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Extent of Gully Erosion in an Agricultural Field in Northeastern Nebraska at Section 35 Township 29 North Range 1 West in Cedar County

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Extent of Gully Erosion in an Agricultural Field in Northeastern, NE at Section 35 Township 29 North Range1 West in Cedar County

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Abstract:

My thesis project examined a gully within Section 35 Township 29 North Range 1 West. This gully has been noticed for five years and has grown substantially in those five years. The extent and causes of gully erosion were examined by considering the soil, the climate, the land management history, by measuring the gully physically, by using GIS, and by using an economic support tool was estimate soil loss. Appropriate recommendations were developed to reduce gully erosion.

TABLE OF CONTENT

<u>List of Tables</u>

<u>List of Equations</u>

<u>List of Figures</u>

List of Figures (con't)

List of Graphs

List of Graphs (con't)

List of Inserts

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Introduction

With an ever increasing human population projected to rise to over 9 billion people before 2050, the demand for food, fiber, and energy production is also increasing (U.S. Census Bureau, 2004). Thus, the pressure on the 11 percent land resource available for crop production will increase (The Habitable Planet, 2010). Arable land will decrease due to the increased use of less favorable lands for agricultural purposes, poor land management practices, and urban development. Cropland acreage declined 15 percent from 420 million acres in 1982 to 357 million acres in 2007 within the United States alone according to the National Resource Inventory 2007 summary (Southeast Farm Press, 2010). During the last 40 years, nearly one-third of the world's arable land has been lost by erosion and continues to be lost at a rate of more than 25 million acres per year (Pimental et al, 1995).

Agricultural practices have been the source of the modern societies in which we live today. However, the practices in agriculture have not always been sustainable. As described in *Dirt: The Erosion of Civilizations* by David R. Montgomery, civilizations can fall and rise with the productivity of the soil. Poor soil management and unsustainable practices have historically been documented to cause salinization, erosion, and losses in fertility, consequently reducing food production levels.

The Dust Bowl of the 1930's is a good historical example of poor soil management and unsustainable practices. It contributed to the United States' Great Depression as it pushed hundreds of thousands of people from the countryside to the West (Mink, 2004). The Dust Bowl era limited farming production in the Midwest due to drought and wind erosion. According to the Soil Conservation Service, in 1938 as much as 10 million acres had lost the upper 5 inches of topsoil, and 13.5 million acres had lost 2.5 inches, with an average loss of 480 tons of topsoil per acre (Hansen, 2004).

Understanding the effects that soil erosion was having on the farmland and the economy, the United States government took action by initiating soil conservation efforts. The United States did not recognize the need for soil conservation in the years prior to the Dust Bowl, even though Hugh Hammond Bennett had been calling for it since before 1928. After the Dust Bowl era, Bennett's call for soil conservation program was finally heard (Bennett, 1928). President Franklin D. Roosevelt signed the Soil Conservation Act of 1935 into law (NRCS, 2010).

One of the primary mandates of the newly created Soil Conservation Service was to reduce the amount of erosion. One definition of erosion is a group of processes that, acting together, slowly decompose, disintegrate, remove, and transport materials on the surface of earth (Net Industries, 2010). Erosion rates can surpass the rate of soil genesis, depleting vital soil nutrients and soil stability. The removal of soil nutrients can cause reductions in land productivity and could even get to a point where production is no longer possible.

Water erosion can occur as sheet, rill, and gully erosion. Sheet erosion is the removal of soil uniformly across an area. Rill erosion is concentrated erosion that creates pathways or rivulets in the soil through which water may travel and increase the rate of erosion. However, rill erosion can be easily corrected by the movement of soil. Gully erosion is the extreme case of rill erosion in which the rivulets are too large to be filled in using soil in a quick and cost-effective management method, for example disking.

While sheet and rill erosion are the most commonly researched areas of erosion due to their more predictable spatial and temporal constraints, gully erosion can be the largest contributor to sedimentation. For example, five Midwest states had an average 0.89 tons of soil lost per acre by gully erosion in 1997. Comparing these gully erosion rates as a percentage of all water erosion, gully erosion accounts for 43% of soil lost (Casali, 2000).

Slope gradient influences water flow rate during precipitation events and thus is a major factor in gully erosion. Steep slopes with gradual rains will erode less soil than medium slopes with high intensity rainfall events. Sub-surface water movement can also create a piping event in which a piping-roof-collapse occurs and a gully can be formed, most commonly seen in sodic soils (Faulkner, 2004). Gully erosion may also be triggered by changes in land management, leading to a depletion of soil organic matter, reducing the soil's structural stability and increasing soil crusting. This increases runoff and creates gully erosion (Valentin, 2005).

With agricultural systems being primarily managed systems, management plans need to account for erosion occurrences and the effects which gullies can have on a system. The objective for every manager should be to develop land management plans to not only increase production but also maintain soil resources.

The study focused on gully erosion in an agricultural field located in Cedar County, NE Section 35 Township 29 North Range 1 West. The objectives of this study were 1) To determine how historical (within the last 40-50 years) farm management practices of the field relate to soil loss by gully erosion; 2) To estimate the amount of soil lost and associated carbon and nutrient losses from gully erosion; 3) To develop appropriate recommendations to reduce gully erosion of this field.

Methods

The study area is within northeast Nebraska. Section 35 Township 29 North Range 1 West is located on the border with Piece County. The gully in question for this study is within the southwest quarter of the southeast quarter of the section (Figures 1, 2, and 3). The south east quarter of the field has been under cultivation since before 1937. The crop rotation for the last 30 years has been corn- soybeans

<u>Objective 1</u>: Determine field conditions and management history.

Historical data and information were collected for the field in many different formats and with a variety of information. Data of the crop history was collected by interviewing the land owner and by looking at past aerial photographs. In conjunction to the crop history, climate patterns were considered to examine the occurrences of intense precipitation (rains of over two inches in 24 hours). Soil characteristics and soil tests were also examined to understand susceptibility to erosion and estimate carbon and nutrient losses.

An interview was conducted in early January 2011. The questions were as follows:

- When did the land come under your ownership?
- What is the cropping history and rotation since the time that you purchased the land?
- Have you done any soil test?
- If yes, how often and what type of soil sampling method have you applied?
- What nutrients have been applied to the fields?
- When and where are these nutrients applied?
- How were the nutrients applied?
- What system of cultivation has been applied?
- How long has the grove been there?
- What conservation efforts have you done on the land?
- When did you implement your conservation efforts?
- When did you see the gully being created?
- What conditions would you say that it was in when you first noticed the gully erosion?
- Have you taken any efforts to control the gully erosion in your tree line?

For confirmation in the interviews of historical data of the cropping record, the owner provided records that would help with information on the crop history. The land has been certified with the County for the past 20 years and the records from the County would be the best official sources of information.

Another source of historical data over the years came from the use of aerial photography. Nebraska Maps provided two aerial photographs from the farm for the years 1937 and 1955. These maps will provide information on the grove and the gully presence and size.

Soil information was found through the Natural Resource Conservation Service's Web Soil Survey. This data will give insight to what properties that the soils may have.

The long range climate data of Cedar County was retrieved from the High Plains Regional Climate Center. Among the climate data, the annual precipitation data was highlighted to relate climate and management interactions which may have led to gully formation.

Objective 2: To Estimate the amount of soil and associated carbon and nutrient losses from gully erosion.

In mid-March 2011, soil samles were taken from the area surrounding the gully (Figure 4). Samples were taken from the top 8 inches using a 1.4 inch soil hand probe. The goals of these samples were to measure the amount of total carbon and other nutrients lost within the soil from the gully. Samples were placed in plastic bags, homogenized, and air-dried before analysis. Air-dried samples were analyzed for pH, organic matter, extractable P and K, and nitrate-N (Ward Laboratories).

Physical assessments of the gully were made by measuring the length, width and depth of the gully. Width and depth measurements were made every ten feet. The width was measured at two points of the ridge top and at the middle point (Table 1). Measurements were then averaged to calculate the total volume of soil lost using a range of 1.2-1.45g cm^{-3} average soil bulk density values. The bulk density range is densities of soils within the region. The high and low range was applied to account for the variability in the soil and the density change with depth.

Aerial photo analysis was completed by digitizing the 1937, 1955, and 2006 photos. Nebraska Maps has provided aerial photographs of the field for two years: 1937 and 1955 (Figures 5 and 6) and a photo from the Web Soil Survey was screen captured for the 2006 photo (Figure 7). The photos were digitized and a measure of the visible erosion was made.

For the digitization of the aerial photographs, ArcGIS 10 was used. A spatial reference of Cedar and Pierce counties were downloaded from the U.S. Census Bureau. The spatial references were used to create the size and relative locations of the land. In the ArcGIS program the photos were georeferenced and the spatial references were projected to State Plane_Nebraska_NAD_1983. After the photos were referenced, a shapefile was created to draw out the shape of the gully and estimate gully size. The editor program was used to create a shapefile of the gully to best represent the area of the gully showing within each photograph (Figure 8).

Objective 3: To develop appropriate recommendations to reduce gully erosion in Section 35 Township 29 North Range 1 West.

A cost benefit analysis was completed to create possible management alternatives to reduce gully erosion. An application of the Soil-Erosion Economic Decision Support Tool (SEE-DST) for Land Management in Nebraska was used to create alternative management scenarios with corresponding cost-benefit analysis. (Mamo et al., 2009, Ginting, et al., 2009) (Figure 9). For the SEE-DST program, the inputs are in table 2. Many of the program's values were default but climate data, management for the field and yield information was the determined from the land owner.

Results and Discussion

The soil

The majority of the field in this 160 acre area consists of Nora (Fine-silty, mixed, superactive, mesic Udic Haplustolls) and Crofton (Fine-silty, mixed, superactive, calcareous, mesic Udic Ustorthents) soils series. There were 9 total soils found with the field: Crofton, Nora, Moody, Alcester, and Awoa (Table 1). The Crofton series is a very deep well drained soil that formed in calcareous loess. These soils are on uplands and have slopes ranging from 1 to 60 percent. The Nora series also consists of very deep well drained soils formed in loess on uplands with slope ranging from 0 to 30 percent. These soils are closely related to one another; therefore, they are often occur together as are the Moody series and Alcester series seen within the field in smaller amounts.

All the soils come from the Mollisol soil order. This means that the soil was once prairie. The lasting effects on the soil can be seen as increased levels of humus within the upper layers of the soil from the growth of the native grass vegetation. These types of soils are considered to be highly arable soils used for growing grains and forage crops.

The Revised Universal Soil Loss Equation (RUSLE) factors for these soil series come within the 'normal' range. The normal range is the generally seen erosion rates for soils under traditional conditions (Prior to cultivation). The RUSLE takes into account the rainfall, the soil erodibility, slope length, slope steepness, cover management, and support practices. The K factor, which represents the susceptibility of soil to erosion and the rate of runoff, seen for this field is considered within the moderate to highly erodible ranging from .28-.43. The T factor, which estimates the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity, was reported to be 5 tons per acre per year according to the web soil survey report.

The hydrological connection/water movement direction

The Section 35 Township 29 North Range 1 West's southeast quarter has three distinct directions of water flow by land surface (Figure 10). The field contains no wet streams. However, dry waterways are present and play a huge part in the water flow during heavy rain events and cause concentrations of rain water flow.

The southeast quarter can be divided down the middle from north and south dividing the land into East and West halves. The west side has a flow into a single valley going in a southerly direction. The east side of the field can also be divided into two halves, north and south. The north contains a valley that flows to the east. The south half of the east half flows to the south. In this south half, water flowing to the south can only come out one of two valleys. This concentrates the water flow creating favorable conditions for gully development. Both valleys that flow to the south proceed south until joined one third of a mile into Pierce County and meet a wet stream that comes from the northwest (Figure 11).

A wider perspective of the area is that the water flow of the area, Section 35 Township 29 North Range 1 West, is contained within the USGS Logan watershed. The Logan watershed has a southeast water flow. Logan is part of the sub-region Elkhorn River basin. This river basin will continue in a southeastern flow until it joins the Missouri River. (Figures 12, 13, and 14)

According to the USGS, the Logan watershed has no monitored waterways within this watershed, suggesting that at the present time; there have been no reported major contaminations that have warranted the need for regulation.

Climate/Temperature of Site

The annual temperature, for the last 68 years (1941-2008), was an average of 49 °F. The annual precipitation for the area has increased for the past 31 years (1977-2007) from 25 inches to 27 inches. However, during the months (March through June), when gully erosion occurrences are more likely to occur, the annual precipitation rates have not increased. The annual precipitation for this area seems to have been steady for many years. However, this would suggest that the increase of two inches of precipitation occurs between July and February. The months between March and June have an average rainfall of 12 inches. On a normal precipitation year, these four months contribute 60 percent of the annual rain for the area.

However, gully erosion is not as affected by the amount of rain that occurs over a long time period as much as it is affected by the amount of rain that occurs in a single precipitation event. Gully erosion takes large amounts of rain (greater than 2 inches or 1.5 inches) within a short (24 hours' time) to create a gully.

The precipitation between March to June was evaluated to estimate the proportion or frequency of rainfall occurrences of 0.01 inch of rain, 0.5 inch of rain, 1.5 inches of rain, and 3 inches of rain in 24 hours. There is a strong indication that these small (0.01 and 0.5 inches) rain occurrences are increasing. On average, the number of these small rain occurrences between March and June increases from two to seven in the last 30 years.

The rain occurrences of 1.5 inches or greater have stayed relatively stable over the last 30 years. However, the occurrences of rainfalls two inches or greater in these months have decreased nearly in half from .8 to .4. This would suggest that one idea for the increase in gully erosion cannot be caused by an increase in high rainfall occurrences.

Field History

The parcel of land was purchased in 1990 and has been in cropland before and after it was purchased. The trees were planted in the 1940s to protect homesteads from northern winds during winter (Figure 7). The cropping system has been dry land corn-soybean rotation since purchase by current land owner (Table 3).

The cropping system includes alfalfa in the rotation with spring oats sown with alfalfa. Oats are grown in the summer and harvested in late summer for grain and baled for straw. Alfalfa will be sowed in the fall and grown for the next three years. The last time that alfalfa was a part of the rotation was in the early 1990s after the land was purchased. During the early 2000s, the section's northwest quarter of the southeast quarter was sown with rye in the fall and harvested the next summer for grain and straw. In early 2003 the eastern fourth of the field was planted with alfalfa and oats. The following three years alfalfa was harvested three times for hay (Figure 15).

In this field, soil tests have not been done since land purchase. Nutrients have been applied to the field regularly. Fertilizer applications have been determined mainly through advice of a fertilizer consultant. The basis of fertilizer recommendation by the consultant was not provided.

Primary nutrients applied were phosphorus and nitrogen. Phosphorus is typically applied in the fall while nitrogen is only applied days before planting and cultivation. Fertilization was done before cultivation so that the fertilizer could be mixed into the soil and to reduce nutrient runoff and time on the field prior to plant growth.

The tillage of the field has been reduced over the years. The field was plowed regularly for planting and then cultivated in the spring to control weeds. In more recent years (1990), disking and chisel plowing were done under the field debris prior to planting. Cultivating for weed control and after crop emergence has been replaced by herbicide for the past 15 years.

Conservation efforts have been taken to reduce tillage over the years. When the land was purchased, grass was seeded in the valleys of steep hills to reduce the erosion in those areas. However, herbicide spraying in more recent years has caused a reduction in grass and/or a complete removal in some valleys.

The gully that is of interest was first noticed 15 years ago and was initially a dip in the tree line. The field to the south has always been affected by water flow concentrations because of a bridge being used as a road. In the last five years, the gully has especially expanded. During summer months, the grass and trees hide the gully, as does snow during the winter months.

Even though concerns have been raised, little to no action has taken place to remediate the gully. One reason for this delay comes from the county replacing many older wood frame bridges with culverts. The change from a bridge to a culvert would mean some reworking of the ditch and the way water flows. A second reason is that the gully issue is seasonal in that it is visible in the spring when heavy rains occur and when soil is moved downstream.

Extended historical data was not provided for two reasons. Records have not always been kept. After the end of the year, many records were thrown away. The second reason was many records that are kept are financial records and could not be disclosed.

<u>Soil Lost</u>

The gully measured 127 ft. long. Then every ten feet height of the gully was measured as well as width at the top of the ridge and at the midway point in the height. (Calculations

Appendix) These two measurements of width were averaged to calculate a more representative measure of width. The gully area was estimated at 405 square feet and represents of less than one percent of the section (section is 640 acres). The bulk densities of 1.2 g cm^{-3} and 1.45 g cm^{-3} were used as the lower and upper range, respectively, for soil loss estimation. With the soil samples being from the top 8 inches, differences of bulk density with depth was assumed to be negligible (Table 4).

The total amount of soil lost from the gully ranged between 19.2 and 23.2 tons in the last 5 years with an average of 3.8-4.6 ton per year. Although area size of the gully is small relative to the section, its contributions annually total erosion from the entire section.

Soil Nutrient Lost

The tree line and the gully were planted with trees and grass in the early 1940s. This should have allowed for the soils to create similar nutrient levels. The field just north of the tree line has been worked for many years. Thus, it is expected that this would result in lower nutrient levels, such as nitrogen, carbon and phosphorus while the tree line should have higher levels. Therefore, it is assumed that the nutrient levels for the gully should be less than the tree line and greater than the field.

As previously assumed, the soil within the tree line had higher levels of carbon, nitrogen and phosphorus. The soil within the tree line had 4.3 and 4.4 percent organic matter. The organic matter level was 0.5 percent less than the field (3.7-3.8 percent soil organic carbon for the gully). The soil in the field north of the tree line had an organic matter content of 3.2-3.3 percent. The soil within the gully still has higher levels of organic carbon than the field, suggesting that the eroded soil from up hill may be accumulating within the gully.

These results are then continued onto the N levels of the soil. The gully contained 6 lbs N A^{-1} while its counterparts within the tree line contained between 42- 51 lb N A^{-1} and the field had higher levels than the gully between 12-14 lb N A^{-1}. The third expected area to see differences within the soil samples, the phosphorus concentration, showed further evidence that the gully has been losing nutrients. The field and the tree line had soil phosphorus levels between 39 and 46 ppm. The gully had result between 25 and 34 ppm phosphorus. This creates evidence that the important top soil layer (where soil phosphorus is easier to extract) has been degraded if not lost.

GIS Estimation

The amount of erosion estimated using aerial photographs and GIS. Because the 1937 photo quality was poor, it was omitted from the GIS gully aerial analysis. The 1955 and 2006 photos were subsequently used for GIS gully analyses. GIS analysis of the 1955 aerial photo indicated presence of the gully with an estimated area of 375 square feet. This is about 30 square feet less than what was measured physically in spring 2011. The second photograph from 2006 had an estimated gully size of 527 square feet, and is about 120 square feet higher than the 1955 estimation and 2011 field measured gully size (Figures 16 and 17).

The difference in gully size between 1955 and 2006 suggests an estimated gully expansion rate of 3 square feet per year. Differences in gully size between measured value and GIS estimation may be due to quality of the photographs and the precision of the delineation using photographs.

Cost-Benefit Analysis

The Soil-Erosion Economic Decision Support Tool (SEE-DST) for Land Management in Nebraska tool had two different alternatives suggested. The calculated current pollutant loading was very steep. The water ways without grass resulted in erosion rates of 9.9 T soil A^{-1}, 38.2 lb.

total P A^{-1}, 21.7 lb. total N A^{-1}, and 276.4 lb total organic carbon A^{-1}. For the alternative system the following stipulations were set: erosion target (5.5), Tolerance of Net Income Loss (3), Conservation Practice (Non-Terraced), Irrigation (Dry Land) and Crop Rotation (Corn-Soybean). The alternative practices suggested by SEE-DST was the same for both of the conservation types applied to the software (no till corn-no till soybean).   The preferred alternative suggested an erosion reduction of 4.7 T/A. Reductions in N loss, P loss organic C for grassed were 5.9, 22.7, and 132.5, respectively (Table 5).

Conclusion

Based on the qualitative and quantitative information data from this project, the gully has been affected more by the land management than by the climate. If the climate was the cause of the soil erosion, it would have been more likely that the gully would have been decreasing in size in the last five years. This assumption comes from the fact that without large amounts of rain to continually wash out the gully it would continue to grow substantially. The field/land has been used to ‘gully washer’ rains through out history. The change in how the field has been managed must have triggered a loss of soil of larger proportions than have ever been seen before.

The photographs supporting the fact that gully has been there disproved the notion that the gully formed just recently. However, since the photographs are old and not taken regularly (none recently), it is hard to come up with any solid answers to why the gully has appeared as it has.

Recommendations

The recommendation for alternative land management for this field is outside of the landowner’s present financial capabilities or willingness to consider. The implementation of putting in no till management may be a few years away. However, the solution of increasing the grass within the waterways and the ability to start capturing some of the water and soil that comes through the gully are possible. Grass seed is purchased every few years to help with the maintenance of the waterways in many of the other fields. This will reduce the cost of purchasing seed because it is already budgeted.

Upon discussion with the farm manager, suitable management practice was devised to reduce the amount of erosion that is occurring within the field and give the farmer a chance to set grass for the waterways for the field. Oats and alfalfa are going to be sown within the field this year. This is a change of what was planned for the field. After the field is sown in the oat-alfalfa mix, the son intends to sow a grass mix within the waterways of the field to help trap some of the water that is flowing through the field and reduce the overall erosion within the field.

Direct restoration to the gully will be applied to reduce the amount of soil that is lost. With the gully already below the root line to help capture soil and slow water movement, debris (trees) will be laid down within the gully. Maintenance will be done over the next four years while the oat and alfalfa are in the field. The goal is to have the gully filled in by the time corn-soybean rotation is once again applied to the field. As improvements to the land management are made, the amount of erosion should decrease and the amount of the productivity will increase.

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Tables:

Table 1: Soil Characteristics for the southeast quarter of section 35 Township 29 north Range 1 west.

Soil Type	Number of Acres	K factor*	T factor**
Awoa Silt Loam	7.2	0.37	5
Alcester Silt Loam, 2 to 6% slope	12.8	0.28	5
Crofton-Nora Complex, 2 to 6% slope	14.2	0.43	5
Crofton-Nora Complex, 6 to 11% slopes	30	0.43	5
Crofton-Nora silt loams, 6-11% slope	20.1	0.43	5
Nora Silt Loam, 6 to 11% slope	17.2	0.32	5
Nora Silty Clay Loam, 6 to 11% slopes	23.6	0.32	5
Crofton-Nora Complex, 11-17% slopes	3.5	0.43	5
Moody Silty Clay loam, 2-6% slopes	2.5	0.32	5
Moody Silty Clay Loam, 6 to 11% slopes	15.7	0.32	5

*Values of K range from 0.02 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water. The K factor represents both susceptibility of soil to erosion and the rate of runoff.

**The T factor is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Table 2: Information plugged into the SEE-DST program for the southeast quarter of Section 35 Township 29 North Range 1 West in Cedar County, NE

Cost/Prices Data	Input Values	Input Values	**Watershed Information**	Input Values
Power Units	$/hr		County	Cedar
Tractor	35		Weather Station	Concord
Combine	75		Main Soil	Crofton
Implements	$/hr	A/hr	Watershed Area	160
Field Cultivator	1.6	33	USLE-Length slope factor	4.26
disk	3.5	12.2	**Current Conservation Practice**	
Moldboard	6.4	3.5	Current Conservation Practice	Ephemeral channel Tilled and planted
Row Cultivator	1.7	7	**Current Management**	
Chisel	2.7	13	Irrigation Practice	

Implements (cont.)	Input Values	Input Values	Current Management (cont.)	Input Values
Ridge Till	3	13	Crop Rotation	Dry land
Row Planter	2.25	9.3	Corn, Bu/A	Corn-Soybean
Drill Planter	3	6.8	Soybean, Bu/A	150
Seeder-Packer	1.75	13	Corn	60
Knife Applicator	1.75	25.6	Soybean	Conventional
Sprayer	0.75	25.6		Conventional
Corn Header	9.45	9	Commodity/Input Prices	
Soybean header	8	12	N, $/lb N	0.6
Small grain header	5.5	6.8	P,$/lb P	0.7
Swather	3.5	10.2	Herbicide, $/lb active ingredient	50
Windrow Turner	3	13	Insecticide, $/lb active ingredient	10
baler	6	3.01	Corn, $/bag	90
Bale remover	0.5	13	Soybean, $/bag	50
Stalk Chopper	3.4	7.8	Wheat, $/lb	0.6
Conservation Costs			Alfalfa, $/lb	7
Grassed Water Way only		2 $/A	Corn, $.Bu	7
Areal Fraction of watershed under grassed Water Ways		0.01 AC/A	Soybean, $/Bu	15
Whole Field Terraces, Surface Outlet		15 $/A	Wheat, $/Bu	9
Whole Field Terraces, Grassed Water way		10 $/A	Alfalfa, $/Ton	110
Partial Terrace for Ephemeral Channel		8 $/A		
Increase of Operational Time for Contour vs. Non Contour		30%		

Table 3: Breakdown of the field history for southeast quarter of Section 35 Township 29 North Range 1 West in Cedar County, NE

Year	Event
Pre 1990s	
Unknown date	Mono-culture cultivation
Early-1940s	Trees were planted as a shelter belt.
1990s	The land was purchased by the current land owner
Early 1990s	The field was planted in to alfalfa
Even years	Corn**
Odd years	Soybeans**
2000s	
2003	East fourth of quarter was planted into alfalfa
2004	Rye was planted in the Northwest section of the field*
Odd years	Soybeans**
Even years	Corn**
2011	Oat and Alfalfa sown in western half

*See figure 5 for reference.

**Rotation is applied to entire field unless specified.

Table 4: Width and height measurements every ten feet for gully located in section 35 Township 29 North Range1 West in Cedar County, NE.

Points measured	Height	Width Ridge	Width Middle
0 Ft	4 in	51.5 in	53.5 in
10 Ft	13 in	38 in	38 in
20 Ft	16 in	32 in	30 in
30 Ft	17 in	30 in	30 in
40 Ft	19 in	29 in	26.5 in
50 Ft.	21 in	26 in	24in
60 Ft.	24 in	24in	24 in
70 Ft.	26 in	26 in	26 in
80 Ft.	19 in	35 in	30 in
90 Ft.	19 in	40 in	40 in
100 Ft.	12 in	48 in	50 in
110 Ft.	8 in	50 in	48 in
120 Ft.	8 in	54 in	56.5 in
127 Ft.	6 in	56 in	57 in
Totals Average	15.14	38.54	38.11

Table 5: Reported results and recommendations for southeast quarter of Section 35 Township 29 North Range 1 West in Cedar County, NE.

Calculated Current Pollutant and Budget				
Pollutant Loading			Crop Budget	
Erosion (T/A)		9.9	Total Cost ($/A)	126.27
Total P (lb/A)		38.2	Yield Income ($/A)	975
Total N (lb/A)		21.7	Non-Adjusted Income ($/A)	848.73
Total Organic Carbon (lb/A)		276.4		

Alternative Practices	Erosion Reduction (T/A)	Non-Adjusted Income Benefit ($/A)	Benefit Ratio (T/$)	N Loss Reduction (lb/A)	P Loss Reduction (lb/A)	Organic Carbon Loss Reduction (lb/A)
Alternative 1	4.77	-0.97	4.77/0.97	5.85	22.73	132.5
Alternative 2	4.47	14.64	4.47/14.64	5.62	24.01	124.44

Alternative 1: Description
Practice: No Terrace, Contour, No Grass Waterways
Rotation: Corn-Soybean
Irrigation: Dry Land
Management: Notill Corn-Notill Soybean

Alternative 2: Description
Practice: No Terrace, Contour, Grass Waterways
Rotation: Corn-Soybean
Irrigation: Dryland
Management: Notill corn-Ridge till Soybean

Equations:

Equation 1: Calculation to determine how much soil was lost within the gully (lower limit).

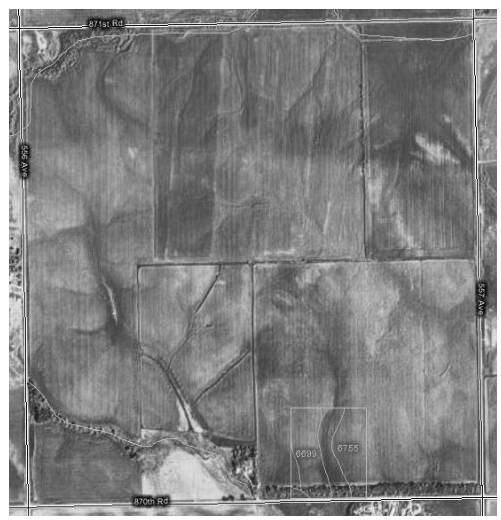
$$ft^3 \times 28{,}316.8466\,\frac{cc}{ft^3} \times 1.2\ \frac{g}{cc} \times 1.10231131 \times 10^{-6}\,\frac{ton}{g}$$

Equation 2: Calculation to determine how much soil was lost within the gully (higher limit).

$$ft^3 \times 28{,}316.8466\,\frac{cc}{ft^3} \times 1.45\ \frac{g}{cc} \times 1.10231131 \times 10^{-6}\,\frac{ton}{g}$$

Figures:

Figure 1: Nebraska state map with Cedar County darkened in to show location Nebraska State map.



Figures 2: Aerial photograph of section 35 Township 29 north Range 1 west from 2006 taken from the NRCS Web Soil Survey.

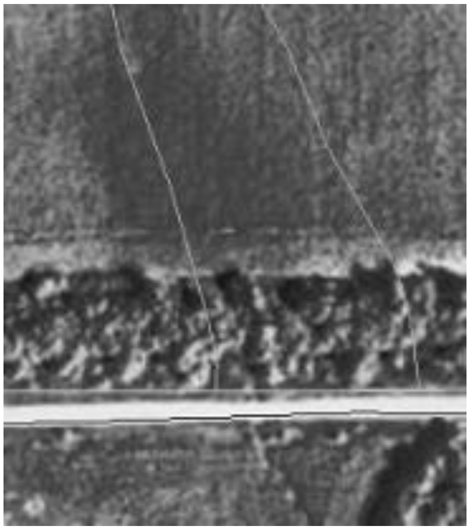


Figure 3: Zoomed into the location of gully within section 35 Township 29 north Range 1 west from the 2006 photo taken from the NRCS Web Soil Survey.

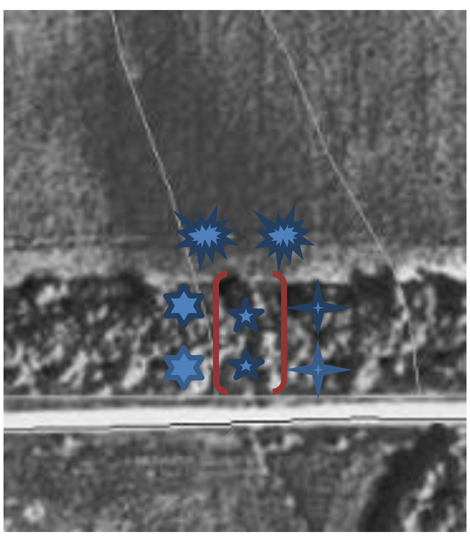


Figure 4: Zoomed in diagram of where soil samples were taken and the reference number that they were given for the soil sample.

: East side (EA1 and EA2)

:West side (W1 and W2)

: Gully (G1 and G2)

: Field (F1 and F2)

Figure 5: 1937 aerial photograph of the southeast quarter of section 35Township 29 north Range 1 west. Photo retrieved from Nebraska Maps.

Figure 6: 1955 aerial photograph of the southeast quarter of section 35 Township 29 north Range 1 west.

Figure7: 2006 aerial photograph of the southeast quarter of section 35 Township 29 north Range 1 west. Photo retrieved from NRCS Web Soil Survey.

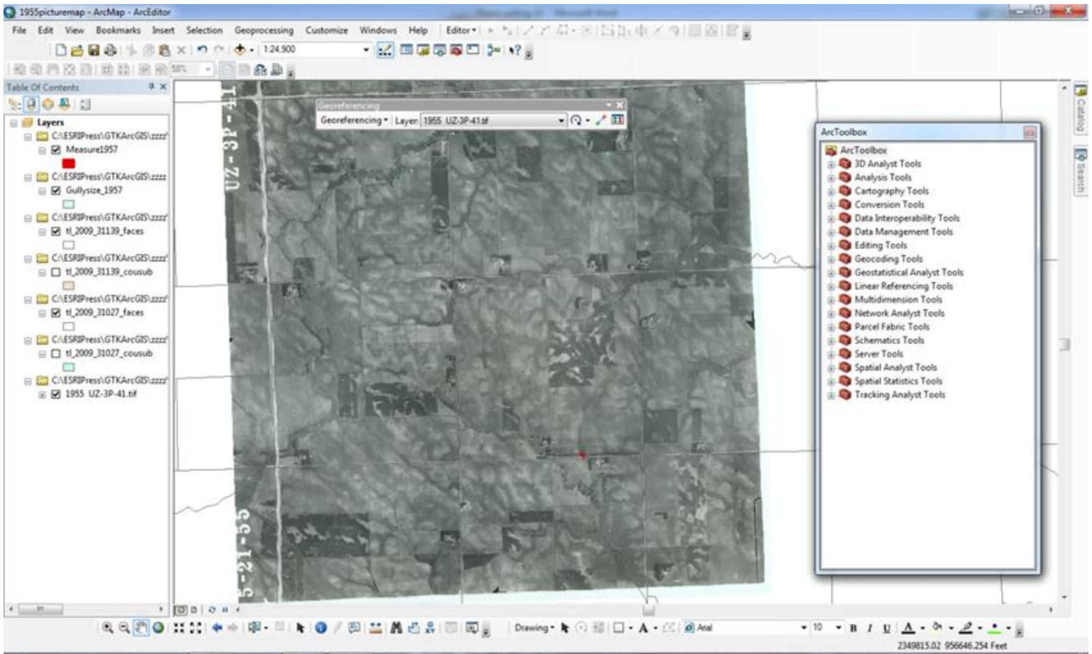


Figure 8: Image of ArcGIS program while working on 1955 aerial photograph while measuring the area of the gully.

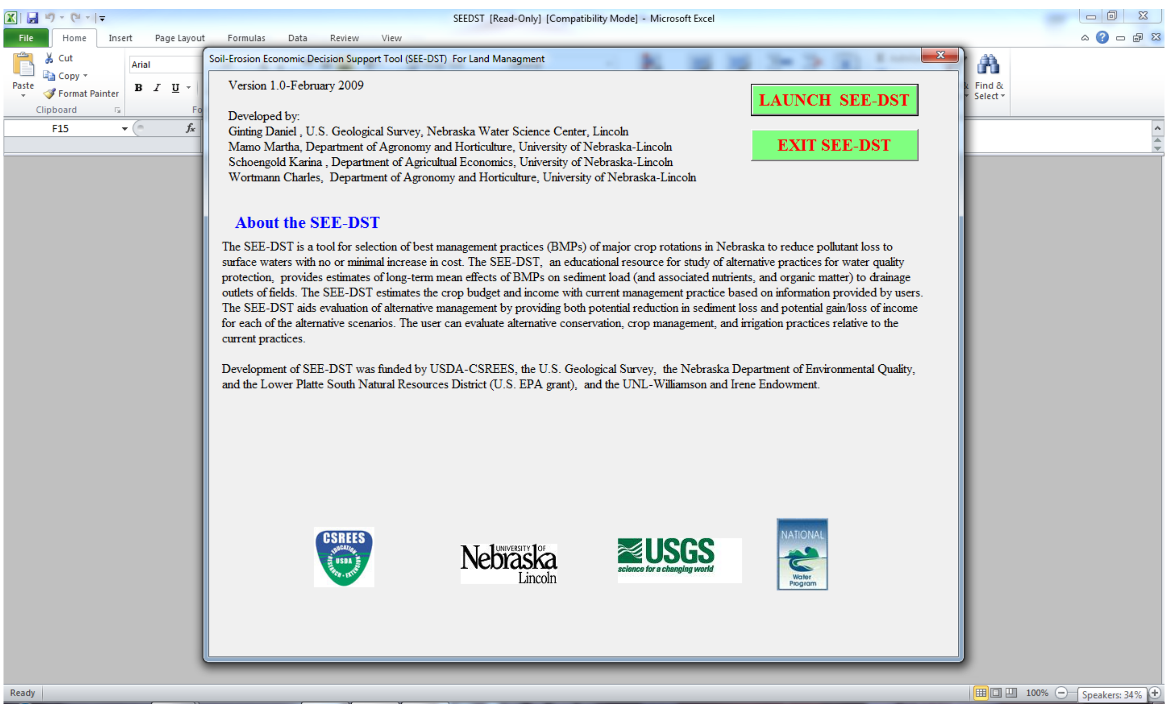


Figure 9: Display of the SEEDST program startup page.

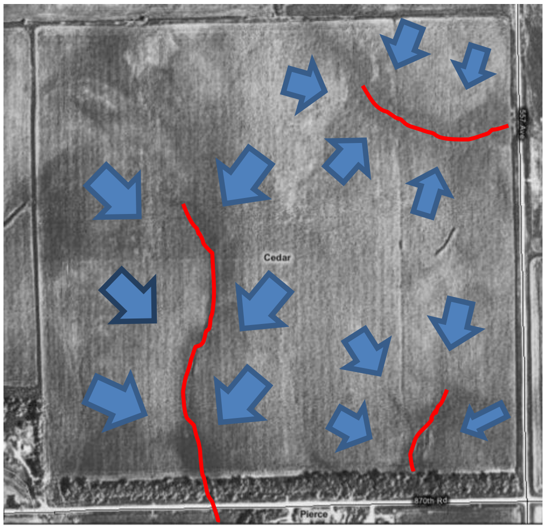


Figure 10: Diagram of water movement within the southeast quarter of section 35 Township 29 north Range 1 West. Red lines show the relative placement of the dry waterways. Background image was taken from NRCS Web Soil Survey.

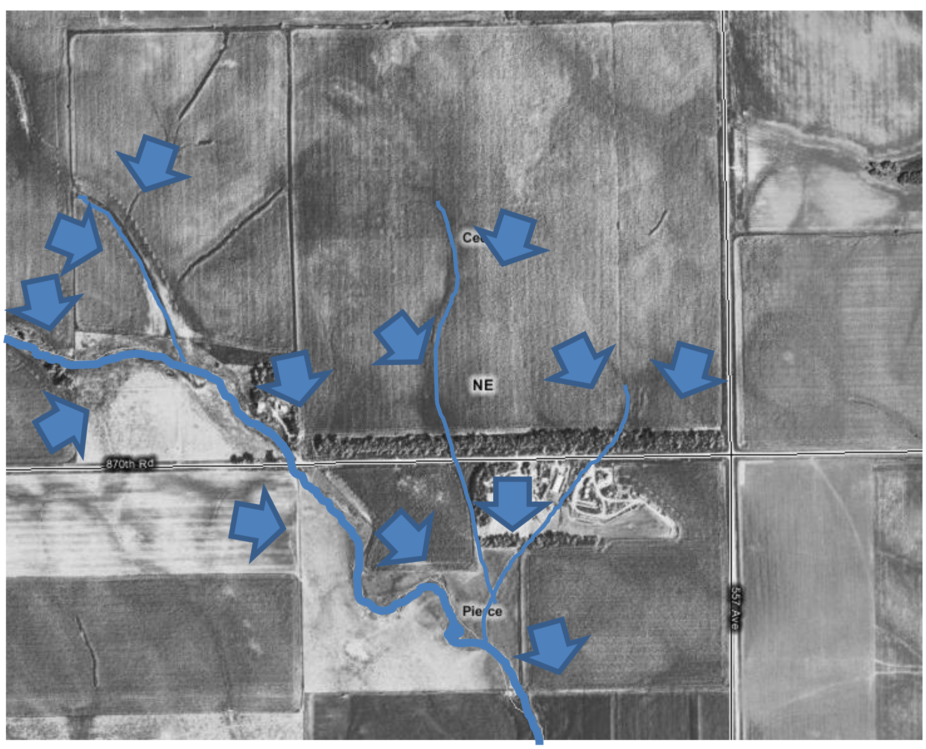


Figure 11: Expanded view of water movement encompassing sections 35 Township 29 north Range 1 west and section 2 Township 28 north Range 1 west. Blue line shows the relative placement of waterways. Background image was taken from NRCS Web Soil Survey.

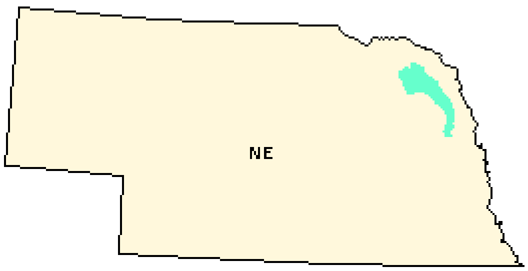


Figure 12: Nebraska map showing the location of the Logan watershed. The image was taken from the US geological survey.

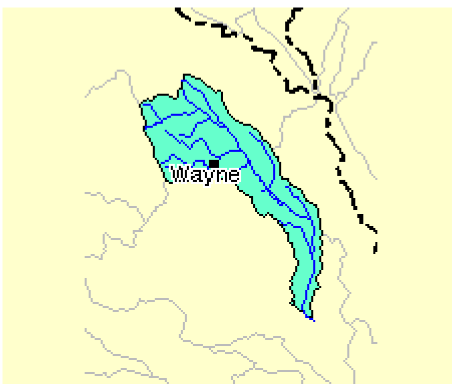


Figure 13: Logan watershed zoomed in to show the Wayne to help show location. The image was taken from the US geological

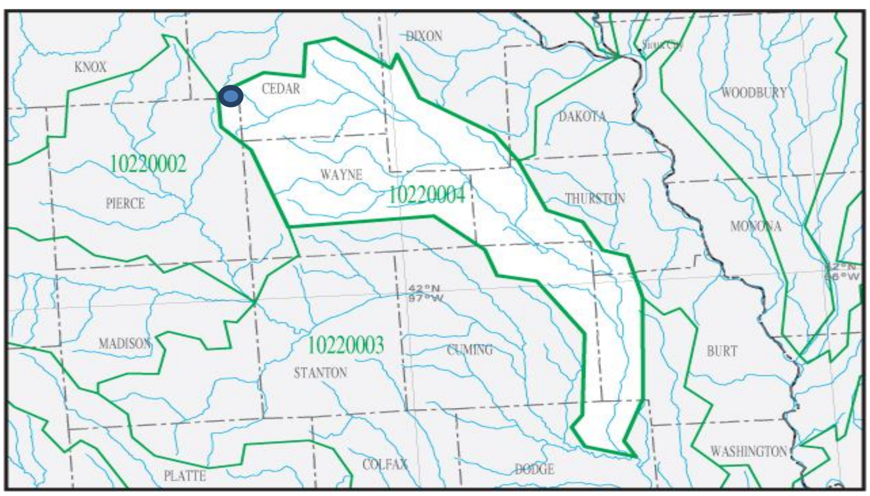


Figure 14: Logan watershed zoomed showing the counties that Logan watershed is contained within. The blue dot represents relative location of field. The image was taken from the US geological survey.

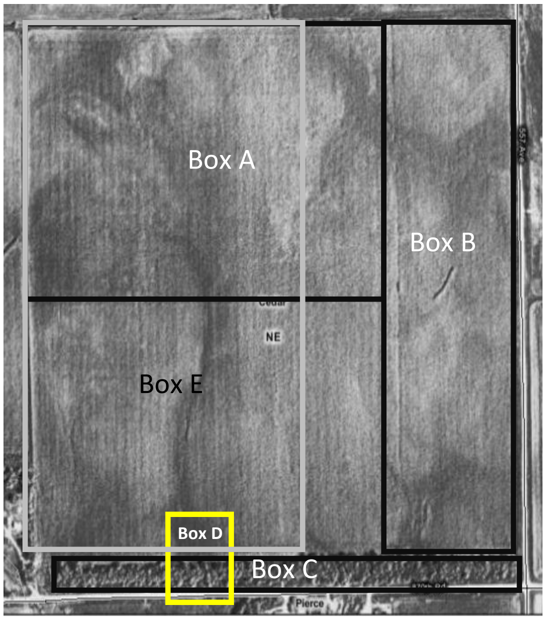


Figure 15: Diagram of the relative locations of areas discussed within the field history section. The image is of the southeast quarter of section 35 Township 29 north Range 1 west.

Box A: Northwest section, contained rye in early 2000s

Box B: East fourth section, contained oats/alfalfa from 2003-2007

Box C: Shelter belt, planted in 1930s

Box D: Area of interest containing gully

Box E: Western half, sown into oat/alfalfa in 2011

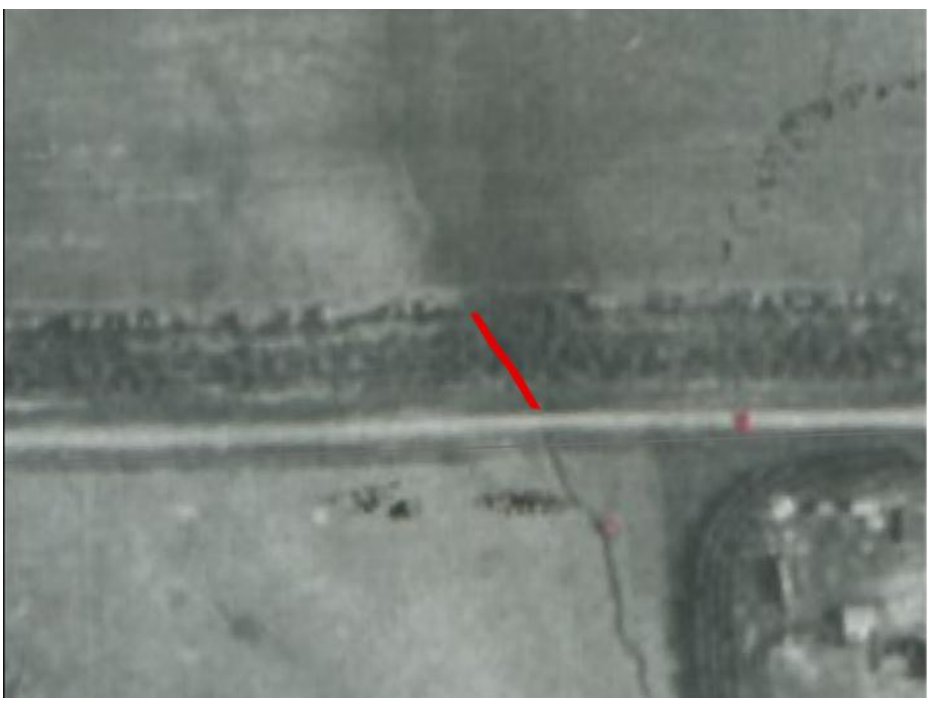


Figure 16: 1955 aerial photograph with measured area of gully in red within section 35 Township 29 north Range 1 west.

Figure 17: 2006 aerial photograph with measured area of gully in red within section 35 Township 29 north Range 1 west.

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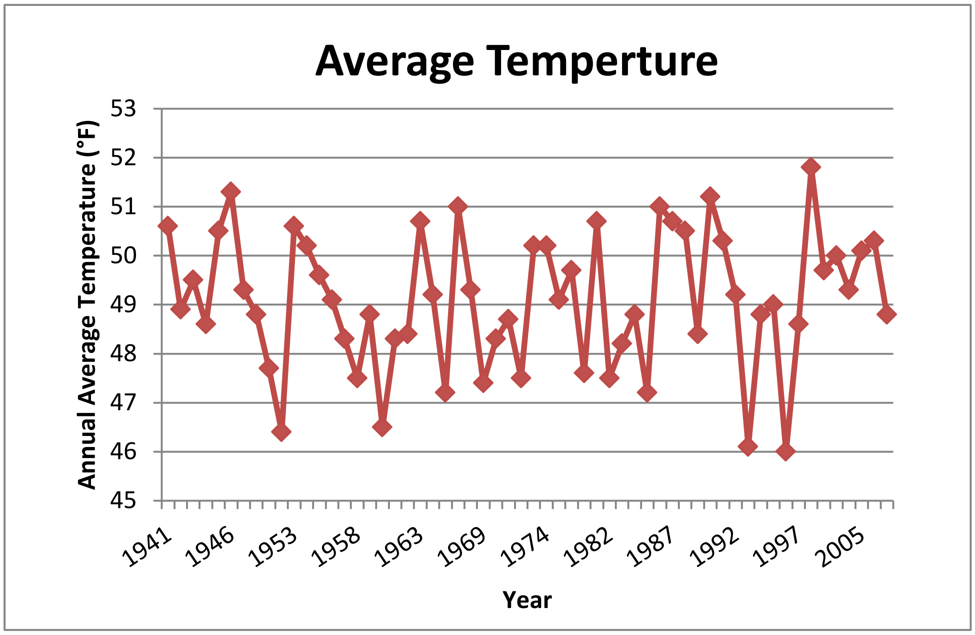
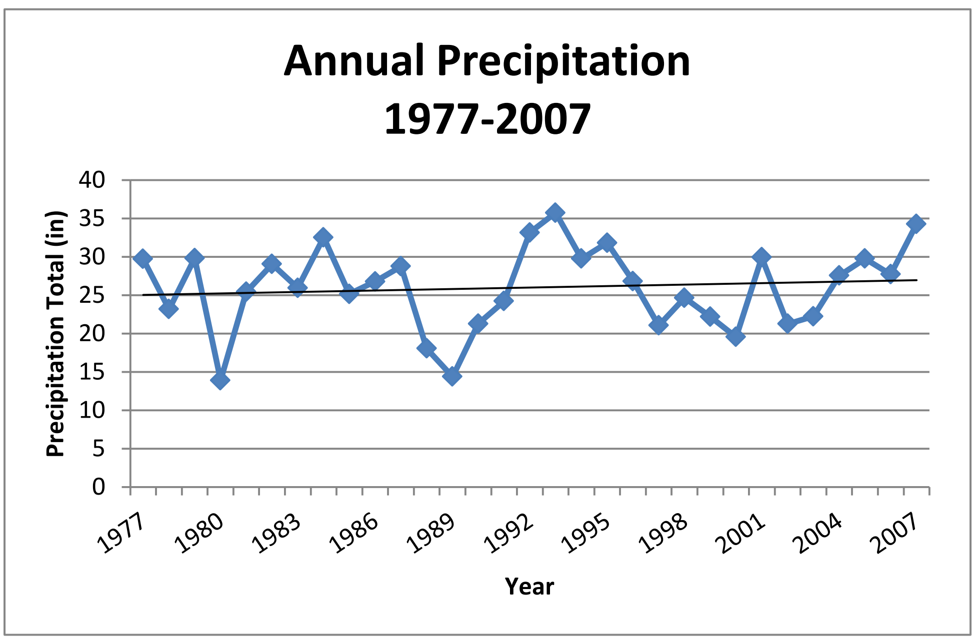
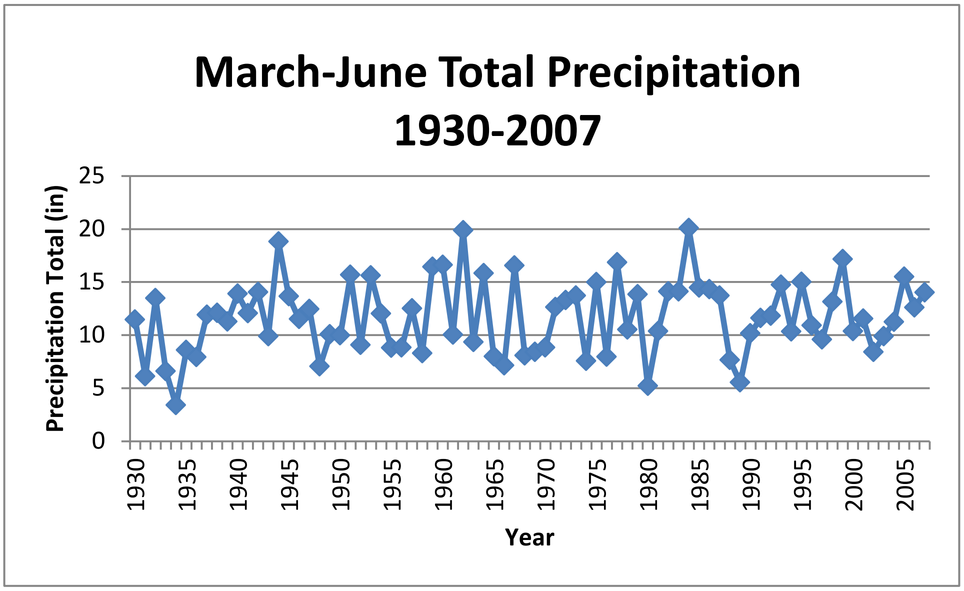
Graphs:



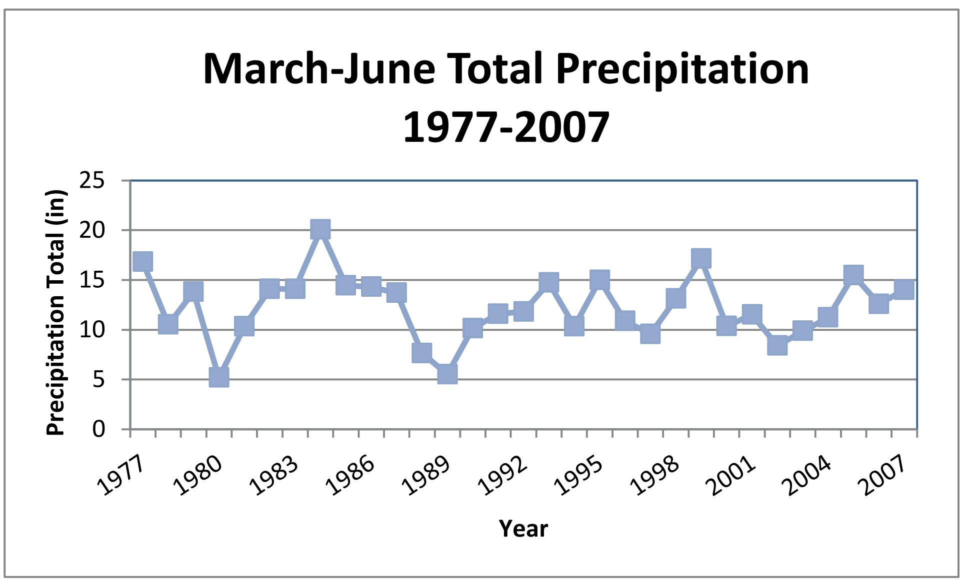
Graph 1: Average air temperature (1941-2008): Data from the High Plains Regional Climate Center Osmond station.



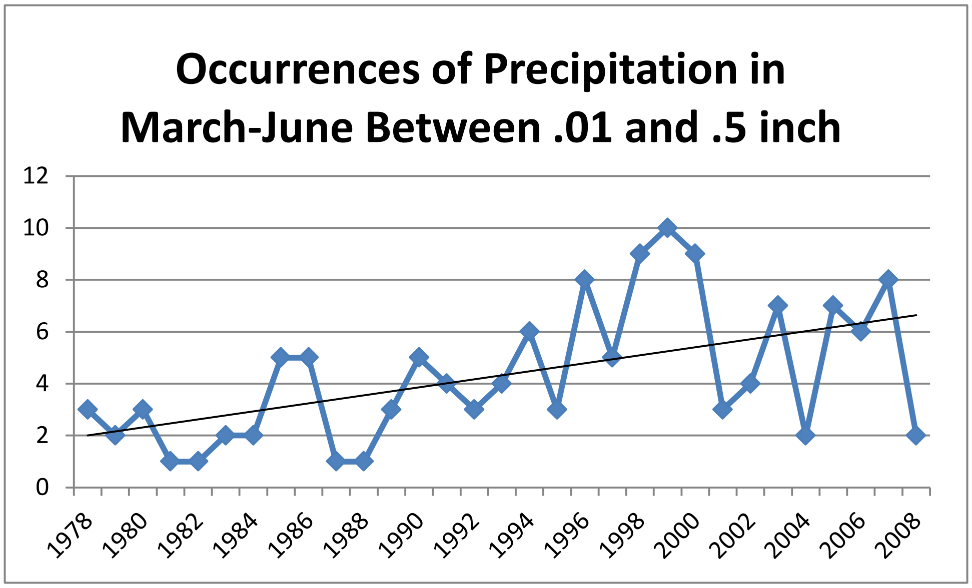
Graph 2: Annual Precipitation (1930-2007): Data from the High Plains Regional Climate Center Osmond station.



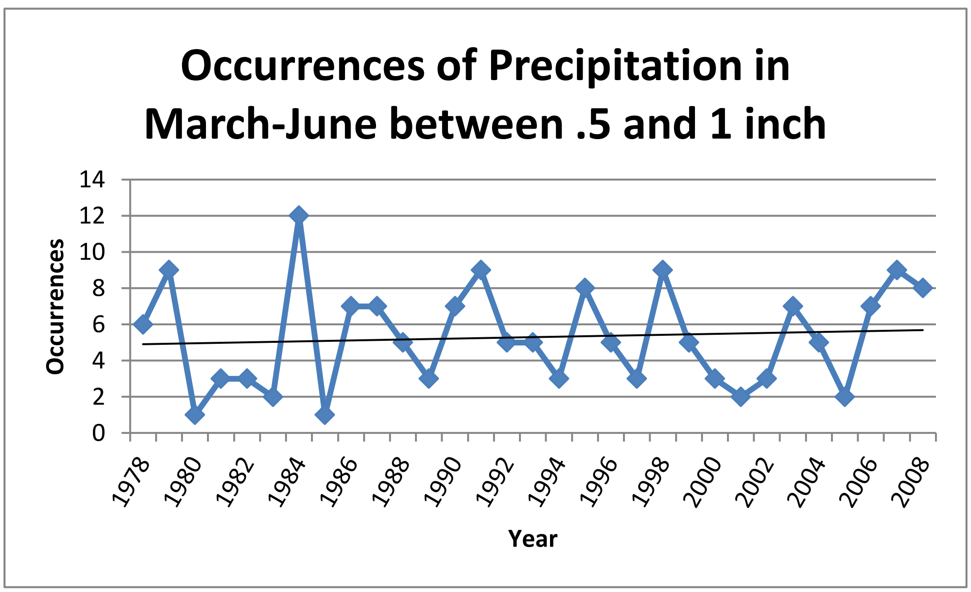
Graph 3: Annual Precipitation (1977-2007): Data from the High Plains Regional Climate Center Osmond station.



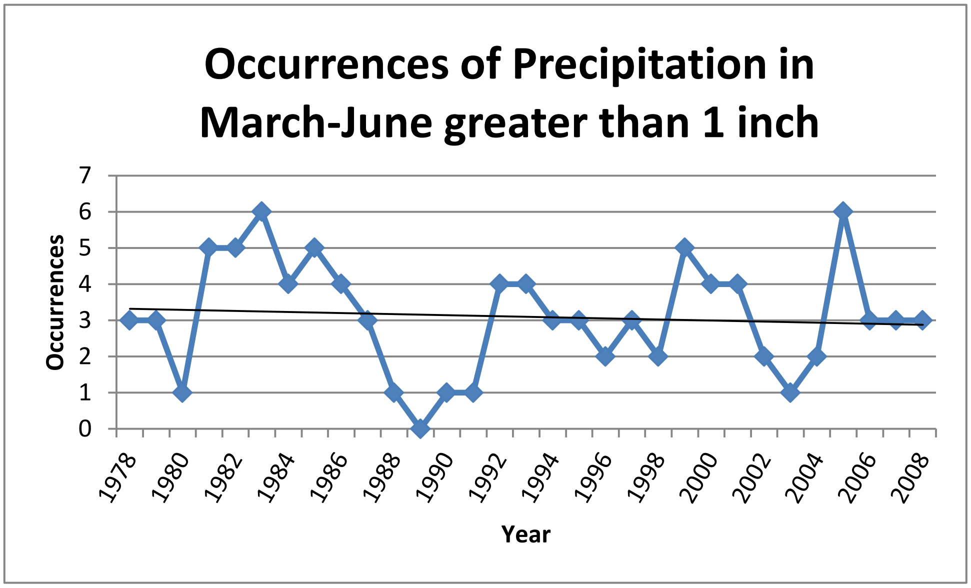
Graph 4: March- June Total Precipitation (1930-2007): Data from the High Plains Regional Climate Center Osmond station.



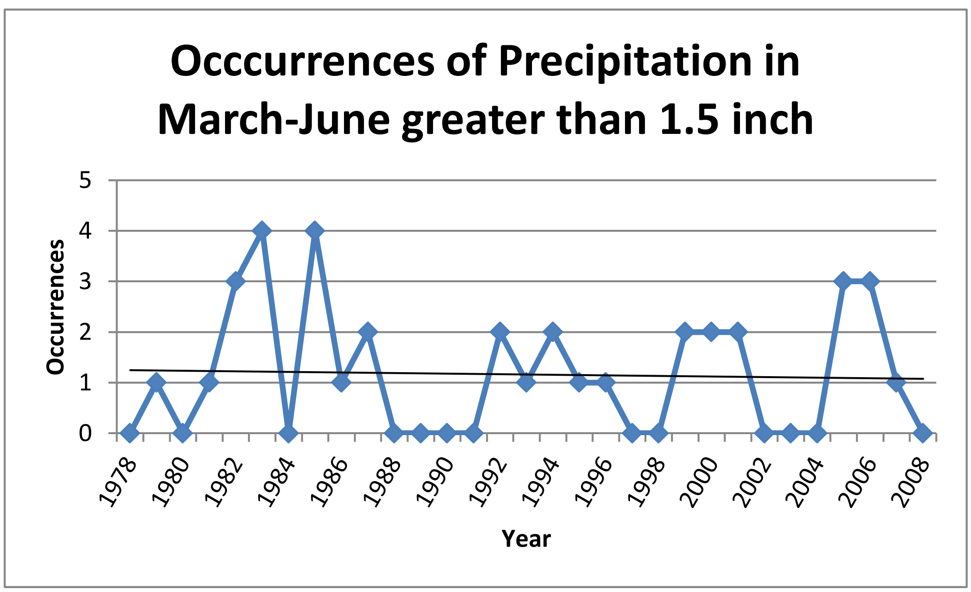
Graph 5: March-June Total Precipitation (1977-2007): Data from the High Plains Regional Climate Center Osmond station.



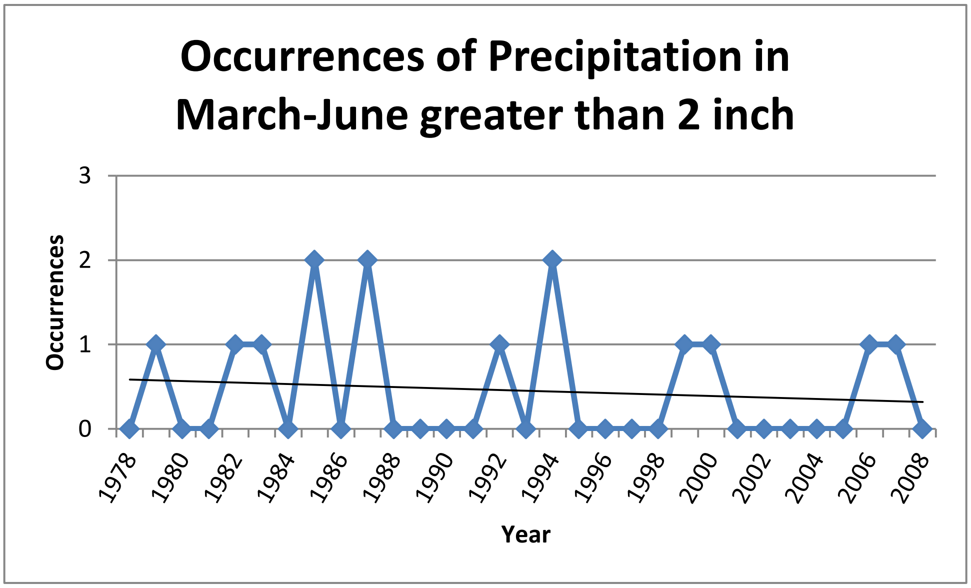
Graph 6: Occurrences of between 0.01 and 0.5 inches Precipitation in March-June (1978-2008): Data from the High Plains Regional Climate Center Osmond station.



Graph 7: Occurrences of between 0.5 and 1 inch Precipitation in March-June (1978-2008): Data from the High Plains Regional Climate Center Osmond station.



Graph 8: Occurrences of greater than 1 inch Precipitation in March-June (1978-2008): Data from the High Plains Regional Climate Center Osmond station.



Graph 9: Occurrences of greater than 1.5 inches Precipitation in March-June (1978-2008): Data from the High Plains Regional Climate Center Osmond station.

WARD Laboratories, Inc.

Ag Testing - Consulting

Account No. : 50939

Soil Analysis Report

MAMO, DR MARTHA
AGRONOMY & HORTICULTURE DEPT
139 KEIM HALL
LINCOLN NE 68583-0916

Invoice No. : 1084672
Date Received : 03/29/2011
Date Reported : 03/31/2011

Results For : AGRONOMY & HORTICULTURE DEPT
Location : 1

Sample ID / Lab No.	Soil pH 1:1	Modified WDRF BpH	Soluble Salts 1:1 mmho/cm	Excess Lime Rating	Organic Matter LOI-%	FIA Nitrate ppm N	Depth / Nitrate Lbs N/A	Method / Phosphorus ppm P	Ammonium Acetate K ppm	Ammonium Acetate Ca ppm	Ammonium Acetate Mg ppm	Ammonium Acetate Na ppm	Ca-P Sulfate ppm S	DTPA Zn ppm	DTPA Fe ppm	DTPA Mn ppm	DTPA Cu ppm	Hot Water Boron ppm B	$CaNO_3$ Chloride ppm Cl	Sum of Cations me/100g	% Base Saturation H	K	Ca	Mg	Na
F1							0 - 8 in	M-P3																	
31267	7.5		0.38	NONE	3.2	5.0	12	43	386	3242	451	17	21	1.93	25.5	13.2	1.44			21.0	0	5	77	18	0
F2							0 - 8 in	M-P3																	
31268	7.2		0.36	NONE	3.3	5.9	14	39	376	3150	437	17	12	1.84	25.1	13.4	1.25			20.4	0	5	77	18	0
G1							0 - 8 in	M-P3																	
31269	6.7		0.30	NONE	3.7	2.6	6	25	563	3201	524	17	12	0.74	29.0	23.1	1.26			21.9	0	7	73	20	0
G2							0 - 8 in	M-P3																	
31270	6.8		0.29	NONE	3.8	2.4	6	34	517	3008	487	11	13	0.84	31.0	24.2	1.24			20.5	0	6	73	20	0
EA1							0 - 8 in	M-P3																	
31271	7.3		0.49	NONE	4.3	17.4	42	43	419	2904	327	14	21	2.05	22.2	11.5	1.09			18.4	0	6	79	15	0
EA2							0 - 8 in	M-P3																	
31272	7.3		0.46	NONE	2.8	18.4	44	44	415	2825	318	13	25	2.26	20.1	10.6	1.05			17.9	0	6	79	15	0
W1							0 - 8 in	M-P3																	
31273	7.3		0.43	NONE	4.3	21.1	51	46	396	2583	297	15	21	2.13	20.9	12.5	0.94			16.5	0	6	78	15	0
W2							0 - 8 in	M-P3																	
31274	7.3		0.46	NONE	4.4	20.2	48	45	440	2916	328	12	23	2.10	21.9	12.1	0.93			18.5	0	6	79	15	0

Reviewed By: Raymond Ward   Copy : 1   4/1/2011   Page 1 of 1

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