Using Remote Sensing to Detect Land Degradation in Agricultural Lands: A Case Study in Manhattan, KS

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Abstract

This research involves land degradation of agricultural lands in the great plains and the validity of using remote sensing in order to measure land degradation and soil erosion. This research specifically focuses on land degradation on the Kansas State Agronomy field in Manhattan, KS, but can be translated to many other landscapes and be used to assess soil erosion as well as prevent or mitigate the effects of land degredation. Assessing soil degradation based on survey data can be time consuming and costly. This study aims to explore the potential of remote sensing in detecting land degradation. We aim to answer: Can satellite imagery detect land degradation? What types of management practices can be made in the area? In this study, we calculated the Normalized Difference Vegetation Index (NDVI) retrieved from Sentinel 2 imagery and Topographic Wetness index(TWI) retrieved from Digital Elevation Model (DEM). In addition, a literature review was conducted in order to analyze and evaluate the best management practices in the study site. The goals of this study are to assess the potential of remote sensing in detecting soil erosion and how this could be used moving forward. Soil degradation has many lasting effects and many can be disastrous, soil degradation contributes to things like landslides, floods, increases in pollution, desertification and declines in food production. The implications of this study can result in more fertile and healthy soil helping out the entire habitat of an area as well as helping vegetation to thrive and promoting more biodiversity in an ecosystem. Moving forward this will improve the capacity of soil and its ability to contain nutrients helping combat food prices, climate change and other environmental hazards. Management practices such as cover crops, plant growth that promotes rhizobacteria which is bacteria that boosts the resilience of the ecosystem and prairie strips that can be used to reintroduce natural ecological benefits mimicking the habitats found in natural prairie ecosystems.

Keywords: Land Degradation, NDVI, SAVI, TWI and Digital Elevation Model

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Abstract

1. Introduction

As economic and environmental pressures increase, the importance of restoring and efficiently managing our limited natural resources is emphasized. Evidence based on research suggests that since 1950, over 35 percent of agricultural land has been degraded in varied degrees due to human induced activities (Gupta, 2019). The Great Plains, which provide 51% of the nation's wheat, 40% its sorghum, 36% of its barley, 22% of its cotton, 14% of its oats, and 13% of it's corn, are facing reduced plant and soil productivity as extensively managed soils are further degraded through mismanagement and tallgrass prairie conversion. (Donfrio and Ojima, 2022). With the potential to largely affect food production and global food supply, producers and researchers in the Great Plains are focused on the implementation of management practices that both improve long-term land productivity and reduce environmental impact. The movement towards sustainable agriculture has increased interest in precision data monitoring and prescribed applications which can be achieved through remote sensing technology.

Remote sensing is widely used in the world of agronomy and agriculture and is an effective way to detect vegetation health and land degradation. Remote sensing has many advantages compared to other forms of physical testing. Field surveys and lab testing require large amounts of time and effort, and they are limited spatially. Remote sensing, on the other hand, is advantageous because of its ability to gather data quickly, at regular intervals and accurately over large spatial areas. Agricultural applications of remote sensing include estimating biomass and crop yields, monitoring drought stress, analyzing crop phenological development, mapping cropland and land cover changes, identifying physical disturbances, irrigation management, precision agriculture, and many others (Atzberger, 2013).

Vegetative Indices (VIs) are an important aspect of agricultural remote sensing. Different plants, like all objects, reflect light at certain wavelengths within the visible light spectrum. Satellites and drones use special equipment to receive this reflected light, and using the VI algorithms, information can be gathered about a plant's structural, physiological, and biochemical properties (Pooja et al., 2018). One of the most popular VIs is the Normalized Difference Vegetation Index (NDVI), which was developed in 1978 and has grown in popularity and applications since then. NDVI is highly correlated to the Leaf Area Index (LAI) and plant photosynthetic rates, so it is a good indicator of overall crop health (Atzberger, 2013).

Land restoration refers to the recovery of degraded land to sustainably support its land uses. Land management aims to conserve and prevent the degradation of land resources. Restoration and management practices are designed to address the deterioration of resources such as soil, which directly impact plant health and productivity. Major factors negatively affecting soil quality in the Great Plains are erosion and the depletion of nutrients by unsustainable management practices (Ayub, et al., 2020).

Geologic erosion is one of earth's most consistent processes and is consistently occurring all of the time. Under natural circumstances erosion is slowed by the presence of vegetation, but when the landscape has been modified the erosion can become more erratic, more aggressive and unpredictable (Sharpe and Agriculture). Human interaction with nature has accelerated soil erosion tenfold, and it wasn't until the 50's when the US Department of Agriculture (USDA) was created when Americans started to acknowledge the negative effects of soil erosion and take efforts to mitigate it (Montgomery, 2007). The effects of soil erosion become more extreme based on the intensity of rainfall, the volume of runoff, wind strength, slope of the landscape, plant cover, land management, soil erodibility, infiltration capacity and soil management (Gabriels, 2004).

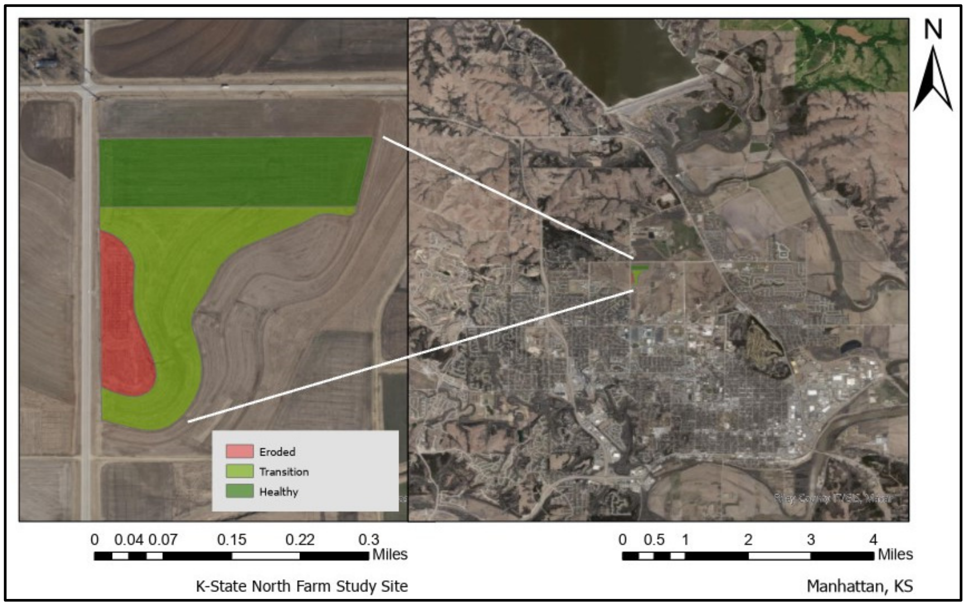
Objectives

The main goal is to analyze the potential of remote sensing in detecting land degradation. Our main questions are: Can satellite imagery detect land degradation? What types of management practices can be made in the area? Using an integrative approach with remote sensing, field data, and topographic assessment, we sought to discover the answers to these questions.

2. Materials

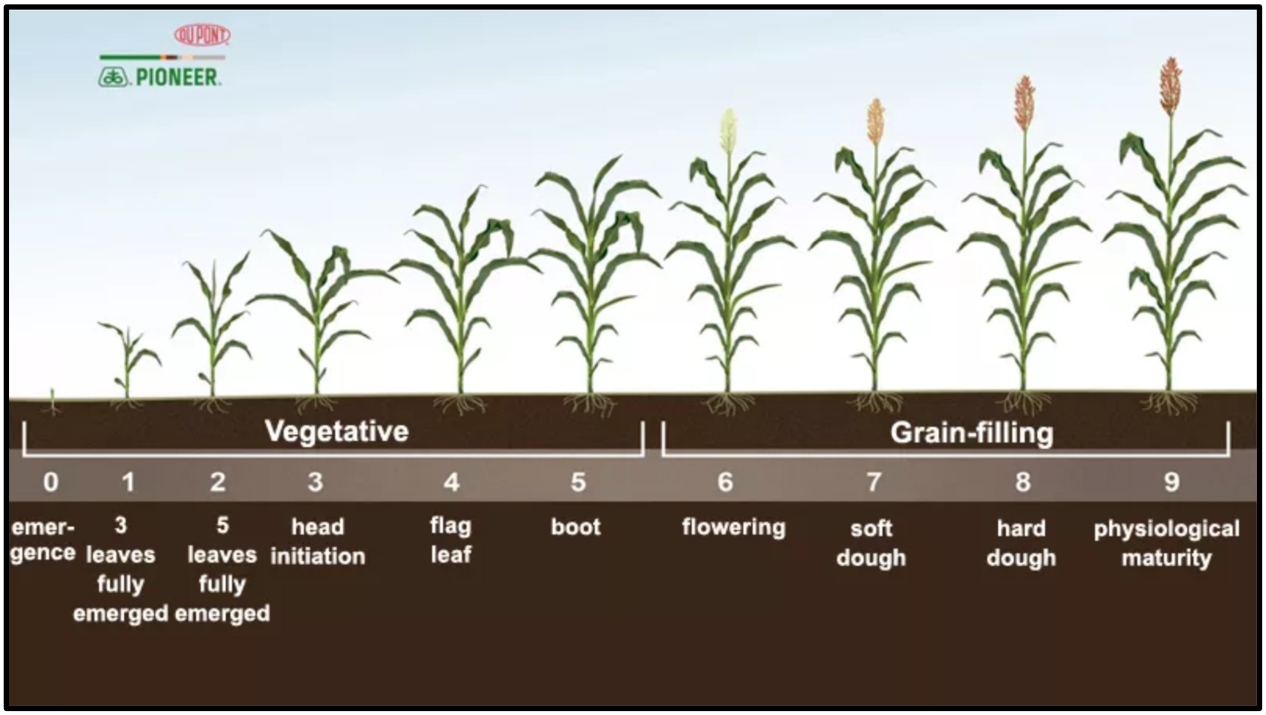
2.1 Study Area

The study site is located at the north end of KSU's agronomy farm in Manhattan, KS. The field is about 60 acres in size and is currently in use for agricultural production of sorghum. Silt-loam accounts for roughly 80% of the soil type in the area, making it susceptible to erosion during intense rain events. Areas of the landscape with a greater slope show severe soil degradation and decreased crop production. (Figure 2.1.1) shows a map of the study site.



(Figure 2.1.1): **Map of the Study Site**

This year, the field is being used for the production of grain sorghum. Sorghum is an important cereal grain grown throughout the world, ranking fifth in cereal production globally, behind corn, rice, wheat, and barley. Sorghum is very resilient to high temperatures and can grow in arid to semi-arid conditions, making it a very versatile and hearty crop (Stefoska-Needham et al., 2015). Sorghum has ten major growth stages, shown in (Figure 2.1.2) below. The timeframe of each growth stage can vary in length, depending on a variety of factors including depth of planting, temperature, soil moisture, soil compaction, soil nutrients, and others (Rao et al., 2008). A typical growing season can last an average of 136 days, with a planting date in mid-April to May and harvest in the fall when the grain moisture range falls below 20% (*Grain Sorghum Management*, 2022).



(Figure 2.1.2): **Sorghum Growth Stages (Grain Sorghum Management, *2022)***

2.2 Datasets

2.2.1 Satellite Imagery

Sentinel-2

The satellite imagery used for this study was gathered via the Sentinel-2 satellite operation. Sentinel-2 consists of two satellites orbiting in the same path 180° from each, with a single satellite gathering data every 10 days for a specific location. With both satellites, this gives a five-day temporal resolution. The satellites are equipped with optical instruments to measure 13 spectral bands, including four bands at a 10m resolution, six bands at a 20m resolution, and three bands at a 60m resolution (Delwart, 2022).

DEM

A Digital Elevation Model is the representation of the bare ground without trees, buildings or any man made developments, the data used to create the digital elevation method was retrieved from the "Ciampitti Lab" done by the Agronomy department at Kansas State University. The file was labeled as a 1m x 1m resolution meaning that each pixel of the image represents an area that is 1 meter by 1 meter (*Crop Physiology*, 2022). The DEM is the base dataset that is used to determine the slope and Topographic Wetness index (TWI)

2.2.2 Field Survey

The team conducted a physical assessment of the study site, with the assistance of K-State's Ciampitti Lab, which included digging soil pits, lab testing of soil samples at key areas, and a hands-on analysis of the sorghum plant health at the time. This fieldwork was carried out on September 14th and 16th, 2022. Three distinct areas of the study site were identified during the assessment trips – an eroded area (Figure 2.2.1 below), a transition area (Figure 2.2.2 below), and a healthy area (Figure 2.2.3 below) – based on the terrain grade, quality of the soil, and the apparent health of the sorghum crops. The team dug soil pits at each location, looking at the soil horizons and noting the soil texture, soil color, root structures, biodiversity, and overall soil quality.


***(Figure 2.2.1):* Eroded Area**


(*Figure 2.2.2):* Transition Area


(*Figure 2.2.3:* Healthy Area)

Soil and vegetation samples were taken for each of the three locations, with around 15 individual samples taken and compiled for each location. These samples were sent to the Kansas State Soil Testing Lab for analysis of chemical composition. The GPS location of each of the three areas was also gathered during these site visits.

Soil data: Healthy Sample (39°13'00.8"N, 96°35'48.4"W), Transitional Sample (39°13'01.0"N 96°35'47.2"W), Eroded Sample (39°12'53.9"N 96°35'51.5"W)

***Management data*:** Literature Review articles and journals

Vegetation data: Harvested sorghum biomass samples

2.2.3 Management Practices and Restoration Assessment

The management practices and restoration assessment are based on a literature review that is composed of journals studying different practices and methods to decrease soil erosion. Around 30 articles were read and analyzed for this review. Some of them are listed below.

Authors	Sample Size	Type of study conducted
De Baets (2011)	9	Cover Crop
De (2020)	241	Prairie Conservation
Du (2022)	459	Water Erosion/Conservation Practices
He (2020)	120	Conservation Practices
Martins (2021)	87500	Water Erosion/Conservation Practices
O’Neal (2015)	5 state model	Conservation Practices
Plastina (2018)	16 farmers from 3 States (Iowa, Illinois, Minnesota)	Cover crops
Tilley (2022)	100	Prairie/Native Species Conservation
Torok(2010)	8,000	Prairie Conservation
Rowe(2013)	9000 hectares	Prairie Conservation
Vandever(2021)	280	Prairie Conservation

3. Methods

3.1 Vegetation and Terrain Indices

3.1.1 NDVI

NDVI is one of the most popular and commonly used vegetative indices, so there is a large amount of research associated with it. The equation for NDVI is [(RNIR – Rred) / (RNIR + Rred)], where RNIR is the near-infrared reflectance band and Rred is the red reflectance band (Pooja et al., 2018). Healthy vegetation strongly reflects the near-infrared wavelengths and absorbs the red wavelengths (GISGeography, 2017). For the Sentinel-2 satellite, these bands are band 8 for the NIR, and band 4 for the visible red. The resulting values from this equation range between +1 and -1, with the values closer to +1 representing healthy vegetation, the values closer to 0 representing soil or unhealthy vegetation, and values closer to -1 representing areas with water (GISGeography, 2017).

NDVI can, however, have many limitations in the areas of both implementation and data interpretation. Factors that can limit the effectiveness of NDVI include saturation at higher leaf area indices (LAIs) usually a peak season, separating climate and land degradation effects, cloudiness, autocorrelation effects on trend analysis, the influence of below-ground soil parameters, and unexpected extreme weather events. A final important consideration is the fact that NDVI trends can greatly underestimate the reality of soil degradation, as the true soil quality has been "masked" by an increasing global use of fertilizers over the years (Yengoh et al., 2015).

3.1.2 SAVI

SAVI is another vegetative index similar to NDVI. SAVI was developed to address one of the limitations associated with NDVI – soil interference. In areas of low vegetation, the soil brightness can affect the NDVI results. The equation for SAVI is [(NIR - Rred) / (NIR + Rred + L)) * (1 + L)], where L is a soil adjustment factor (*Landsat Soil Adjusted Vegetation Index*, 2022). The Sentinel-2 bands are the same as with NDVI, band 8 for the NIR and band 4 for the Rred, with L set to 0.5.

3.1.3 TWI

In addition to NDVI and SAVI, to further reinforce remote sensing's ability to detect soil erosion one can also use a Topographic Wetness Index (TWI). A TWI first consists of a digital elevation model, which is essentially a topographical map excluding all vegetation, buildings and other surface objects (*What Is a Digital Elevation Model (DEM)? | U.S. Geological Survey*, n.d.). The digital elevation model is then manipulated with tools available using "QGIS" to determine slope, flow direction, flow accumulation and the overall wetness index; this analysis is mainly used to determine the productivity of the site and illuminate vegetation patterns (Beven & Kirkby, 1979). Topographic wetness index can be used to show the pattern of moisture on soil and in turn reflects patterns of soil degradation (Schmidt & Persson, 2003). The lower the TWI value the higher the slope of the area and the less surface moisture and vice versa. The TWI can Illuminate the path of soil moisture and illuminate the process of soil degradation.

3.2 Literature Review: Management and Restoration Practices

A literature review was conducted to identify management and restoration practices which would improve plant and soil health at the study site based on field sample data and remote sensing data. Online resources such as Google Scholar and scientific journals provided peer-reviewed and reputable articles. A portion of the articles focus on returning the sorghum site to native prairie. The rest of the reviewed literature explores management practices which would improve and restore soil and plant health while remaining under crop production.

3.3 Data Processing

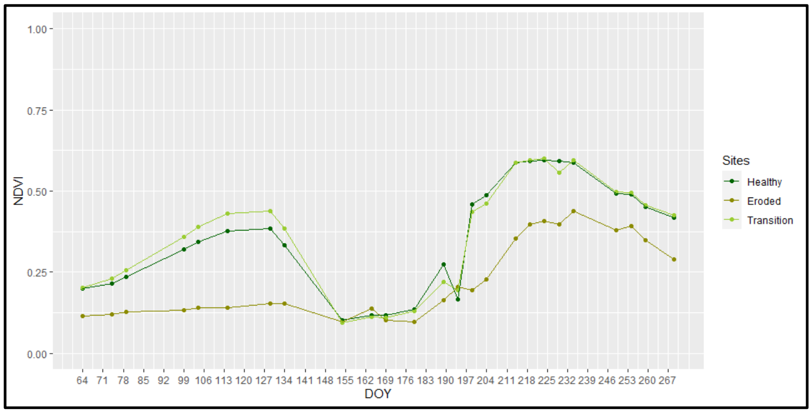
For the remote assessment, the first step was to develop a shapefile for the study site using the program ArcGIS Pro. First, a polygon shapefile was drawn encompassing the entire study site. Then, the GPS coordinates for each of the three locations were imported into ArcGIS Pro, and three distinct areas were delineated, dividing the study site into the three locations - eroded, transition, and healthy. (Figure 3.3.1) below shows the shapefile of the study site. To analyze the sorghum health over the course of the growing season, time series for both the NDVI and SAVI values were developed. A time series graph depicts the NDVI and SAVI values over a period of time, in this case, the growing season. Google Earth Engine, a platform that integrates satellite imagery and geospatial data from many different sources together with a programming interface for data analysis, was used to create the time series. The shapefile for the study site was imported into Google Earth Engine, and a program was written and used to gather NDVI and SAVI data from the Sentinel-2 satellite and generate the data for the time series graph. The data was then exported into excel to be cleaned and organized. Finally, the data was imported into RStudio to produce the final time series graphs.

(Figure 3.3.1): **Shapefile of the Study Site**

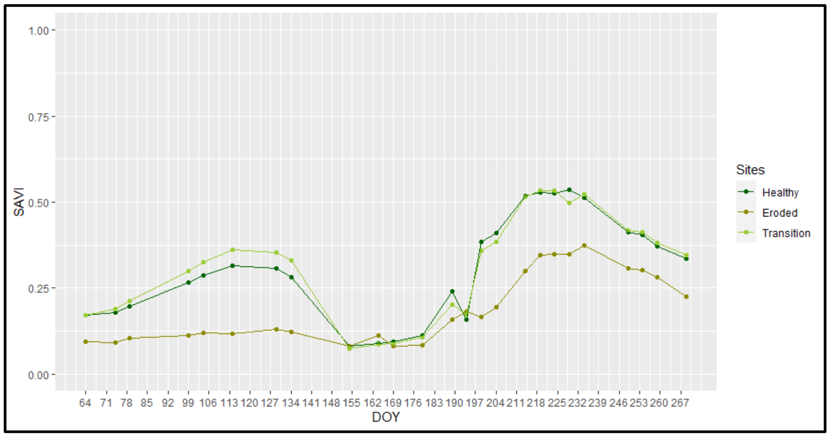
4. Results

4.1 Vegetative Indices Time Series

The time series graphs for the study site are shown below. (Figure 4.1.1) shows the graph of NDVI values over time, and (Figure 4.1.2) shows the graph of SAVI values over time. The healthy area is shown with dark green, the transition area with light green, and the eroded area is shown with yellow green. The plot ranges from day 64 (March 5th, 2022) to around day 270 (September 27th, 2022). To note, the sorghum planting date was June 17th, 2022, (day 168). The NDVI and SAVI values shown before this date represent a winter wheat cover crop grown on the field, which was chemically terminated on May 5th, 2022, (day 125). Other notable dates on the graph would be day 197 (July 16th, 2022) when the NDVI and SAVI values begin to rapidly increase and day 235 (August 23rd, 2022) when the NDVI and SAVI values begin to diminish. The healthy and transition areas show very similar time series plots, while the eroded area has significantly lower NDVI and SAVI values for the majority of the growing season. The NDVI plot is very similar in shape to the SAVI plot, which shows that interference due to soil reflection is not a huge concern with this study site.



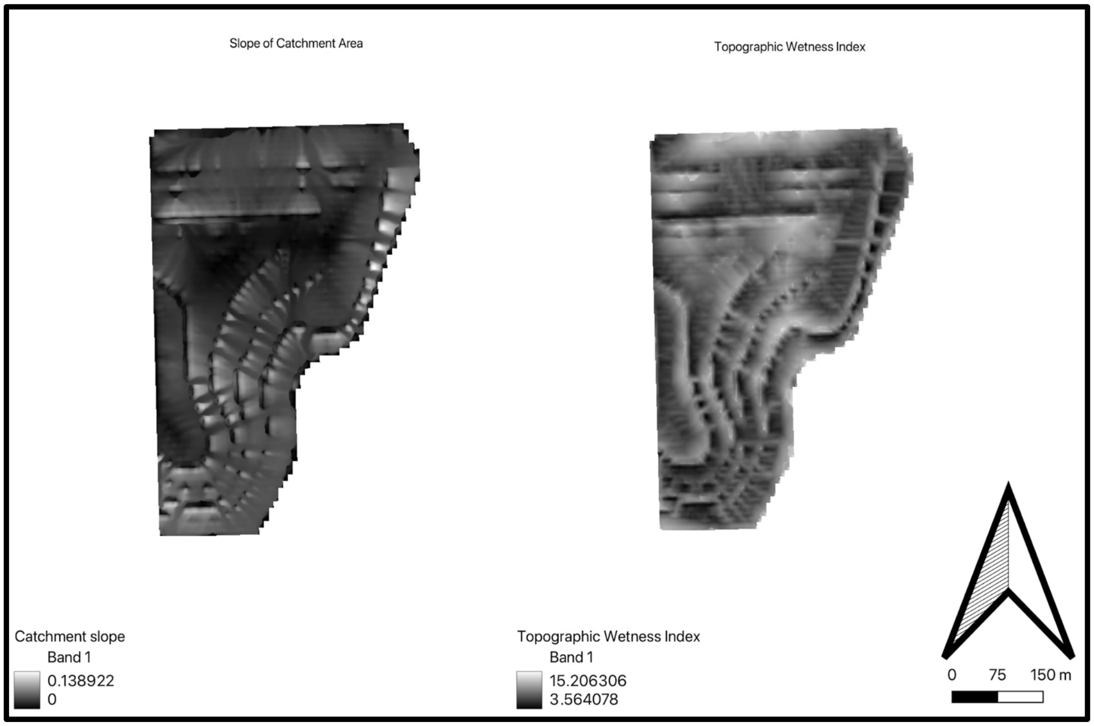
(Figure 4.1.1): **NDVI Time Series Plot**



(Figure 4.1.2): **SAVI Time Series Plot**

4.2 Topographic Wetness Index

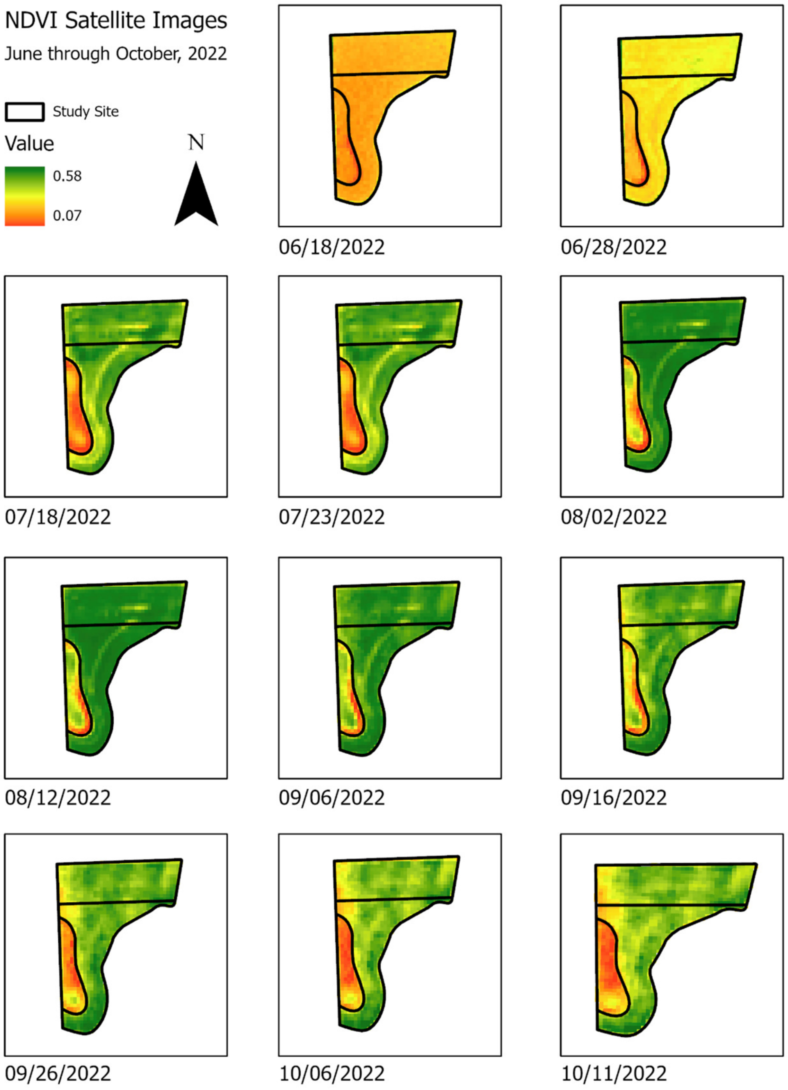
These maps can be used to show the potential for wetness and runoff of the landscape, this can translate to overall soil degradation. The first map on the left of (Figure 4.2.1) shows the slope or the gradient of the area; this can illustrate the flow accumulation and where the soil erosion is at its most extreme. The areas with a lower slope typically have the most absorption and areas with the higher slope have more erosion because this is where more runoff passes through degrading the soil. The wetness index on the second map on the left of (Figure 4.2.1) measures the potential of water absorption of the area, where the wetness index is higher. Those are the areas that are capable of containing the most water and therefore have experienced the least amount of soil erosion. These two maps are close to inverses of each other because areas with the steepest slope will have the least potential to contain wetness and vice versa. (Figure 5.1.4) shows the eroded area in the field, that picture is taken from the northwestern side of the study area and facing southeast. Here you can see the areas to the southwest of the study area that have the most slope and the least potential for moisture are the areas where there is a change ingredient and a lack of vegetation.



(Figure 4.2.1): Slope and TWI Maps

4.3 NDVI Maps

Online sources were used to collect satellite images of the field. Using Copernicus Open Access Hub and accessing data from the Sentinel-2 mission, images were selected that were representative of the growing season (June through October 2022) and had the least amount of cloud cover percentage (0-3%) to reduce error in the result. The identified images were then analyzed with ArcGIS Pro and Band 4 and Band 8 were used in the NDVI equation to create the color gradient maps seen in (Figure 4.3.1) The green area with a higher NDVI value is healthier than the area with red color as the higher value represents more green in the field. On the map, the Eroded Area of the field is the section on the far left, and it's evident in the images because it is often the area with the most red or yellow color, indicating unhealthy plants. The top portion is the Transition Area, which appears to be somewhere between the lowest values in the Eroded Area and the highest values found in the Healthy Area, or the area on the right side of the maps.



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(Figure 4.3.1): NDVI Maps with corresponding dates of image capture.

4.4 Field Data

Data from soil and plant sampling in (Figure 4.4.1) and (Figure 4.4.2) revealed that the eroded areas of the site had higher concentrations of nitrogen and phosphorus but less soil organic matter. Vegetation is far less productive in the eroded areas which can be seen by the sorghum biomass data (Figure 4.4.3).

(Figure 4.4.1) Soil Data

Sample Area	**Soil pH**	**Sikora pH**	**SOM %**	**P-M ppm**	**K ppm**	**Ca ppm**	**Mg ppm**	**Na ppm**	**CEC meq/ 100g**	**Sand %**	**Silt %**	**Clay %**
Healthy Area	6.2	6.7	3.5	50	329	2624	474	20	24.0	13	53	34
Transition Area	6.5	6.8	3.2	48	273	2445	448	27	21.5	12	57	31
Eroded Area	7.0	7.1	2.5	9	263	3620	658	26	24.4	14	47	39

(Figure 4.4.2) Management data: Soil Nutrients (NPK)

Sample Area	**N%**	**P%**	**K%**
Healthy Area	0.81	0.137	2.61
Transition Area	0.61	0.187	2.25
Eroded Area	1.11	0.180	1.69

(Figure 4.4.3) Vegetation Data: Sorghum Biomass

Sample Area	**Dry Weight (g)**	**Sample Area (sq meter)**
Healthy Area	405.86	1.625
Transition Area	393.66	1.625
Eroded Area	365.26	1.625

5. Discussion

5.1 Soil Health

Our data indicates runoff and erosion from healthy areas in the landscape may cause nutrient and sediment transport to eroded areas. There was a strong correlation between the sampling data and the NDVI maps. Remote sensing can be considered for the efficient and accurate analysis of soil and plant health.

(Figure 5.1.1): **Eroded Soil Profile**

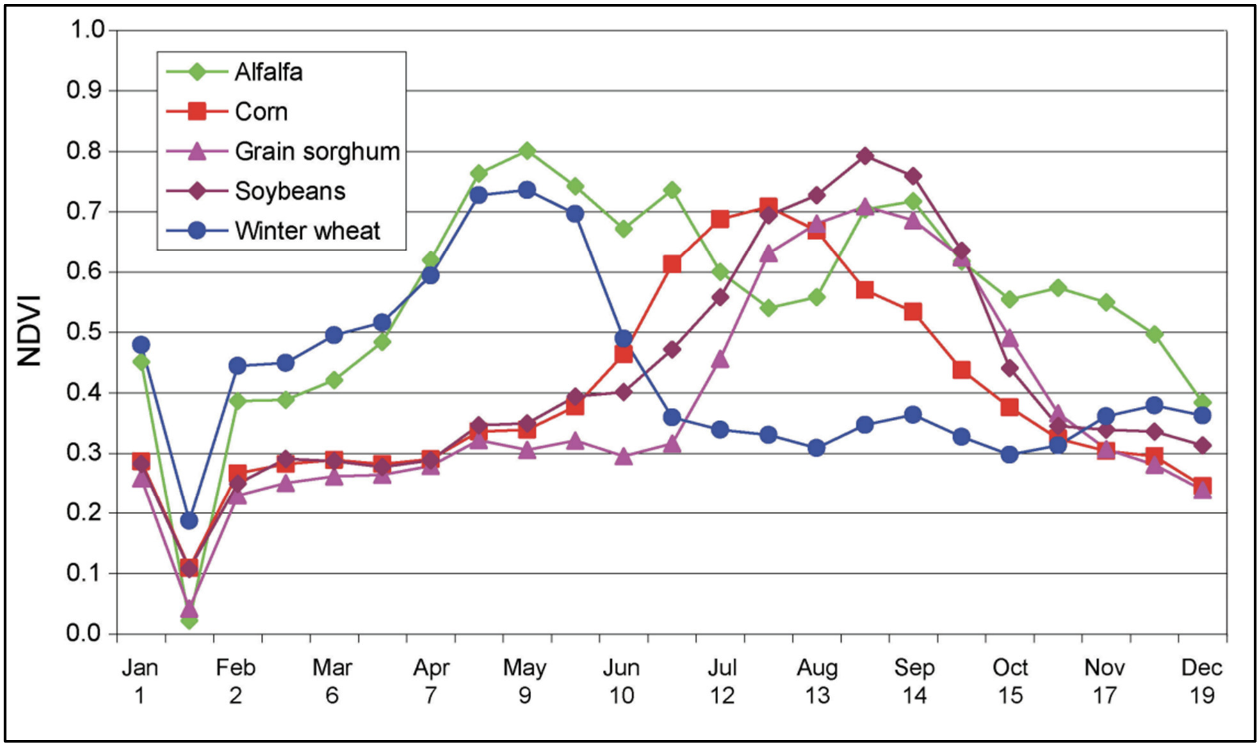
(*Figure 5.1.2):* **Transition SP**

(*Figure 5.1.3):* **Healthy SP**

(Figure 5.1.4): **Eroded Area Washout**

5.2 Time Series Comparison

In another study, Masialeti et al. (2010) explore whether NDVI time-series plots can be used to identify different row crops, based on their unique time-series curve. Data for alfalfa, corn, grain sorghum, soybeans, and winter wheat from fields in Kansas was gathered for both 2001 and 2005. This NDVI data was gathered from MODIS, with data for all five crops from farms all over the state of Kansas. (Figure 5.2.1) depicts the time series of the five crops for 2005. The shape of the grain sorghum time series shown below highly correlates with the time series developed for the team's project – although this study's planting date is earlier – which confirms the time series results developed for the project.



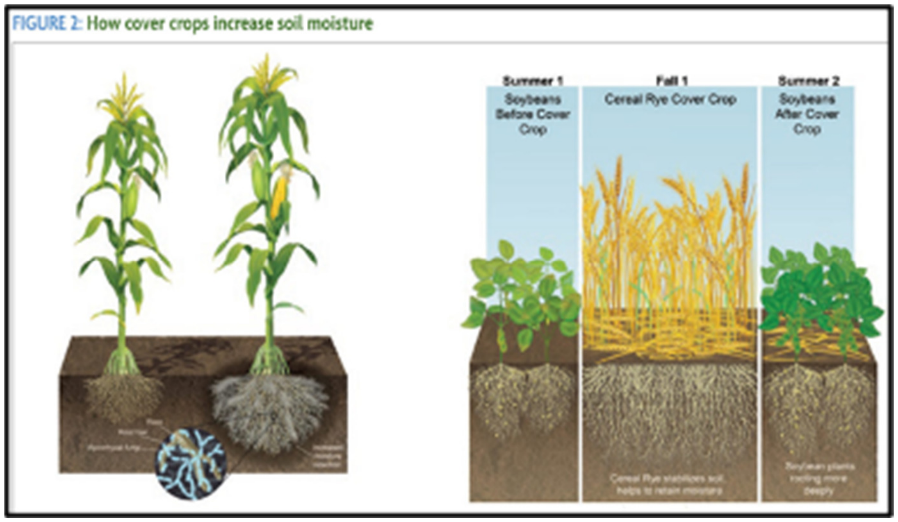
(Figure 5.2.1): **NDVI Time Series Data for Five Major Crops (Masialeti et al., 2010)**

5.3 Recommended Agricultural Management and Restoration Practices

The following sections explain the potential of selected agricultural management practices to restore and improve the degraded soil conditions at the study site while remaining under agricultural production.

5.3.1 Cover Crops

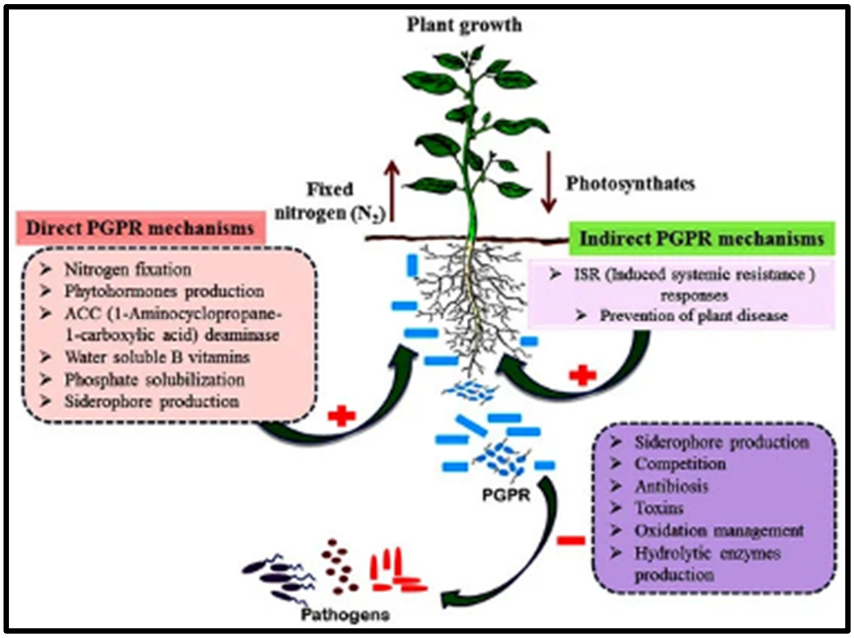
Utilizing cover crops can reduce soil erosion by protecting the soil surface during wind and precipitation events. Cover crops are tools to keep the soil in place, bolster soil health, improve water quality and reduce pollution from agricultural activities (Clark, 2022). Improved soil structure and diversified root systems improve water infiltration, in turn reducing nutrient and sediment loss by runoff. Cover crops protect water quality by curbing soil erosion and reducing nitrogen losses by an average of 48%. By stimulating biological activity in the soil, cover crops planted on a large scale can sequester huge amounts of atmospheric carbon (Clark, 2022). Improved water infiltration, nutrient availability, and microbial activity from cover crops leads directly to increased crop growth and yield (Frasier, et al., 2022). (Figure 5.3.1) displays a clear difference between the root systems of soybeans alone and soybeans in the presence of a cover crop (Myers, et al., 2019). The cover crop ensures that living roots remain in the rhizosphere for as long as possible and provides beneficial residue. Selecting an appropriate cover crop is a site-specific endeavor and should consider the objectives of their addition. A mixture of cover crops can be used to address areas of land with multiple cover crop objectives. The incorporation of a soybean cover crop into our sorghum study site would improve root and soil structure and reduce susceptibility to erosion. Stabilizing the degraded soil and providing residue will help prevent nutrients from being transported to low points of the field.



(Figure 5.3.1): How cover crops increase soil moisture (Myers, et al., 2019)

5.3.2 Plant Growth Promoting Rhizobacteria

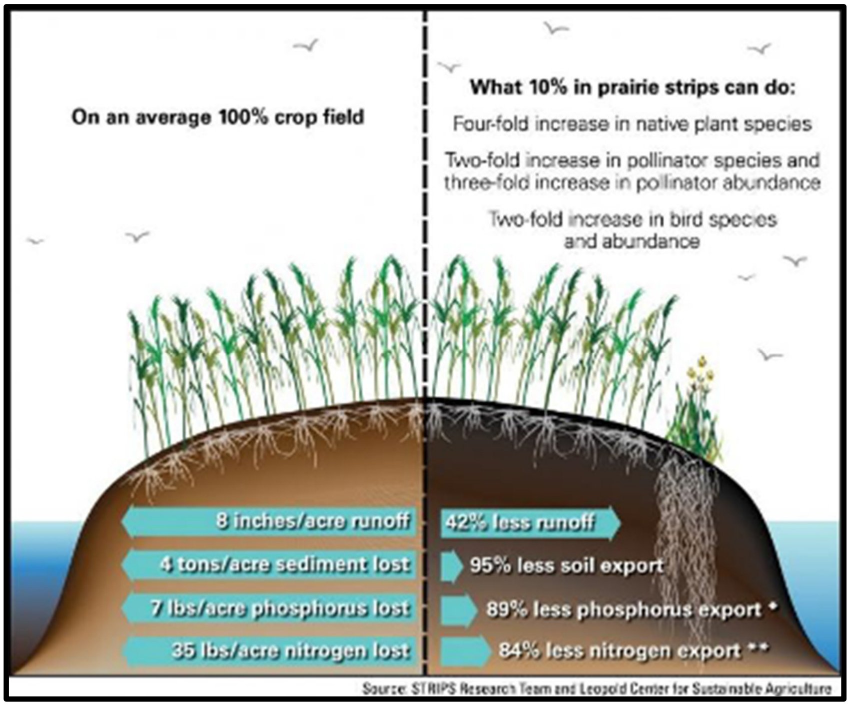
Introducing plant growth promoting rhizobacteria (PGPR) has been shown to improve plant stress tolerance, disease resistance, and pest resistance, and promote natural ecosystem services that enhance plant growth. Associative N fixation, a process involving nitrogen fixing bacteria, comes with a lower cost and higher use-efficiency than synthetic fertilizers. Many PGPR have been shown to alleviate drought-stress effects in plants under poor conditions (Niu et al., 2018). Nutrient losses to leaching, runoff, and erosion are reduced as microbes promote enhanced root systems and improved soil structure. PGPR mediated root trait alterations can contribute to agroecosystem through improving crop stand, resource use efficiency, stress tolerance, and soil structure (Bodhankar, et al., 2021). While many studies have reported positive benefits from introducing plant growth promoting rhizobacteria, the science is still new and there is limited research on the long-term ecosystem effects of such practices. Like other introduced species, plant growth promoting rhizobacteria (PGPR) have unpredictable ecosystem consequences and legacy effects; these outcomes are a current knowledge gap (Moore et al., 2022).



(Figure 5.3.2): Mechanism of PGPR (Chandran, et al., 2021)

5.3.3 Prairie Strips

The conversion of native prairie to agricultural land has reduced soil productivity and many interconnected ecosystem services. Implementing prairie strips is a way to reintroduce the natural benefits of native prairie while remaining in crop production. “Research shows that by converting 10% of a crop field to diverse, native perennial vegetation, farmers and landowners can reduce sediment movement off their field by 95% and total phosphorus and nitrogen lost through runoff by 90 and 85 percent, respectively” (Iowa State University, 2022). Prairie vegetation comes with deep, diverse root systems, and biodiversity in general. This complexity enhances soil structure and therefore infiltration. Residue and ground cover, provided by native vegetation, assist with infiltration and protection from erosion and raindrop impact. As plant diversity grows, habitat for pollinators and local wildlife is created. Enhancement of ecosystem goods and services through practices like prairie-stripping also means fewer chemical inputs. As soil improves, nutrients and water cycle efficiently, creating optimal conditions for plant productivity. Many of the management practices used to restore and manage degraded soil, attempt to mimic nature and the ecosystem services provided by native systems.



Source: STRIPS Research Team and Leopold Center for Sustainable Agriculture

(Figure 5.3.3): What Prairie Strips Can Do (STRIPS, 2015)

6. Conclusion

Using NDVI and SAVI data, we determined the health of the sorghum from June 2022 to October 2022. Using the TWI, we were able to determine the water runoff of the field section where we took soil samples. Using the soil samples, we were able to determine the composition of the healthy, transitional, and eroded soil areas. The results of this case study have shown that nutrients from the soil have been carried downslope by erosion. This causes the degradation of soil health and soil stability. The sorghum in this area are not as healthy, and suffer from disease and nutrient loss. To stabilize the soil and prevent soil degradation, we have researched different conservation management practices and erosion preventative measures.

First, we looked at the usage of cover crops. As mentioned above, cover crops are used to stabilize soil, reduce pollution, strengthen the health of the soil, and improve water quality. We believe that cover crops would be beneficial in this area. The eroded area would be stabilized by these crops, the erosion that is happening would be reduced, and the nutrients loss would be curbed by the plants. Cover crops are a useful tool that would exceed in reducing the erosion of nutrients.

Second, is the use of plant growth promoting rhizobacteria (PGPR). This process was suggested as a way to increase disease resistance, pest resistance, plant stress tolerance, and to promote natural ecosystem services. The use of nitro fixing bacteria would be to help bolster soil nutrients at a lower cost with higher efficiency than synthetic fertilizers. However, the study of PGPR is still new and more research needs to be conducted on the long-term uses of this method.

Finally, we have decided on prairie strips. These strips of native vegetation help to significantly reduce the movement of sediment and the runoff of nutrients. The root systems of native prairie plants move deep into the soil increasing stabilization and infiltration. The increase of native plants attracts pollinators and increases biodiversity. Native prairies come with many benefits to native wildlife, crops, and the soil. This method helps to conserve native plants while also keeping sediment runoff and nutrient loss to a minimum.

Each of these options provide methods and measures to reduce the impact of erosion or the loss of nutrients in the eroded area of the field. These results will help to guide management of the area in the future.