focus on sustainability issues, such as deforestation, air pollution and climate change; agricultural soil erosion on the other hand, tends to be left off the radar. This important issue needs to be addressed, as each and every one of us is collectively contributing to agricultural soil erosion.

RESEARCH AREA

This research focused on the State of Utah and the agricultural practices that are being implemented throughout this region. Utah is located in the western section of the USA, which has the geophysical features from three diverse geological regions, the Rocky Mountains, Great Basin and the Colorado Plateau. The rocky mountain region is located on the eastern section of the state, which is derived from higher elevation of mountainous terrain and plateaus. Throughout this region there is a lower population of individuals and agricultural areas, as a majority of these lands are entitled to Indian Reservations that consist of grazing lands instead of agricultural usage. In the southern proportion of the state, the Colorado Plateau consists of a sandstone arid region that supports minimal agricultural activities. This location is mostly popular for its deserts, deep ravines, canyons and sandstone arches that can be portrayed as an arid region with minimal human activity. In the Wasatch valley region of the Great Basin, approximately 80 percent of the state's 2.7 million residents live within this area (US Census Bureau, 2010). Throughout this region there are numerous valleys that consist of fertile agricultural soils. Unfortunately, due to the demand of space for residential developments most of the agricultural lands have been removed. An additional factor that needs to be considered when evaluating the agricultural areas throughout the state is the amount of land that is under the control of the US federal government. Current publications declare that approximately 70 percent of the State falls under federal control (Utah Trust Lands). In the additional sections of this chapter, the internal validity of the geophysical attributes of agricultural areas has been addressed to provide a comprehensive insight on how agricultural erosion is greatly connected to the geophysical features of a location. By understanding the how local actors develop agricultural soil conservation practice throughout Utah, this research can aid towards other agricultural locations that have similar geological features, such as much of the Western Region of USA. These semiarid-mountainous locations are not only found within the USA, but are evident across the globe. Additionally as global climate change is impacting our climatic patterns this project could also be used to help develop solutions for regions that transition from agricultural favorable lands to a more semiarid climate in the future.

2.2 Soil Erosion

The definition of soil erosion within this project is partially based on the description given by the EU Commission of Land Management and Natural Hazards as the "*wearing away of the land surface by physical forces such as rainfall, flowing water, wind, ice, temperature change, gravity or other natural or anthropogenic agents that abrade, detach and remove soil or geological material from one point on the earth's surface to be deposited elsewhere*" (EU Joint Research Center, 2007).

The description above provided by the EU Commission of Land Management and Natural Hazards is a very broad one. Therefore, for the purpose of this research, the only type of erosion considered within it, is the erosion caused by fluvial processes only. Hence, indicating types of erosion by the means of water, in which soil particles are detached, transported and deposited. There are also vast amounts of alluvial erosion, erosion by the means of wind, throughout the State of Utah, but the ability to quantitatively identify alluvial erosion locations couldn't fall within the scope of this project.

In many cases, agricultural soil erosion begins when the topsoil has been uplifted through tillage practices and becomes susceptible to weathering conditions. Some usual types of plowing equipment that are currently being used in agricultural management are: the Moldboard Plow, Chisel Plow, Tandem Disc, and Seed Drills. Each piece of equipment has a unique tillage method as addressed in section 2.5.

Particle detachment via fluvial means first occurs from "rainsplash". During this process, actual raindrops strike the soil surface detaching individual soil particles from the soil mass, initiating, in this way, the erosion process. In Figure 2.1 clearly illustrates rainsplash erosion and its effects on the individual soil particles.

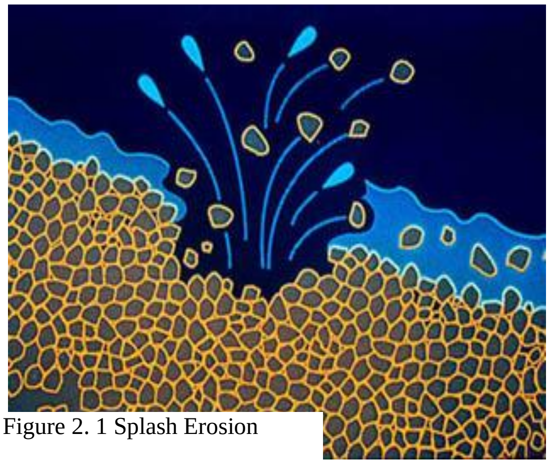


Figure 2. 1 Splash Erosion

(Source: Montcalm County)

With significant rainfall, the soil itself starts to become saturated, whereby a layer of water flows over the soil's surface. After enough rain water is collected in an area, runoff starts to accumulate and "sheet erosion" or "surface runoff" begins the soil transportation process. Rill Erosion becomes visible after the water flows start to become consolidated in small channels and the velocity of water starts to increase along the surface of the soil. These smaller rills begin to accumulate more water over the length of the slope and continue to increase the potential of erosion capacity. During rill erosion, one of the most intensified areas of erosion is the converge point of two or more rills, which develop gullies. Gully erosion is produced after rill erosion has become concentrated enough to develop deep channels through the soil surface. The concentration of erosion in gullies result in numerous impacts, such as soil washouts leading to an increase of topsoil removal and its deposition of sediments offsite or downstream. One can appreciate examples of rill and gully erosion along agricultural areas on Figure 2.2 respectively. Note, that the direction of crop management follows the same direction of water flow throughout these fields. An agricultural best management practice (BMP) in avoiding this type of erosion, is to sow crops parallel to the contours of the surface of the earth or provide infrastructure to minimize runoff velocity, such a terracing or vegetation strips. To analyze the transportation of soil particles, erosion problems are categorized by both offsite and onsite effects.

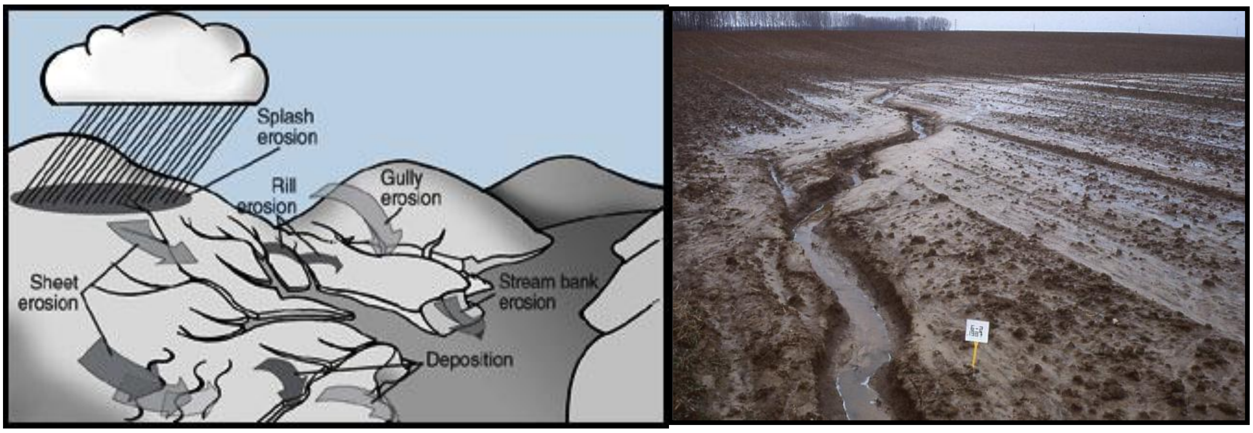


Figure2.2 Type of Erosion

(Source: Image 1 Broz et al, Image 2 Kwaad)

PHYSICAL PROPERTIES OF SOILS

The physical properties of soils need to be explained before continuing to develop a deeper understanding of the effects that erosion can have on agricultural lands and crop production. Soil compositions are derived from a mixture of organic matter and minerals, which are arranged in a specific pattern. The variance in the particle sizes of the mineral composition of the soil identifies the actual soil type. Therefore, the soil texture provides three distinct soil classifications: Sand, Silt, and Clay.

Sand is identified through its granular composition with particles size larger than 0.02mm (National Soil Survey Handbook, 2011). The particles are not cohesive and break apart easily. Sand is a very erosive soil type, but normally is not found within the locations of agricultural production. Additionally, due to the size of the soil particles, erosion with sandy soil normally takes place in large powerful storms, which produces torrential rainfall within a short period of time.

Silt can be described as finer composition of particles that has a floury texture. These particles are between 0.002 and 0.02 mm (National Soil Survey Handbook, 2011) in size that creates a more cohesive soil structure, but do not have plastic or tight bond between individual particles. Therefore, silty soils are easily erodible due to the size of the particles and lack of adhesiveness between minerals.

Clay is derived from extremely small particles, which consist of minerals that are less than 0.002mm (National Soil Survey Handbook, 2011). The properties of clay structures differ greatly from sand and silt, as when clay soils are wet they portray an elastic cohesive soil structure that is difficult to erode. When these clayey soils are under dryer conditions the clay begins to harden, making a firm rock like soil that is difficult to cultivate.

Through identifying the classification of the soil texture, this report used a national soil datasets to determine the level of soil erosion capacity in agricultural areas. In Figure 2.5 the soil triangle indicates the composition of soil structures; it includes one type of soil classification that is not mentioned above: loamy soils. A loamy composition is a mixture of the three main components of soil. Figure 2.5 portrays how loamy soils normally are derived from 40 % sand, 40% Silt and 20% clay. Loamy soils are mainly characterized by their tendency to maintain a high level of nutrients and retain water moisture. Hence, these characteristics of loamy soils are most favorable for agricultural production, but 80% of its soil composition is derived from highly erodible soil textures, such as sand and silt.

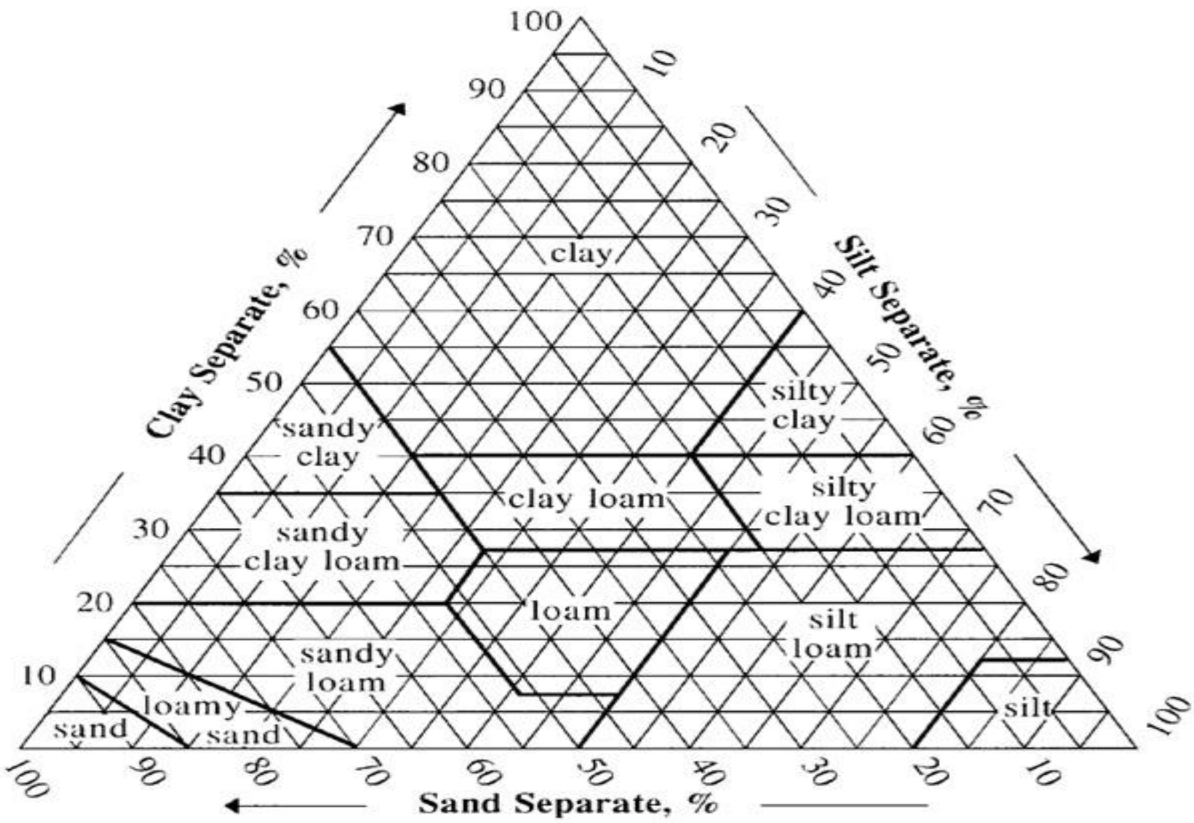


Figure 2. 3 Soil Triangle

Source NRCS Soil Calculator

Offsite Erosion

Offsite erosion addresses the circumstances that take place through the sedimentation of soil particles from one location to another. Such as, soil particles that are transported downstream and deposited in riverbeds, which may lead to an increase of flooding and/or blockage of dams. Additionally, offsite deposition may lead to an increase of fertilizers and pesticides in our water supply aiding toward further environmental consequences. In regards to agricultural soil erosion, the effects of offsite deposition can be considered very destructive to farming practices, as the topsoil is removed from the farmers plot and transported to an offsite location. Scenarios like these, slowly but continually leave farmers with less and less topsoil annually, which over time degrades the total soil productive capacity.

Onsite Erosion

Onsite erosion, on the other hand, addresses the effects on the actual land where the erosion is taking place at. In agricultural areas onsite erosion is an enormous issue, whereby the needed topsoil for crop production is partially vulnerable to erosion throughout the year. Through modern farming practices the topsoil is tilled or uplifted to allow easier access for sowing crops. Inadvertently, the soil is introduced to numerous physical properties that change the soil's structure. For example, R. Morgan a soil scientist for the UK National Soil Resource Institute based out of Cranfield University explains how onsite erosion declines the natural organic and nutrient fertility of the soil content (Morgan, 2005). Therefore, farmers have to put more effort and cost in resources, i.e. gas and fertilizers, to maintain the same yields year after year. In figure 2.4 there is a pristine example of excessive onsite and offsite erosion. This data is provided by the USDA's National Agricultural Imagery Program (NAIP), which was acquired in the 2009 agricultural growing season. This image displays numerous scenarios that are the consequences of agricultural production. The "white areas", also known as white knobs in the aerial photo are locations that have slightly higher elevation throughout the field. These locations tend to have excessive runoff, whereby the topsoil and nutrients have been decreased slowly over time. This has happened due to the land owners soil management and plowing techniques that have removed the needed moisture and nutrients leaving the soil low in fertility. As portrayed below in Figure 2.4 these areas are still being used for agricultural purposes regardless of the low production outputs. Hence, the overall costs to produce crops within these marginal areas are significantly higher, in terms of input versus output. In this aerial photo it is also evident that some BMPs are being used, such as terracing. Terracing is used to minimize the velocity of water and to eliminate a channeling effect that can lead to gully erosion, which could further lead to offsite erosion effects. Finally, the south eastern section of this figure pinpoints an area of offsite erosion between property 1 and property 2. This location should be addressed, because the topsoil is being transferred from one location to another.

To complicate problems further, global climate change scenarios are predicting shifts in weather patterns that could greatly affect the intensity of erosion events. Currently, this year in the State of Utah, there has been an abnormal increase of precipitation and extremely low temperatures throughout the region. Consequently, the vast levels of snow pack in the higher elevations, in conjunction with an extremely wet fall and spring threatened the region with flood predictions and excessive runoff.

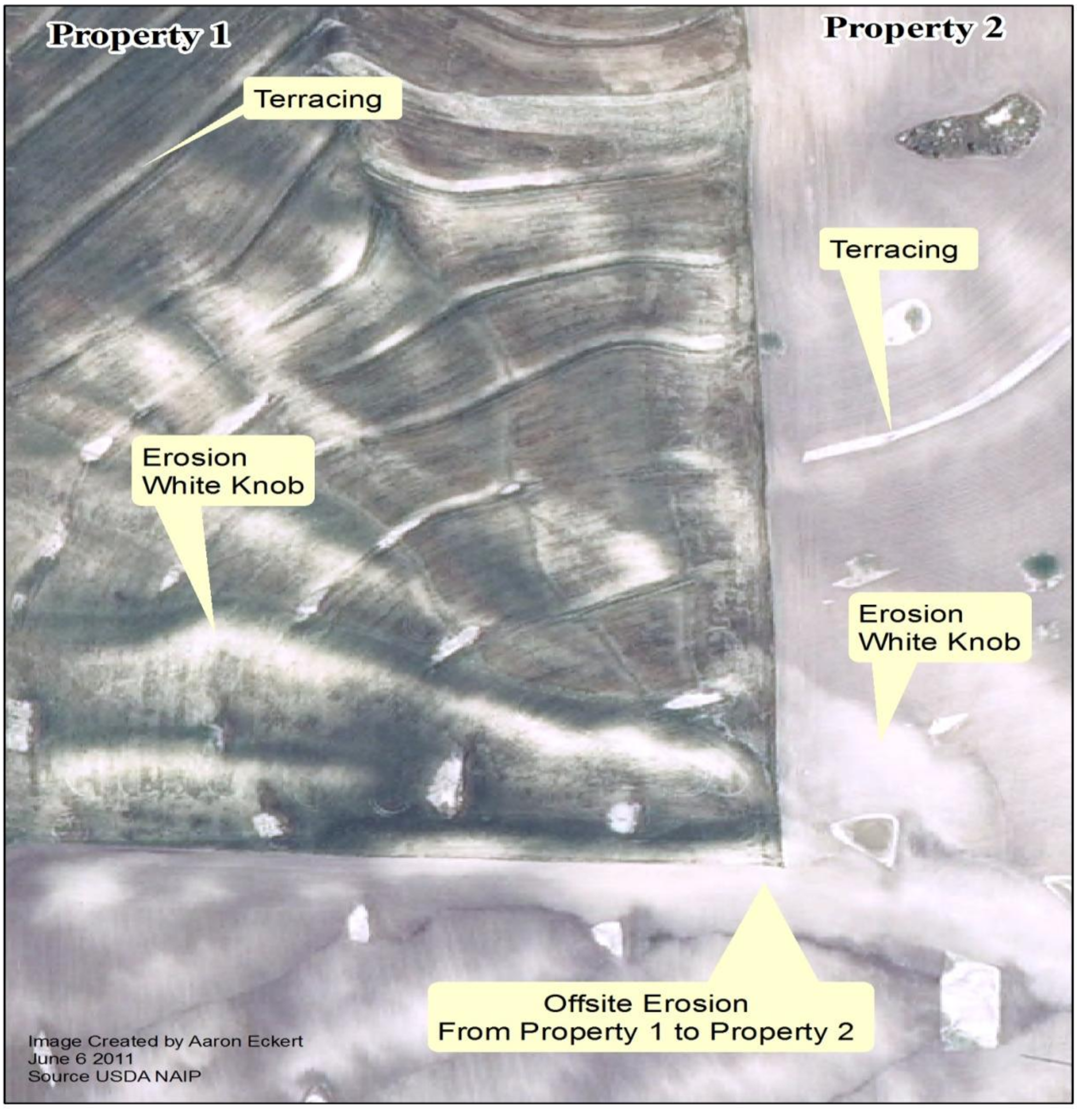


Figure 2. 4 Erosion Map

2.3 Agricultural Soil Erosion at Global Perspectives

In 1987 the Brundtland report brought forth the notion of sustainable development. Within the Brundtland report soil erosion was addressed as a concern towards our ability to provide for the generations of tomorrow. It stated that *"the loss of agricultural land through erosion is estimated at 6 or 7 million ha per year with an additional loss of 1.5 million ha annually as a result of waterlogging, salinization and alkalinization"* (Brundtland et al., 1987). In addition to the problems mentioned above with agricultural soil erosion, the pressure from the market to produce enough food for the demand of the world's populations adds to the dilemma. According to the UN Population Division in 1985 farmers had to supply for 4.8 billon people in comparison to the circa 7 billion inhabitants of nowadays (United Nations, 2011). By making a simple calculation (**Current Population – 1985 Population**) / (**1985 Population**) = (**% of current population compared to 1985 population**) ((7.0-4.8)/4.8), farmers have to produce approximately 46 percent more food today than in 1985. In doing so, farmers today have to create innovative ways to manipulate food production ability. Change in land use practices, such as deforestation for agricultural land with the intensification of farming methods, leave areas prone for increase runoff levels and magnify erosion intensity (de Roo et al, 1996). For example, farmers are producing more with the applications of nitrogen and pesticides in conjunction with intensified use of heavy equipment and irrigation systems. Wohlmeyer points out that

> *[I]ncreasing intensification of farming is recognized as one of the main causes for soil degradation in many industrial countries. Industrial agriculture is characterized by an increasing use of heavy machinery, consolidation of farmland, mono-cultivation of plants with a high yield, excessive use of fertilizers and pesticides and intensive irrigation*. (Wohlmeyer 2002, p. 234)

For most people within society, agricultural soil erosion is not a mainstream environmental issue, as this problem is not completely apparent to human observation. Due to the longevity of agricultural soil erosion to become evident, scientists over the past few decades have been introducing new technological modeling methods that have allowed for policy makers and/or environmental regulators to observe the set changes over time. For example, the United Nation Environmental Program (UNEP) funded research on the Global Assessment of

Human-Induced Soil Degradation (GLASOD) that gave an in-depth description of soil erosion across the globe in a cartographic format.

Unfortunately, the GLASOD project is currently the only global assessment of soil erosion and due to its date of release, over twenty years ago in 1990, it is reasonably difficult to determine its accuracy. Therefore, erosion assessments at a smaller scope, such as at regional or local level, could lead to an improve understanding of the factors reflecting erosion rates. In addition to the ability to observe and predict changes of our landscape overtime, scientists can pinpoint areas of concern to provide a better understanding on why the scenarios are occurring and how potential BMPs can be implemented.

2.4 Agricultural Soil Erosion at Local/National Perspectives

According to soil scientist Royston Morgan, "*soil erosion cost the USA between 30 and 44 billion US dollars yearly"* (Morgan 2005, p 1). These costs are the result of both on- and off-site erosion problems affecting not only the local farmers, but also impacting the environmental, social and market perspectives of sustainable development. Therefore, the sustainability of our agricultural topsoil cannot be left unaddressed, especially as this environmental dilemma directly impedes on the accomplishment of the first Millennium Development Goal (MDG): "Eradicate Extreme Poverty and Hunger". In identifying the reasons for agricultural soil erosion and possible solutions to overcome its externalities, individuals from different sectors of society (government, market, and civil society) are needed to develop BMPs and to distribute knowledge for erosion solutions. These networks of actors, i.e. farmers, government agencies, consumers, and other members of society, all have a specific role to play within the decision making process towards a coordinated landuse policy, which at the end will determine the future consequences caused by agriculture soil management.

Therefore, this project has utilized geographic information systems (GIS) to analyze the State of Utah in determining locations, which have a high probability of agricultural soil erosion. This initial GIS analysis, used Landuse, Elevation, and County datasets, provided by the US Geodetic Survey (USGS), to identify two counties regions. These two counties were then further analyzed using Landuse, sub meter Light Detection and Ranging (LiDAR) elevation models in conjunction with property ownership data to identify local land ownership. The initial statewide analysis pinpointed Box Elder and Cache County, which are both located in the northeastern region of the state. Both of these areas depend greatly on agricultural production and erosion can be found extensively throughout them.

2.5 Methods in Managing Agricultural Soil Erosion

REVISED UNIVERSAL SOIL LOSS EQUATION (VERSION 2) RUSLE2

As mentioned in the introduction of this research project, the USA has undergone one of the most severe agricultural soil erosion phenomena of the last century. This tragedy that left the USA Great Plain States as a barren wasteland, brought recognition that erosion prevention models were needed to prevent further disaster. In the 1940's data collection and research on soil erosion led to one of the world's first guidelines for erosion prediction and prevention. The Universal Soil Loss Equation (USLE) was developed by analyzing empirical data that was not based off from mathematical functionality (Wischmeier, 1981). The USLE was considered relevant until the early 1990s until the introduction of the Revised Universal Soil Loss Equation (RUSLE), which used a more physical based model approach in calculating erosion variables. When modeling our environment, scientist continually attempt to improve on existing models to receive a better understanding of the big picture. Through continual research and development of the soil erosion models, the US Department of Agriculture released the RUSLE 2 in 2003. Currently this model is still the most relevant in soil science and is used by numerous governments and private agencies. As mentioned later in this chapter, the RUSLE 2 model can be considered the backbone of US agricultural policy, whereby all agricultural producers need to be evaluated by this model in order to receive any governmental subsidy.

The RUSLE 2 uses a mathematical expression to address six variables that influence the probability of soil erosion. The RUSLE 2 model has been developed to analyze all three components of soil erosion, detachment, transportation and deposition. For the scope of this project, the purpose of this model is to pinpoint locations of interest towards identifying the interviewees. The following section explains the RULE 2 formula: A=RKLSCP

Total Soil Erosion

A = "*average annual soil loss from rill and inter rill erosion caused by rainfall and its associated overland flows, expressed in tons/acre/year*". (NRCS 2003)

Rainfall

R = climate erodibilty: This factor identifies the amount of rainfall. With current technology, rainfall can be calculated in real-time, daily, weekly, etc. The amount of rainfall directly impacts the intensity of erosion events. For example, cold fronts can product larger amount of precipitation within a very short time span. In 2011, flash flooding occurred with precipitation amounts of 1 to 3 inches of rain within a few hours. (NOAA, 2011)

Soil

K = soil erodibilty measured under standard conditions: This factor identifies the type of soils located in a region. Soil type is based off from its composition between the mixture of clay, sand, and silt. As identified in this Chapter, the soil triangle indicates the soil texture, which can designate the amount of erosion that could occur to a specific soil type.

Topography

L = slope length, S = slope steepness: These two factors can be evaluated together as the steepness of the slope is directly proportional to the length of the slope. Slope length and steepness are both calculated through simple mathematical formulas: Length - Pythagorean Theorem and Steepness – Rise over Run. The L and S can be determined as the two most important variables in identifying locations of agricultural soil erosion. This project indicated locations with slope levels higher greater than 10%. This process exceeds the national erosion policy, which categorize highly erodible lands greater than an 8 % slope.

Land Use

C = cover management P = support practices: These two factors can also be evaluated together in identifying soil erosion events. Cover management looks at what type of vegetation is on the land, for example, bare land increases erosion probability much more, than if the soil was covered by dense forest or grasslands. Support practices reflect on the types of BMPs that landowners use to prevent erosion events. Some common types of BMPs are contouring, vegetation buffers, non tillage practices, and terracing.

AGRICULTURAL TECHNIQUES

Throughout the USA, the nation is divided into several climatic regions in which farmers need to develop appropriated agricultural techniques for food production. These regions are greatly diversified, but a larger proportion of these areas can be classified as arid or semiarid, especially in the western half of the USA (Creswell Page.2). Within the State of Utah there are two distinctive types of agricultural practices that are used for food production: irrigation farming and dryland farming. Both of these practices have a distinct approach in how individual farmers manage their land for both production and conservation. To comprehend the division between both of these agricultural techniques, it is important to understand the geophysical characteristics found from within the state. The State of Utah can be considered a semi-arid, mountainous region (Creswell Page.2), which has an extremely low annual precipitation rate. According to the Western Region Climate Center the agricultural areas throughout the state normally accumulate between 10 and 15 inches of rainfall per year (Western Region Climate Center, 2011). This hurdle can be considered a significant challenge to most farmers, when compared to Dutch farmers, who receive twice as much precipitation at 31.2 inches annually (KNMI, 2011). As precipitation is an enormous factor is determining the type of agricultural practices used in a specific area, the topography of the area also creates another physical barrier in how farmers manage their crop production. For example farms that are located in the valley have better access to irrigation practice, in comparison to farmland on steep terrain have to resort to other methods.

Irrigation Farming

Irrigation farming can be considered the most popular means of agricultural production within the state. Throughout these areas farmers make the use of canals in conjunction with irrigation equipment, such as Wheel Lines and Pivots, to provide for water accessibility. Diagrams explaining the various types of irrigation systems are viewable in the Appendix. Creswell defines irrigation farming, as the locations *"where water is brought in by wells, canals, or other means so that normal agriculture can exist, in spite of the aridity of the climate"* (Creswell 1998 p. 2). Normally these irrigation areas are located within valley planes, whereby these lands portray a minimal change in elevations and can be considered relativity flat. Due to this reason these irrigation systems can efficiently be operated automatically with minimal impact to soil erosion conservation practices. In Chapter 4 of this report, the GIS analysis clearly indicates the minimal amounts of soil erosion located throughout the irrigated land, but these areas are not completely resistant against all erosion activities. These agricultural lands are located throughout lower elevations, which make them prone to annual and flash flooding events.

Dryland Farming

In the locations where water resources cannot be accessed via canals, wells or conventional irrigation methods, farmers have developed ways to cultivate marginal agricultural lands with minimal water dependences. According the Utah State University, most dryland agricultural areas need roughly 15 inch of precipitation annual to maintain soil productivity (Utah Climate Center, 2011). Within the state of Utah dryland farming is normally located throughout the higher elevations and/or along mountainous regions, which additionally makes them susceptible to erosion events. In fewer words, dryland farming is a multifaceted technique that incorporates water and soil conservation practices into modern day farming. According to Creswell, these practices include the management of water absorption into the topsoil, reduction of water runoff, and reduction of water evaporation and transpiration to ensure that crop production can sustain yields year after year (Creswell 1998). Therefore, farmers managing dryland areas must have an extensive knowledge in conservation practices to prepare for climatic changes yearly.

CONTEMPORARY EQUIPMENT IN AGRICULTURAL PRODUCTION

Over the past century, farming practices have changed considerably among the industrialized world, as farmers have shifted from animal powered practices to an industrial mindset. These leaps in technological advancement have in creased output yields appreciably, giving way to the contemporary food production systems, whereby less than 2% of Americans can provide food production for the whole nation (NC State University). Unfortunately, these advancements in technology are very costly, as modern equipment can cost hundreds of thousands of dollars, leaving farmers with the decision to change current equipment for up to dated practices or remain with the older fuel and resource intensive equipment. This section only addresses some of the most relevant equipment, which is being used in changing the conditions of agricultural soil.

Moldboard Plow

The Moldboard plough can be considered one of the most soil intensive pieces of agricultural equipment used in modern practices (Morgan 2005). This piece of equipment is usually assimilated with farming practices, as the normative ideas about farming indicate that farmers need to overturn their soils for weed management. Adversely, this type of cultivation leaves the topsoil exposed to climatic properties that could result in erosion events or removal of organic/moisture content. The following description of the Moldboard plow can be quoted via numerous farm equipment companies' websites throughout the globe.

> *"Mould Board Plough is the most important plough for primary tillage in canal irrigated or heavy rain areas where too much weeds grow. The objective for ploughing with a Mould Board is to completely invert and pulverize the soil, up-root all weeds, trash and crop residues and bury them under the soil. The shape of mould Board is designed to cut down the soil and invert it to right side, completely burying the undesired growth which is subsequently turned into manure after decomposition." (MF Tractors)*

The above quote is not provided by any research or university institution, but by a farming equipment vendor in India. Therefore it gives us an insight for a normative understanding on how westernized agriculture and weed management is portrayed within the developing the world.

Tandem disc

This piece of equipment is also known as a disk harrow, it used to break up topsoil and cut up unwanted weeds and leftover vegetation, also known as Residue, from the previous seasons. Normally this tool replaces the use of the moldboard plow in dryland areas, due to its ability to leave some vegetative residue on the surface of the soil. This residue is crucial in maintaining the soil's integrity, because the plant's initial root structure remains sound and it mitigates the ability of soil particle from detachment during rain events. Even though the disk harrow does increase soil particle detachment through breaking up the soil surface, its ability to maintain organic matter and residue is essential during the rainier fall and winter months. (Clark, 2002)

Chisel Plow and Cultivator

Chisel plows and Cultivators are generally used in dryland farming areas, whereby residue and vegetation management is implemented to maintain soil attachment. These types of equipment are normally used in areas where the disk harrow would have increased the probability of erosion events and extensive residue management is needed. The difference between disks plows and chisel plows are that chisel plows are constructed of spring type sweeps that penetrate the soil surface. The usage of "*sweeps with low crowns loosen the soil* *but do very little turning. Chisel plows with sweeps typically leave 70 to 85 percent corn residue with each pass."* (University of Wisconsin, 2010) A diagram of chisel plows is provided within the Appendix on the Agricultural Equipment Section. The Sustainable Agriculture Research and Education Organization (SARE), is a quasi governmental organization working towards farm education and sustainability, explains the ability that the chisel plows and cultivator can have on agricultural areas by maintaining a considerable amount of vegetative growth and providing weed management. For example, the implementation of a chisel plow or cultivator will maintain between 50 – 80% of residue in dryland areas, maintaining a high percentage of vegetation and therefore greatly decreasing the risk of erosion events. (Clark, 2002)

Direct Seeding Drill

The previous types of farming equipment can be found on most farms throughout the USA and within my research area. The practices that are associated with these types of equipment have been implemented and proven successful over the past half century, but there have been concerns in the overall sustainability of these practices. In 1943, at the University of Oklahoma, Edward Faulkner published his findings on the ability of farmers to produce annual crop yields with minimal soil disturbance. Since the release of his findings, there has been a vast amount of research in the field of non tillage and direct seeding practices and how they may be used in sustainable agriculture and soil conservation. According to No-Tillage consultant Rolf Derpsch "*no-tillage is defined as a system of planting crops into untilled soil by opening a narrow slot, trench or band only of sufficient width and depth to obtain proper seed coverage. No other soil tillage is done*" (Derpsch et al 2009). One of the most important breakthroughs, which has allowed for non tillage agriculture to develop is the expansion of chemical weed pesticides, such as "round-up." These applications of chemicals have allowed farmers to spray rather than disturb the soil surface. When referring to conventional tillage practices, Khaledian, author of "*Evaluating direct seeding on mulch on a field scale"*, mentions that less than 15 percent of residue is remaining in the soil surface after sowing yearly crops, but with the usage of direct seeding equipment farmers can maintain higher levels of residue with very little disturbances to the topsoil (Khaledian, 2006). Yet again if the topsoil is minimally disturbed, the chances of erosion actually occurring declined significantly. On the other hand, direct seeding is not a fix for all agricultural erosion problems and there are other consequences affiliated with no tillage practices. For example, farmers need to apply chemical round-up at an extensive rate to minimize weed impacts, which has an additional impact on our environment.

2.6 Best Management Practice in Soil Conservation

The ability to develop management techniques in order to mitigate human induced environmental problems or to prolong the resilience of ecosystems from degradation can be considered in the best interest to humans exploiting a specific resource. In the field of agricultural production the resource to be exploited is the fertile topsoil, wherein nutrients and water content provide the needed properties for plant growth. The Best Management Practices (BMPs) that are affiliated with agricultural services are greatly concerned with limiting the exposure of bare soils to weathering properties. This section focuses on some of the accepted conservation practices that are found throughout the area of research. Morgan's work breaks down agricultural BMPs into three categories: Mechanical Methods, Agronomics Measures and Soil Management.

MECHANICAL METHODS

Mechanical methods in managing cultivated lands have been implemented by human societies for thousands of years, as cultures from all over the globe have used these practices for agriculture. For example, in the Dutch province of Limburg terracing has been used for hundreds of years to minimize erosion runoff. In South America, Native Americans used step terracing to cultivate lands throughout the mountainous regions of the Andes. Hence, mechanical methods are ways that humans have implemented for the construction or engineering methodologies to mitigate offsite soil erodibility. These practices provide farmers with the ability to cultivate marginal lands with minimal environmental impact. Two of the most common mechanical BMPs found within my study area are terracing and waterways. Terracing is the usage of large soil mounds or steps in the surface of the earth to manage water runoff and velocity. The construction of waterways allows farmers to install culverts, dams, stones and vegetation to direct water moment throughout their land to reduce the impact on the cultivated locations.

Terracing

Terracing is a practice in which land embankments or dams are built up throughout an agricultural field in order to minimize water velocity and runoff. In locations where farm managers are conducting intensive agricultural practices, such as multiple sweeps of their land with tillage equipment annually, the soils begin to be prone to erosion events. Therefore, terracing allows farmers to conduct conventional tillage practices on high elevations and slopes with minimal concern about offsite erosion. To understand the functionality of terraces more expansively, terracing can be broken-down into three specific types: diversion terraces, retention terraces and bench terraces.

Diversion terraces are normally used on flat locations of farmlands, not exceeding a 7% slope and are not used to completely stop the movement of water over the cropland. These terraces can be described as gradual waves or swells on the soil surface that impede on overall water velocity. As mentioned above in the RUSLE 2 section, the length and slope of the soil surface greatly determines how much erosion takes place. By implementing diversion terraces the length and slope of the farmland is divided up into smaller segments, which allows for the water to speed up over a short distance and then slow down again. Additionally, these terraces attempt to shift the water direction perpendicular to the slope leading excessive runoff into designated waterways.

Retention terraces and diversion terraces are very similar in characteristics and the means of construction. Both types of these terraces are not meant to completely stop water runoff or erosion, but are used to provide additional erosion controls to deviate water across relatively flat areas of agricultural production. Morgan mentions that retention terraces are normally constructed on slopes less than 5% and it has the ability to store or detain water on the hillside. (Morgan 2005 p.156) This ability to preserve water onsite is one of the main differences between the two; additionally, it is essential for retention terraces to have strategic locations as permeable soils are needed to permit the percolation of water into the soil layers. For example, if the soil structure where the retention terrace is built on was derived from a clayey composition, then there would be an increase chance that the water wouldn't penetrate through soil surface. Consequently, this construction failure could cause the terrace to overspill and lead to further erosion occurrences.

The stereotypical perception of agricultural terracing is normally generalized with a **bench terracing** systems. "*Bench terraces consist of a series of alternating shelves and risers and are employed where steep slopes, up to 30°, need to be cultivated. The riser is vulnerable to erosion and should be protected by a vegetation cover o***r** *faced with stones or concrete. Unprotected risers can be the source of most of the erosion in terraced systems"* (Morgan

2005, p213). Throughout the State of Utah the usage of terraces is important to agricultural areas found along the mountainous regions. These structures have allowed farmers to produce cash crops with limited effects from erosion. Unfortunately, bench terracing is only a mechanical structure and without continuous maintenance and upkeep, these structures can quickly become an environmental hazard. On the other hand, when farmers are confronted with situations of excessive erosion, most of the soil runoff will become trapped within the terrace basins. Thus the land managers can retrieve their soils and transport it back to the affected areas. Morgan describes terracing as *"earth embankments constructed across the slope to intercept surface runoff, convey it to a stable outlet at a non-erosive velocity and shorten slope length"* (Morgan 2005, p 212). Figure 2.6 is a clear example of contemporary bench terracing practices that are used within the state of Utah.

Waterway Management

Waterways that are applied in agricultural practices are used mainly to direct excessive water runoff in such a manner that will greatly reduce the risk of erosion events. Most of the time, both terracing and waterway systems are used in conjunction with each other to minimize water runoff speeds. As mentioned above, each particular terracing system has a specific function, which normally correlates to a predefined waterway disposal system, which has been outline through the work of Morgan as diversion channels, terrace channels and grass waterways. Diversion channels are normally located at higher elevations above agricultural areas and can be considered as the first line of defense in erosion management. Within the research areas there is a tendency to only cultivate lands found at lower elevations and of lesser slopes, by doing so farmers leave possible productive agricultural lands higher up on the mountainside. There are various reasons why farmers do not use these lands, such as equipment capability, erosion management, crop yields on high slopes, etc. Unfortunately, these areas will still produce significant amounts of water runoff into the cultivated lands during rain events. Therefore, the implementation of diversion channels actually begins intercepting runoff even before making contact to the cultivated lands. These waterways then channel the excessive runoff into the grass waterways. Terrace channels also perform the same functionality as diversion channels, but these waterways are located within the actual cultivated fields. As previously mentioned, the riser location of the terrace needs to be completely stabilized in order to maintain the integrity of the terrace for channeling excessive runoff. Lastly, grass waterways tend to be located in lower elevations of the agricultural area, whereby natural water runoff has developed secondary streams during high levels of precipitation. Within these waterways there is usually a permanent vegetative growth that maintains the soil composition. Within these grass waterways there are also numerous types of BMPs that are used to minimized water velocities, such as dams and/or strategic boulder placement.

AGRONOMICS MEASURES

According to Morgan, "*agronomic measures for soil conservation use the protective effect of plant covers to reduce erosion"* (Morgan 2005 p 176). With the implementation of these practices, farmers integrate methodologies for crop placement, crop cover type and height, timeline for field productivity and harvesting practices. Hence, famers can enhance the effectiveness of mechanical BMPs through the usage of vegetative controls. This section outlines some of the most relevant agronomical practices that are currently being used throughout my study areas.

Rotational Practices

Rotational practices are an approach that farmers use to divide their agricultural areas into multiple crop locations. These locations alternate from year to year allowing for soils to regenerate from highly soil intensive crops to crops with lesser soil impacts. *"The aim of multiple cropping is to increase the production from the land while providing protection of the soil from erosion. The method involves either sequential cropping, growing two or more crops a year in sequence, or intercropping, growing two or more crops on the same piece of land at the same time"* (Morgan p. 185). For example, row crops such as maize (corn), increase erosion events significantly, as its physical properties allow for splash erosion to occur at higher intensity than lower height and higher foliage species. When farmers produce row crops without rotational practices, the soil conditions slowly become degraded overtime and could lead to a decrease of productive yields. By using a multiple rotational method, farmers can maintain yields and diversified their overall production, while using vegetative management to minimize erosion. Throughout Northern Utah, especially in the dryland areas, rotational practices are implemented in cyclic patterns to allow for soil regeneration. The reason for this is not completely due to erosion management, but it reflects numerous variables, such as: nitrogen fixation, water evaporation, and soil fertility. The normal pattern that is applied is described below:

- Season 1: Cultivation of wheat. Wheat is the largest cash crop in the region. During this phase, the wheat needs excessive amounts of nutrients to provide a good crop growth. After one season of growth, the soil's nutrient levels are depleted and need to be regenerated to produce another health yield for production.

- Season 2: The field will be left in fallow. Fallow can be defined as uncultivated land, during this season the soils can be regenerated. For the soils to naturally regenerate, the left over residue from the previous wheat harvest helps maintain the soil structure, keeps in soil moisture and also provides organic matter in the soils.

- Season 3: The field is planted with a crop that fixes the soils with nitrogen. Nitrogen fixation can be accomplished by planting legume species; normally legumes are plants that have pod or beans on them. Some legume species, such as soy, alfalfa and sainfoin, can be used to add natural nitrogen back into the soil then sold back on the market as a commodity.

This rotation process is conducted over and over again, attempting to maintain soil quality through a crop rotation process.

Cover Crops

Most conventional farming practices are multifaceted production systems, which leave the soil surfaces vulnerable to erosion throughout a large percentage of the year. Initial tillage begins in early spring and is used to remove all unwanted weeds and residue left over from the previous season in preparing for crop seeding. After sowing the crops, the soil is still not completely protected until leaf foliage and individual root structures are well developed. When the crop structures reach their potential growth capacity, harvesting takes place, whereby the once protected soils are now exposed yet again to weathering elements. In the late fall there is once more a chisel plow sweep conducted to remove any excessive residue. Unfortunately, these practices are very demanding on the fertile topsoil and with the excessive tillage these soils are most likely to degrade over time. One technique that farmers have developed in order to minimize erosion, has been through the usage of cover crops to protect the soils over the winter months. The cover crops provide a conservation measure, by the means of root structures, which maintain soil stability and vegetative cover, which doesn't allow for water to directly impact the soil surface. Morgan explains that "*cover crop must be* *quick to establish, provide an early canopy cover, be aggressive enough to suppress weeds and possess a deep root system to improve the macro porosity of the soils*"(Morgan 2005, p 181). These crops, such as winter wheat and winter rye, can be considered as a win-win situation, as famers can produce an agricultural yield, as well as, maintain soil integrity over the winter months. Morgan also mentions that "*in The Netherlands the practice of winter rye crops provide great assets to sugar beet, potatoes and maize producer in order to prevent wind erosion.*" (Morgan 2005 p. 181)

Strip Cropping

Strip Cropping is an agricultural practice which employs the usage of two or more crops to mitigate the potential erosion runoff. In the crop rotation section, it is mentioned that each vegetative species has a specific level of erosion, which is based off from its physical characteristics. Strip cropping attempts to interconnect the capability of specific protection-effective crops to minimize erosion from high yielding soil intensive row crops, such as maize, soybean and wheat. Both the row crops and protection crops should be planted parallel to the contours of the terrain, also known at contouring, and alternate between species. For example, if a farmer would be cultivating an area that has a consistent 15 percent slope across the landscape, then, according to Morgan, the Minimum width of the crop strips will have to be no greater than 15 meters (Morgan 2005). These 15 meters strips will alternate between a row crop and a legume or grass throughout field.

Mulching

One of the most common and practical BMP used in preventing soil erosion is the usage of vegetative growth on the surface. As mentioned earlier, the initial onset of erosion begins with the splash effect from raindrops impacting the surface of the soil. Normally, splash erosion occurs within the early stages of plant growth since farmers have stripped the farmland for weed control, which leaves their soils prone for soil detachment. Mulching is a technique that incorporates the left over plant byproducts from harvesting to create a layer of organic material which helps stabilize soil surface. This layer decreases the splash effect and the remaining root structures assist in clumping the soil together. Morgan states that "*mulching is the covering of the soil with crop residues such as straw, maize stalks, palm fronds or standing stubble. The cover protects the soil from raindrop impact and reduces the velocity of runoff and wind.*" (Morgan 2005 p. 187) Throughout the study areas, especially within the dryland farm locations, mulching is extensively used for numerous reasons: Firstly, it builds up an organic matter in the top few inches of the soil. Secondly, the vegetation maintains the soil moisture content, and finally the plant roots greatly aid to erosion prevention, as roots structures have the potential to composite soils together.

SOIL MANAGEMENT

Soil management and conservation can be considered the most important concept in understanding the successes and failures for agricultural producers. In almost every type of agricultural production farmers need to disturbed the topsoil in sowing their crops, weed removal and harvesting, hence without soil conservation systems farmers could be depleting the soil resources faster than its national regeneration rates. The concepts of soil conservation are relatively straightforward; soils that are fertile and have a good composition will produce a good agricultural output. Therefore, this section outlined some conventional soil management practices that are used to preserve soil fertility and structural conditions.

Contour Tillage

Contour tillage is a cultivation technique in which farmers plant their crops parallel to the natural contours of the earth's topography. In doing so, this method attempts to slow down the velocity of sheet erosion across the soil surface, which is necessary to maintain rill or gully erosion from occurring. Morgan mentions that contouring is not always adequate enough to prevent erosion events and therefore it should be used in conjunction with other BMPs, which were introduced in the agronomic and mechanical section. (Morgan 2005)

No Tillage

"No tillage describes the system whereby tillage is restricted to that necessary for planting the seed. Drilling takes place directly into the stubble of the previous crop and weeds are controlled by herbicides. Generally between 50 and 100 per cent of the surface remains covered with residue" (Morgan 2005 p.205). Although no till practices maintains a very high percentage of crop residue, which is beneficial for erosion management, there are additional consequences connected to these methods. The largest concern to farmers is their ability to manage weed infestations when implementing no till practices. One of the ways that farmers have overcome these problems has been with the application of chemical pesticides, such as round-up, to kill off all unwanted species. Unfortunately, these extensive chemical applications have produced additional circumstances regarding the weed's resilience.

Strip Tillage

Strip tillage is a system that uses a mixture between no till and conventional tillage practices, which allows farmers to sow their crop in till soils and maintain moderate levels of residue. When farmers make a pass with their strip tillage equipment, the knives of the plow cuts out small segments (5-10cm in width) into the soil, placing the seeds directly into the ground. These Strips will be the only locations without any residue throughout the field and even being directly exposed to the elements the surrounding stubble will greatly prevent erosion events. "*With strip tillage, the soil is prepared for planting along narrow strips, with the intervening areas left undisturbed. Typically, up to one-third of the soil is tilled in a single plough–plant operation."* (Morgan 2005, p. 206)

Minimum Tillage

Within the research area most farmers find themselves applying some sort of minimum tillage practices for soil conservation. "M*inimum tillage or reduced tillage refers to practices using chiselling or discing to prepare the soil whilst retaining a 15–25 per cent residue cover."* (Morgan 2005, p. 206)

2.7 US National Soil Conservation Policies

This section identifies some of the national policies, which directly impact erosion management programs in agricultural areas. One of the key concepts in understanding how U.S. agricultural policy is implemented, has been through the usage of a mix policy arrangement that interrelates voluntary agreements with government regulatory and economic control. Agricultural conservational policy can be considered much different from most conventional policy making, due to the fact that there is absolutely no mandating regulation on how farmers must operate. Therefore, agricultural producers have no regulative guidelines in how much pollution, i.e. pesticides, fertilizers, erosion runoff, etc., they can produce. As a consequence, they cannot be held responsible for the externalities of their pollutants. On the other hand, U.S. agricultural policy has been shaped through the usage of economic incentives to bring farmers to the drawing table, for enrollment into voluntary agreements that are back by regulatory stipulations. To explain this concept more clearly, this thesis uses the Federal Crop Insurance program as an example on how farmers would find themselves enrolling into a governmental program, which is bounded to environmental regulation. Normally most agricultural areas have some sort of crop protection insurance that allows farmers to make claims, if a natural disaster would greatly affect their crop output. The USDA Farm Service

Agency provides a catastrophic crop insurance program at a very low price, which can be used for insuring crops that do not fall under normal crop insurance policies. By voluntarily entering into these governmental programs, due to the financial cost of catastrophic insurance, the government mandates that the farmer has to follow specific guidelines that also include the development of best management practices in preventing excessive offsite pollution. In addition to the Federal Crop Insurance program, if any agricultural producers would like to apply for any type of federal subsidy or grant, they also need to be registered in compliance to FSA regulation. The fact of the matter is that most farmers have been experiencing great changes in their financial obligations over the past decade, as global oil cost have been increasing steadily, therefore impacting their overhead cost of operation. When governmental subsidies are injected into the system, farmers really have no choice except to voluntarily enter into a governmental contract, whereby these funds can help offset their obligation to petroleum based products such as diesel fuel. This section provides an overview of some of the agricultural programs that are currently being implemented in the study area, as well as, answer research sub question 1.

Conservation Stewardship Program (CSP)

The CSP is a voluntary governmental program that was set up *"to encourage producers to address resource concerns in a comprehensive manner by undertaking additional conservation activities, and by improving, maintaining, and managing existing conservation activities"* (Farm Bill 2008, 2010). This program can be considered as a type of reward program that designates producers that go above and beyond current stewardship activities. In doing so, CSP allows farmers to develop a five year contractual agreement for improvement on agricultural BMPs in return for financial incentives. The initial prerequisites for this program spotlights farmers who are currently attempting to implement some sort of management practice, but could increase their effectiveness with additional support or incentives. The overall objective of CSP is to provide landowners with the tools, technically and financially, to implement stewardship practices in improving soil, water, air, and natural resources quality throughout the nation. For example, the usage of mulching to provide vegetative residue and soil structure might be implemented through an agricultural area, but its effectiveness might be weak because of a lack of a specific piece of equipment. The CSP program would identify this weakness and develop an approach to increase residue management through other means, such as cover crops, contouring or less invasive tillage practices.

Environmental Quality Incentives Program (EQIP)

The environmental quality incentive program (EQIP) "*provides primarily cost-sharing assistance, but also technical and educational assistance, aimed at promoting production and environmental quality, and optimizing environmental benefits"* (Conservation Programs Manual, 2003). This program allows farmers to receive up to $300,000 dollars of financial assets to implement conservation plans. These plans are developed through the assistance of the NRCS representatives, which focus on identifying environmental targets in mitigating agricultural impacts. As the CSP is focusing on providing incentives through BMP improvement, EQIP provides farmers with the ability to offset the cost to purchase equipment that provides conservational improvements. During the interview process for this project, one of the interviewees stated the following: "If I would give you my entire farm for free, but made you purchase my equipment. Then you would be over $200,000 in debt just on the equipment alone." This line of thought is important to understand, as the EQIP program is attempting to bridge the cost of environmental conservation with agricultural equipment subsidies.

Highly Erodible Land Policy

The highly erodible land policy (HEL) is a program that has indentifies agricultural areas throughout the nation that are suspected in having excessive agricultural erosion. This program is mandatory with the enrolment of benefits that are received through USDA. According to the NRCS "*All persons that produce agriculture commodities must protect all cropland classified as being highly erodible from excessive erosion*" (NRCS). On the other hand, if farmers were not enrolled into any USDA programs, they could supposedly over produce and degrade their cropland without any regulatory consequences. As the HEL program is used to classify the locations of high agricultural erosion, it also works in conjunction with the Conservation Reserve Program (CRP) that is used to take HEL areas out of agricultural production for a specific amount of time.

Conservation Reserve Program

The conservational Reserve Program is a "*share cost and rental program"* (FSA, 2011), which identifies agricultural areas that have a high erodibilty and convert these locations out of agricultural usage. As the HEL was mandatory for any USDA subsidies the CRP program provides farmers with cash incentives to not cultivate these areas. Throughout my research this program can be considered as one of the most important federal program implemented in managing soil conservation. Normally CRP contracts span over a 10 year duration, which allows the soils to regenerate back to an improved condition. When speaking with one farmer, he mention that when he was younger his HEL section of his farm was always developing erosion problems, but due to the CRP program this land has improved significantly. Additionally his CRP contract has expired, but he has no intentions to reinstate this land back into production, because of the issues in the past. Not only has his CRP contract expired, but also those contracts of his local neighbors. Unfortunately, they do not share the same point of view, as current crop commodity costs have persuaded them to re-cultivate these erodible locations.

2.8 Conclusion

This chapter outlined some of the contemporary erosion problems and practices that farmers are facing around the globe. Sub-research question 1 was answered by identifying the governmental policies that address agricultural soil erosion. Finally, a systems thinking approach has been used to identify some of the external variables that lead to excessive agricultural soil erosion. These variables were mentioned during meetings and interviews of individual agriculture producers. The following diagram reflects only a small segment of the agricultural system, but provides some of the most relevant factors that farmers are facing on a daily bases.

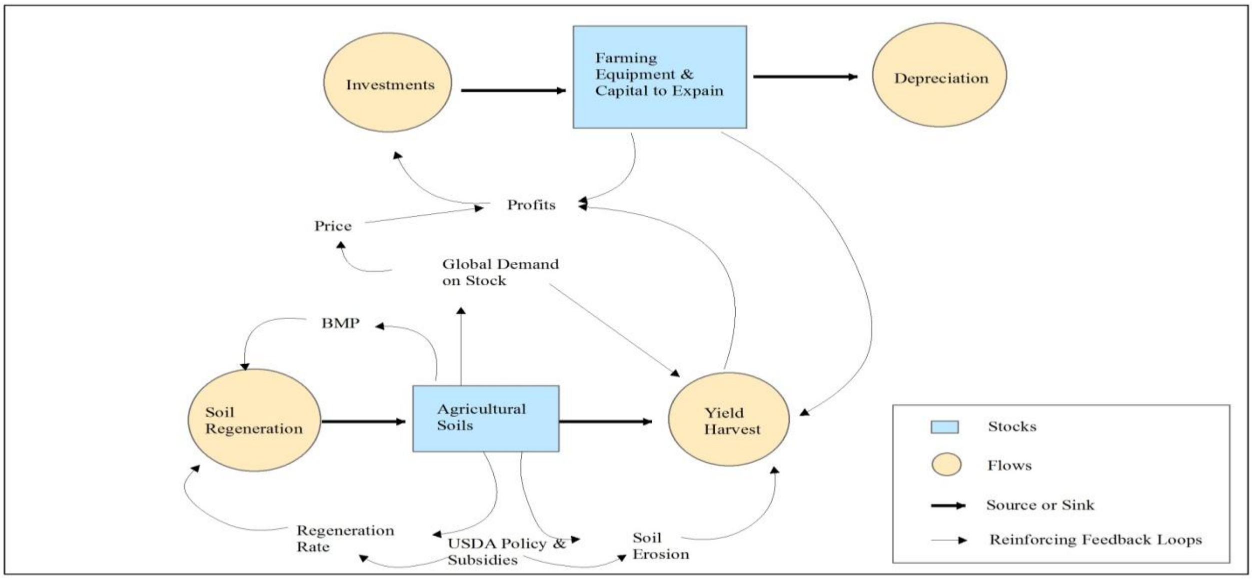


Figure 2. 5 Agricultural System Complexity by Aaron Eckert

The above diagram addresses a two stock model reflecting the farmer's equity (Equipment and Capital) and agricultural soils. The agricultural soil is the principle stock in this figure, as it is dependent on two major flows in and out of this stock: soil regeneration and harvest. Two reinforcing feedback loops addressing soil regeneration are the human and natural capacities to rebuild and maintain the agricultural soils. These two feedback loops, provide balancing loops for the harvesting sink. The harvesting flow is much more complex, as the equity of the farmer's business is directly related to the level of his production. Assume that a farmer's harvest surpasses the soil's natural carrying capacity, due to the fact that global food demands are higher than ever. This overproduction, year after year, would slowly marginalize the farmer's soils to such an extent that he would need to invest into larger equipment, increase chemical treatment or purchase more land in order to meet their previous production levels. This situation could lead to an additional overproduction of the farmland, as profits are needed to maintain the depreciation of the farmer's equity stock. As a consequence of excessive production, a possible overshoot of the soil stock could occur, if the farmer would maintain this level of production. To attempt to mitigate this scenario of collapse, governmental interventions, such as CRP, CSP and EQIP are introduced to increase soil regeneration and slow down erosion that was produced through overproduction. This situation is not only found within the agricultural sector, but these phenomena occur around the globe in numerous sectors with renewable resource, such as forestry and fisheries.

Chapter 3: Literature Review – Theory

3.1 Introduction

This chapter addresses the academic research and publications reflecting on both the theories and implementation of models used within this report. The majority of the theoretical concepts utilized throughout this thesis reflect on the current developments of Social Network Analysis (SNA) to expand on the empirical data towards answering the central research question. SNA emphasizes on the structure of actors within an organization or governance arrangement to determine the organizational capacity to develop solution for specific problems. The academic research regarding SNA from Sandström and Rova is utilized within this report to analyze the network structures from two farming communities within the state Utah, which can help to determine their ability to derive solutions for preventing agricultural soil erosion.

3.2 Social Network Theory

Sandström and Rova's work focused on the ability to analyze networks, in order to receive a better understanding of the governance arrangement's capacity to develop solutions towards environmental problems. In the USA the Environmental Protection Agency (EPA) and the US Department of Agriculture (USDA) have developed policies regarding agricultural runoff pollution. These onsite and offsite pollutants can be categorized as follow: Fertilizers, Pesticides, and Erosion. Unfortunately, the developed policies cannot provide a one fix solution for the whole nation, as the USA is divided into various climatic regions from high desert to temperate rainforest. Hence, even when environmental policy attempts to mitigate environmental degradation at a national scale, the lack of local expertise prevents a comprehensive policy to be implemented at a national scope. As Sandström and Rova mentioned, the ability to identify network structure can be used to determine if the governance arrangement is addressing the problem appropriately, as mention in the above statement "the *network structure is assumed to affect the behaviour of the individuals and the quality of their interactions, consequently affecting the institutional arrangements regulating resource use*" (Sandström and Rova, 2010 p. 529).

Social Network Analysis allows researchers to examine how individuals and governments work towards solutions for complex social and environmental problems. In the past these complex problems were addressed through a linear way of thinking that often lead to a misinterpretation in devising solutions. The use of SNA can provide policy makers with an increased understanding on how stakeholders work together in deriving collective action and developing outcomes. Sandström and Rova's research identifies two key independent variables, Network Closure and Network Heterogeneity, which can be used to determine the dependent variable of the network. As mentioned in Chapter 1, this project focuses on agricultural soil erosion and how individual actors develop solutions in preventing erosion. Therefore, the dependent variable addresses the local farming communities' ability to develop solutions towards preventing soil erosion and preventing onsite and offsite externalities, while the independent variables address the network's characteristics, which are described below:

Network Closure

Understanding the network closure is an essential step in determining how the stakeholders within an organization are arranged to distribute knowledge and resources among each other. To analyze the network more closely, network closure is broken down into *density* and *centralization.* "*Density refers to how many connections the structure is comprised of and centralization to what extent these connections are indirectly channeled through a single actor, reflecting the level of hierarchy within the network*" (Sandstorm and Rova, 2010 p. 534). Referring back to the USDA, they are most likely to have a very high density of actors, as being the national regulatory authority. On the other hand, they might have a much lower level of centralization, as other actors found within the network could provide the goods and services that the Government cannot.

In order to calculate the *density and centrality* of a network, it is first needed to understand a few key basic concepts in SNA.

Node: A node can be considered as any actor found within the network. For example, if a network is concerned with agricultural sustainability then individual farmers, government organizations, universities and anybody else affiliated with the network can be considered as a node. Throughout the empirical section of this thesis, both individual actors and organizations are considered nodes within this network. In determining if a node is affiliated within the network, a snowball data collection method has been used to gather associations among actors. This method was implemented and continually more nodes were added to the network as they were unveiled through the interview process.

Links: Links determined a connection between the individual nodes. For instance, if a network was constructed from five nodes then there is a total possibility of 10 links between all of the actors. In this thesis a link represents a bidirectional transfer of knowledge or resources, therefore both actors have the same level of connectivity between each other. SNA could become much more complex when analyzing the directional transfer of resources, but due to the scope of this project, directional linkages have not been evaluated.

Network density can be considered as the simplest indicator in evaluating network closure. The theory assumes that denser networks have higher levels of interconnectivity and closure among the individual actors.

To calculate Network Density the following formula is provided through the research of Sandström and Rova: $L/(n(n-1)/2)$

- L = the number of links
- n = the number of nodes

In order to calculate the final network density, the total possible amount of links that could be derived from the nodes have been divided by the actual amount of connections that were recorded during the interview session. Figure 3.1 displays a network that has a very low level of density of 25%, as there are a total of 27 bidirectional linkages between the nodes of the network. These 27 links were then divided by the actual number of connections (7) in the network; hence, figure 3.1 has a density of 25% or .25d.

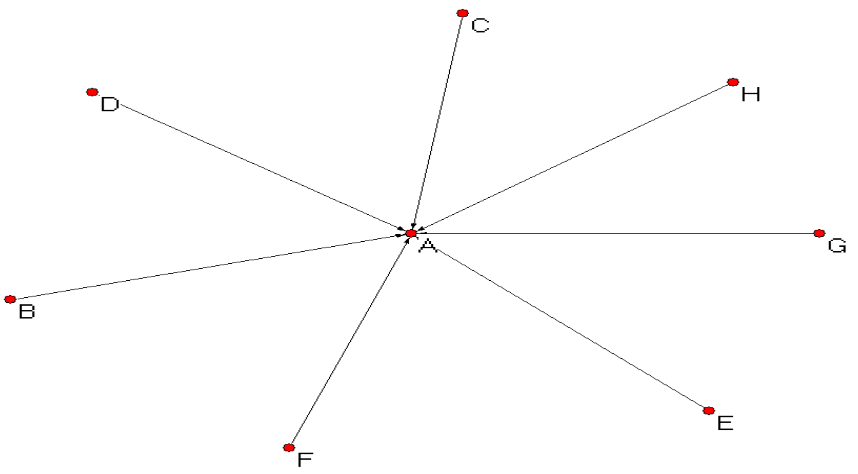


Figure 3. 1 Network Example by Aaron Eckert

As density focuses on the total amount of connections in comparison to the actual connections of actors, the **Network Closure** reflects on how information and resources are passed throughout the network. Sandström and Rova identified two variables, which reflect on the level of Network Closure: Degree of Centrality and Betweenness.

Degree of centrality is best described as how actors within a network interact among each other. To explain this concept Sandström and Rova mention that the "d*egree centrality considers the numbers of direct links to and from an actor, giving the actor with the most links the highest centrality score"* (Sandström and Rova, 2010 p. 536). An actor that is located in this position is provided with the opportunity of extensive access to knowledge and/or resources. These positions of higher degree of centrality tend to identify locations of hierarchical organizations and/or extensive resources within a network. To explain this more in depth figure 3.1 will be addressed again. Actor (A) finds himself in a location of a 100% degree of centrality. This means that every actor within the network has the ability to contact actor (A) for assistance. Normally the degree of centrality is calculated at the total network level. This indicator is very import in evaluating which actors collaborate with other actors for disseminating knowledge across the network. To demonstrate centrality, a simple question is asked: is there the ability for (B) to contact actor (C)? In the network structure of Figure 3.1, there is no way for (B) to directly associate himself with (C).

As centrality is concerned with the direct links between actors, **betweenness** represents how knowledge is transferred between actors. Reflecting back on figure 3.1, all knowledge and resources have to be transferred through actor (A). Let say that actor (D) needs to contact actor (E), at the current network structure it is impossible for these individuals to go directly to each other. Therefore, actor (A) controls what information and resources that are being passed between actors. Actor (A)'s position is considered as a broker within the network and could exploit this position to steer results in his favor, as actor (A) controls the flow of assets of others. Actor (A) has 100% betweenness and the network is great disabled, due to this situation. Networks that have a lower level of betweenness have an increase of connections between actors and can circumvent any brokers found within the systems.

It is also of high relevance to take **network heterogeneity** into consideration, since it focuses on "*the diversity of actors involved in the process and their level of cross boundary exchange."*(Sandström and Rova, 2010 p.536) As furthered mentioned by Sandström and

Rova, heterogeneity can have both positive and negative effects on the development of networks. Networks that find themselves too diverse may have difficulties in coming to a conclusion, but do tend to have greater resources towards developing knowledge and expertise. The more homogeneous the actors are, the higher chance they have to collectively come to an agreement on how to address a problem, but may also lead to shortcomings, knowledge gaps or one sidedness in the decision making process. This thesis clearly points out that heterogeneity of networks can be a great asset in evaluating where the strengths and weaknesses of governance arrangements lay.

3.3 Modes of Networks

In order to assess the success within networks, Provan and Kenis developed an understanding of how the individual network structures represent the types of governance arrangements. These characteristics are beneficial when evaluating the research area, with the aim to determine how the solutions were derived for managing agricultural soil erosion. The forms of network structures that Provan and Kenis identify within their work are the following: Participant-Governed Networks, Lead Organization–Governed Networks, and Network Administrative Organizations.

Participant-Governed Networks

Participant-Governed Networks are arrangements of interest members that collectively organize, manage and develop decisions focusing on collective action problems. These types of governance networks do not fall under a specific governance organization, such as international regimes. However, these arrangements do have some sort of structure in the organizational and problem solving capacity. According to Provan and Kenis, "*participant-governed networks can be highly decentralized, involving most or all network members interacting on a relatively equal basis in the process of governance*." (Provan, 2007 p. 234) In order to manage these forms of networks there is an extreme importance on the member's obligations to work on the issues of concern and to provide a source of commitment towards other members. The relevance of these commitments is essential, since there is a lack of a central organization in the steering of the governance arrangement.

Lead Organization–Governed Networks

Lead Organization–Governed Networks are governance arrangements that differ greatly from Participant-Governed Networks by the means of how the stakeholders are managed. In these networks "*all major network-level activities and key decisions are coordinated through and by a single participating member, acting as a lead organization.*" (Provan, 2010 p.235) The lead organization manages the networks goals and objectives by a more centralized approach. This type of approach is becoming more relevant throughout the world; a good example of this is Unilever and their push for sustainable palm oil. In this governance arrangement Unilever is the main source for change and without them the governance would not have the ability to manage and organize sustainable issues as it does today.

Network Administrative Organizations

Network Administrative Organizations are much different than the previous two network structures, as there is one independent entity that governs the network from outside the governance arrangement. This means, there is an organization that is a facilitator in how the networks must operate, providing mandates in other organizational criteria. This actor could be a government entity, private company or even a nongovernmental organization that works as a second party in network development.

Key Predictors of Effectiveness

Key Predictors of Effectiveness are found within each of the three forms of network governance, Provan and Kenis identify four key variables that can be used to "*predict the successful attainment of network-level outcomes, or what some have referred to as network effectiveness*" (Provan,2010 p. 236). These variables are the following: Trust, Number of Network Participants, Network Goal Consensus, and Network-Level Competencies. Throughout the work of Provan and Kenis, these variables are extremely important in their theory on network effectiveness.

3.4 Collective Action

In an initial analysis towards the understanding of collective action problems, Garrett Hardin, in 1968, developed the concept of the *Tragedy of the Commons*. The analogy that he used, displayed how an open access resource (community pasture) was unintentionally exploited (too many animals/over grazing) by the community; therefore, leading to a degradation of resources and a net loss to the community. This theoretical concept gained great interest within the academic community over the next 20 years. According to Hardin's work, human rationality would maximize short term material benefits towards self-interest. Therefore, he developed two key concepts in order to avoid the *Tragedy of the Commons,* whereby privatization and external governing was needed to prevent ecosystem collapse. This was based on the idea that local communities could not collectively govern common pool resources.

In the early 90's Eleanor Ostrom published her findings in the *Governing of the Commons,* where she concluded that Hardin's analysis was not completely accurate. Through her investigation she noted that collective action arrangements allowed people to construct institutions that could result in the sustainable resource management without negative consequences. Ostrom therefore provided some common variables that could be used to explain why certain institutions were developed towards managing the commons. The following are her observations:

- *The feasibility of improving the resource*
- *Available information about the resource*
- *Predictability of resource flows*
- *Relatively small spatial extent of the resource*

(*Ostrom, 1990.*)

In conjunction with the actual resource's variables, Ostrom also identified characteristics about the individual resource users and communities. The following variables are:

- *The majority of appropriators dependent on the resource system*
- *A shared understanding of the resource system*
- *A long-term view of Common Pool Resource benefits*
- *Trust and norms of reciprocity*
- *Autonomy to organize*
- *Prior organizational experience and leadership among the community*

(*Ostrom, 1990.*)

These variables that Ostrom points out are not only relevant in the Institutional Analysis and Development (IAD) Framework, but they also overlap many of the aspects that are implemented in SNA. For example, *access to information* and *autonomy to organize* reflect on the network closure, as well as *shared understanding* and *trust reflects* the network heterogeneity.

3.5 Conceptual Model

The conceptual model, Figure 3.2, utilized in this report reflects a Social Network Analysis framework outlined in section 3.4. This approach in analyzing the attributes of the network to determine its ability to derive solutions is displayed in the conceptual model below. SNA identifies the independent variables bases off from two key network characteristics: Network Closure and Network Heterogeneity. These two variables provide an understanding on how actors of a governance arrangement address specific problems. Sandström mentioned that a high level of Network Closure demonstrates the prioritization of the organization and its ability to improve the efficiency among stakeholders (Sandström 2008 p.103). Network Heterogeneity addresses the access of resources among members, as well as, their ability to derive knowledge from different points of views (Sandström 2008 p.103). When these independent variables are present within a network, they influence the dependent variables, levels of soil erosion that are interconnected to the intensity of onsite and offsite externalities

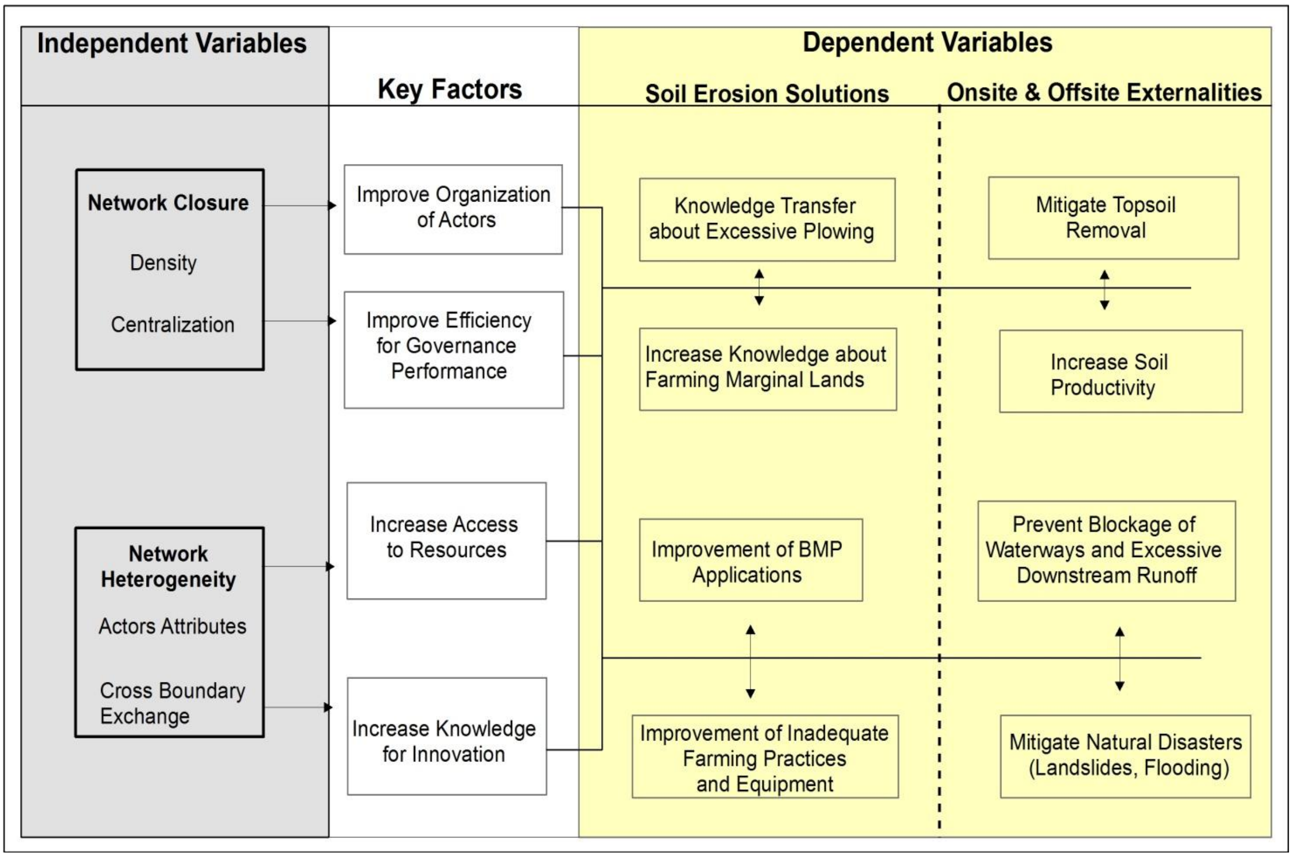


Figure 3. 2 Conceptual Model by Aaron Eckert

3.6 Conclusion

Identified in the previous sections of this chapter are the theoretical concepts that are used in this report. As this thesis focuses on agricultural soil erosion, it also reflects on how a social network analysis can be used to identify how the actors work towards solutions for sustainable practices. To approach the problem of sustainability accordingly, the following hypothesis from Chapter 2-3 of this report has been developed.

If governing networks addressing agricultural soil erosion are both dense and centralized on the one hand, but heterogeneous on the other, *then* these network arrangements are more likely to engage in forms of adaptive governance, therewith enhancing their potential effectiveness for sustainable agriculture.

This hypothesis is based off from the literature that was outlined in the earlier sections of this chapter. The main aspects of this hypothesis reflect on the work of Sandström and Rova to provide an initial understanding of SNA. The Additional literature from Provan, Kenis and Ostrom has supplemental overlap in the areas of network theory and collective action. Therefore, their publications have been utilized throughout this report.

Chapter 4: Research Methods

4.1 Research Locations

Throughout this chapter the second research question has been answered in identifying "*What areas in the State of Utah have a high probability of agricultural soil erosion?"* In developing the methodology to identify the research locations, this project conducted a geographical information systems analysis of the whole state of Utah at a 30 meter digital elevation model (DEM) resolution. This DEM in conjunction with state landuse and soil datasets were used to calculate the underpinning variables outline by the RUSLE 2 model. This analysis selected the two counties with the highest amounts of erodible agricultural lands. In Chapter 2, it is explained that the RULSE 2 model (A=RKLSCP) is used to calculate the total amounts of soil detachment, transportation and deposition during erosion events. For the scope of this project, the RULSE2 model has been solely utilized to pinpoint the locations of interest, but not to calculate erosion values. After identifying the two research counties, this process was repeated at a 5 meter DEM resolution to receive an accurate evaluation at the individual landowner level. The following processes and GIS methodologies are explained below.

Rain Fall (R)

The amount of rainfall is used to calculate a precise model in determining the total level of erosion capacity. As mentioned above, this model has been used to pinpoint areas of concern, rather than establishing total runoff levels. Therefore, rainfall has not been calculated in this report as its computation wouldn't affect the analysis' outcomes.

Topography (LS)

A digital elevation model (DEM) is a raster representation of the earth's surface that provides XYZ coordinates that signify the latitude (X), longitude (Y) and elevation (Z) of the earth's topography. Raster dataset are created through the usage of individual pixels that represent a specific element on the map. For example, in a 30m DEM one pixel or cell represents a 30m by 30m area that is characterizes a precise elevation. Figure 1 in the appendix provides an example of a raster dataset displaying the XYZ values found in a DEM. This data can be collected in numerous ways, such as ground surveys, aerial photos and/or remote sensing through satellite technology. The 30 meter DEM that was utilized in this project was derived from the US Geodetic Survey's (USGS) National Elevation Dataset program (NED).

This DEM alone does provide great insights on the characteristics of Utah's topography, but the DEM needs to be recalculated to evaluate the slope variables used in the RULSE2 model. This function is calculated by an elementary mathematical formula of Pythagorean Theorem ($a^2 + b^2 = c^2$), which derives a slope evaluation of the entire state. Additionally, by calculating the slope, the length is also predefined, as the hypotenuse is also derived from the above equation. In Figure 2 in the appendix an example of slope model displays the deviation between high and low slope areas through a calculation conducted by a GIS surface analysis.

Soil Type (K)

The characteristics of soil composition of agricultural lands are extremely important in understanding how a specific area is more vulnerable to erosion than others. As mention in chapter 2, soil texture, particle size, permeability and porosity, and organic material all work together in outlining exactly how much a rain event would affect the soil conditions. The dataset used to verify the soil conditions consist of a digital soil survey provided by the USGS, which was developed in June 2009.

Landuse (C)

The national land cover dataset integrates the usage of satellite remote sensing technology over a five year period in determining the changes in US landuse practices. This dataset finalized the overall locations of my research areas and my interviewees, as it establishes identifiable agricultural areas throughout the state. The support practices (P) category of the RUSLE2 model cannot be determined during an initial selection of the research areas, as there is no such datasets currently available for public use. Therefore, the support practices have not been evaluated in determining the research areas but are addressed at the individual interview segments.

Composition of Data

The final step of this process brought together all the spatial dataset into one analysis. This analysis process firstly eliminated any locations that were not considered as agricultural lands. These areas were evaluated by a Boolean analysis, which processed the variables to locate only the agricultural locations and remove the rest. The Agricultural areas were then reclassified to a numerical value of 200. The value of 200 was calculated for the final selection of the agricultural lands.

The second step was to identify and provide all of the soil types in the agricultural areas with a distinct variable that represent the soil's erodible characteristics. In chapter 2 soil classes were explained and provided an in depth description of soil attributes. These soil types were reclassified based off from their level of erodibilty: Low (value 10) Medium (value 20) and High (value 30). Low classification types are soil types with gravel and stony elements. These soil types are very difficult to erode because of the rocky structure that prevents excessive splash erosion. Medium classification types are soils that have a clay component in their composition, as mention in chapter 2 clay particles are much smaller and provide a dense structure that are less prone to erosive events. In the high erosive classification, are the compositions of loamy and silty soils that have fine but loosed soil particle structures, which are easily detached through splash and sheet erosion processes.

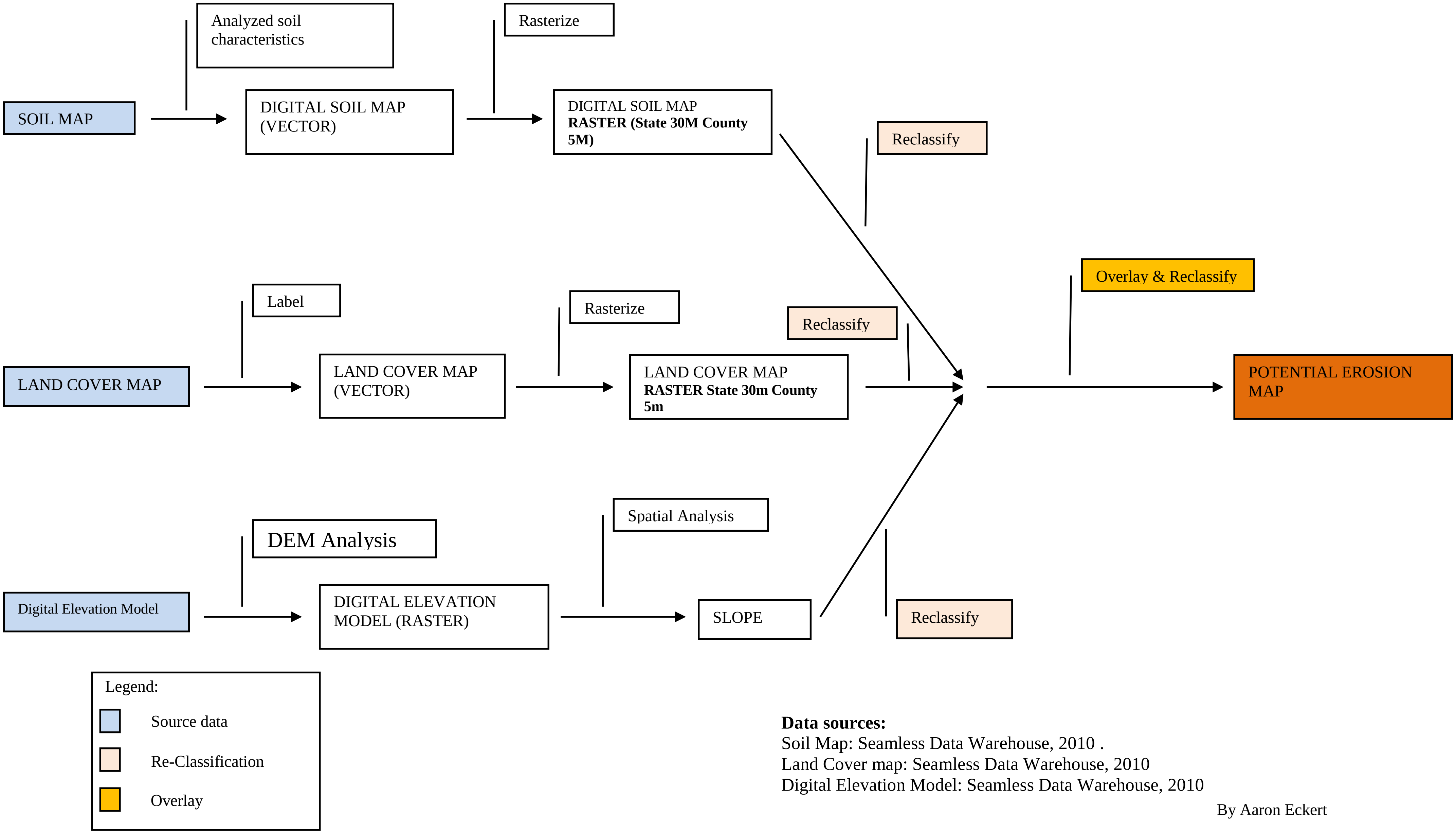
The final analytical process reclassified the topographical terrain features based off from the slope characteristics found within the in the agricultural areas. According to De Roo, agricultural locations with slopes greater than 18 percent slope render the characteristics of highly erodible lands. Therefore, all slopes exceeding 18 percent that are located on agricultural lands with highly erodible soil classifications have been pinpointed within the project's methodology section. The final slope product reclassified slopes as: Low 0-10% slopes (Value 1), Medium 10-18% slopes (Value 2), High > 18% slopes (Value 3). Table 4.1 provides a breakdown of the erodibilty classification and the locations that has been used for the selection criteria of the case study areas.

<u>Flow Chart of GIS Design</u>

Figure 4.1 provides an in depth description of the methodology used in locating the research counties and interviewees. In the flow chart there is some GIS terminology that needs to be clarified to completely comprehend the overall process. Normally GIS data is extracted from a data source in an ArcGIS shapefile or raster format. These shapefiles are composed of points, lines and polygons that represent specific object on the surface of the earth. For example, a road will be represented by a line, a house by a point and a city park by a polygon, these types of data are also known as vector data. The reason why most GIS datasets are used in a vector format is because these data files can maintain a large database (attributes) of information with normally little computer memory. In addition to vector, GIS programs also perform analysis with raster data. Raster datasets are constructed of pixels, i.e. digital

photography, and normally cannot maintain large attributes tables of information and tend to consume significantly more memory for processing.

The below flow diagram indicates the term “Rasterize”, the definition of rasterize in this report signifies that an ArcGIS shapefile has been transformed from a vector format to a raster format. “Reclassifying” is the process that transforms the core description of a raster element, i.e. soil type, landuse, into a numerical value. For example, the raster slope model produced millions of pixels based off from the calculated value of the slope; to be able to analyze the values greater than 18% it is necessary to combined all of these values into one category. The last term to be defined is “Overlay”. Overlay is a process of calculating all the values together in order to receive an end result. To conduct this process, this project utilized the raster calculator function to add together all the key variables mentioned above. The final result produced a numerical value that describes the exact properties of a specific location. For instance the value 123 represents: 100 – Non Agricultural land, 20 – Soils with a higher proportions of clay content, 3 – Slopes over 18%. The example of 123 would have been removed from the list of selected locations, because it doesn’t represent agricultural lands, which is indicated by the 100 Value.



Data sources:
Soil Map: Seamless Data Warehouse, 2010 .
Land Cover map: Seamless Data Warehouse, 2010
Digital Elevation Model: Seamless Data Warehouse, 2010

By Aaron Eckert

4.2 Selection of Research Areas

To perform the final selection for indicating the two research counties, this project conducted a map algebraic equation with the raster calculator function, which added all the spatial variables together. The maximum value of 233 was used to determine the total area per county that has the highest percentage of erodible land. The results of the analysis are displayed in table 4.1. The table identifies the statewide values and their characteristics, based off from the scores provided though the raster analysis.

Some key characteristics that have been portrayed by this analysis are:

- Rocky/Gravel soils classifications consist of the least amount of agricultural production.
- The majority of Rocky/Gravel soils are cultivated on lower slopes.
- The majority of clay based soils are cultivated on lower slopes.
- Highest amount of Agricultural production is found on soils with erosive characteristics (Score 231) but moderately flat slopes.
- Statewide agricultural lands with highly erosive soils on the steepest slopes consist of an area of 1060 Acres (428 Hectors).

Table 4.1 Description of the total statewide scores for the agricultural areas.

State Score for Agricultural Areas	Description	Total Amount of 30 x30 Meter Raster Cells	Percent (%) of Agricultural lands
211	Agricultural Lands, Erosive Soils Low, Slope Low	519,563	7,59
212	Agricultural Lands, Erosive Soils Low, Slope Medium	22,489	0,33
213	Agricultural Lands, Erosive Soils Low, Slope High	2,808	0,04
221	Agricultural Lands, Erosive Soils Medium, Slope Low	1,447,308	21,15
222	Agricultural Lands, Erosive Soils Medium, Slope Medium	5,240	0,01
223	Agricultural Lands, Erosive Soils Medium, Slope High	295	0,004
231	Agricultural Lands, Erosive Soils High, Slope Low	4,803,865	70,20
232	Agricultural Lands, Erosive Soils High, Slope Medium	41,585	0,61
233	Agricultural Lands, Erosive Soils High, Slope High	4,765	0,07

Table 4.1 GIS Erosion Scores by Aaron Eckert

Upon the completion of the state erosion model, each county was quantitatively assessed to determine the total raster score values demonstrated in the above table. In table 4.2 are the top five counties consisting of the largest areas of possible agricultural soil erosion.

County	Total Cropland per county (Acres)	Total amount of **Harvested** Cropland (Acres)	Total **Raster Cells** with Score of 232 (Medium Erosion)	Total **Acreage** of Score of 232 (Medium Erosion)	Total **Raster Cells** with Score of 233 (High Erosion)	Total **Acreage** of Score of 233 (High Erosion)	Ranking
Box Elder	327,695	137,779	7,950	1,768	277	61	2
Cache	143,716	100,999	18,154	4,037	1,106	245	1
Millard	153,728	96,473	203	45	22	4	5
Sanpete	98,230	54,929	730	162	51	11	4
Utah	117,766	72,335	1,470	326	57	13	3

Table 4. 2 Top 5 Counties with Erodible Agricultural Land by Aaron Eckert

After the initial statewide analysis Box Elder County and Cache County both displayed the largest areas of highly erodible agricultural lands. In table 4.2 are the results of the final analysis that determined the selection of the research counties.

During this investigative process two assumptions were made that could be used to scrutinize the methodology in identifying the research areas and locations of erosion probability.

Assumption 1: The GIS datasets used in this project (Elevation, Landuse and Soil Type) maintain a verifiable accuracy. Therefore, the data source is being used as an absolute truth, since it has been provided by the US Government and meets all Federal guidelines for spatial data accuracy.

Assumption 2: The GIS datasets that are being used maintain the most current and actual features represented in the erosions model. Hence, the landuse and soil classification features are current and there have been no changes throughout the state since the establishment of these datasets.

One area where this GIS analysis might be scrutinized is through a comparison of total acreage of actual agricultural lands in comparison to the output areas of the erosion model. These areas could not completely indicate the precise area, due to the fact that the raster cell size of 30x30 meters is a very rough element. Although, a more precise model, at a smaller raster resolution, would have significantly increased accuracy, due to time constraints and computer capacity a smaller cell size at the state level was not feasible for this project. In order to address the raster resolution, this project did not use the result from the state level analysis to indicate the specific areas of erosion at the county level. Hence, a five meter DEM has been implemented to increase accuracy in assessing erosive areas in both Box Elder and Cache County.

4.3 Selection of Interviewees

In selecting both Cache and Box Elder County as the research areas of the state, the GIS analysis was relatively straightforward in determining the landuse, slope and soil in conjunction with 30 meter raster cell size. The reason for this was because the scope of the state was too large to analyze the agricultural lands at a finer level. When working at a county level to determine the actual property landowners then it is necessary to evaluate the county at a higher degree of accuracy. Therefore the raster cell size for the county analysis is at a 5m cell resolution. Figure 3 in the appendix displays the locations of where the erosion is occurring, however, there is no information on the landowners. In order to receive such information, an authoritative property appraisal dataset, provided by each county GIS office. This dataset can be considered as the final piece in verifying the report’s interviewees in researching the networks of actors involved in managing soil erosion events. With the combination of the erosion model and property dataset the final target audience was revealed, indicating that both Cache and Box Elder counties consist of numerous agricultural areas with possible erosion concerns. The final analysis pinpointed 958 properties in Box Elder County and 586 properties in Cache County; due to the large selection of actors this project utilized a random value generator to select the 50 landowners in order to eliminate any concerns of biasness. Unfortunately, this project was conducted during the summer months, whereby the majority of farmers were occupied. Therefore, from the initial 50 farmers selected, only 15 individual structured interviews were conducted per county.

Throughout the state of Utah, a GIS analysis was conducted to determine the locations of agricultural soil erosion. This analysis was used to identify the two counties with the highest amount of possible agricultural erosion, answering the second research question. Box Elder and Cache County were identified and this analysis displays that there are great deviation between the amounts of erosion in the top two counties in comparison to the rest of the state. This erosion analysis was repeated at the individual county level, which has indicated that hundreds of locations with possible erosion concerns and identified the project target audience.

4.4 Operationalization of Research Variables

The operationalization of the independent and dependent variables in this thesis are based off from the literature outlined in Chapter 3. To test the validity of my hypothesis, a comparative case study reflecting the two farming communities was designed. The underlining dependent variables indicate the sustainability of agricultural practices, as the network structures can be used to identify more than erosion problems, but also reflect on the actors' ability to prevail over additional social, economical and environmental dilemmas to come.

Independent Variables

In the literature review, the theoretical concepts of SNA were identified through the work of Sandström and Rova that shed some light on the variables that needed to be operationalized within the network. These characteristics of Network Closure and Network Heterogeneity have an effect on the networks ability to learn, adapt and develop solutions for soil conservation practices.

Network Closure

The information regarding network closure was collected to indentify the *density* and *centrality* of the agricultural networks. This information was obtained through interviews, meetings, and conferences within the research areas. During the semi structured interviews, a standard set of questions were used, which addressed the following: organizational affiliations and actors, knowledge building, knowledge transfer, community leaders, and technological developments and innovations. These results are displayed in the following chapter, as each individual interviewee provided answers that focused on the specifics of network structure. The answers were compiled and provided a total list of stakeholders, which were evaluated by the methods outlined by Sandström and Rova.

- Density is calculated by dividing the number of connections present in the structure by the maximum number of possible connections (Scott 2000, 71).

- Centralization is represented by the *numbers of direct links to and from an actor, giving the actor with the most links the highest centrality score."*(Sandström p. 534)

Network Heterogeneity

Network heterogeneity represents the diversity of members within the network; therefore "*the number of links connecting actors with different organizational belongings is divided by the total number of links in the network*." (Sandström and Rova p. 535). In this research the heterogeneity of the network's stakeholders is reviewed by determining the actors place within society, such as market, government, or civil society.

Dependent Variables

Upon analyzing the independent variables, the dependent variables were then analyzed to determine if there is a casual correlation between network structure and the solutions made towards preventing agricultural soil erosion. In order to minimize bias from this research, the GIS analysis was used to select the interviewees, as well as created a random sample from all of the possible candidates. During the semi structured interviews specific questions were implemented to identify the onsite and offsite externalities, caused through excessive soil erosion. The questions addressed knowledge transfer, BMP improvements, and techniques for increasing soil productivity, preventing of onsite and offsite runoff and limiting natural disasters caused by improper management schemes. Furthermore other meetings and conferences gave supplemental feedback on how the individual producers develop soil conservation solutions, through the interactions of other stakeholders. An additional support to validate this research is through the implementation of National Agriculture Imagery Program (NAIP) to identify if soil erosion and on and off site externalities are actually occurring on the interviewee's land. Table 4.3 displays the matrix that is implemented to point out the underlining indicators reflecting on agricultural soil conservation.

Agricultural Soil Erosion	Level	Onsite and Offsite Externalities	Level
Transfer of Knowledge Between Stakeholders	High	Mitigate Topsoil Removal	Med
Ability to Increase Knowledge	High	Increase Soil Productivity	Med
Ability to Improve on Mechanical BMP	High	Prevent Blockage of Waterways or Excessive Downstream Runoff	Low
Enhancement of Agricultural Practices and Equipment	Med	Prevent Natural Disasters	Low

Table 4. 3 Example of Dependent Variables by Aaron Eckert

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4.5 Methods of Data Collection

Table 4.4 consolidates the type of methods used for data collection throughout both case study areas.

Data Collection Approach in both Case Study Areas	
Method	**Interviews per Study Area**
Soil Conservation District meeting	2
Individual Semi-structured interviews	15
Conference with NRCS Office	1
Conference with FSA Office	1
Meeting with the Utah State University Agriculture Department	1
Meeting with the State NRCS Agricultural and Economical Programs Directors	1
Meeting with the State FSA Director	1
Farmers' Conference with the Sustainable Agriculture Research and Education Organization (SARE)	1
Meeting with the USU County extension Agent	1

Table 4.4 Data Collection Methods by Aaron Eckert

Chapter 5: Case Study – Cache & Box Elder County

5.1 Introduction

This chapter examines the network structure throughout Cache and Box Elder County in attempting to create a deeper understanding of the actors involved in preventing agricultural soil erosion. These case studies incorporate the theoretical stand point from Sandström and Rova in answering the research question.

In order to acquire the pertaining information regarding the network structure within Cache and Box Elder County, a combination of formal and informal interviews, meetings, and conferences has been performed. A detailed description of the different characteristics and different stakeholders pertaining to each county is explained ahead.

5.2 Cache County

5.2.1 Geographic and Demographic Conditions

Cache County is located in the northeastern mountainous region of Utah. Throughout this county, the climatic properties are portrayed by a semiarid region that acquires on average 19.1 inches of precipitation annually. (Utah Climate Center, 2011) The geophysical features of Cache County can be described as central valley religion, whereby the majority of the county's population and agricultural lands reside. The main metropolitan area and county seat of the region is the city of Logan, maintaining a population of 49,534 habitants from the total county population of 112,656 habitants (US Census Bureau, 2011). The city of Logan also provides the majority of the services for the region, since the State and Federal governmental organizations are located there, as well as the only agricultural and natural resource university in the State of Utah: Utah State University. According to the 2007 USDA Crop Census, Cache County has 1,195 farms covering a total landuse of 251,550 acres of farmland. Between the years of 1995 and 2008 the US Government invested $59,063,453 of federal subsidies in Cache County farm project, accounting for 9.9% of the state's federal funding (2007 Census of Agriculture Report, 2011). The breakdown of the federal spending is $35.8 million in commodity subsidies, $2.39 million in crop insurance subsidies, $15.3 million in conservation subsidies, $5.56 million in disaster subsidies (EWG, 2011). In addition to the above facts, the development of the region is highly dependent on the agricultural output, as mention by the Cache County Chamber of Commerce, as 23% of the area's income is generated directly or indirectly through the interaction with agricultural production (Benson, 2010).

5.2.2 Agricultural Areas

Throughout Cache County, agricultural practices are very predominating, as mentioned above close to one quarter of the county's economy relies on agricultural practices. To describe how the agricultural areas are disbursed throughout the county, there is a clear distinction between dryland and irrigated farmed regions. Normally, irrigated land can be found throughout the central region of the valley, whereby the lower elevations and lack of topography aid to the implementation of irrigation equipment. In contrast to the irrigated lands, dryland farms maintain some very distinguishing properties that characterize them with erosive traits. For example, these areas are mostly located along the mountainous slopes of the Cache Valley region, which consist of loam / silty soils classification. These locations are extremely vulnerable to erosion during the spring and the winter seasons, as the snowpack is accumulated in the higher elevations causing excessive water runoff into the valley.

5.2.3 Stakeholder Identification

In order to identify the local actors involved in developing solutions towards preventing soil erosion, a two-step procedure was undertaken. First, through a GIS analysis of the State of Utah, the two counties with the higher amount of agricultural erosion were identified: Box Elder and Cache County. A further GIS analysis with an improved resolution was performed to identify the areas of interest within each county. Secondly, once the areas were localized, in order to identify the local actors, the parcel data information connected to the areas of high agricultural erosion within each county was used. This dataset provided the initial source of information on how to contact the farmers linked to these areas. Initially, through a random sample selection, three farmers, out from the parcel data set of the previously identified high erosion areas within Cache County, were selected and interviewed with a semi-structured interview process. These interviews began to snowball together the setup of the organizations within this County. The snowball method used within this research can be defined as a technique that allows the individual actors to identify other members or organizations within the total organization (Miles and Huberman, 1994). During the preliminary stage of this process, the GIS identification of the agricultural areas proved itself successful, as the locations did portray elements of erosion. Unfortunately, two of my initial three selected interviewees passed away previous to the research project and the property appraisal datasets were not updated accordingly. In addition to the loss of these two individuals, a similar circumstance reoccurred three more times during the field research, as well as, two individual who refused to cooperate with the interview process. These initial interviews developed a conceptual understanding of the agencies and actors found within the organization.

During the initial stage of the field investigation, the organizations listed below were contacted and semi structured interviews were performed to identify the specific traits and roles of the individual organizations throughout the network. A detailed description of the contacted stakeholders for each county follows.

5.2.4 Cache County Local Actors

In Table 5.1 is an example of the organizational stakeholders found within the research area. Within this section the listed stakeholders have been addressed, in order to provide a good description of the organizational affiliation within the network.

Governmental Agencies	Non Governmental Agencies	Individual Actors
Blacksmith Fork Conservation District	*** Sustainable Agriculture Research and Education Organization** (S.A.R.E)	USU County Farm Extension Agent
Farm Service Agency (FSA)	***Utah Farm Bureau**	***Local Agricultural Equipment Vendors**
Natural Resources and Conservation Services (NRCS)	Utah State University (USU) Agricultural Department	***Local Individual Farmers, Neighbors and Family**
North Cache Conservation District		

Table 5. 1 Cache County Organizations by Aaron Eckert

The actors that are indicated with an asterisk (*) are members that were introduced in later interviews or through meetings with the above organizations.

<u>Blacksmith Fork & North Cache Conservation Districts</u>

The Utah Soil Conservation District is composed from a mixture of governmental and nongovernmental actors, who work together in organizing farm related activities. The fundamental concept of this organization is to impose the expert knowledge of local farmers with the organization and fiscal support of the local, state and federal governmental agencies.

The Soil Conservation District is comprised of a locally elected board of officials that oversees all governmental supported programs, in order to determine the feasibility of their success. Both districts meet monthly to vote on sustainable procedures and individual projects. For example, if a farmer would like to enroll his land into a federal or state agricultural program, the local NRCS office would first conduct a feasibility report to identify if the land actually meets the governmental requirements. After the NRCS has approved the applicant's request, the individual farmer would present his case to the Soil Conservation Board for the final endorsement. Although the federal and state governments are providing the financial subsidies for these programs, the final word belongs to the Soil Conservation District's Board, whose member can take a stand on an agricultural issue with limited persuasion from governmental actors.

Farm Service Agency: Logan, Utah Office (FSA)

The organizational structure of the FSA will be promptly addressed in this section, as the network structure outlining the US government's agricultural programs are complex enough to write an additional research report on. The umbrella organization of most of the US agricultural programs fall under the US Department of Agriculture (USDA), within this organization both FSA and NRCS are affiliated sub-organizations that work collectively with each other towards achieving USDA goals. In each individual county throughout the country, there is a USDA field office with FSA and NRCS representatives, who are focusing on providing agricultural assistance and technical knowledge when needed.

When addressing the situations concerning soil erosion and soil conservation, the FSA finds itself playing a very peculiar role, as it provides minimal programs concerning agricultural soil erosion. The majority of FSA programs are concerned with crop insurance incentives. However, the enrollment into an initial FSA contract is mandatory to become eligible for any governmental farm subsidies or programs regardless of the agency. Additionally, the Cache County office consists of only one FSA field agent, who is also the County Director. Therefore the office's ability to perform the agency's compliance obligations is greatly reduced. To add to the mix of things, the US Government is currently reconstructing its 2012-2013 fiscal mandates, whereby national agricultural programs are expected to be reduced significantly over the upcoming years.

Natural Resource and Conservation Service: Logan, Utah Office (NRCS)

As FSA incorporates farm insurance policies in the risk of natural disasters, the purpose for the NRCS is to implement agricultural sustainability programs across a broad spectrum of audiences. Some of the programs that were mentioned in chapter 2, such as CSP, CRP, EQIP, and EWP all fall under the jurisdiction of NRCS obligations. In the Cache County office there is a combination of five federal and state field agents, three engineers, and administrative support staff, who work together in developing sustainable agricultural practices. One of their major responsibilities is to provide assistance among local farmers in order to develop a proposal for a specific grants or subsidies towards agricultural improvements. In the section regarding the Soil Conservation Districts, it was mentioned that the Conservation District's Board votes on the approval of specific governmental programs. Normally these programs are developed through the local county NRCS office with the support of the county agents. Additionally, all NRCS offices offer the ability for local farmers to access information and consultation regarding farming concern despite of their enrolment into governmental farm programs.

Utah State University

Utah State University located in Logan, is the only higher education institution throughout the state concerned with agricultural and natural resource management programs. The department of Plants, Soils and Climate, which is located within the College of Agricultural, is the department that this research has indicated is the most directly involved with numerous programs concerning erosion activities and soil conservation. Throughout the 1980's and the first half of the 1990's this department developed great strides in improving non tillage conservation farming throughout the region. These applications were derived through the cooperation of local farmers, by allowing the university to install non tillage agricultural sample plots. By allows to do these applications, it had increased the local knowledge base on less invasive agricultural practices. Unfortunately, over the past decade both state and federal funding at the university level has seen a decrease, especially within the area of agricultural soil conservation, therefore leading the department of Plants, Soils and Climate to develop changes within their research funding. In addition to these changes in monetary allocations, the lead professor in charge these experimental no tillage plots was transferred to the director of the Western Sustainable Agriculture Research and Education (SARE).

Sustainable Agriculture Research and Education Organization (S.A.R.E)

Sustainable Agriculture Research and Education Organization is a federal funded research program that provides local farmers with the research opportunities in developing sustainable agricultural practices. The main purpose of this organization is to increase the local knowledge base on agricultural developments in empowering the three "P's" of sustainability, People, Planet and Profit. As mentioned on the SARE website **"***SARE grants and education program has advanced agricultural innovation that promotes profitability, stewardship of the land, air and water, and quality of life for farmers, ranchers and their communities.*(SARE, 2011). This organization is directed through the USU University, but is funded by the USDA. The majority of the funding is provided to university research programs, directing their research in sustainable agricultural practices. One of the most identifiable characteristics of the SARE organization within the State of Utah is its ability to provide grants to local farmers and institutions without FSA contractual requirement. Hence, farmers can receive some sort of federal funding for sustainable research, with limited contractual obligations. In addition to the grant funding the SARE program provides educational farmer conferences, training and provides local assistance when needed.

Utah State University: County Extension Agent

The USU county extension agent incorporates local partnerships between the USU, County and USDA agencies with the local citizenry by providing guidance and knowledge transfer. Throughout Cache County, there is one USU agricultural extension agent, with a part-time intern, who provides a great asset of interlinking the needs of the agricultural community to the local governmental agencies. As mentioned by the majority of the interviewees, the USU county extension agent is great asset to the region and has developed a high level of trust with the local community. In addition to the trust and respect that the county agent has developed, in 2005 the county agent was declined tenure by the university, whereby local farmers collectively came together in order to support the agent's rebuttal.

Utah Farm Bureau

The Farm Bureau is a nonprofit, nongovernmental organization that collectively works towards the improvements of agricultural activities through the state. According to the Farm Bureaus website their goals focus on "*people joining together to solve common problems*." (Utah Farm Bureau) Even though the Farm Bureau doesn't have specialization in erosion management, the bureau provides possible funding, training and knowledge transfer through their water quality experts.

Equipment Vendors

In most professional sectors there tends to be companies that provide the most innovative and up to date equipment in order to increase productivity. This is also the case in agricultural production; as farmers are faced daily with the decisions on how maximize production with minimal overhead cost. For example in the summer of 2008 the cost of one barrel of crude oil surpassed the 100 US Dollars mark. Circumstances like these, have forced farmers to make a call to continue with current production schemes or attempt to minimize fuel consumption. Throughout Cache County there are numerous agricultural vendors that provide farmers with solution for conservation practices. Additionally, vendors need to stay current on equipment innovations and how new concepts are implemented towards sustainable outcomes. On the other hand, equipment vendors are concerned with make money that could become a conflict of interest towards agricultural sustainability.

5.2.5 Analyzing The Independent Variables For Network Structure.

An analysis of the empirical data provided through the field study in conjunction with the theoretical concepts outlined by Sandström and Rova is presented throughout this section. As mentioned in the literature review, the fundamental characteristics of the network structures greatly determine the organizational ability to overcome collective problems. To be able to develop a good insight on how social network theory can be used to determine the effectiveness of the network, the network closure and heterogeneity has been analyzed.

Network Closure – Density

"As the level of network closure increases so does the capability to prioritize, thereby enhancing efficiency" (Sandström and Rova p5). As pointed out by Sandström and Rova, network closure is broken down into two subgroups network density and network centralization. The "density" of a network is one of the most important factors in determining the activity and flows of communication throughout the network. This concept is determined quite easily by dividing the actual number of associations per farmer by the maximum number of connections that could be achieved in the total network. To explain this concept Table 5.1 (above), has been used to identify the organizations (Government Agencies, Universities, and

NGOs) found within Cache County. This first step in the network analysis only identifies the organizations, based off from their association with each other. These results were derived through meeting, conferences and/or semi-structured interviews with each of the organizations. Figure 5.1 represents the agricultural networks throughout Cache County's organizational structure in managing soil conservation concerns.

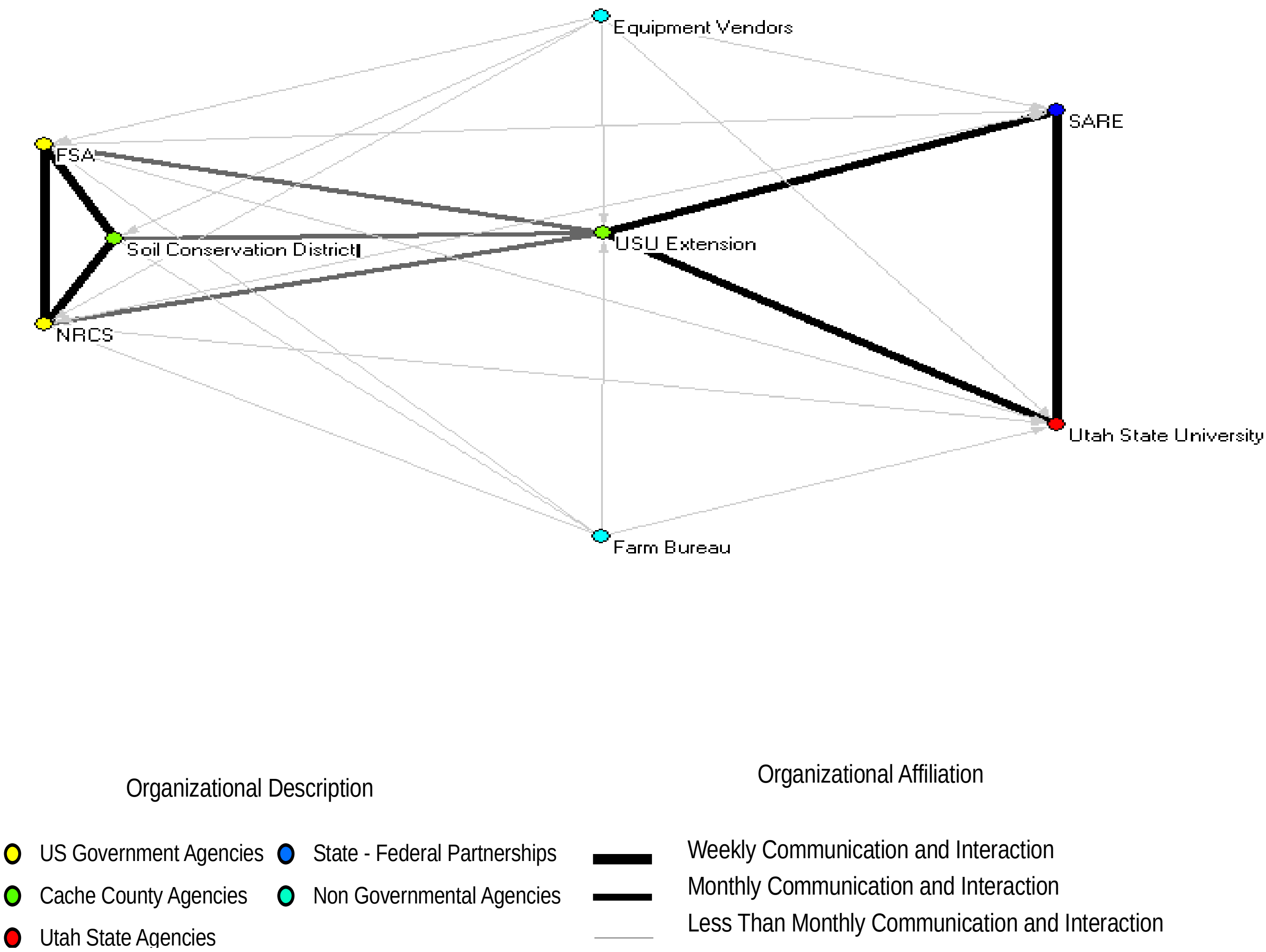


Figure 5. 1 Cache County Organizational Network by Aaron Eckert

Following the evaluation of the network structure of the county's organizations the two main clusters of actors became evident. These clusters are directly connected to the developments of solutions for farmer to overcome soil conservation issues. These two clusters can be characterized by the Utah State University and the Federal/State agencies. To be able to bridge these two clusters together the Utah State University (USU) County Extension Agent is in a centralized location, whereby a majority of knowledge transfer and program development is directly affiliated with the USU Extension agent. As a result of this structural development within the network, a bottleneck is indicated pointing to a location whereby difficulties in the assimilation of knowledge and cooperation between organizations could arise. Additionally, as mentioned above, there is only one fulltime USU agricultural extension agent located in Cache County, which therefore could lead to an inconsistency in knowledge transfer or a lack in ability to provide assistance. Through the organizational analysis it becomes clear that the USU extension is a location of extensive knowledge transfer and a point of influential development. Unfortunately, with too many network flows throughout the USU extension, this organization could become a "network void" due to extensive requests supported by a minimal staff. This highly relevant position concerning support, data- and knowledge transfer could affect the outcome of the whole network if the information is inadequately channeled.

Figure 5.1 indicates the organizational composition of the network without identifying the local agricultural producers; while, Figure 5.2 displays the interaction between the individual actors and the organizations. For further references, the total possible number of network connections produced by the interviewed actors has been clearly listed in Table 2 in the appendix. A total number of 15 actors were identified in the sample set and 9 organizations were identified by the means of the snowball analysis method, therefore having a total amount of 24 actors within this sample subset. The network analysis presented in figure 5.1, points out the core organizations that are associated with developing solutions towards preventing agricultural soil erosion, which has lead to following diagram explaining the total structural engagement of the network. The total actor/organization level of connectivity creates 135 links throughout the network. During the semi-structured interviews each farmer identified the organizations of his affiliation. Their questioners were analyzed, providing an end result of 51.8% +or rounded up to 52% density or .52d.

As mentioned through the work of Sandström and Rova *"The denser the network is, the higher the level of closure is assumed, enhancing all the beneficial elements"* (Sandström and Rova p. 62). When analyzing the density indicator to identify the structural cohesion between individual actors and organizations, the level of density at 52% or (.52d) might be considered significantly low, when considering that only one half of the available links were acknowledged. To examine this scenario by a different perspective, a subsample of 15 individual farmers is significantly small percentage of the larger organizational structure of 845 individual farms ("2007 Census of Agriculture Report, 2011) then the density can be considered as relatively high. In addition to the density as an indicator of structural cohesion, the connectivity needs to be evaluated to paint a broader picture of the network structure. Figure 5.2 presents a complete network analysis of the sampled Cache County agricultural sector that is affiliated with soil conservation.

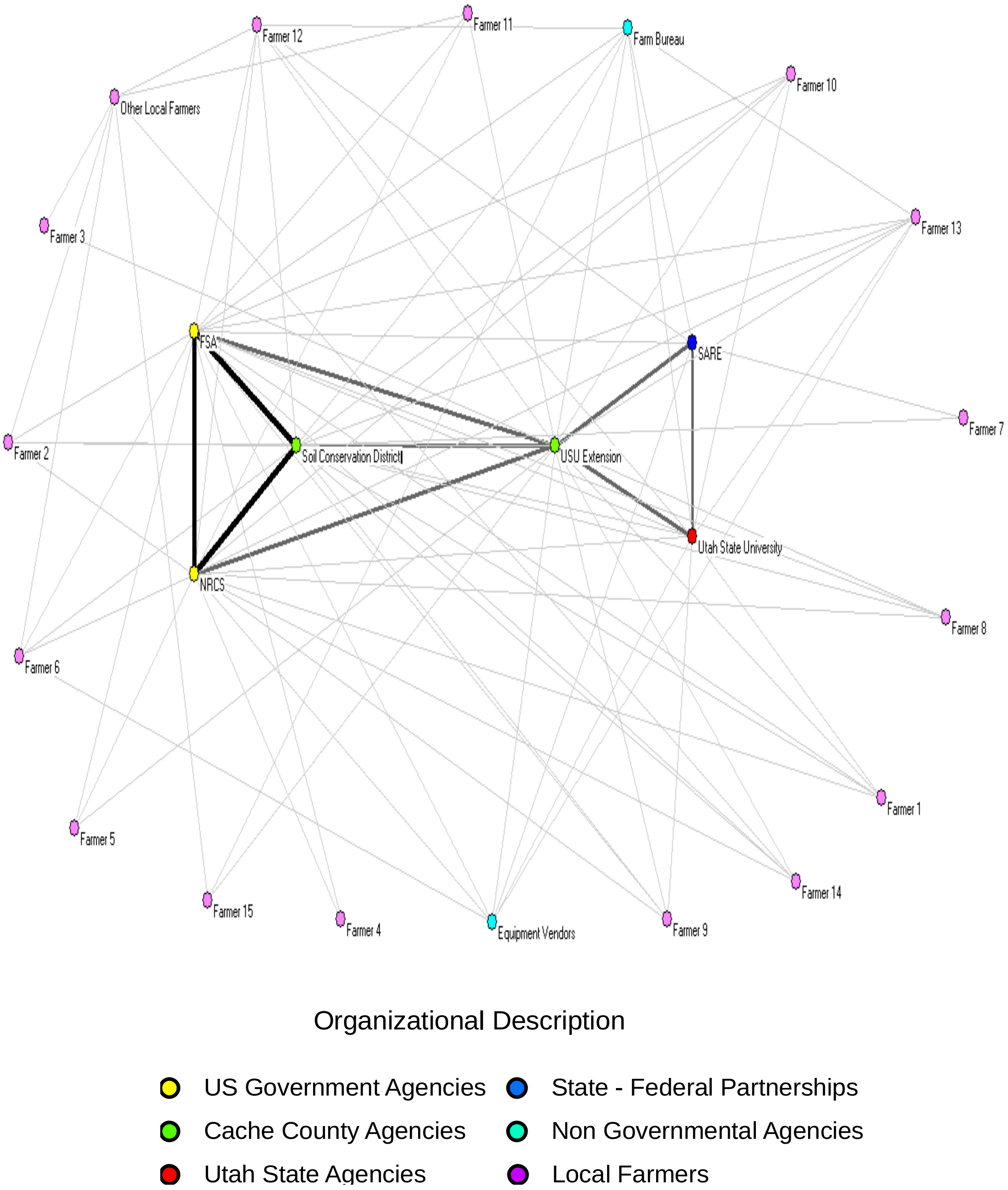


Figure 5. 2 Cache County Full Network by Aaron Eckert

Network Closure – Centralization

According to Sandström and Rova the centralization of a network can be identified between the characteristics of two key variables of the network: *degree of centralization and betweenness of centralization*. The two variables have been calculated in this section to determine the closure of network. The Degree of centralization can be determined through the total number of obtainable links within a network structure, for example figure 5.3 (below) provides an example of completely centralized network. The central actor (A) has a degree of centralization of 100%, as all of the actors are connected to the central vertices. To calculate the degree of centralization 7 (number of links) is divided by the maximum output (7 actors), degree of centralization = 7/7 = 1.0 or 100%. The overall explanation for calculating the degree of centralization, addresses back to the basic concepts of social network theory, whereby individual that have a greater levels of connectivity, therefore find themselves in a better position to influence concepts and ideas among others. Because this thesis is only looking for an existence of connectivity between actors, this project has disregarded the direction of knowledge transfer and only focus on the linkage between the actors.

The concept of betweenness is a much more difficult to explain, as the level of betweenness represents the ability of one actors to provide information to another. To explain this concept figure 5.3 has been used again. Actor (A) is located at the center of this network, whereby it

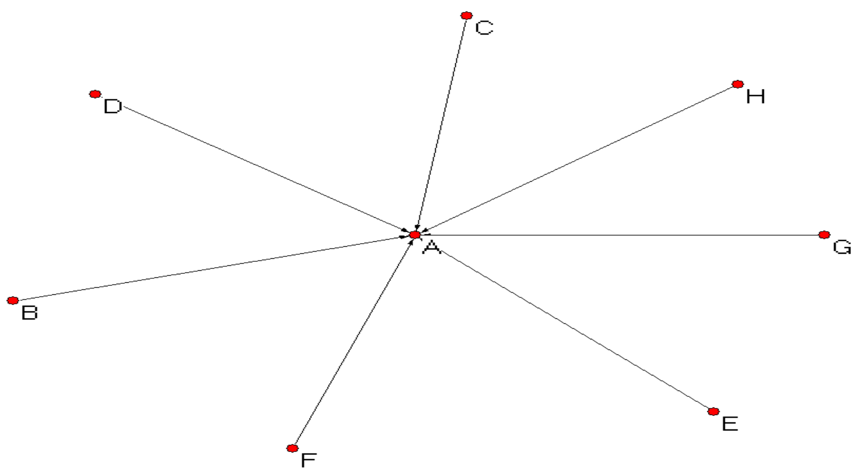


Figure 5. 3 Network Example by Aaron Eckert

For example if actor (B) needs to provide resources or information to actor (G), then (B) need to provide the information first to (A) before a knowledge can be transferred over to actor (G). In this network structure actor (A) has a score of 100% betweenness, as (A) performs the role of a broker, in which the actor can derive limitations within the whole network structure or steer the organization towards a direction that actor (A) receives the highest level of benefit. In dynamic network structures, the level of betweenness can help to determine where there are locations of structural barricades or bottlenecks in the networks performance. By indicating these obstacles, researchers can therefore help develop improvements in the networks flow of information among actors. As calculating the degree of centralization was rather straightforward, the computation of betweenness can become extremely difficult to determine; therefore the implementation of Pajek 1.27 network analysis program was implemented to overcome the complexity of network's structure.

	Degree of Centralization in Percent (%)	Betweenness of Centralization in Percent (%)
FSA	80	17
NRCS	80	13
Soil Conservation District	67	9
Farm Bureau	20	1
Utah State University	40	2
USU Extension	80	22
SARE	13	2
Equipment Vendors	20	0,5
Other Local Farmer	7	7
Total amount of Connectivity	50%	19%

Table 5. 2 Final Network Closure by Aaron Eckert

Network Closure Conclusion

Through the empirical research, provided through the interviewees, it can be determined that the organization concerned with agricultural soil conservation, provide a good network density and closure to assist farmers overcome soil conservation issues. The analysis of the network's density in figure 5.2 signifies that that the network is connected with a 52% density value. This value might be considered quite low, but when considered the sample size, it can be determined that the density value could be quite larger. The network structure doesn't indicate any fragmentation or actors being left out of the network structure. Within this network there is information that points out one distinctive group of core actors, which are concerned with the managing agricultural activities. The high level of betweenness and centralization shown on table 5.3 reveals that the FSA, NRCS and USU Extension Agent all maintain a high level of centralization. Additionally these actors are strategically located in hierarchical positions to influence flows of information within the network. Therefore, it can be stated that the closure of network is relatively high.

Network Heterogeneity

As the network closure illustrates how the network is developed and passes knowledge from and through actors of interest, network heterogeneity represents the "*diversity of actors and the level of cross boundary exchange*" (Sandström and Rova p.69). To identify the level of heterogeneity this thesis focuses on the composition of the network's diversity to develop empirical conclusions about the flexibility of the network structure. Sandström and Rova mention that "*actors with dissimilar backgrounds or dissimilar organizational identities presumably contribute to a richer supply of new resources—an advantage that is associated with the structure" (Page 70).* Therefore, this section investigated empirical data to identify the diversity among the network's actors, in understanding its ability to bridge social, economical and knowledge gaps in preventing soil erosion.

Figure 5.2 displays the network structure that local famers use in developing solutions in managing agricultural soil erosion. This Figure did not only explain the structural elements of the network, but also reflects the diversity of the organizations that can be used in determining the heterogeneity of the overall network as well. For example during my individual interview process, three interviewees expressed great concern on the development of knowledge transfer and research programs provided through the Utah State University. One interviewee mentioned that the university is currently more interested in publication writing and hiring from outside the state other than reflecting on concerns the local agricultural producers. Due to this lack of understanding between the members of the network, this individual had the ability to overcome his problem through other sources of expertise within the whole network. Hence heterogeneity in this thesis addressed the responses from the interviewees to determine what kind of actors are involved in making solutions for overcoming environmental dilemmas, respectively erosion

Figure 5.4 demonstrates the percentage of diversity between the individual organizations, which were identified through the field research having a connection towards soil conservation management. The heterogeneity has been firstly based on the organization's affiliation within society, such as public organization, private organization, or academic organization. At a first glance of figure 5.4, it can be determined that there is an equal amount of diversity between the organizational structures, but this figure doesn't clarify the level of cross boundary interaction at the different sectors of society.

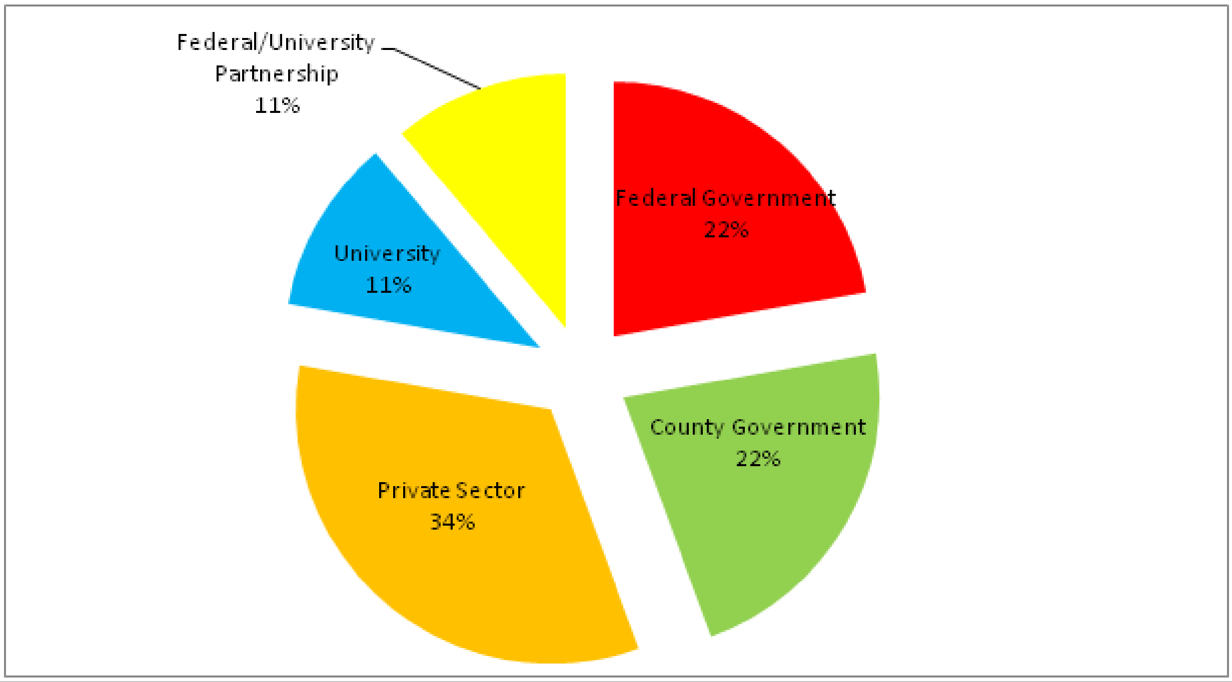


Figure 5. 4 Cache County Diversity of Network by Aaron Eckert

To be able to determine the level of cross interaction between agricultural producers and different organizations within the network, a calculation was obtained from dividing the number of actor-organization relationships by the total number of relationships within the network. The results of this process have identified the percentage of organizations that are contacted to help develop solutions in preventing agricultural soil erosion. Figure 5.5 represents the percentage of cross boundary exchange between the diverse organizations of the network. This figure presents an unequal distribution of the exchange of information between farmers and organizations that can be used to verify the heterogeneity of the network.

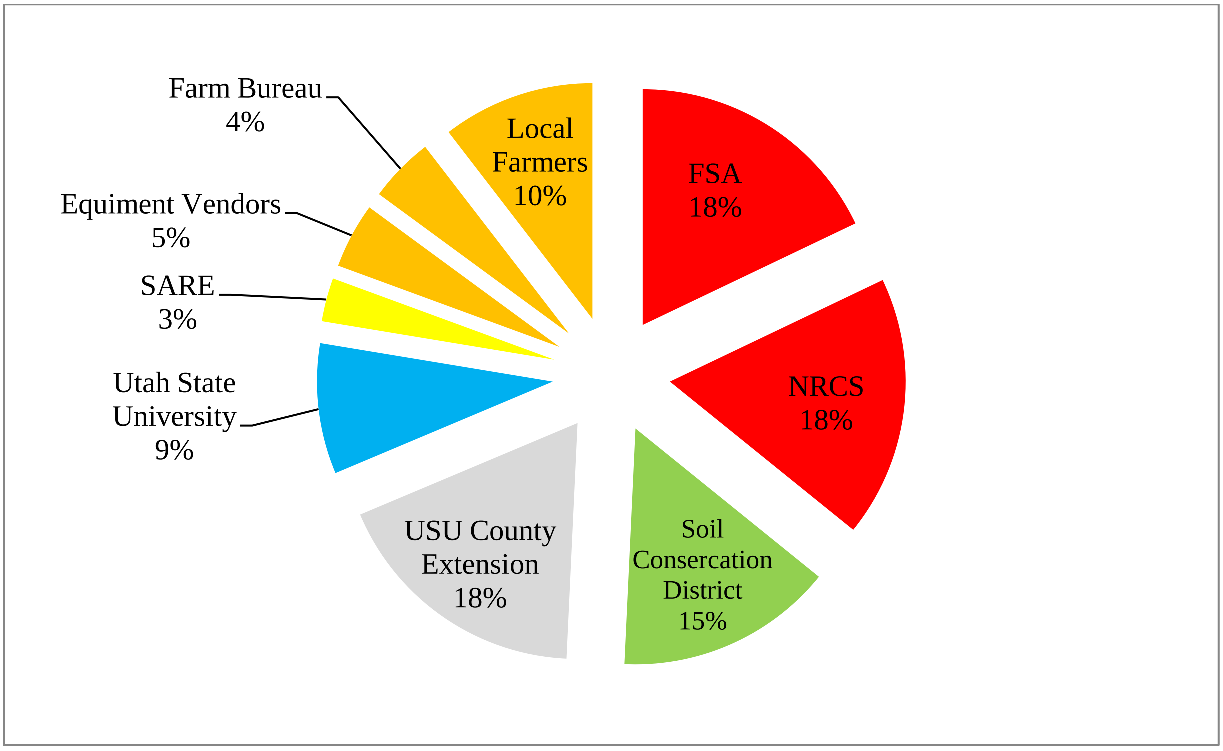


Figure5. 5 Cache County Cross Boundary Exchange by Aaron Eckert

<u>Network Heterogeneity Conclusion</u>

In determining the heterogeneity of the network both the characteristics of the actors and the cross boundary exchanges were verified in this section. When addressing the characteristics of the total network, figure 5.4 identifies the diversity of the organizations found within the different sectors of society. The diversity of the actors found in the network cannot completely determine heterogeneity of the network; therefore the interactions of members of the network needed to be evaluated as well. To evaluate the level of cross boundary exchanges between the actors of Cache County, figure 5.5 identifies the percentage of interactions between local farmers and the organizations inside the network.

Both Figure 5.4 and 5.5 provides an observation that even with having a good distribution of public, private and educational organizations throughout the network, the governmental organizations tend to provide a majority of interactions within the farming community. Another indicator provide by figure 5.5 is unbalance distribution of the university, SARE and private organizations even thought there are numerous links of organizational cooperation between all organizational members. Although the unequal distribution of cross boundary exchanges of knowledge, it can be recognized that this network is heterogeneous, regardless of the imbalance between the actors.

5.2.6 Analyzing The Dependent Variables For Network Structure

The dependent variable within this research reflects on the network's ability to develop solutions in preventing agricultural soil erosion and/or on- and offsite externalities. In order to identify the dependent variable, the network structure and its adaptability has been analyzed to acquire a better understanding on networks effectiveness. To properly determine the validity of the dependent variable this research reflects back on the empirical data provided through the interviews of the actors from Cache County, as well as GIS analysis of each interviewee's property.

The interview data has identified key attributes throughout the network structure; these key attributes reflecting erosion and the externalities caused by erosion are explained in this section. Additionally, it is important to keep in mind that all of the interviewees cultivate agricultural lands, which have a high probability of soil erosion events. In verifying the above statement, every interviewee has suggested the same point of view: that soil erosion is a threat to their business and ability to maintain their production levels. Hence, these farmers do consider erosion as a risk towards the sustainability of their agricultural way of life. Furthermore, each interviewee conveyed that there are reliable sources of knowledge, which are available to all farmers seeking for help or consultation. One discrepancy, which stood out during the interview process, was the reluctances among farmers to use public resources provided by governmental agencies. Most of the famers considered the USU extension agent as a reliable source, whereby the governmental agencies were less popular. This can be considered an inconsistency, since the USU extension agent is a government official. On the other hand, the interviewees didn't consider him as a government employee, but associated him directly with the university. When actors were enrolled into governmental programs such as CRP and CSP, individuals were presented by the NRCS office with clear goals and objectives in managing soil conservation. The CRP was indicated, through the interviews, as a great asset to farmers, as the higher slope and erodible agricultural lands have been isolated from production, which has aided in erosion protection. All farmers knew that the only regulatory obligation for soil conservation practice is through the enrolment into governmental programs. Due to these constraints that are connected to these programs, it was observed that some farmers during the interview process highly rejected the idea of having the government involved in decisions concerning soil conservation and how to manage their farms. Consequently, these farmers then portrayed a higher level of knowledge sharing between neighboring actors and the county extension agent.

Table 5.3 represents the levels of erosion that is perceived through the interviews and analyzing aerial photos of the individual actor's property. Due to the size and amount of aerial photos for each actor, in the appendix is an aerial photo for each actor. One conclusion that can be determined from reviewing the interviews and aerial photos is that there is an inconsistency between the interviews and aerial photo analysis in identifying erosion events. On the other hand, farmers that have white knobs on their fields might not consider these locations as indicators of erosion, because the topsoil has already been excessively eroded to the point that no erosion takes place there anymore. Therefore, the aerial photo analysis could determine locations, where erosion was exceptionally high but nowadays are regions of degraded agricultural production. This can be displayed through the data provide by actor 14, who mentions that "erosion can be easily controlled, but if actors don't watch out for erosion, it could cause significant problems". Both actor 7 and actor 8 indicated that they have no problems with erosion events on their land. As seen in the aerial photos there are locations of onsite and offsite erosion, but through observation the erosion seems to be minor in nature. Therefore, these actors might not completely observe rill or gully erosion occurring on the ground, but splash and sheet erosion could produce the effects observed through the photo analysis.

Farmer	Interview Questions Present Signs of Erosion	Aerial Photos Present Signs of Erosion
Actor 1	No	No
Actor 2	No	No
Actor 3	No	No
Actor 4	Yes	No
Actor 5	No	No
Actor 6	No	No
Actor 7	No	Yes
Actor 8	No	Yes
Actor 9	Yes	Yes
Actor 10	No	No
Actor 11	No	No
Actor 12	Yes	Yes
Actor 13	No	No
Actor 14	No	Yes
Actor 15	No	No
	20% with Erosion	33% with Erosion

Table5. 3 Cache County Identifiable Erosion by Aaron Eckert

Question 16 of the interview process it states*: "With whom do you discuss issues concerning soil quality and soil conservation?"* I ask the interviewees to indicate the most important actor involved in this process. The below table provides a good insight on how the individual actors would rather seek out local expertise, i.e. neighbor, friend, before consulting with other agencies. Additionally the majority of the interviewees also mentioned affiliation with the other organizations, but they were not the specified as the first point of contact

Farmers	County Extension Agent	Government	Other Local Farmers
Actor 1	1		
Actor 2			1
Actor 3			1
Actor 4		1	
Actor 5	1		
Actor 6			1
Actor 7			1
Actor 8			1
Actor 9		1	
Actor 10			1
Actor 11			1
Actor 12			1
Actor 13	1		
Actor 14		1	
Actor 15	1		
Total	4	3	8
Percentage of first point of contact for soil conservation concerns	27	20	53

Table 5. 4 Cache County First Point of Contact by Aaron Eckert

5.2.7 CONCLUSION

As mentioned in section 5.2.3 the network of actors can be labeled as moderately dense network with specific actors maintaining a centralized potion that have a hierarchical role in influencing flows of information throughout the network. In order to determine if this network is capable of developing solutions towards preventing agricultural soil erosion, table 5.3 outlines the results of the SNA, interviews, and aerial photos to shed some light on the validity of this case study. The results addressing soil erosion determined that the network is well connected and heterogeneous, therefore having a high ability to transfer knowledge and resources among actors. When addressing the externalities of soil erosion there is between 20% and 33% of agricultural lands that can be verified in having agricultural soil erosion events. Actor 4 was the only farmer who mentioned about having excessive erosion on his land, as all other actors conclude that erosion events were limited. There were no indications of excessive runoff into waterways as well as natural disasters caused by agricultural means.

One important concept that should be identified is that the governmental agencies and county extension agent find themselves in the most strategically located positions within the network. Hence, increasing their ability to work with and provide resources to the agricultural producers. On the other hand, when farmers are developing solutions for prevention soil erosion, 53% of the selected sample, preferred to discuss solutions with other local farmers instead of other organizational members of the network.

Agricultural Soil Erosion	**Level**	**Onsite and Offsite Externalities**	**Level**
Transfer of Knowledge Between Stakeholders	High	Mitigate Topsoil Removal	Med
Ability to Increase Knowledge	High	Increase Soil Productivity	Med
Ability to Improve on Mechanical BMP	High	Prevent Blockage of Waterways or Excessive Downstream Runoff	High
Ability to Enhance Agricultural Practices and Equipment	High	Prevent Natural Disasters	High

Table 5. 5 Cache County Dependent Variables by Aaron Eckert

Through the dissimulation of knowledge between local actors, without the intervention of governmental agencies, I would consider the sustainability of local agricultural practices as well developed. This conclusion can be made through the network's adaptive learning capacity at a collective level. Therefore, if there were fundamental changes within the network, i.e. governmental programs, resources, and organizational structure, I believe that the local actors would be able to adaptively create institutions among each other in providing sustainable outcomes and are resilient to changes in resources.

5.3 Box Elder County

5.3.1 GEOGRAPHIC AND DEMOGRAPHIC CONDITIONS

Box Elder County is located in the northeastern mountainous region of Utah; portraying the semiarid climatic conditions of this area, this county has an average annual precipitation of 16 inches annually (Utah Climate Center, 2011). The population within Box Elder County is not agglomerated within a valley region; on the contrary, it is spread throughout the entire county area. According to the Census Bureau the population of this county as of 2010 was 48,619 habitants. The main agricultural city within this county is Tremonton, which is the location of the federal governmental institutions, while the county agencies are located in Brigham City to the south. Tremonton is centrally located within the farming region of the county, while Brigham City is more isolated to the agricultural industry.

According to the 2007 USDA Crop Census, Box Elder County has 1113 farms covering a total landuse of 137,779 acres of farmland. Between the years of 1995 and 2010 the US Government invested $144,000,000 dollars in federal spending for Box Elder County, accounting for 30% of the state's federal funding ("2007 Census of Agriculture Report, 2011). The agricultural subsidies are broken down as follow: $65.1 million dollars in commodity subsidies, $6.34 million dollars in crop insurance subsidies, $47.4 million dollars in conservation subsidies, and $24.9 million dollars in disaster subsidies. (EWG)

5.3.2 AGRICULTURAL AREAS

When understanding the differences between the two studied counties, it is important to comprehend that in Cache County the majority of agricultural actors live within the central valley region. On the other hand, in Box Elder County the individual actors are displaced at a much larger scope, which account for numerous changes in the geophysical properties of the land. In Box Elder County there is a centralized valley region, like in Cache Valley, but this location is normally consisting of irrigated farmland. In the western section of the county the agricultural land shifts away from the irrigation use to dryland farming. These areas can be described as large rolling hills with grassy plain like vegetation. The Blue Creek Watershed is one of the main geological features standing out in this region. This location can be characterized as a very desolate landscape, which is only used for extensive agricultural production. Most of these farming locations consist of only a shop or a garage area to store equipment or produce, while in Cache County the most of farmers live on the same land that they are farming.

5.3.3 BOX ELDER COUNTY LOCAL ACTORS

In order to identify the local actors involved in developing solutions towards preventing soil erosion in Box Elder County, the GIS analysis and snowball method was reused to identify the fundamental network structure in Box Elder County. The following table 5.6 outlines the organizational actors that were pointed out after the initial analysis. As both of the counties are found within the same state, there tends to be a lot of similarities in the organizational structure of the network.

Governmental Agencies	Non Governmental Agencies	Individual Actors
Northern Utah Conservation District	Sustainable Agriculture Research and Education Organization (S.A.R.E)	USU County Farm Extension Agent
Farm Service Agency (FSA)	Utah State University (USU) Blue Creek Research Farm	***Local Agricultural Equipment Vendors**
Natural Resources and Conservation Services (NRCS)	Utah Farm Bureau	Local Individual Farmers, Neighbors and Family
Box Elder County Special Service District	Church of Jesus Christ and Latter Day Saints (LDS) Welfare Farm	***Farmers Union**

Table5. 6 Box Elder County Organizations by Aaron Eckert

The actors indicated with an asterisk (*) are members that were introduced in later interviews or through meetings with the above organizations.

<u>Northern Utah Conservation Districts</u>

The Northern Utah conservation District is composed of a publicly selected five member board panel. The fundamental concept of this organization is to work with local, state and federal actors towards developing organization and solutions for promoting sustainability throughout the region. The Northern Utah Conservation District meets on a monthly basis to vote on sustainable procedures and individual projects. For example, if a farmer desires to enroll his land into a federal or state agricultural program, the local NRCS office would first have to determine if the land actually meets the governmental requirements. Following the NRCS approval, the individual farmer would present his case to the Conservation Board to obtain the final endorsement. The conservation districts throughout the state maintain the same conceptual idea of approving USDA programs through the interaction of the local civil society and governmental agencies. The only differences between these districts are the amount of actors that are involved in their approval processes. As mentioned in the introduction to Box Elder County, Box Elder County receives approximately one third of the whole state's agricultural budget. This means that the conservation district has the largest responsibility of fund allocation throughout the state. Additionally, question 21 on the questioner inquires the following: "*Are there any other important actors found within the local region?"* More specifically, I would ask about any leaders who standout in developing agricultural sustainability. Generally, this question obtained a denial as answer; except for five instances in which the president of the Northern Utah Soil Conservation District was mentioned.

Farm Service Agency: Tremont, Utah Office (FSA)

Every county within the USA has a FSA and NRCS representative assisting the public with agricultural and technical knowledge. However, the FSA offers mainly programs addressing crop insurance incentives and very few programs targeting agricultural soil erosion. Despite of this, it is necessary to be enrolled into an initial FSA contract in order to be eligible for any governmental farm programs. The FSA office in Tremonton follows approximately the same guidelines as the Cache County office; therefore, no fundamental differences between the two locations were observed.

Natural Resource and Conservation Service: Tremont, Utah Office (NRCS)

The main goal of the NRCS is to implement agricultural sustainability programs across a broad spectrum of audiences Within Box Elder County office there is a combination of five federal and state field agents, one engineer and one administrative support staff, who work together in developing sustainable agricultural practices. Their main duty is to offer assistance to local farmers in developing proposals for a specific grant or subsidies towards agricultural improvements. The NRCS office in Tremonton works towards the same governmental programs and objectives, as the Cache County. There are very few differences between the offices, except for the level of funding provided and project enrolments at the county level.

Box Elder County Special Service District

The Box Elder County Special Service District is based out of Brigham City, Utah, which is located in the southern section of the county. The Brigham City is the location of the county seat, but its geographical location isolates it from the majority of the agricultural production. This organization is developed from a mixture of county and elected local farmers who meet twice a year to consult about watershed activities throughout the region. Within the research area, one of the most distinguished project that has been implemented by the Special Service District has been the Blue Creek watershed terracing project. This project was implemented in 1972 to mitigate erosion events in agricultural lands throughout the county. Through the construction of this project, the county developed a method that allowed the government officials to have entitlements to the location where the terraces were constructed at. In doing so, the Special Service District devised easements and right of ways onto farmer lands without any prior approval or authorization. Approximately 36 years later, in the summer of 2008, larger weather systems passed through Box Elder County producing torrential rainfall. The events following this storm left numerous areas of terracing with significant damage. The most devastating outcome of this storm was the collapse of a group of terraces, producing a landslide effect, which flooded and blocked a section of Interstate 84. This situation brought great attention to the agricultural practices implemented in Box Elder County; therefore, governmental funding from the Environmental Watershed Protection (EWP) program financed a 75 percent share of the terracing reconstruction. In addition to EWP funds, the Special Service District financed the additional 25 percent allowing for this reconstruction to be cost free for the landowners. Currently, in 2011, this project is still under construction, whereby there is an improvement in watershed best management practices, but this raises the question, if whether or not this is a permanent solution or just a temporary fix on a much more complex issue.

Sustainable Agriculture Research and Education Organization (S.A.R.E)

As mentioned in Cached County, the SARE organization works with local farmers to develop research on contemporary agricultural practices. This organization plays the exact role in both counties.

Utah State University (USU) Blue Creek Research Farm

The Blue Creek Research Farm was originally developed through the collective organization of local farmers within Box Elder County, in order to help establish experiments in crop management. According to the county extension agent, this property was later entrusted to the Utah State University for research and development practices for knowledge transfer about dryland farming. In the 1980s, this location was utilized extensively for no tillage practices and provided university research with great strides in the research field. As mentioned in the University Section, during the mid 1990s the university moved away from no-till research, as the leading professor connected with this program was promoted the head of the SARE organization. One key concept that was identified through the Box Elder County interviews was that most of the farmers associated the university with the Blue Creek Research farm and not with the main campus based out of Logan.

Local Agricultural Equipment Vendors

The vendors throughout Box Elder County maintain the same characteristics as in Cache County; therefore for information on this topic refer to the previous section.

Church of Jesus Christ and Latter Day Saints (LDS) Welfare Farm

The LDS welfare farm could be classified as same as the individual farmers within the network, but this actor operates the largest no tillage farming operation in the State of Utah. By doing so, the farm director, is an important point of contact to obtain information on how to implement minimal tillage practices, or even more important how to convert from a conventional plowing schemes to a direct seeding program. One of the attributes that really stands out by this actor, is the level of financial resources the LDS farm has in comparison to other actors. Additionally, the farm manager is a main point of contact with all of the local agencies, as a good percentage of Box Elder County farmers are observing the success of the LDS farm's non till program. This program is relatively new to the LDS farm, as in 2005 the decision was made to convert all conventional dryland farming operations to no till. The farm director stated during his interview that "the development of new agricultural practices has been a continual learning process since 2005"; furthermore, he mentioned that cooperation between numerous agencies and individuals from around the country have helped increase his knowledge and understanding about more sustainable practices.

Farmers Union / Utah Farm Bureau

During the interview process of Cache County the identification of the Farm Bureau was quite evident after speaking with some of the local agricultural producers, but there was no designation of the Farmers Union. In Box Elder County, only two local farmers indentified their affiliation with the Farmers Union, which addresses some of same issues as the Farm Bureau. According to the Farmers Union's website, the Farmers Union deal with grassroot level organizations towards improving national scale farmer issues, as well as promoting *"positive legislation, responds to proposed rules and regulations, and bring[ing] rural matters to the attention of top officials through regular meetings, letters, issue briefings, testimony and media coverage"* (Utah Farmers Union, 2011). In order to determine a better understanding of the deviation between these two organizations, one local actor, who is associated with both organizations, mentioned that the Farm Bureau is larger but a conservative organization, while the Farmers Union is concerned with influencing governmental regulation at a national level through smaller grassroot movements.

5.3.4 Analyzing The Independent Variables For Network Structure

This section has analyzed the empirical data provided through my field work, which displays the network development within Box Elder County. This section will follow the same format as in the previous section: Identifying the Network Closure and Network Heterogeneity, which will be used to look at the network structure in determining the networks ability to develop solution to overcome soil conservation issues.

Figure 5.6 on the following page, identifies the organizational structure as it was portrayed through meetings and conversations with organizational actors.

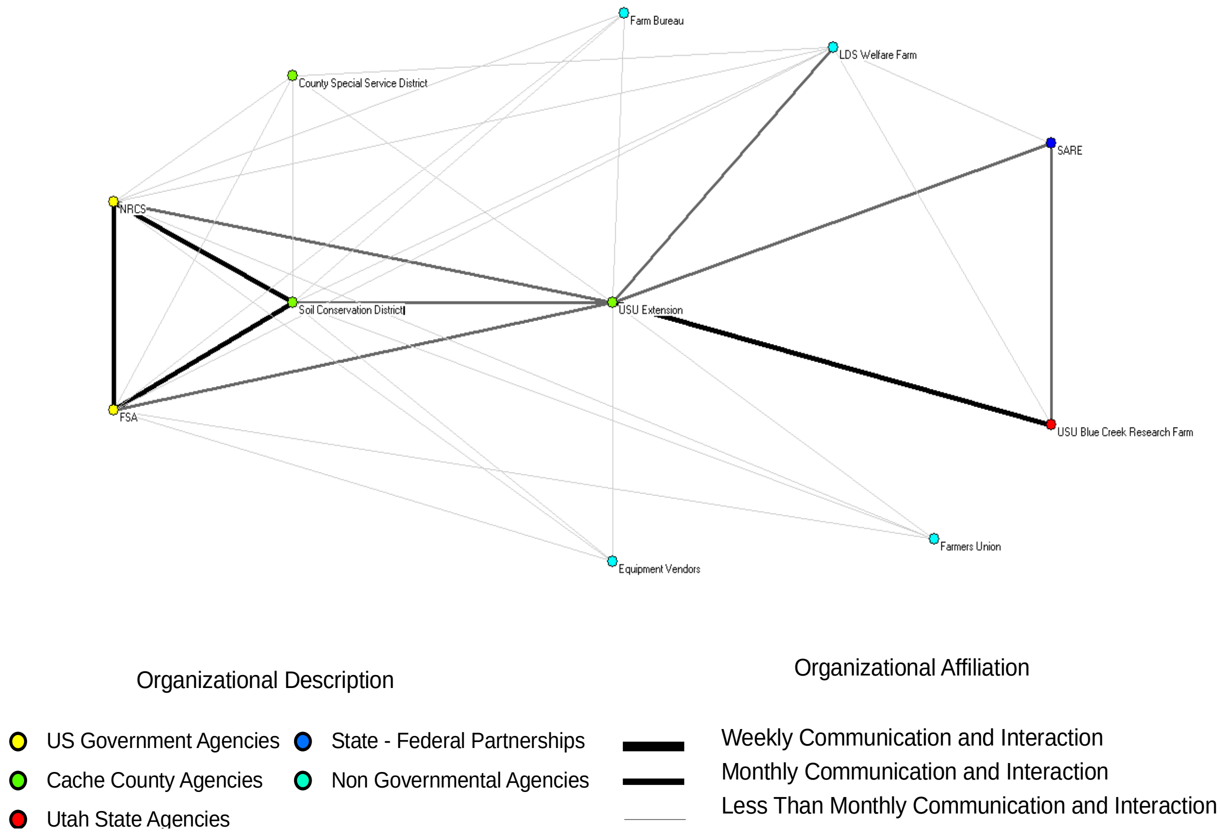


Figure 5. 6 Box Elder County Organizational Network by Aaron Eckert

Within the literature review and Cache County section, the description of network density was explained as the number of connections that a total network has, in comparison to the actual number of connections made. In Box Elder County three more organizations were introduced to the overall organizational structure, these organizations were the County Special Service District, Famers Union and LDS Welfare Farm. It can be noted that the USU Extension Agent is yet again located in a pivotal point of the network. Hence, there is a possibility that USU Extension Agent could become a broker within this network structure and steer the governance arrangement towards the agent's agenda. In order to determine the density of the total network, the responses from the network's farmers are evaluated in Table 3 located in the appendix of this report. This table identifies that the density of Box Elder County is 50%.

Box Elder County also maintains a network density that is relatively similar to Cache County. This conclusion could have been made beforehand, because the key organizations found within both counties, do not significantly differ from one and another. Figure 5.7 portrays the total network structure that has been provided through the feedback from the interviewees.

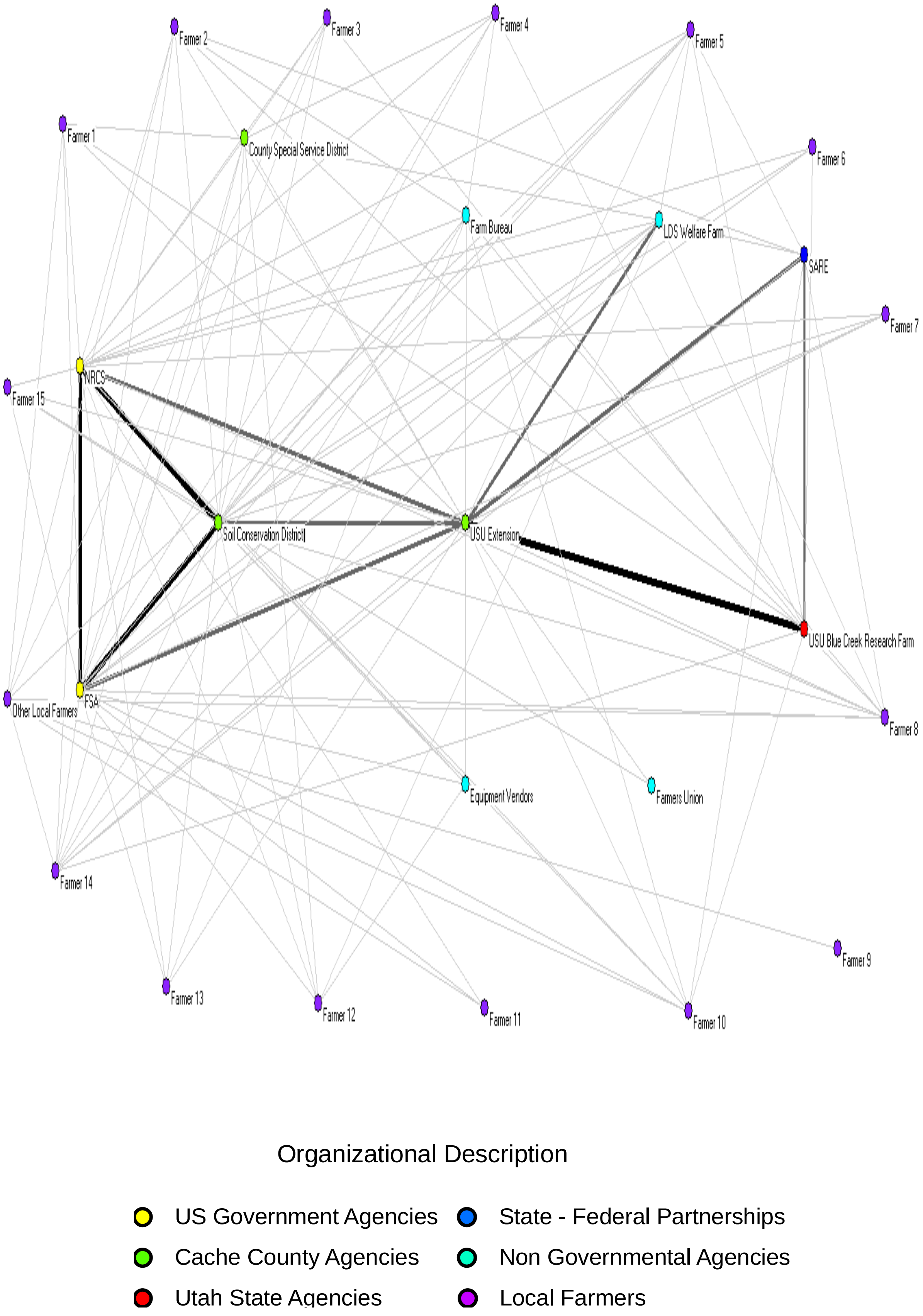


Figure 5. 7 Box Elder County Full Network by Aaron Eckert

Network Closure – Centralization

Yet again, Figure 5.7 does represent a similar pattern that was constructed in the Cache County case study. Alternatively, this observation can only be determined through calculating the independent variables that underpin the network closure. The degree of centralization can be understood as the amount of connections an organization has in comparison to the maximum number of links within the network. Table 5.7 displays a very larger percentage of the sampled farmers do interact with the Tremonton USDA office towards developing solutions for soil conservation. This level of centralization around the governmental organizations, can lead to assumptions about the network structure within Box Elder County, hence the network could portray levels of hierarchical order. The betweenness of the network, on the other hand, can significantly determine if there are any brokers within network structure. Normally, organizations that find themselves in these positions can influence the assimilation of knowledge between actors of the governance network. As stated in Table 5.7, the level of betweenness throughout Box Elder County is relatively low and distributed rather evenly among some of the key actors in the network.

	Degree of Centralization in Percent (%)	Betweenness of Centralization in Percent (%)
FSA	93	14
NRCS	93	14
Soil Conservation District	80	10
Farm Bureau	40	1
USU Blue Creek Research Farm	40	4
USU Extension	60	10
SARE	33	0.5
Equipment Vendors	6	0.01
County Special Service District	33	1
LDS Welfare Farm	33	1
Farmers Union	13	0
Other Local Farmer	60	9
Total amount of Connectivity	54%	12%

Table 5. 7 Final Network Closure by Aaron Eckert

Conclusion Network Closure

By analyzing the information provided in the interviews, the closure of Box Elder County's network can be determined as high. The first indicator in identifying the above statement reflects on the network density. The density of 50 percent signifies that the actors within the network have a good ability to give and receive information across the network. There is a central hierarchical order within this county, which portrays a very high level interaction among the community, especially as the USDA organizations scored an almost perfect result. The last variable in addressing network closure is the betweenness of organizations. The result of this variable is also quite interesting, since highly centralized networks are also very diverse in its flow of information among its users. The betweenness can indicated that an actor might have numerous approaches in developing solutions +to overcome conservation issues. This doesn't mean that an actor would be completely circumvented, but that the flow of information from point A to point B could take an alternative course of action.

The previous statement can be supported through the interview processes, whereby some actors mention that in 2008 there was a black bug infestation throughout the region, in which local farmers collectively created a solution to overcome this problem. Black Bug infestation creates large problems for farmers, as they feed on most agricultural crops by removing the chlorophyll within the plants, which can dehydrate and consequently kill the crops (Hodgson, 2008). Infestations like this can develop populations of over 1000 bugs/sq ft (~9 sq ft = 1 sq meter), which within a few weeks could produce significant impacts to the farming community (Hodgson, 2008). As mention in the section regarding the soil conservation district, the district's board meets only one time on a monthly basis. In the case of the black bug infestation, if the local actors would have waited for the bureaucratic processes to release funds for pesticide management, the region would have been greatly affected. In order to overcome this problem, local farmers went through various points of contact and constructed a statewide awareness regarding this situation. Consequently, this network of actors managed to prevent extensive cropland damage, as well as minimized possible economical shortcomings throughout Box Elder County.

Network Heterogeneity

In describing the level of heterogeneity within Box Elder County, it is evident from looking at Figures 5.8 and 5.9 that the organizational network is very similar to Cache County. On the other hand, Box Elder County has displayed an increase of organizations in the study area.

Therefore, by providing more organizations, there is a greater possibility of resource sharing within the county. Too many organizations can also become an issue, as pointed out through the work of Provan and Kenis, when *"the number of organizations in the network gets larger, however, shared governance becomes highly inefficient, with participants either ignoring critical network issues or spending large amounts of time trying to coordinate across 10, 20, or more organizations"* (Provan & Kenis, 2007 p 238). Figure 5.8 displays a breakdown of the organizations that represent the different sectors of society. Red and green represent the governmental organizations, orange stands for the private sector and NGOs, blue signifies the Utah State University, and yellow indicates University/Federal partnerships.

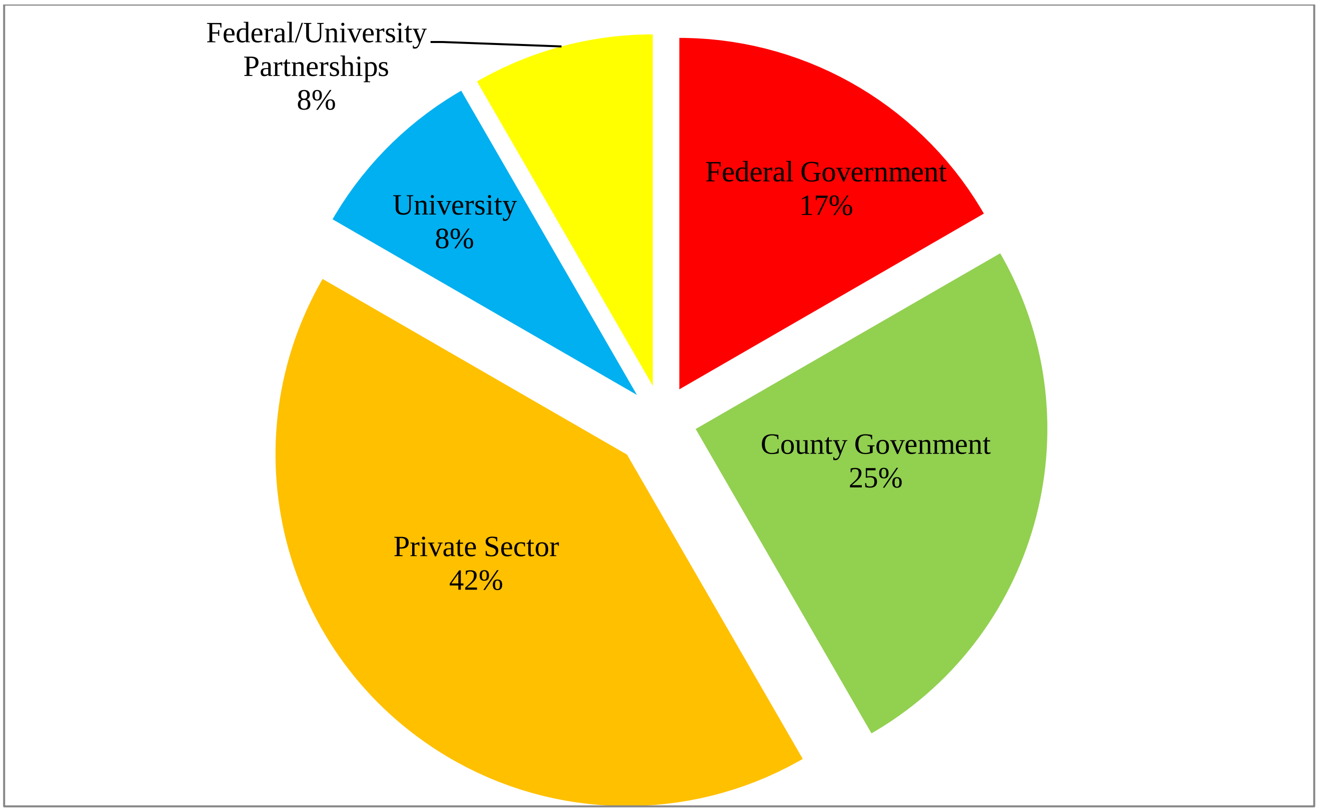


Figure 5. 8 Box Elder County Density of Network by Aaron Eckert

Figure 5.9 shows the percentage of the organizational influence within the total network. This diagram points out that the network is composed of numerous actors from all sectors of society. Additionally, the private sector makes up approximately one quarter of the network, the organizations that are affiliated with the university (SARE and Extension agent) make up another quarter of the network, while the governmental organizations compose the final half of the network. This does indicate that the network is derived from a heterogenic group of actors throughout the county.

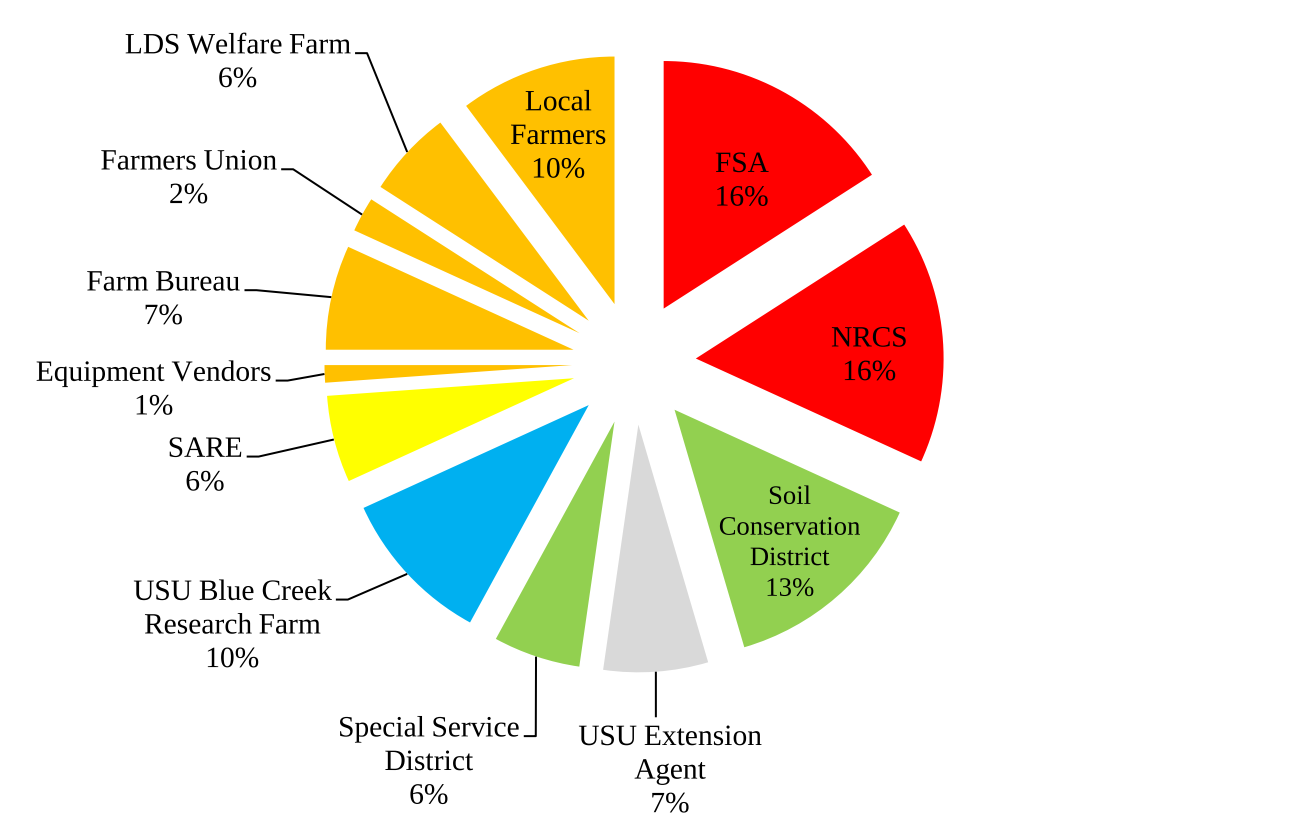


Figure 5. 9 Box Elder County Cross Boundary Exchange by Aaron Eckert

Network Heterogeneity Conclusion

This section analyzes the characteristics of and the level of exchanges between individual actors within the network. Figure 5.8 is used to identify the deviation of the organizational affiliation within the specific sectors of society. When addressing the three spheres of sustainability: Government, Market and Civil Society, at an organizational level, there is an adequate representation of the actors from all sectors of society. In contrast to Figure 5.8, Figure 5.9 demonstrates the level of exchanges between the actors of the network, which illustrates the government as an important actor in the network structure. It is very obvious from Figure5.9 that there is an imbalance between the government and the other two sectors of society. However, with the combination of the epistemic community with the private organizations, the network is almost completely balanced. Hence, the individual farmers that are confronted with hardships have a very empowering network that enables them to develop solutions for tomorrow.

5.3.5 ANALYZING THE DEPENDENT VARIABLES FOR NETWORK STRUCTURE.

This research is concerned with understanding how the network structure of the research area affects the local farmers' ability to develop solutions towards preventing agricultural soil erosion. In analyzing the dependent variable this report utilized a conjunction of interview questioners and the National Agricultural Imagery Program aerial photos in determining the effectiveness of the network.

The characteristics displayed within the interviews and aerial photos determined the networks ability to develop solutions in preventing agricultural soil erosion (Table 5.8). The actors that were interviewed were selected through the GIS erosion analysis; hence, there is a high level of probability that erosion is occurring in these locations. During the actual interviews, information was established in regards to a large scale soil conservation project, wherein numerous terracing programs began in the 1970s. According to most of the interviewees, these projects greatly benefited the local producer, as well as limited the amount of erosion within this region. Actor 3 mentioned that before the terracing program, his farm had significant erosion issues; gully erosion that developed on his land was so intense that his equipment would have to circumvent around these locations. He further stated that after the initial terracing project this level of erosion activity greatly diminished.

Actor 3 was not the only farmer mentioning the impacts of this project, as other farmers within Box Elder County have provided information in regards to this same project. One other scenario that often arisen during the interviews was the impacts of some large storm systems that came through the region in 2009. These storms destroyed and greatly impacted the local terracing and water control infrastructure within this region. During one of these rain events a water control structure collapsed, causing considerable impacts to not only agricultural structure, but also produced a landslide effect resulting in the flooding and blockage of interstate 84.

Farmer	Interview Questions Present Signs of Erosion	Aerial Photos Present Signs of Erosion
Actor 1	Yes	Yes
Actor 2	No	No
Actor 3	No	No
Actor 4	No	No
Actor 5	Yes	Yes
Actor 6	No	Yes
Actor 7	No	No
Actor 8	Yes	Yes
Actor 9	No	No
Actor 10	Yes	Yes
Actor 11	No	Yes
Actor 12	No	Yes
Actor 13	No	No
Actor 14	Yes	Yes
Actor 15	No	No
	33% with Erosion	53% with Erosion

Table 5. 8 Box Elder County Identifiable Erosion by Aaron Eckert

The above table identifies the results from the interviews and aerial photograph analysis in determining the causality of the network's ability to develop solutions for preventing soil erosion. The table points out that even with a good network structure, agricultural soil erosion is causing problems within the region. From the 15 farmers contacted, over 50% of them have some sort of erosion developing on their land. It can be assumed that this is a consequence of the geophysical terrain features of this region, as in Cache County the majority of highly erodible lands are located only on the sides of the valley. Additionally, these locations have a defined tree line and vegetative growth in the higher elevations above the cropland. Hence, there is a buffer to minimize the velocity of storm water, which could aid to the farmers success in erosion management. In Box Elder County the erodible farmland is located more in the western region of the county. There is no centralized valley region, but the topography of the area is a more desolate rolling hill region. There is very minimal tree growth and this region represents a larger grassland type environment. As mentioned within the literature review, slope length and crop cover are an important variables to calculate the RUSLE 2 model. Therefore, by reducing crop cover, i.e. trees, and increasing run off lengths, there is an obvious reason for the observed increase of excessive erosion in Box Elder County. Looking at this phenomenon more in depth, in Cache County there is a small region located in the north central part of the county that has some of the similar properties displayed in western Box Elder County. Throughout this location there are rolling hills with no trees and signs of excessive erosion can be identified on the majority of the parcels. Figure 5.10 shows a map displaying a comparison between both counties and how the terrain features affect the network's ability to manage soil conservation.

Farmers	County Extension Agent	Government	Other Local Farmers
Actor 1		1	
Actor 2		1	
Actor 3		1	
Actor 4		1	
Actor 5	1		
Actor 6		1	
Actor 7		1	
Actor 8		1	
Actor 9			1
Actor 10		1	
Actor 11		1	
Actor 12			1
Actor 13		1	
Actor 14		1	
Actor 15			1
Total	1	11	3
Percentage of first point of contact for soil conservation concerns	6%	73%	20%

Table 5. 9 Box Elder County First Point of Contact by Aaron Eckert

Table 5.9 portrays another important variable in the network structure and identifies with whom the local farming actors interact with for creating conservation solutions. By the means of the interview questions, the results display that 11 out of 15 actors would first contact the USDA representatives to gain knowledge or resources in order to overcome conservation issues. This result, in my empirical research, clearly indicates that there is a deviation between the two counties in managing agricultural practices. In Chapter 6 this phenomenon has been discussed more in depth.

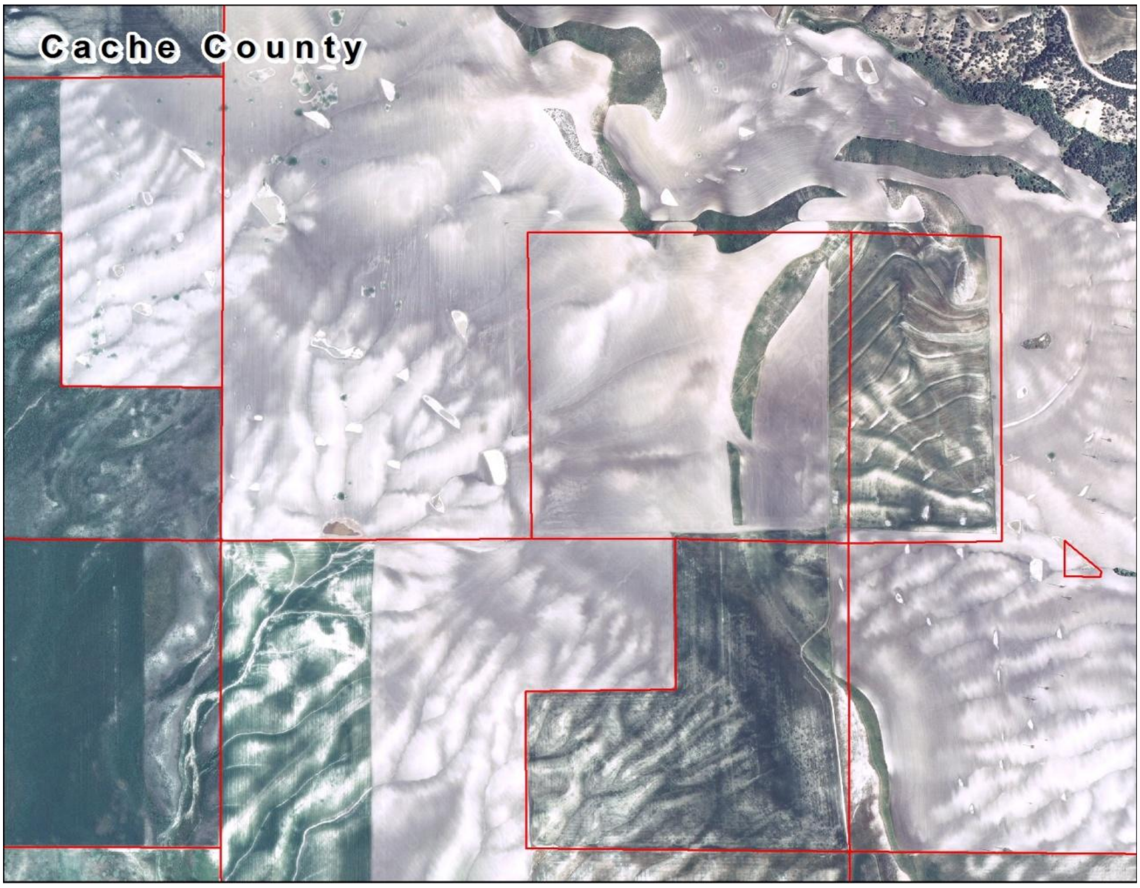
5.3.6 CONCLUSION

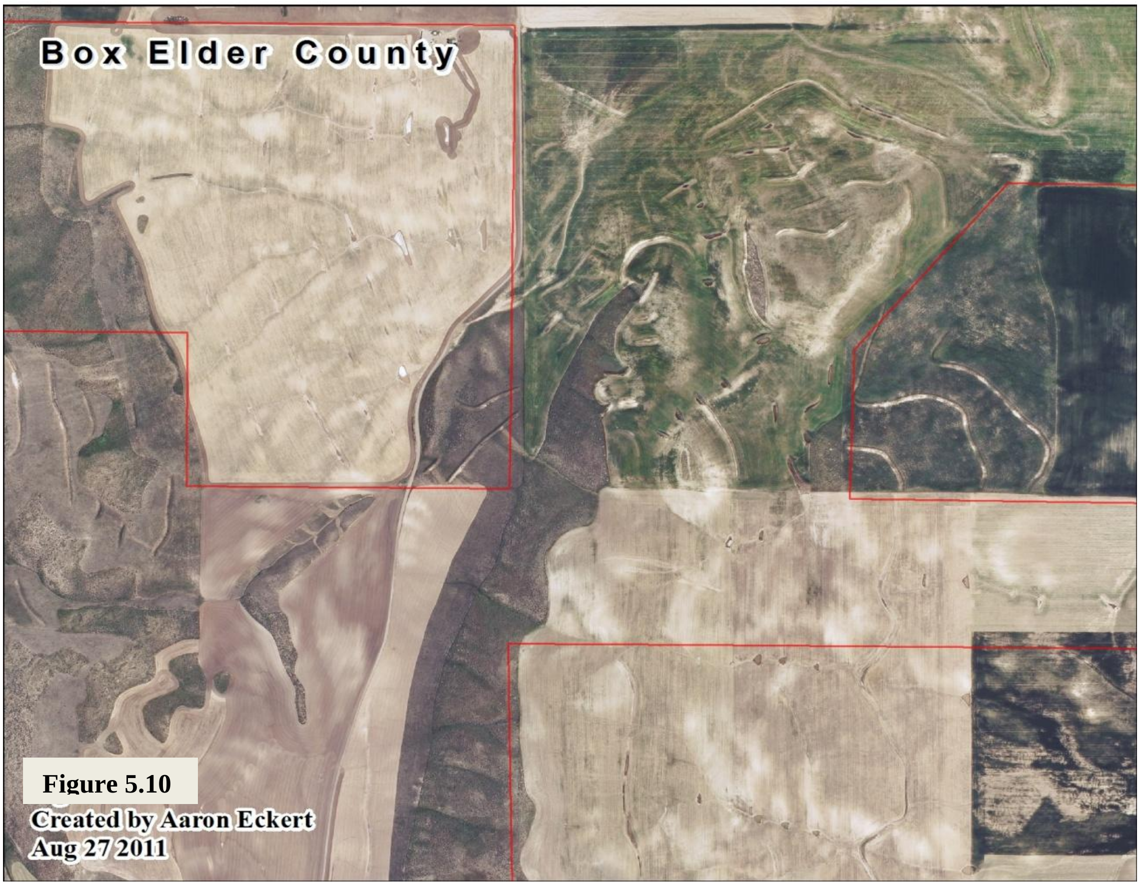
Through the empirical data provided in this chapter, there are clear indicators that the county has an adequate network structure in developing solutions for soil conservation. Over the past 40 years, programs within the county have developed large scale terracing projects in order to mitigate the externalities involved with erosion. According to first hand experience, these terracing programs are relatively successful and have allowed farmers to invest more resources in other activities. However, when these terraces are not properly managed as an integrated system and the demand on these systems are beyond their carrying capacity then these BMPs could result in an increase of soil erosion events. Therefore, one farmer's success can become another farmer's failure when there is limited betweenness among the actors and the government agencies are working as brokers. The lack of knowledge on the root causing the problem can increase neighboring farmers' frustration among each other inhibiting betweenness and increasing dependence of mediators, who may or may not be able to ease the situation.

In this county, there are clear indicators indentifying the network's ability to provide and increase knowledge and resources to the agricultural actors in this region. On the other hand, Box Elder County has more presentable cases of erosion events than in Cache County, as well as one larger scale environmental disaster, which is directly connected to agricultural practices. Additionally within the blue creek watershed there has been an increase of discussion among farmers, regarding the amounts of offsite erosion within the region.

Agricultural Soil Erosion	Level	Onsite and Offsite Externalities	Level
Transfer of Knowledge Between Stakeholders	High	Mitigate Topsoil Removal	Med
Ability to Increase Knowledge	High	Increase Soil Productivity	Med
Ability to Improve on Mechanical BMP	High	Prevent Blockage of Waterways or Excessive Downstream Runoff	Low
Enhancement of Agricultural Practices and Equipment	High	Prevent Natural Disasters	Low

Table 5. 10 Dependent Variables by Aaron Eckert


Cache County


Box Elder County
Figure 5.10
Created by Aaron Eckert
Aug 27 2011

5.4 Synthesis Bringing Both Case Study Areas Together

To finalize this Chapter, a summary of both study areas are compared to derive the differences in creating solutions for agricultural soil conservation. The result of the network analysis displayed that both counties have highly complex network structures that have the characteristics necessary in preventing agricultural soil erosion. On the other hand, both counties display a differentiation between the methods used in overcoming environmental dilemmas. In Cache County the empirical data displays a tendency to limit the amount of governmental influence at the individual actor level. When situations arise, local actors would prefer to contact other local actors 53% of the time. Additionally, if these farmers would need supplementary assistance they have a higher probability to contact the Cache USU Extension Agent, rather than the government agencies. The USU Extension Agent can also be determined, as a focal point of the overall network structure. In this county, the USU Extension Agent provides essential organization at the University level, knowledge transfer and cross boundary exchanges at the government level; furthermore, assists local farmers with conservation issues or concerns. During the interview process, the USU Extension Agent was very surprised to observe his role within the network. Furthermore, he mentioned that this observation of the empirical data is consistent with his daily obligations to numerous actors within the network. As mentioned above 53% of the sampled Cache County farmers sought after local expertise in developing solutions for soil conservation, this data can provide an observation of self organization for collective action. Meaning that these local farmers are currently self organizing for sustainable outcomes, wherein minimal governmental influence is used to determine how local actors develop solution to manage agricultural soil erosion.

In Box Elder County, the empirical data provides another method for creating solutions to prevent soil erosion events. As also exhibited in Cache County, the Box Elder USU Extension Agents is located in a central location for the organizational structure, but when the individual farming actors are introduced to the network there is a fundamental shift in the network's structure. Hence, this network displays a very centralized governance arrangement, which has developed connections to circumvent key actors when needed. This functionality, as explained in the previous section, is caused by the low level of betweenness among the stakeholders. This can be observed through the empirical data provided within the interviews. Three cases of collective action were identified during the interview process, which were derived from individual farmers working together towards developing a quick solution for environmental problems. These issues were the following: Black Bug Infestation 2008, Canal Water Rights 1998 Drought, and current negotiations about excessive erosion events in the Blue Creek Watershed.

In 2008 a black bug infestation affected the area, as these insect populations fed on the yearly crops. This infestation could have drastically impacted the region, but local farmers collectively came together and derived a plan to quickly receive emergency aid for pesticides treatments. These treatments were essential for the successful recovery of their crops, without any further damage.

In 1998 within the irrigated crop region of the county, the local irrigation canals had significantly lower water levels. This situation brought forth the opportunity of local actors to cooperatively work towards new irrigation plans. These plans allowed for farmers to receive a water share to meet their minimal irrigation levels. After the drought had passed, the local farmers had minimal crop damage due to their ability to collectively organize during a time of need without any secondary type of intervention.

Over the past 6 months, there have been concerns regarding the development and removal of water control structures throughout the Blue Creek Watershed. This Watershed, within Box Elder County, is approximately 32 km long and consists of numerous farming stakeholders. This region has greatly been impacted by many erosion events; therefore, large scale terracing projects have been implemented throughout this area. However, poor management of these BMP infrastructures led to further environmental damages in 2008, as one of these terraces gave away, creating a land slide effect that blocked the local interstate. Over the past few years, new issues have been arising, as some farmers in the valley are remaining with conventional dryland practices, while others are moving towards less intensive no-till farming. This develops a problem, since non-till farming affects downstream farmers, who do not adhere to the same soil conservation practices. This situation is a consequence of the lack of terraces, where no-till farming is being implemented, due to the fact that the increased velocity of water runoff impacts the downstream land, where conventional farming methods are still being used. Over the summer of 2011, the local actors began facilitating meetings addressing ways to develop solutions in preventing excessive erosion in the lower farming locations. These talks were developed at the local actor level, but also involved representatives from different government organizations to provide for resource needs.

Despite this initial development at the collective level, solutions are still being sought, due to the fact that there are numerous and diverse points of view on how to handle this issue.

One of most interesting factors regarding Box Elder County is that even though this region has a very well network structure and is provided with 1/3 of the state's allotted resources, however soil erosion is still a drastic problem in this region. Through interviews, conferences and meeting, two possible reasons for these results became evident. The first and more plausible reason reflects back on the geophysical properties of the region, i.e. climate, terrain and soil type. The current resources that are being implemented into Box Elder County are maintaining the resilience of the soil quality, but there are still erosion problems occurring, because of the harsh conditions of the county. The second reason reflects back to the interview with the state level NRCS economist, whereby she stated that the "U.S. government wants to have farmers as free-riders in agricultural programs." She further mentioned that by doing so this minimizes the possibility of environmental disasters from occurring. However, free-riding on government programs could be the cause for some of the erosion issues that the county is having. Hence, local farmers would be in a better circumstance, if they received government conservation subsides, i.e. terraces, and provide minimum effort to maintain these structures. In the case of the landslide, this situation brought in more federal and county funds into the farming community and overall question is: Will these subsidies aid toward sustainable practices or just lead to the next natural disaster?

Chapter 6: Conclusion, Discussion and Recommendations

6.1 Introduction

In order to analyze the sustainability of local agricultural producers throughout Cache County and Box Elder County, Utah, this project implemented a two step process. Step 1 developed a GIS erosion model to foremost identify locations of agricultural soil erosion and individual actors that were directly involved in soil conservation management. Step 2 conducted a SNA on the actors throughout the communities in determining how agricultural producers developed solutions towards soil conservation. This process provided the tools to acquire the information needed to address all the sub-questions listed out in Chapter 1 and have a broader understanding to answer the central research question:

> *Under which conditions do the networks found within the research areas develop solutions towards preventing agricultural soil erosion and preventing onsite and offsite externalities?*

Following the network analysis' results, it became evident that networks found within the research areas required the following conditions in order to develop solutions towards preventing agricultural soil erosion and preventing onsite and offsite externalities:

- Availability of government programs (CSP, CRP, EQIP)
- Access to monetary resources
- Educational access and promotion
- High level of network closure and density
- High level of network heterogeneity

From the conditions listed above, the funding provided by the governmental programs has shown to be one of the most critical factors influencing land management practices throughout the study areas. The fact that program subsidies play such a vital role on how farmers develop solutions towards conservation practices, make many of these practices unsustainable, since it is uncertain to which extend and for how long funding will be available for into the future.

The access to monetary and educational resources definitely impacts the decision taken when it comes to land management. Depending on the monetary wealth of the farmers, different harvesting tools such as: plows, tractors, seed drills, etc. are implemented. The quality of these tools obviously depends on the farmers' monetary resources and what they are able to afford. However, in some cases, utilizing soil tillage equipment does not solely depend on its cost, but on unawareness of the damage that this type of machinery is causing to their land. Therefore, access to educational resources and the promotion for further development are essential conditions for successful land management practices within a network.

High levels of network closure, density, and heterogeneity lead to a cooperative scenario, providing resolutions to all parties involved. Additionally, it was observed that the highest heterogeneity, the more likely it is to develop broader and sustainable solutions, since diverse points of view bring more knowledge to the table. These different perspectives, address the problems from different angles minimizing flaws in the solution that is being developed. However, it is important to point out that the successful and unsuccessful outcome on farming practices augment or decreases the actor's credibility and input acknowledgment on how to solve the different issues.

The analysis of the network structures and land management practices within Box Elder and Cache County corroborates the theory proposed by Sandström and Rova, which states that "*the network structure is assumed to affect the behaviour of the individuals and the quality of their interactions, consequently affecting the institutional arrangements regulating resource use* (Sandström, 2010 p. 529)*."*

In order to analyze the internal and external validity of this project, it is important to recall the initial hypothesis of this research project, which stated:

If governing networks addressing agricultural soil erosion are both dense and centralized on the one hand, but heterogeneous on the other, then these network arrangements are more likely to engage in forms of adaptive governance, therewith enhancing their potential effectiveness for sustainable agriculture.

By examining the conceptual model (p. 44) a clear cause and effect relationship between high network heterogeneity and closure and the implemented erosion management practices can be appreciated. This relationship reflects the high internal validity of this research. Additionally, regardless of the geophysical disadvantages causing higher erosion problems in Box Elder County, the heterogeneous-, dense-, and centralized network structure of said county, has allowed them to come up with cooperative and flexible alternative methods. These techniques have enhanced the potential of their arid lands and have allowed them to work towards sustainable management practices that are not only reflecting soil conservation practices, but address various agricultural issues.

After considering the different results yielded by this research and acknowledging the random sample approach implemented, I consider this project to have a high external validity in areas with similar geographical and social characteristics. The external validity of this project could be threatened if its conclusions are tested in areas where extreme geophysical features are causing the erosion problems; where the improper use of technology prevail i.e. westernized machinery for marginalized farming; or where social violence and corruption prevent actors from developing transparent network connections.

6.2 Recommendations

As mentioned above, both of the counties that were analyzed in this thesis provided an adequate network structure in organizing solutions for soil conservation purposes, but within the individual network structures there are some elements that could be improved, such as the examples below:

Utah State University - Cache & Box Elder County:

For both counties there was an obvious trend on the interaction between the Utah State University and the local actors, which has been declining over the past two decades. Some farmers during the interview process mentioned that during the recent years there have been some fundamental shifts on how the university actors are concerned with the local agricultural practices. They mentioned that the university brings in professionals from completely foreign environments that do not understand the actual needs of the local actors. Additionally, in 1995, the Utah State University's no till program was put on an indefinite standstill, as the director of this program was promoted to the S.A.R.E. organization, which aims to develop agricultural grants for research purposes. To the date, the director for the no till program has not been replaced; a replacement is expected to arrive for the fall semester of 2011, breaking up a 15 year standstill of this program. The new arrival does not signify that the previous success of the program will continue, since the confidence of the local actors will need to be regained. Moreover, when the no till program was "canceled", the local actors' perception on this type of agricultural practice was also predefined as a failure.

The network analysis displayed that in both counties the level of centralization for the university was at 40%, this level is relatively low, since the USU is the only agricultural institution within the state. Therefore, this project would recommend integrating and improving linkages of the USU research within the local network structure. Some possibilities that could be implemented are the following:

- Reinvest back into the USU no tillage program.
- Improve on local relationships, hire local knowledge professional for research
- Improve network linkages through the USU Extension Agent
- Build public trust through educational meetings and community research

One of the most important elements that the university has towards developing results is the USU Extension Agent, whose relationships with local farmers allows for trust and interactivity with the community. In both counties the extension agents are strategically located in a position to assimilate knowledge transfer; hence, they can increase the university's connectivity by providing points of contact and updates on university research.

<u>Cache County USU Extension Agent:</u>

In Cache County the network analysis identified that the USU Extension Agent is an important actor within the total network. After interviewing him, it can be considered that his location within the network is crucial to the success of the total network´s structure, because the information that the extension agent acquires is crucial to the connectivity among the different actors. Additionally, since this point of contact is not a big institution rather a single representative, the level of trust and confidentiality expressed by the interviewees was very high, making the extension agent the most important stakeholder of the network's structure. Since this position has been identified, as a crucial point for the success of the network, a further recommendation would be to provide an additional member to the extension agent, who can also provide expertise, gain local trust, and secure information transfer throughout the network.

Cache County Government Actors:

As observed in the network structure, the governmental organizations in Cache County find themselves in a hierarchical position of the network. Conversely, through the interview process the government organizations are not the first point of contact for farmers with conservation concerns. This result indicates that the local government actors should be cognizant of this situation and create possible outreach programs that can be used to improve public trust.

In Box Elder County the network structure provides a very hierarchical development around the centralized government organizations. This factor is very important in understanding how solutions are developed within this region. A low level of betweenness has been identified as another key feature within this network, which has allowed for actors to circumvent organizations to develop collective solutions. As a result of low levels of betweenness, more actors can become involved within the governance, but as Provan and Kenis mentioned "[a]s *the number of organizations in the network gets larger, however, shared governance becomes highly inefficient, with participants either ignoring critical network issues or spending large amounts of time trying to coordinate across 10, 20, or more organizations"* (Provan and Kenis p. 239). Although the network within this county is more complex, the recommendations remain minimal, due to the high interconnectivity between the local actors, who have the ability to collectively derive cross organizational solutions in preventing soil erosion. Therefore, concerning the network structure, I would not recommend any further external organizational actors intervention, rather an increase of local cooperation and knowledge transfer at a local level. Additionally, concerning the overall sustainability of the farming practices, I recommend changes in agricultural subsidies.

One critical issued observed in Box Elder County is the high level of government capital invested within this region. Box Elder County receives approximately 1/3 of the State's farming subsidies; this is very likely the reason why the government agencies are so highly centralized and are the main points of contact throughout the network. When reflecting on the overall sustainability of Box Elder County it is difficult to determine if this network structure would be the same after reductions of government spending take place. Therefore, I recommend that an analysis of Box Elder County's subsidies will be preformed, since it is expected that fiscal cuts will greatly impact government expenditures in the proximate future.

Consequently, it is essential to identify potential solutions that could replace government funding in the future, as well as, identify and minimize any free riders in the current system.

6.3 Recommendation for Further Research

Two recommendations for further research in determining the network analysis and sustainability are listed below:

- Network Analysis at the local individual actor level would provide a more in depth understanding on how farmers interrelate with each other. The analysis of the organizational structure can be used as the foundation in determining how the individual actors collectively work together.

- An analysis of the role that subsidies play in everyday practices throughout Box Elder County and Cache County. I consider that a research on this subject is highly relevant to the local actors. Especially, as the US government is currently looking for areas to remove funding in order to balance the national budget.

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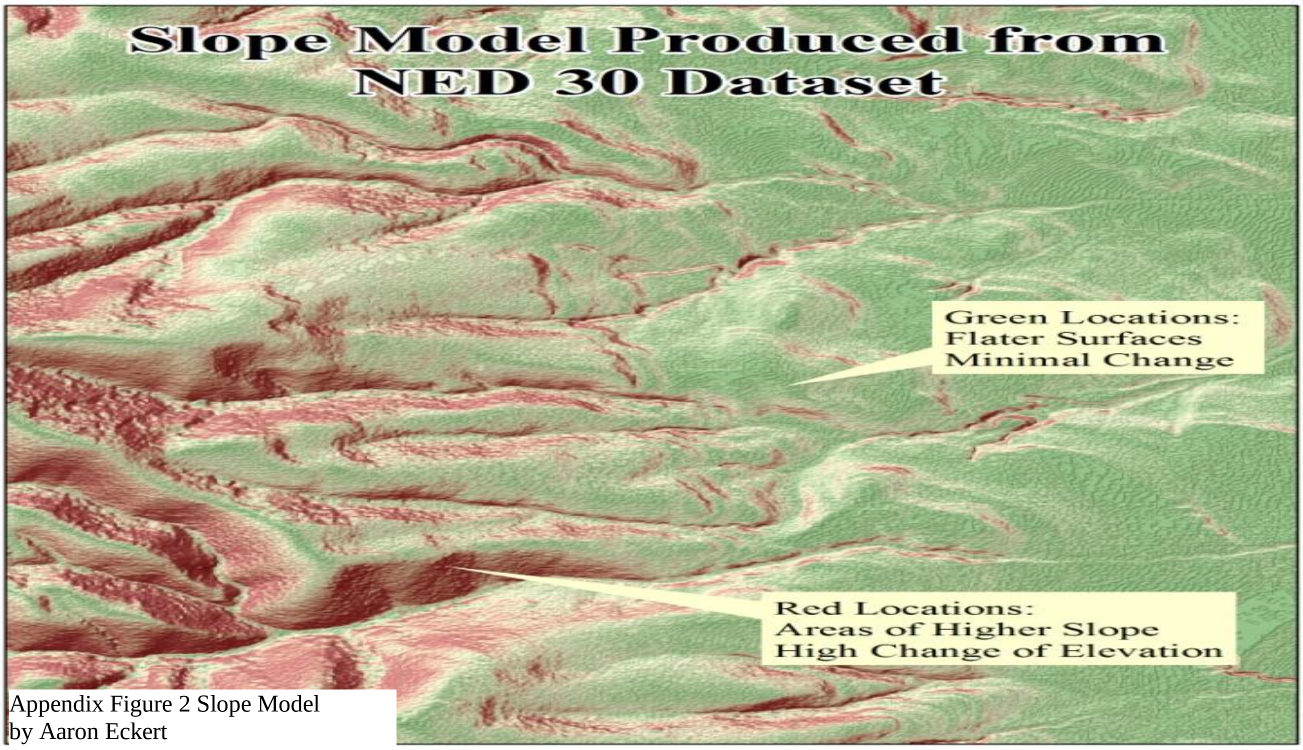
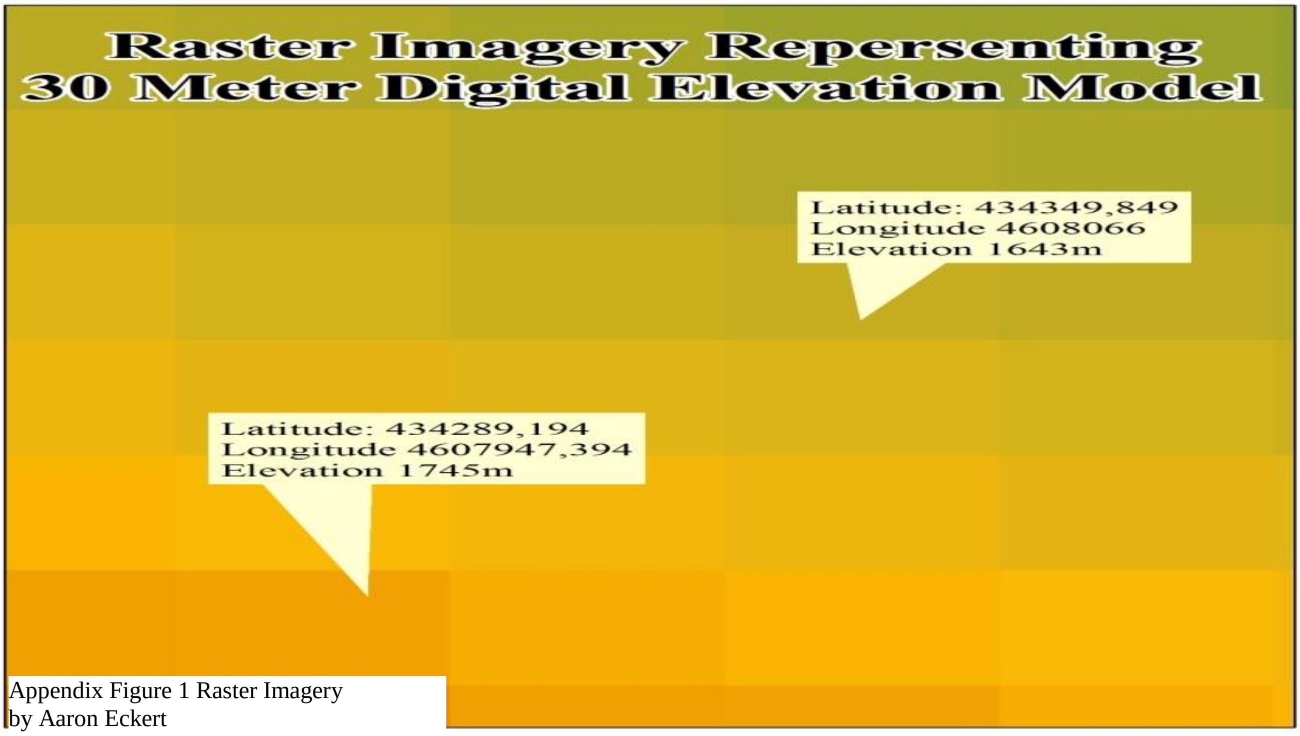
APPENDIX

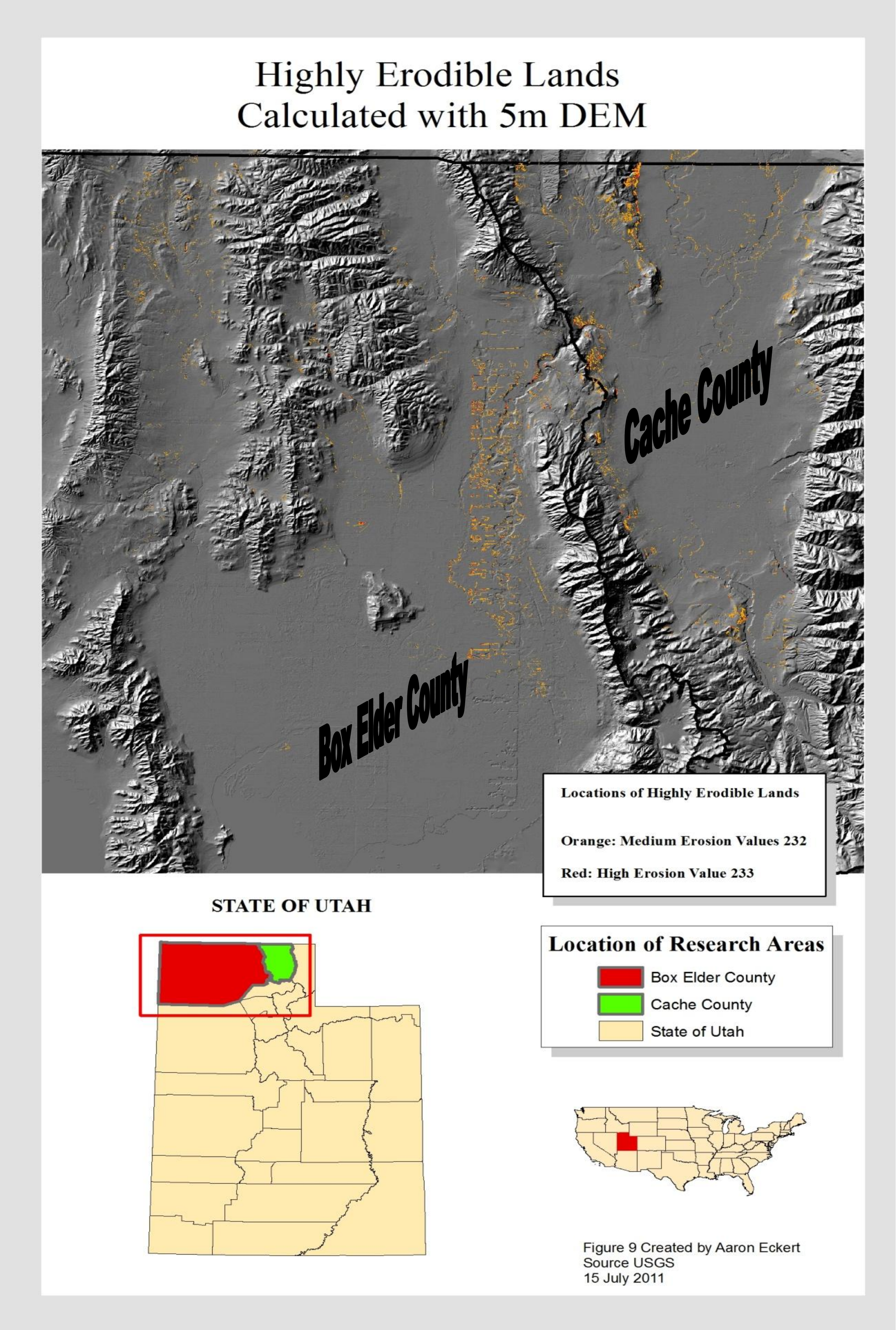
SECTION 1 RESEARCH LOCATION GIS ANALYSIS



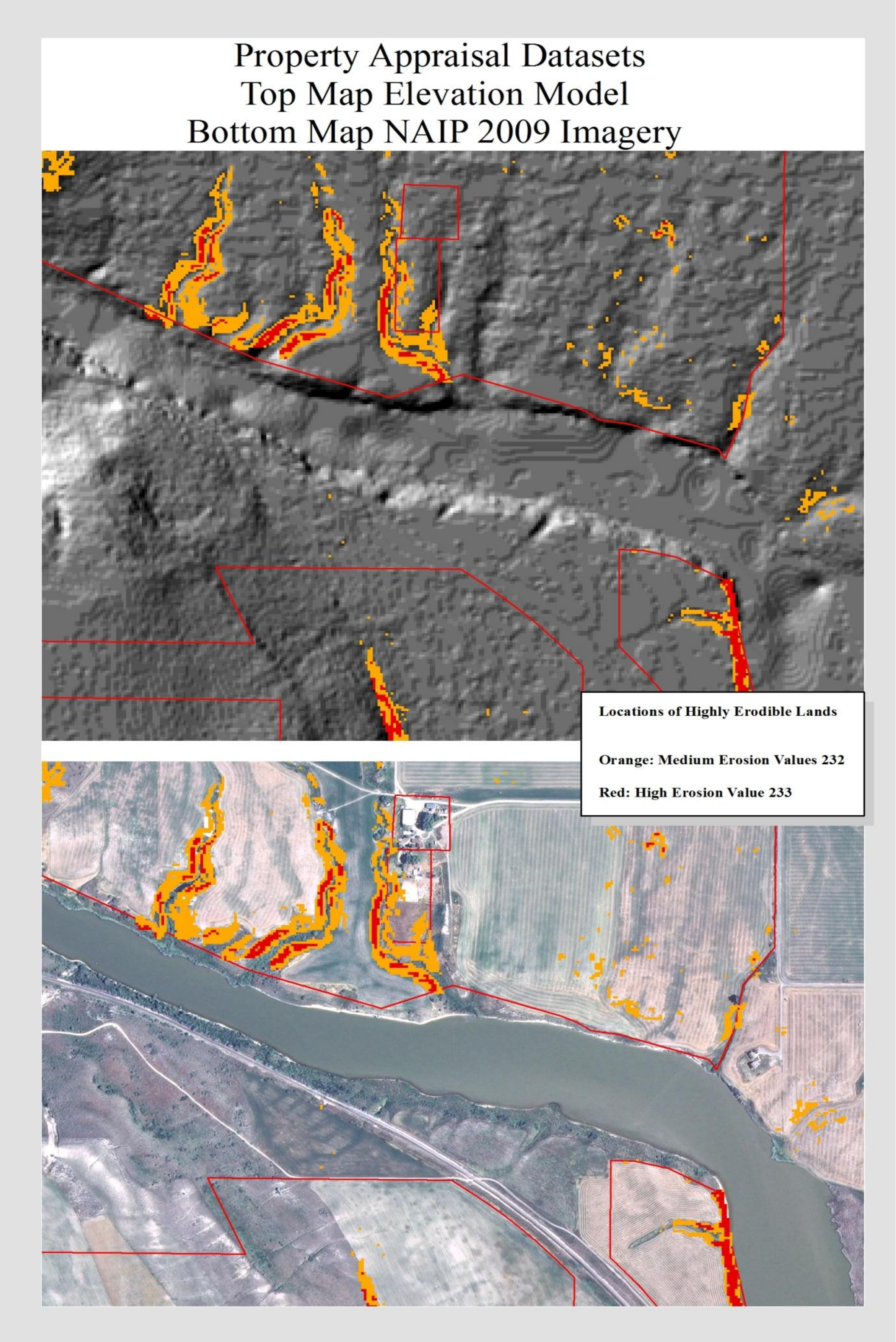
Appendix Figure 2 Slope Model
by Aaron Eckert



Appendix Figure 1 Raster Imagery
by Aaron Eckert



Appendix Figure 3 Study Area Erosion Map by Aaron Eckert



Appendix Figure 4 Erosion Map by Aaron Eckert

Land Description	**Classification Value**
Non Agricultural Areas	**100**
Agricultural Areas	**200**
Soil Erobibiliy	
Rocky & Gravel Soils (Low)	**10**
Clay Composition (Medium)	**20**
Loamy & Silty (High)	**30**
Slope Classification	
0-10 Percent Slope (Low)	**1**
10-18 Percent Slope (Medium)	**2**
< 18 Percent Slope (High)	**3**

Appendix Table 1 Erosion Values by Aaron Eckert

Network Density Results provided by Semi Structured Interview Process									
connections	FSA	NRCS	Soil Conservation District	Farm Bureau	Utah State University	USU County Extension	SARE	Equipment Vendors	Local Farmer
Actor 1	1	1	1		1	1			
Actor 2	1	1	1			1			1
Actor 3						1		1	1
Actor 4	1	1							
Actor 5	1	1				1			
Actor 6	1	1	1		1			1	1
Actor 7			1				1		1
Actor 8	1	1	1			1			1
Actor 9	1	1	1		1	1			
Actor 10	1	1	1		1	1			1
Actor 11	1	1				1			1
Actor 12	1	1	1	1	1	1	1		1
Actor 13	1	1	1	1	1	1		1	
Actor 14	1	1	1			1			1
Actor 15				1		1			1
Total Links	12	12	10	3	6	12	2	3	10
Total Network Connections: 135			Links between Actors: 70				Percent of Density of Network: .52d		
*NOTE: Numbers are based on the initial 15 interviews that were received out of 58 farmers who were attempted to be contacted.									

Appendix Table 2 Cache County Density Tables by Aaron Eckert

Network Density Results provided by Semi Structured Interview Process												
Connections	FSA	NRCS	Soil Conservation District	Farm Bureau	USU Research Farm	USU County Extension	SARE	Equipment Vendors	Local Farmer	Special Service District	LDS Welfare Farm	Farmers Union
Actor 1	1	1			1	1			1	1		
Actor 2	1	1	1	1	1	1	1		1		1	1
Actor 3	1	1	1		1				1	1		
Actor 4	1	1	1	1	1					1		
Actor 5	1	1	1		1	1	1		1		1	
Actor 6	1	1	1		1							
Actor 7	1	1	1			1						
Actor 8	1	1	1	1	1	1	1		1		1	
Actor 9									1			
Actor 10	1	1	1	1	1	1	1		1			
Actor 11	1	1							1			
Actor 12	1	1	1					1		1	1	
Actor 13	1	1	1	1		1						
Actor 14	1	1	1	1	1	1	1		1	1	1	
Actor 15	1	1	1			1						1
Total Links	14	14	12	6	9	9	5	1	9	5	5	2
Total Network Connections: 180			Links between Actors: 91				Percent of Density of Network: .50d					
*NOTE: Numbers are based on the initial 15 interviews that were received out of 30 farmers who were attempted to be contacted.												

Appendix Table 3 Box Elder County Density Table by Aaron Eckert

Appendix Figure 5 Moldboard Plow, Source: Moldboard Plow, 2011

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Appendix Figure 6 Disk Plow, Source Encyclopedia Britannica, 2011

Appendix Figure 7 Chisel Plow, Source: Cox, 2011


Appendix Figure 8 Direct Seed Drill, Source Graeme, 2011

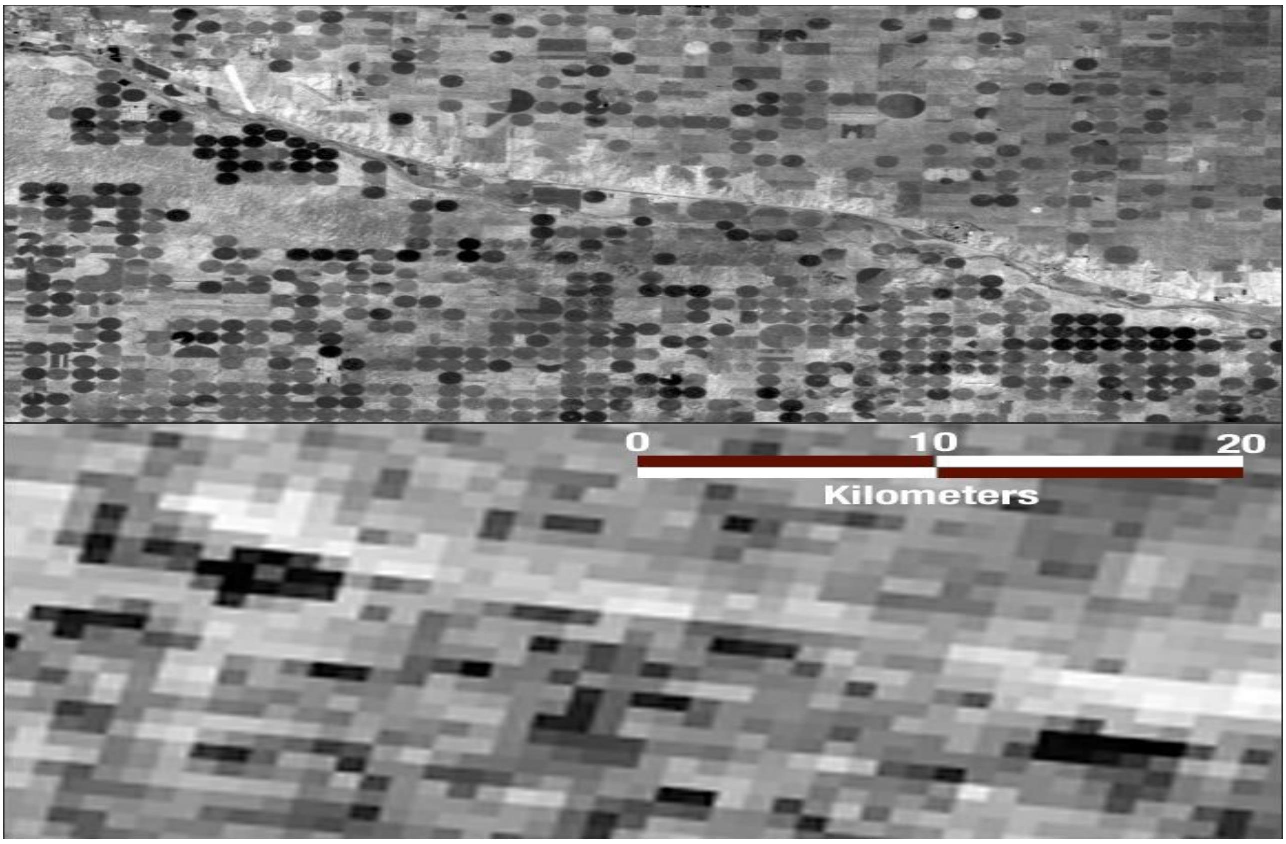
Appendix Figure 9 Terrace , Source Laumer 2011

Appendix Figure 10 Grass Waterways, Source Betts 1999

Appendix Figure 11 Crop Stripping and Contouring, Source Aralin 2009

Appendix Figure 12 Mulching and Residues Management, Source Bernardi 2010

Appendix Figure 13 Wheel-Line Irrigation, Source Rocchio



Appendix Figure 14 Pivot Irrigation, Source Rocchio

Interview Questions

Name: Age:

Address:

City: State:

Background

1. Are you a farm worker or owner? How Long
2. Do you participate in BMPs in managing erosion events (prevention)?
3. In which way do you change the soil conditions?
4. Do you consider soil erosion a threat to your business and/or the possibilities to maintain agricultural production in the short or long term?
5. Are you affiliated with any organization or persons that are concerned with erosion activities?

Agricultural Soil Erosion

6. How would you describe the quality of your soil ?
7. Are there any factors found within the society, market or government that strongly affect your ability to manage soil erosion?
8. How do you increase your knowledge about soil quality and soil management?
    a. Do you have access to reliable information concerning soil conservation?
    b. Who has access to information regarding to agricultural soil erosion?
    c. How is the information distributed among users?
9. Is there a common view concerning soil erosion management?

Soil Erosion Management

10. Do you receive aid from the US Government for farming subsidy?

a. Do you precipitate in CRP or FSA loans or insurance?

11. Do local farmers take part in soil conservation management?
12. Are there rules stipulating when and how farmers can cultivate the soil for agricultural production?

13. Do you think that the environmental policy set by the Government has affected the quality of soil?

    a. How are the rules monitored?

    b. Do you think that the rules are obeyed?

    c. Are there any differences between the formal rules and “what people actually do”?

14. What happens if actors have different points of view in soil conservation?

    a. How are differences handled?

Network

15. With whom do you discuss issues concerning the soil quality and soil conservation?

16. Does the legal framework regulating soil conservation appropriately managing the resource in a good way?

17. What relationship do the local actors have to local and public administrative actors?

    a. What is the level of mutual understanding?

    b. Have these relations changed over time?

18. What relationship do the local actors have to the universities and scientific representatives?

    a. What is the level of mutual understanding?

    b. Have these relations changed over time?

19. Are there any other important actors? (Leader)

NOTE* These questions were modified or used the same question format to follow the interview structure provide by Sandström’s research in addressing resource management (Sandström 2008)