ECONOMIC EVALUATION OF REGENERATIVE AGRICULTURE ON PRODUCER PROFITABILITY

A Thesis

by

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ABSTRACT

A recent shift in popularity of growing processes of traditional production agriculture has taken over. The new buzzword heard by producers is “regenerative agriculture.” Many believe these practices lead to increased soil health and lower the carbon footprint of humans. Conservation production efforts have been the priority of producers for well over 20 years. These practices include cutting back on the amount of erosion of the soil, enhancing soil porosity and infiltration, and an increase in natural soil health.

The practices that encompass regenerative agriculture are things such as: low/no tillage, growing cover crops, crop rotation, and lack of synthetic inputs to naturally revitalize soil.

The primary objective of this study was to evaluate the profitability of a producer if they utilized regenerative agriculture production practices. This was done through a partial budget analysis examining the investment costs to the producer as well as the impact increased soil health practices have on the operation’s bottom line, as well as yields of an operation. The study identified different levels of regenerative production and the economic impact to the producer.

The model result indicated that the highest probability of positive net cash income occurs with conventional agriculture. The exception to this is when the producer implements a no-tillage system and sells certain conventional equipment in this first year of production.

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Contributors

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The data analyzed was provided by the Agricultural and Food Policy Center. The analyses were done with the assistance of Simetar, provided by Dr. Joe Outlaw.

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INTRODUCTION

The Biden Administration has established goals aimed at reducing the impacts of climate change in the United States. One way to achieve the new goals of decreasing atmospheric greenhouse gas emissions is production agriculture. The new buzzword used by climate activists is “regenerative agriculture,” these are production practices that farmers are being encouraged to integrate into their operations. Regenerative agriculture is defined as the intention to restore degraded soil and increase soil health, through the avoidance of synthetic inputs, which in turn enhances water quality as well as natural vegetation (Rhodes, 2017). Regenerative agriculture is appealing to climate advocates who have also found support from soil health advocates because the primary practices that sequester carbon in the soil are also thought to increase soil health. Long-term climate impacts humans have had on the earth and how to mitigate damage have now become the focus of policymakers and interest groups across the United States. It is believed that to lower the carbon footprint of humans, agriculture can and should play a major role.

Conservation production efforts have been the priority for most producers in the United States for well over 30 years. From terms like sustainable agriculture and soil health, the idea of regenerative agriculture and the practices farmers use are not new. These practices include cutting back on the amount of erosion of the soil, the porosity of the soil, and an increase in natural soil health. The practices that encompass regenerative agriculture include:

- Low/No Tillage, trying to disturb the least amount of soil possible
- Growing cover crops, these help slow erosion and naturally add nutrients back into the soil
- Crop rotation, giving the soil a chance to recover after production by not utilizing the same fields for the same crops, year after year
- A reduction in synthetic inputs to naturally revitalize soil

In Executive Order 14008, the Biden Administration launched a new initiative of climate smart practices, to incentivize U.S. farmers to reduce greenhouse gas emissions by sequestering carbon through production practices. If implemented, farmers would transition their operations further from traditional practices and move towards those that are more environmentally conscious. These practices could also be incentivized by the emerging carbon credit market. Recently, many corporations have pledged to work towards 'net carbon zero emissions,' and the main way they hope to achieve this is through purchasing carbon offsets from agricultural producers. It is believed that production agriculture can help these companies offset their carbon dioxide emissions through carbon sequestration (Paustian et al. 2009). To participate in the growing carbon market, farmers would have to adopt environmentally conscious farming practices to receive a payment based on the amount of carbon sequestered in the soil. Despite the excitement surrounding regenerative agriculture, to date, there is no analysis available to producers that show them if regenerative agriculture is economically viable for their operations.

Objective

The primary objective of this study was to evaluate the change in profitability farmers across Texas would experience if they adopted regenerative agriculture production. A secondary objective was to determine to the extent possible which regenerative agriculture practices will likely work best in different growing regions across Texas.

Justification

If producers are going to consider changing their farming practices from conventional to regenerative agriculture practices, they would need to know the impact on their farm's profitability. Currently, there are few analyses available to assess the change and profitability for the operation or the risk a farmer would have to assume by moving to regenerative agriculture. This analysis will provide Texas producers information to use in their decision-making regarding changing their farming practices.

CHAPTER II

BACKGROUND AND LITERATURE REVIEW

Background on Regenerative Agriculture

The term regenerative agriculture is not a new concept. While agricultural conservation practices have been around for over a century, the idea of sustainable agriculture first became relevant in the United States in the late 1980s during the farming recession. Farming in the 1980s was extremely difficult financially for producers, so many looked for ways to lower their production costs (Pfeffer, 1992). Some of the practices that farmers focused on during this time frame were eliminating the use of chemicals and diversifying production. Following the initial push for environmentally friendly farming, the late 1990s coined a new name for these same practices -- soil health. Doran and Zeiss define soil health as the sustainability of plant and animal productivity as well as the enhancement of water and air quality. Over time, although the name has changed, the practices have stayed the same. The Climate Smart Solutions for agriculture initiative from the Biden Administration has sparked interest in many of the same environmentally friendly production practices. The term it is now most recognized as is regenerative agriculture.

Regenerative agriculture is explained by those that participate in it as a philosophy change to a farming operation that works with the natural environment. It is comprised of a few basic principles such as: prioritizing soil health, respecting the natural ecosystem, and a reduction in reliance on synthetic inputs (Sharma et al, 2022).

This project will utilize previous research over regenerative production to see how it applies to different levels of conventional agriculture. It is imperative to understand how much the transition to regenerative production will cost producers.

Regenerative production is not a one size fits all operations (Newton, Peter, et al. 2020). There are different levels of participation within regenerative agriculture. Understanding what current practices regenerative producers are engaged in will be important to understanding the potential profitability. The main practices that encompass regenerative production are low/no tillage, growing cover crops, crop rotation, and lack of synthetic inputs to naturally revitalize soil (Wezel, 2013).

Yield Change with Regenerative Agriculture

Advances in technology have shown that current conventional practices allow for higher yields. This can primarily be attributed to crop protection inputs such as pesticides and fertilizers (Schrama et al. 2018). With regenerative production, there could be a decrease in the application of crop protection inputs, which could potentially result in a decrease in cost. However, it is a concern that regenerative agriculture will not be able to produce yields at the same level of conventional production during the early years of practice transition. While there could be long-term benefits of regenerative practices such as no-tillage and cover crop systems, the short-term could cause yield losses for farmers (Brown 2022). For most soil health practices, early years can show a decrease in yields and long-term success is dependent on the practice mix as well as the geographical area of the crop (Miner et al. 2020). A similar form of production to regenerative is organic farming. De Ponti et al. (2012), states that at a certain point in time, organic production can only produce approximately 80% of what conventional farming is able to achieve.

Regenerative Agriculture Practices

According to Claassen et al., conservation tillage is defined as methods of tillage that disturb the soil and keep crop residue on the soil surface to reduce erosion and increase soil porosity. The lack of tillage means a reduction in plowing or disking of a field. Some examples of conservation tillage include no-till, strip-till, ridge-till, and mulch-till.

Allowing the soil to be completely undisturbed, some farmers look to no-till systems to increase soil health. The only time soil is disturbed with no-till is when the seed is put into the ground, there is no planting preparation necessary with this practice (Mannering and Fenster 1983).

For a strip-till system, seeds are planted in narrow strips of tilled soil that are typically 6-8 inches long (Wade and Claassen 2016). The strip-till system allows most of the field to remain undisturbed and covered with crop residue on the soil surface.

Ridge-till systems are typically used on soils that are level and have poor drainage. This system plants seed into a prepared ridge made with disks, coulters, or row cleaners, the soil is left undisturbed from harvest to planting with this method.

One conservation system that disturbs the soil more than others is mulch-tilling. This system uses chisel plows, disks, sweeps, etc. to till the soil. With mulch-tillage the soil is not completely turned over, but rather leaves the soil surface rough (Wade and Claassen 2016).

Another method of conservation agriculture that is considered a regenerative agriculture practice are cover crops. NRCS defines cover crops as “grasses, legumes, and forbs planted for seasonal vegetation.” This practice reduces erosion because a thick cover is established by planting the mix of seeds. This practice is also reported to increase organic matter in the soil.

For nitrogen fixing in the soil, legumes can be grown as a cover crop. This could be crops such as hairy vetch, arrowleaf clover, or Austrian winter pea (Reeves 1994).

Non-legume cover crops can also be grown to enhance soil health as well as prevent erosion and increase soil organic matter. Examples of these are wheat, rye-grass, and oats (Clark 2015).

To plant the next years cash crop, cover crops are typically terminated. This can be accomplished by rolling/crimping, a method that flattens the crop and crimps (breaks) the plant to prevent regrowth. Synthetic herbicides can also be used to terminate the cover crop. Both methods intend to leave large amounts of biomass on the soil surface (Bergtold 2020).

Previous Analysis

North Dakota farmer Gabe Brown recently published a book, *Dirt to soil: One family’s journey into regenerative agriculture*, following his farming operations transition away from conventional agriculture. Brown mentions the large changes in his farming operation such as lowering or completely cutting out the amount of tillage and fertilizer. He also gives an in-depth explanation of how he worked through trial and error to create the perfect combination of seeds for his cover crops given certain environmental challenges depending on the year. His journey started over two decades ago and he is continually adjusting his production practices each crop year. This book shows the endless possibilities of regenerative production as well as emphasizes the fact that every operation is different. The book is based in North Dakota, a state where the soil is known for being fertile, which could potentially make the transition to conservation practices easier. Due to the differences in climate and soil, the practices that worked for Brown may not be applicable to Texas. Also, Brown does detail the profitability of his operation and how his journey to regenerative production can translate to different geographical areas.

Many producers are not open to change unless they can see it will benefit them in the long-term. Any decision a producer makes could result in an economic consequence to their operation (Wade, Claassen, & Wallander, 2015). Regenerative production could potentially mean an increase in cost without a pay-off for many years. This project will provide data to allow producers to make an informed decision regarding regenerative agriculture adoption. A change in production can be impacted by many different variables. A decision to change practices can be dependent on the time span. A farmer must make a decision based on potential profitability as well as the amount of risk that comes with it. One way to help aid in decisions during times of uncertainty is scenario analysis to address price and production variability (Backus et. Al 1997).

To gain a better understanding of what the potential profits are for changing to regenerative agriculture, it is important to know the implementation costs of each conservation practice. There are many barriers to entry for farmers to pivot their current management practices to conservation agriculture. Some of these barriers are economic factors such as initial costs, commodity prices, input costs, etc. Others could be issues such as resistance to change, lack of information, compatibility with existing practices, or the complexity of site-specific implementation (Rodriguez et al 2009). An important calculation will be determining how much it will cost upfront for a producer to transition away from traditional agriculture. Cusser et al. broke down the following practice changes from conventional to no-till (2020):

Table 2.1 Practice Comparison

Conventional	**No-Till**
Planting	Planting
Soil Finishing	Spraying
Tillage (moldboard or chisel plow)	Mowing
Custom Work: labor, fuel, and equipment rental	

Depending on what farmers currently own, the purchase of new equipment could be necessary. Along with this, there could be extra costs incurred for cover crop seeds and more herbicides in early years (Schronk 2022). However, there could be a cost decrease in the amount of passes over the field with no-till which could potentially result in less labor (Stanley 2022).

Plastina et al. (2018), conducted a partial budget analysis of cover crop usage by farmers in Iowa. This analysis used a survey sent to farmers asking about the amount of land they had in cover crops, how the cover crop was terminated, years of experience in cover crops, tillage practices, and planting method. By doing this, they were able to determine where the differences in conventional versus cover crop production occurred. This also allowed them to calculate the net returns of planting cover crops and if it was economical for the farmer. The analysis concluded that Iowa farmers were not profitable when adopting cover crops unless they utilized the cover crops for grazing livestock or forage. This partial budget analysis provided a guide to this project for determining which variables could potentially change when transitioning from conventional practices. While variables used as the baseline of the Iowa study will be similar to that of this project, the data for this project will be gathered in a different method than the Iowa analysis. Also, one would assume the Iowa results would likely not be applicable to Texas farms due to the difference in soil, climate, and production.

The Soil Health Institute (SHI) recently did an economic analysis of soil health benefits in nine states across the United States. This was funded by Cargill to gain an understanding of the impact on producer profitability from transitioning to regenerative practices. The analysis recognized that because every farm is different, the profitability can vary. The analysis used conventional farm budgets from research farms and compared them to farms in the same area that were engaged in conservation practices. SHI obtained the numbers for their analysis through interviewing local farmers in each state. Also, the amount of time a producer had been involved in regenerative practices was not distinguished, meaning there was no way to know exactly how long it took to see results from the production practice transition. The SHI analysis was useful for this project because it showed which variables would likely change the most when comparing conventional versus regenerative practices.

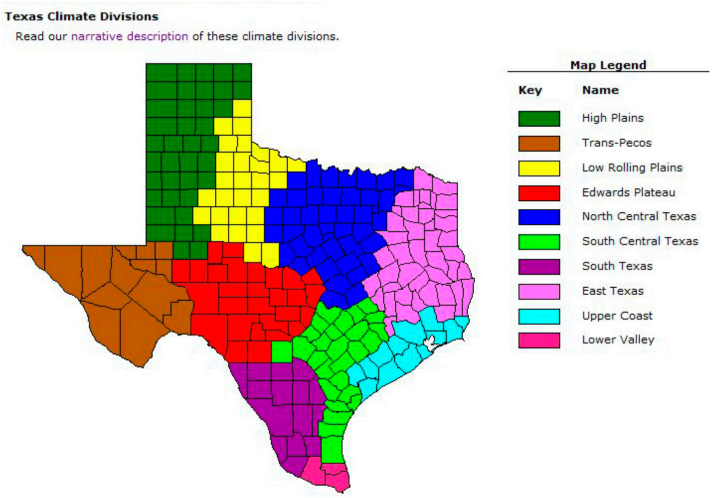


Figure 2.1 Texas Climate Divisions

Geographic Variability of Texas

Texas is home to an array of agricultural production, climate, and soil types. Due to its size and diversity in geographic regions, Texas has extreme variability in its climate (Vaughan et. Al 2012). Located in the green section of Figure 2.1 is the Texas High Plains, known for an abundant production of row crops, this area contains a semi-arid climate as well as a large variability in rainfall (Colaizzi et. al 2009). Both the Southern and Northern High Plains of Texas irrigate using the Ogallala Aquifer, which also services the heavy agricultural producing states of Oklahoma and New Mexico; parts of Kansas, Colorado, Wyoming, Nebraska, and South Dakota also pull from the Ogallala. The shared usage of this aquifer has resulted in a severe lack of water, especially in the southern portion of the Ogallala (Modala et. al 2017). This could have significant impacts on the agricultural industry in this area as well as put farmers at a bigger risk for new practice adoption. Found in the darker blue section of Figure 1, Central Texas produces mostly dryland corn and cotton and receives more rain than the northern parts of Texas but has a similar climate to the High Plains (Nielsen-Gammon 2011).

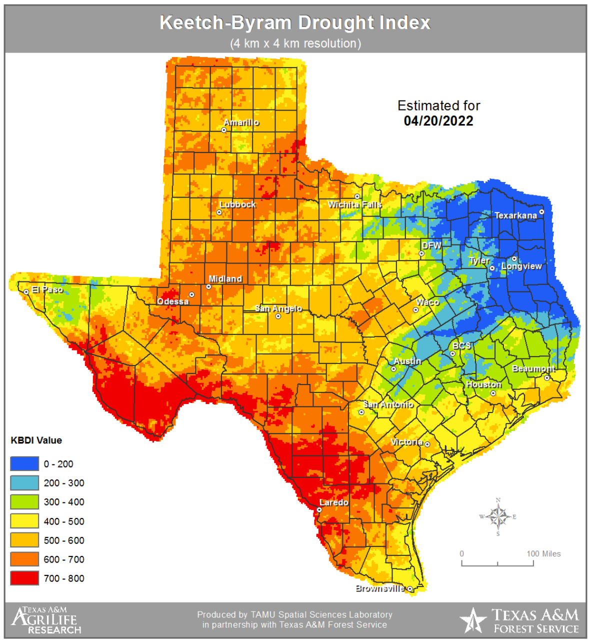


Figure 2.2 Drought Index

The lighter blue portion of Figure 2.1 shows the coastal area used for this analysis. With a warm and damp climate, the Gulf Coast of Texas primarily focuses on the production of three crops: corn, cotton, and sorghum. Although the area has irrigation systems, often rainfall is the main source of water (Ning 2003). In short, the integration and profitability of regenerative agriculture could be vastly different depending on the production area.

As seen in Figure 2.2, the Keetch-Byram Drought Index showcases the large difference in rainfall across Texas. Current drought conditions could play a significant role in production decisions for farmers. Depending on the level of drought, the farmer may shift the focus of their operation.

Agricultural Carbon Credit Markets

As mentioned previously, many large corporations are looking to agriculture, particularly row crop farmers, to offset their carbon emissions. The thought is that farmers are able to store more carbon from the air in the ground through a change in their production practices (Wongpiyabovorn 2022). Corporations then buy the carbon credits from producers. Achieving a goal of net zero is much cheaper to accomplish through the purchase of carbon credits than it is for the corporation to change how much greenhouse gas they emit into the atmosphere (Keenor 2021).

Currently, two types of carbon markets exist, voluntary and compliance markets. Voluntary markets are geared towards those businesses or individuals that wish to offset their carbon emissions but are not legally bound to do so (Aiken 2021). More commonly found in Europe, compliance carbon markets are those where the business or other entities are legally required to reduce their GHG emissions. The largest difference between the markets is the certification process for carbon credits. While many voluntary markets are likely held to the same standard of scrutiny as the compliance market, there is currently no regulation as to what represents a metric ton decrease in carbon emissions. As of now, there is no central marketplace in the United States for carbon credits, almost all transactions are between the buyer and seller.

With no current regulation or central entity to sell carbon credits in the voluntary market within the United States, it is hard for a producer to make an informed decision. Currently, there is very little research into the necessary practice changes as well as how much the carbon credits are worth. One focus of this paper is to gauge how much it could potentially cost a producer to change from conventional practices to those conservation practices required to sequester carbon in the soil. American Soybean Association Economist, Scott Gerlt, released a report showing that most carbon credit programs are offering around $15 per ton for sequestered carbon (Gerlt, 2021). He also mentions that payment amounts can vary as well as be practice-based.

According to Sellars, et al., there are currently two approaches for farmers looking to enter carbon markets. Aggregators, where the farmer sells carbon control and credits through a contract. This gives the aggregators control of prices, when to sell, and data collected depending on the contract. Another approach is through a data manager. The farmer will pay a data manager to enter the carbon market, but not sell their carbon credits. Due to the lack of regulation currently existing in the carbon market, there is a large variability in the requirements a farmer must meet to fulfill their carbon contract without being penalized.

The lack of literature available for an economic analysis of participating in the carbon market makes it difficult for a producer to make an informed decision. The current price of carbon credits is not enough for the producer to breakeven (Sellars 2021).

With many carbon programs still in the pilot stages, the demand for carbon credits is much higher than the supply. Also, the lack of transparency between farmers and aggregators is contributing to the lack of participation in the market (Wongpiyabovorn 2022). Farmers are currently facing more questions than answers, adding another barrier to entry on top of production practice changes.

Partial Budgets and Stochastic Simulation

A partial budget analysis was chosen because it will show the cost differences in production from conventional to regenerative (Kay, Edwards, Huffy, 1994). The results of this analysis will be evaluate the change in net returns of the partial budget such as: variable harvesting expenses, diesel used for harvest, changes in receipts, etc. This analysis will allow producers to see what the potential pay-off is for transitioning their operations to regenerative production as well as show Congress what, if any, incentives may be needed to encourage producers to adopt regenerative agricultural practices.

The partial budget analysis will also include price and yield risk using stochastic simulation in Simetar, an Excel-based program. Risk is added to a deterministic model through stochastic simulation by simulating a set of values for each key output variable (KOV) as a representation of each variable's probability distribution. Agriculture is an industry where most variables are out of the control of the producer or manager, therefore, applying risk to a model is helpful because shocks in price and yield are unpredictable. Including risk in the analysis will allow realistic evaluation of the risk in making practice changes and allow for a more informed decision by the producer by giving them a distribution of possible net returns instead of one potential estimation. The model for this project will simulate 500 random draws of unknown variables to best estimate a range of potential outcomes for net returns (Richardson et al., 2008). Using Simetar, this project will utilize Latin hypercube sampling (LHS) to draw each of the random values. LHS was chosen compared to Monte Carlo sampling for simulation due to the efficiency sampling variable from their multivariate distributions (Minasny and McBratney 2006). In LHS, all regions of the probability distribution are sampled. Simetar calculates values for mean, standard deviation, covariance, minimum, and maximum of the 500 iterations for each of the KOVs.

This project will outline the positive and negative effects of integrating regenerative agriculture practices in the first year. Instead of having one fixed number as a dollar value for either a cost or benefit, the results will display a specified range to account for risk. The focus of this study is to evaluate the cost of implementing regenerative agriculture practices and compare it to the potential benefits of the agricultural carbon markets. By making the partial budget analysis stochastic, the possibility of many outcomes can be captured, leading to a more informed business decision for a producer.

As noted above, while there is much discussion regarding the environmental benefits of regenerative agriculture, there is very little economic analysis to indicate whether these practices will pay off for producers in either the short run or the long run and nothing has been evaluated for Texas.

CHAPTER III

METHODOLOGY

A partial budget analysis will be conducted for this study to evaluate the change in cost of production from conventional to regenerative agriculture practices. This study will utilize four representative dryland cotton farms across Texas to analyze the profitability of integrating regenerative agriculture practices into an operation. The data for this project is provided and maintained by the Agricultural Food and Policy Center (AFPC) at Texas A&M University (Outlaw et al., 2022). The relative profitability of these farms was analyzed using a stochastic simulation model created in Excel utilizing Simetar. Stochastic simulation allows for the inclusion of risk into the partial budget for each production practice with stochastic prices and yields that are not yet realized to show a distribution of potential outcomes.

To showcase the per acre cost of changing the production practice, some costs of production were broken down into variable costs. These variable costs are dependent on actual realized yield while the fixed costs are based on budgeted yields. The change in cost was analyzed through a stochastic simulation model. This model is a partial budget analysis that examines only the changes between practices for dryland cotton, rather than the entire farm budget. Dryland cotton was chosen as cotton is the main cash crop in Texas as well as some areas of Texas do not have irrigated cotton. This analysis will be conducted for several major production regions across Texas to identify any differences across soil types. These include the Panhandle, the Southern Plains, Central Texas, and the Gulf Coast.

Model Farms

The farms analyzed in this study are modeled after four different AFPC representative farms. These farms are developed by collecting and maintaining production and financial data from farms across the country. Each representative farm is typically comprised of a panel of four to six farmers per location (Outlaw 2021).

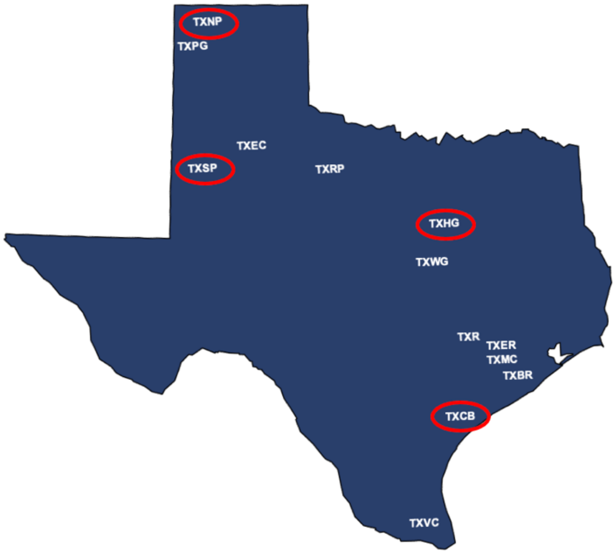
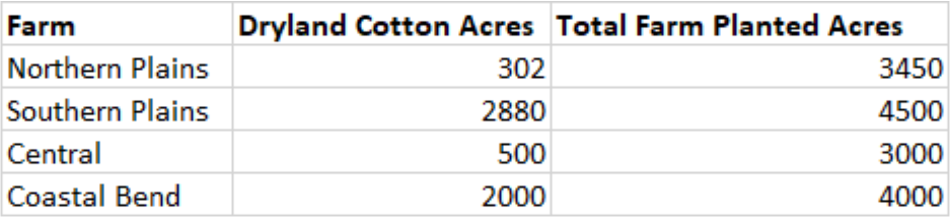


Figure 3.1 Texas Representative Farm Map

This study took descriptive and financial data from four representative farms throughout Texas and created a partial budget analysis to analyze profitability of implementing regenerative practices. Cotton production was analyzed for each farm because it is a primary cash crop for the state. The partial budget analysis quantified the cost of converting to regenerative practices to help a producer better determine if a change in practice is economically feasible.

The table below outlines the amount of Dryland cotton planted alongside the total planted acreage of each representative farm.

Table 3.1 Texas Representative Farm Acreage



Farm	Dryland Cotton Acres	Total Farm Planted Acres
Northern Plains	302	3450
Southern Plains	2880	4500
Central	500	3000
Coastal Bend	2000	4000

Model Structure

The main goal of this model is to determine and simulate the Net Cash Income for each farm for 2022 to show the potential profitability of the given practice. The forecasted and historical cotton prices in this study were generated by FAPRI in April of 2022. The farm-level history was gathered using a combination of AFPC representative farms and National Agricultural Statistics Service (NASS) data. Costs that are typically considered fixed were converted to a variable cost through percentage of receipts of the total farm budget to reflect the changes dryland cotton experienced with a change in practice.

The input data included for each farm includes:

- Variable Costs: seed, fertilizer, herbicides, insecticides, irrigation, ginning, fuel and lube, maintenance and repairs, and hourly labor
- Fixed Costs: rent, salaried labor, taxes, utilities, and insurance

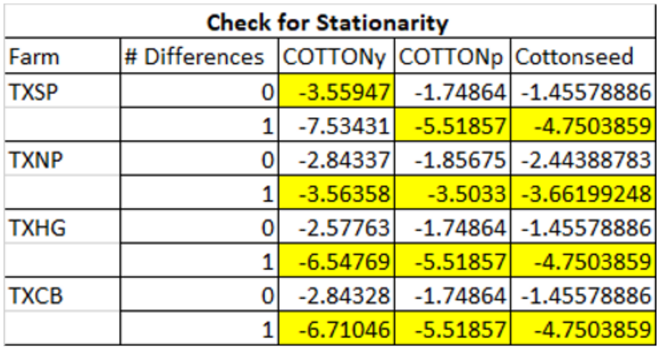
- Price Wedge: Price difference from national to local price received by each representative farm
- Actual Production History: 20 years of yield and APH for each farm.
- Budgeted Yields: Average yields used by the farmers to budget costs

Historical yields from the past 20 years for each farm were used in this analysis to forecast 2022 yields. To simultaneously simulate both price and yield for 2022, correlation between price and yield was necessary to avoid bias. Risk was applied to both price and yield. Risk was incorporated in Excel using Simetar. By incorporating risk, a producer is given a distribution of possible outcomes rather than one deterministic payment to better aid decision making.

In this model, the dryland cotton operation of each farm was analyzed. This included 500 iterations of forecasted 2022 prices and yields used to determine producer profitability.

To develop the model's stochastic simulation capability, several steps had to be taken. First was checking the historical data for stationarity using a Dickey-Fuller test. The results of the Dickey-Fuller test can be found in Figure 3.2 with the significant test statistics highlighted in yellow. The historic cotton yield data was de-meaned. For the cotton and cottonseed prices, the difference of the natural log was taken due to non-stationarity. To approximate standard uniform variables, the percent rank function was applied to the de-meaned and differenced data. These are hereafter referred to as historical U values. Standard normal variables (historical Z values) were created through the inverse transform using the standard normal cumulative distribution function and the historical U values. A correlation matrix was then created from the historical Z values. Fisher Z test was applied to test the significance of the individual correlation coefficients (Fisher 1915). Highlighted in yellow on Table 3.3 are the significant coefficients in a correlation matrix of the Texas Southern Plains farm. All correlations were either not statistically significant or were not of the expected sign. Thus, for the purposes of simulation, they were all assumed to be zero. Next, independent standard uniform draws were generated. Inverse transform of the empirical distribution for each variable was used along with the standard uniform draws to generate stochastic draws for the log differenced prices and yield deviate. Then, the changes in log prices and yield deviates were used to calculate stochastic draws for levels variables.

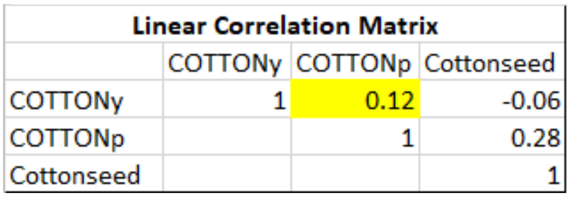
Table 3.2 Dickey-Fuller Test Results



Check for Stationarity

Farm	# Differences	COTTONy	COTTONp	Cottonseed
TXSP	0	-3.55947	-1.74864	-1.45578886
	1	-7.53431	-5.51857	-4.7503859
TXNP	0	-2.84337	-1.85675	-2.44388783
	1	-3.56358	-3.5033	-3.66199248
TXHG	0	-2.57763	-1.74864	-1.45578886
	1	-6.54769	-5.51857	-4.7503859
TXCB	0	-2.84328	-1.74864	-1.45578886
	1	-6.71046	-5.51857	-4.7503859

Table 3.3 Fischer Z Test Significant Variable



Linear Correlation Matrix

	COTTONy	COTTONp	Cottonseed
COTTONy	1	0.12	-0.06
COTTONp		1	0.28
Cottonseed			1

Scenarios and Analysis

Each farm in this model was analyzed to determine the profitability impacts of a producer transitioning their conventional dryland cotton operation to certain regenerative agriculture practices. The representative farms for this analysis were chosen due to their diversity to better reflect the impact of these practice changes across different areas of Texas. Farms from the northern and southern plains as well as the coastal bend and central Texas were chosen for this study.

Due to the lack of data currently available for these practices, assumptions had to be made to develop a complete model. The assumptions of this model were based on previous representative farm data or regenerative based literature. For a no-tillage system it was assumed that fuel and lube, labor, and repairs and maintenance would decrease 30% while yield decreased 10% for the first year (Ribera et. al and Myers et al 2019). Based on Garba, cash crop yields are expected to decrease 7% in the first year (2022). Herbicide costs were broken down on a per acre per pass basis. In a conventional production year, a producer would take four passes to apply herbicide, no-tillage systems require two extra passes for weed control in the early years and cover crops require one extra pass for burn down, or termination spraying (Rohrbach 2022).

The assumptions for this model are as follows:

- Use a percentage total of overall budget to determine fuel and labor costs
- Use a percentage of receipts to calculate how much of the whole farm budget dryland cotton uses
- Assume every crop uses the same labor and fuel per acre

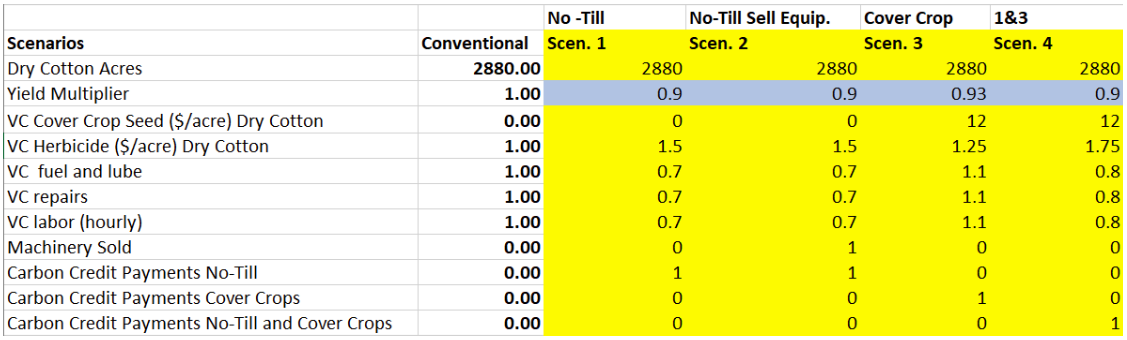
- Sell 3 pieces of older equipment at the beginning of the first year of no-till production for Alternative 2
- Tractors and sprayers on a 5-year lease
- Assume two extra passes over the field with no-till production for herbicide application
- Assume 4 less passes over the field for plowing and disking with a no-till system
- Integrating half of the planted acreage into a regenerative system for one year
- Only analyzed cost changes for the larger horsepower tractors as they are the ones typically used for conventional tillage
- Assume the fixed costs for repairs, maintenance and supplies are broken down as a percentage of receipts.

After each of these assumptions were built into the model, net cash farm income was simulated, and a distribution of possible profitability was created. The same four scenarios were run with each farm and compared to a baseline conventional budget. 2022 net cash farm income for each scenario was then analyzed.

Government payments such as Agriculture Risk Coverage (ARC) and Price Loss Coverage (PLC) were not included in this analysis because there would not be a payment for 2022. Also, the payment for each farm would be the same because payments are based on the reference and national price.

Agricultural carbon credit market payments were included in this analysis on a per practice basis. Based on an analysis by Gerlt 2022, payments were calculated as $3/ac.

for no-tillage, $6/ac. for cover crop production, and $9/ac. if a producer chooses to participate in both.



		No -Till	No-Till Sell Equip.	Cover Crop	1&3
Scenarios	**Conventional**	**Scen. 1**	**Scen. 2**	**Scen. 3**	**Scen. 4**
Dry Cotton Acres	**2880.00**	2880	2880	2880	2880
Yield Multiplier	**1.00**	0.9	0.9	0.93	0.9
VC Cover Crop Seed ($/acre) Dry Cotton	**0.00**	0	0	12	12
VC Herbicide ($/acre) Dry Cotton	**1.00**	1.5	1.5	1.25	1.75
VC fuel and lube	**1.00**	0.7	0.7	1.1	0.8
VC repairs	**1.00**	0.7	0.7	1.1	0.8
VC labor (hourly)	**1.00**	0.7	0.7	1.1	0.8
Machinery Sold	**0.00**	0	1	0	0
Carbon Credit Payments No-Till	**0.00**	1	1	0	0
Carbon Credit Payments Cover Crops	**0.00**	0	0	1	0
Carbon Credit Payments No-Till and Cover Crops	**0.00**	0	0	0	1

Figure 3.2 Model Scenarios

Cumulative distribution function (CDF) graphs will be used to illustrate the results as well as assess risk of each scenario for each farm. Each of these graphs are comprised of 500 iterations of potential net cash income results for each scenario. A risk averse producer prefers the line to the right. Net cash income is represented on the x-axis of each graph while the corresponding probability values can be found on the y-axis. Another method of analyzing results for each model is a summary statistics table. Each table outlines the mean, standard deviation, as well as the minimum and maximum net cash income probabilities for each scenario.

The results of this analysis will be used for evaluating the change in net farm cash income to see what the potential pay-off is for changing their operations to regenerative production. Additionally, these results should help verify incentives, if any, the Federal Government should provide producers who opt into regenerative production.

The current extent of literature on regenerative agriculture overwhelmingly indicates positive benefits to soil health and sustainable production. However, there has been a lack of research on the economic outcomes for farmers.

CHAPTER IV

RESULTS

Results for each of the four representative farms analyzed are provided in this chapter. These results compare the net cash farm income of different regenerative production practices to a conventional production system. The calculations needed to evaluate regenerative agriculture discussed in Chapter III were built into an excel spreadsheet. Using Simetar, stochastic prices and yields for 2022 cotton production were generated. Data from the four representative farms were entered into the model to evaluate the change in net revenue associated with various regenerative agriculture practices.

Net Farm Revenue is the key output variable (KOV) used to evaluate each alternative. The following scenarios were analyzed for each farm:

1. Baseline conventional dryland cotton operation
2. Converting dryland cotton acreage to a no-tillage operation
3. Converting dryland cotton acreage to a no-tillage operation while selling off a few pieces of older tillage equipment no longer needed
4. Implementing cover crops on all dryland cotton acreage
5. Implementing both a no-tillage and cover crop system on dryland cotton acreage

Historical prices were used to generate stochastic price draws for 2022. Stochastic yields for 2022 were generated using historic yields and are correlated with price. Stochastic prices and yields were used to calculate a distribution of potential net cash income for each farm and each regenerative practice scenario.

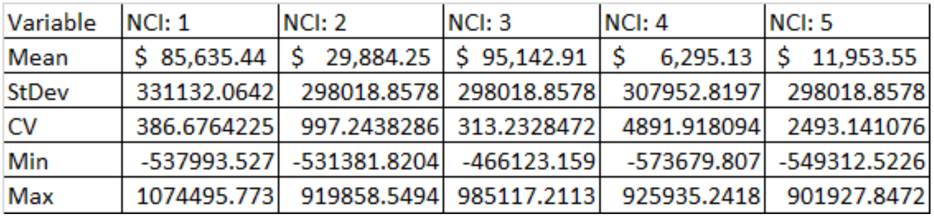
Summary statistic tables are included for each farm analysis to summarize the distribution of net cash income each simulated scenario. To illustrate risk of each practice in the model, Cumulative Distribution Function (CDF) graphs were generated using Simetar. The CDF graphs show the 500 simulated outcomes for 2022 net cash income for each scenario. The Net Cash Income is found on the x-axis of the CDF while the probability values are on the y-axis. For each CDF graph, each scenario is represented by the following colors:

- Scenario 1 - conventional production - black
- Scenario 2 - no-Tillage system - red
- Scenario 3 - no-Tillage system with equipment sold - blue
- Scenario 4 - cover crop system - green
- Scenario 5 - combined no-tillage and cover crop system - yellow

Texas Southern Plains Farm Results

Table 4.1 contains the summary statistics for each scenario of simulated net cash income for the Texas Southern Plains (TXSP) representative farm. Net cash income in Scenario 1 had one of the higher means, but also has the largest standard deviation meaning it has the most variability. Scenarios 2, 4, and 5 all show lower average net cash income. In each of these scenarios a reduction in yield was realized during the first year as a result of the change in production practices which has an impact on market receipts. Scenario 3 had the highest mean net cash income, which can be attributed to the sale of certain equipment in year one to offset potential increased costs and yield loss of changing to regenerative practices.

Table 4.1 TXSP Summary Statistics



Variable	NCI: 1	NCI: 2	NCI: 3	NCI: 4	NCI: 5
Mean	$ 85,635.44	$ 29,884.25	$ 95,142.91	$ 6,295.13	$ 11,953.55
StDev	331132.0642	298018.8578	298018.8578	307952.8197	298018.8578
CV	386.6764225	997.2438286	313.2328472	4891.918094	2493.141076
Min	-537993.527	-531381.8204	-466123.159	-573679.807	-549312.5226
Max	1074495.773	919858.5494	985117.2113	925935.2418	901927.8472

Figure 4.1 illustrates the risk of each scenario in the CDF graph for TXSP. Scenario 1 has a 58% chance of positive net cash income in 2022. Scenario 2 has a 43% chance of positive net cash income in 2022. Scenario 3 has a 61% chance of positive net cash income in 2022. Scenarios 4 and 5 have almost the same probability of positive net cash income, 49% and 50% chance respectively.

Based on the results from this farm, Scenarios 1 and 3 have the similar likelihood of positive net farm income. However, for Scenario 3, selling equipment to offset the costs of new practices largely contributes to the potential for positive net farm income. Combined lower yields and higher input costs for Scenarios 4 and 5 (both containing cover crops) means these scenarios have a lower chance of achieving positive net farm income.

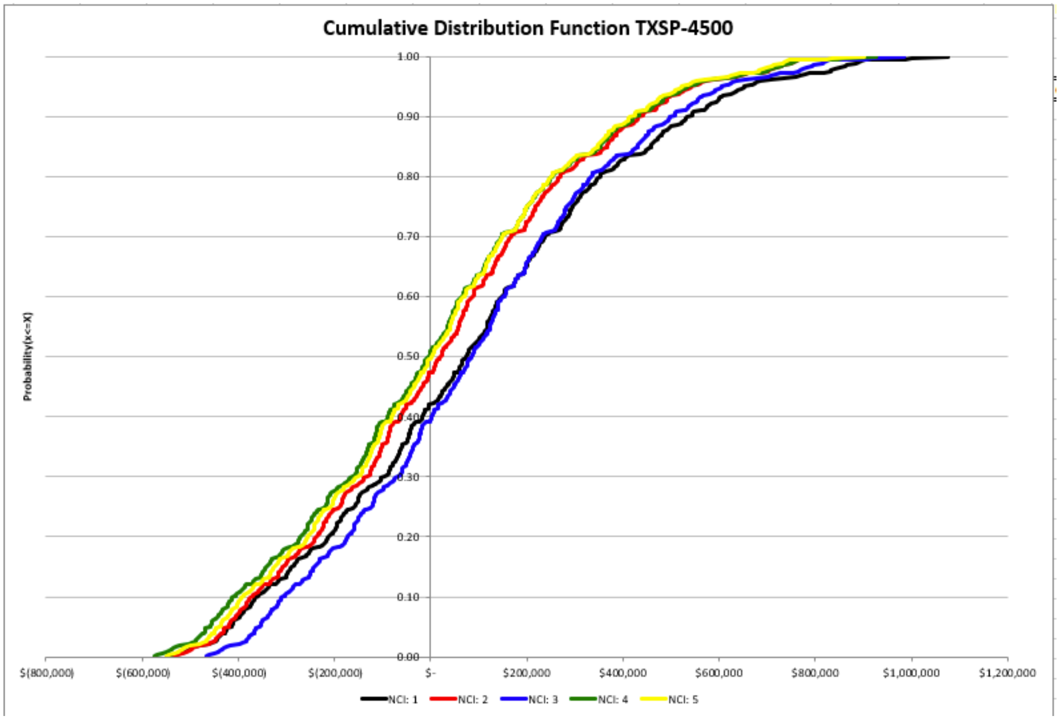


Figure 4.1 TXSP CDF Graph

Texas Coastal Bend Farm Results

The summary statistics for each scenario of the San Patricio County Farm (TXCB) can be found in Table 4.2. Each of the 5 scenarios in this analysis show a negative mean for net cash income for TXCB. The standard deviation for each scenario is also relatively high, meaning a large variability of the outcomes.

Table 4.2 TXCB Summary Statistics

Variable	NCI: 1	NCI: 2	NCI: 3	NCI: 4	NCI: 5
Mean	-158893	-230324	-165065	-220800	-248736
StDev	233518.6	210166.7	210166.7	217172.3	210166.7
CV	-146.966	-91.2484	-127.324	-98.3569	-84.4939
Min	-599179	-626580	-561322	-630266	-644993
Max	534296.3	393547.2	458805.9	423866.3	375135

The risk for each scenario for TXCB is illustrated in Figure 4.2 in the CDF graph. Scenario 1 has a 23% chance of positive net cash income in 2022. Scenarios 2 and 4 have a 16% chance of positive net cash income in 2022. Scenario 3 has a 20% chance of positive net cash income in 2022. Scenario 5 has a 13% chance of positive net cash income in 2022. The results for this farm indicate a low probability of positive net cash income for each of the scenarios in this model. In this instance, Scenario 1 would be the most ideal for a risk-averse producer.

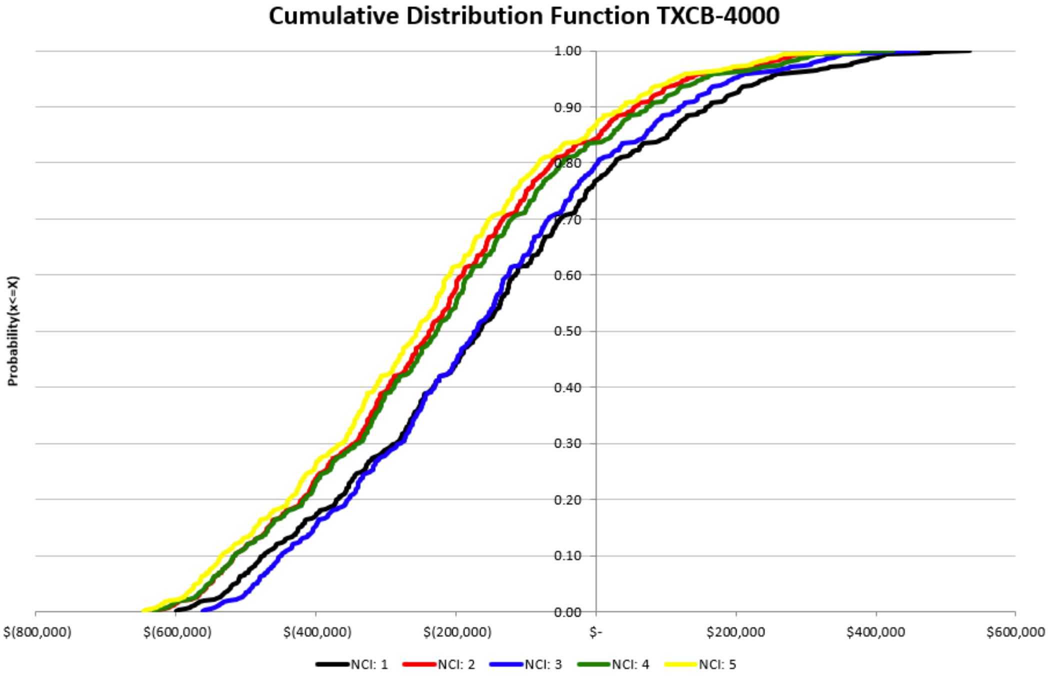
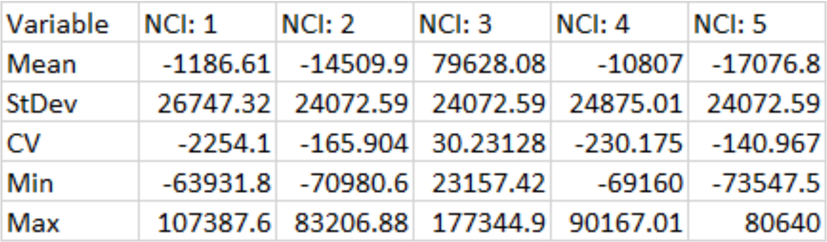


Figure 4.2 TXCB CDF Graph

Texas Northern Plains Farm Results

Table 4.3 shows the summary statistics for each scenario in the Texas Northern Plains (TXNP) analysis. Each scenario results in a positive mean for net cash income. Scenario 1 (conventional production) has the highest projected mean for net farm income; however, it also has the highest standard deviation, showing the largest variability in outcomes. Scenarios 2 and 3 have relatively low standard deviations, meaning the simulated outcomes have less variability than the other scenarios.

Table 4.3 TXNP Summary Statistics



Variable	NCI: 1	NCI: 2	NCI: 3	NCI: 4	NCI: 5
Mean	-1186.61	-14509.9	79628.08	-10807	-17076.8
StDev	26747.32	24072.59	24072.59	24875.01	24072.59
CV	-2254.1	-165.904	30.23128	-230.175	-140.967
Min	-63931.8	-70980.6	23157.42	-69160	-73547.5
Max	107387.6	83206.88	177344.9	90167.01	80640

CDF graph for TXNP is shown in Figure 4.3. Scenario 3 is the least risk averse for a producer in this model with a 100% chance of positive net cash income. Since there is very little of the CDF to the left of the y axis for scenarios 1,2,4, and 5, this indicates a lower probability of positive of net cash income. Scenario 1 show a 48% chance of positive net cash income for their respective practices. Scenarios 2 and 4 both show similar probabilities of positive net cash income (26% and 30% respectively). The lowest probability of positive net cash in come in this analysis is seen with scenario 5 (22%). The results of this analysis show an overwhelmingly high probability of TXNP achieving positive net cash income with scenario 3 due to the amount of equipment sold in 2022.

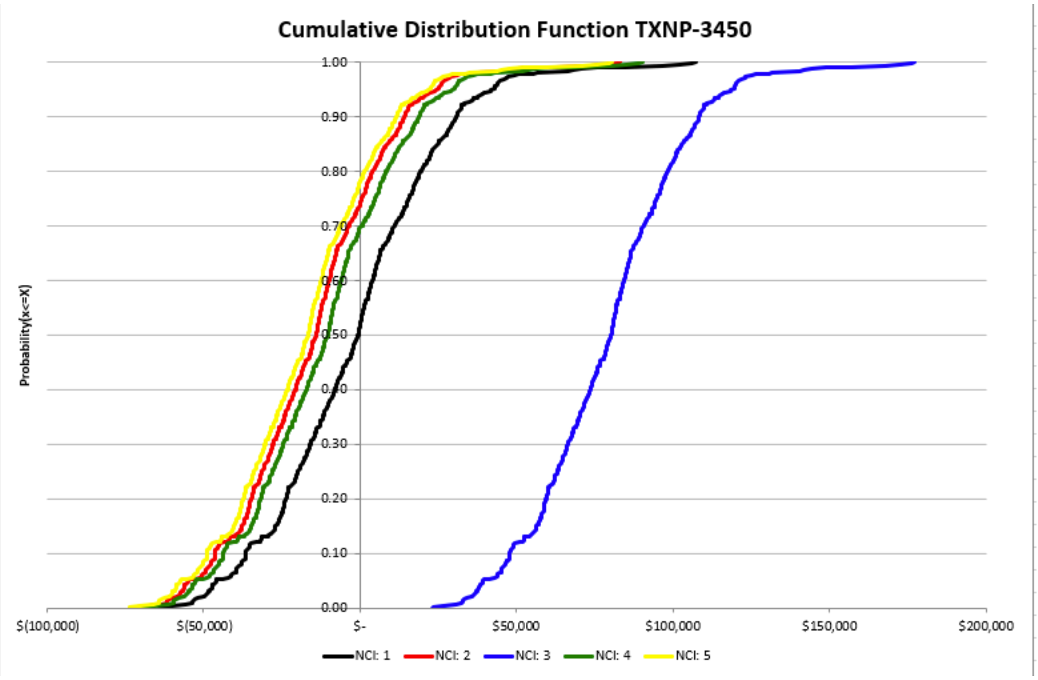


Figure 4.3 TXNP CDF Graph

Central Texas Representative Farm

Each of the scenarios for the Hill County representative farm (TXHG) show a positive probability of positive net cash income (Table 4.4). The standard deviation for the scenarios in this analysis are higher, meaning a large distribution of potential outcomes. Scenario 1 has the lowest mean of any scenario in this analysis, giving this scenario the lowest expectation of net cash income.

Table 4.4 TXHG Summary Statistics

Variable	NCI	NCI: 2	NCI: 3	NCI: 4	NCI: 5
Mean	18589.18	78083.7	181780.7	79075.62	71830.88
StDev	72915.86	63980.9	63980.9	66113.6	63980.9
CV	392.249	81.93887	35.19675	83.60807	89.07158
Min	-147577	-83940	19756.97	-88348.9	-90192.9
Max	279786.5	284968.9	388665.9	292857	278716.1

Risk was assessed in this model by analyzing the CDF generated in this analysis. Scenario 3 has a 100% chance of positive net cash income. Scenario 1 has a 60% chance of a positive net cash income for this analysis. Scenarios 2,4, and 5 had close to the same probability of positive net cash income (88%, 87%, 86%, respectively).

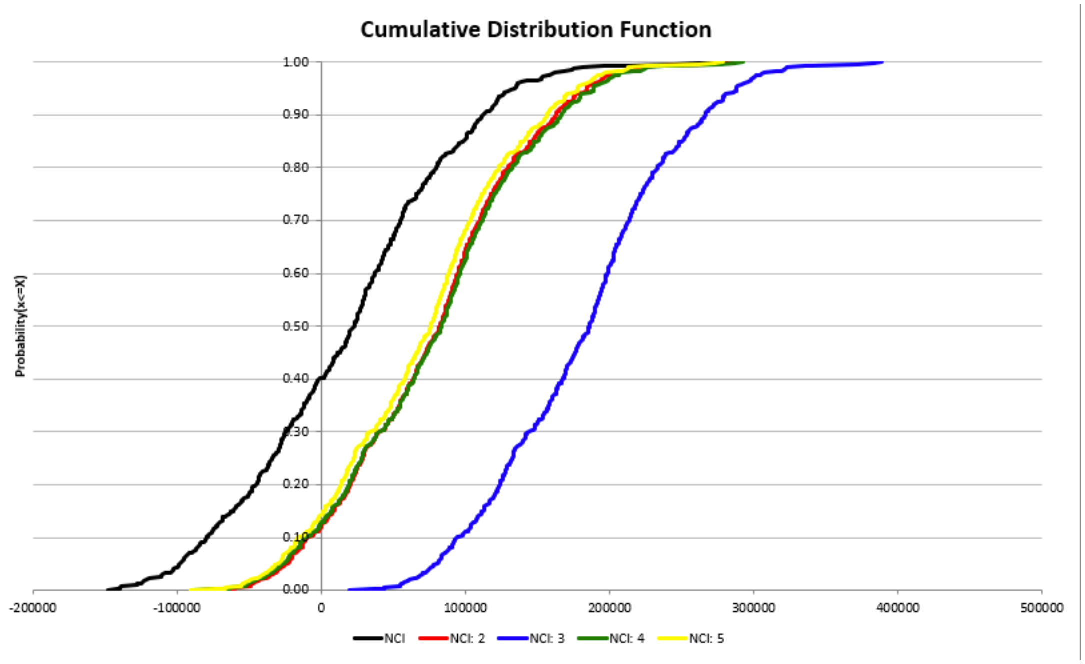


Figure 4.4 TXHG CDF Graph

For this analysis, Scenario 3 is the obvious choice for optimal net cash income. However, this probability can only be achieved by selling equipment that was previously utilized for conventional production. Overall, there is a low probability for negative net cash income for each scenario in this analysis.

Summary

For each model in this analysis, Scenario 3 proved to be one of, if not the highest probability of positive net cash income. This is likely due to the equipment sold in this scenario, meaning that in most cases, the best chance to achieve positive net cash income is on a no-tillage system with equipment sold in the first year. For each model with the exception of the Hill County Farm, Scenarios 2,3, and 4 showed the lowest likelihood of a positive net cash income. Of these three, Scenario 5 proved to be the riskiest practice. The implementation of a no-tillage system without selling equipment (Scenario 2) proved to be the more risk averse option when compared to Scenario 4. Conventional production (Scenario 1) proved to be the highest probability of positive net cash income apart from the Hill County Farm analysis and Scenario 3 in all other models.

CHAPTER V

CONCLUSIONS

Conservation production efforts have been the priority for most producers in the United States for well over 30 years. From terms like sustainable agriculture and soil health, the idea of regenerative agriculture and the practices farmers use are not new. These practices include cutting back on the amount of erosion of the soil, the porosity of the soil, and an increase in natural soil health. The practices that encompass regenerative agriculture include:

- Low/No Tillage, trying to disturb the least amount of soil possible
- Growing cover crops, these help slow erosion and naturally add nutrients back into the soil
- Crop rotation, giving the soil a chance to recover after production by not utilizing the same fields for the same crops, year after year
- A reduction in synthetic inputs to naturally revitalize soil

In Executive Order 14008, the Biden Administration launched a new initiative of climate smart practices, to incentivize U.S. farmers to reduce greenhouse gas emissions by sequestering carbon through production practices. If implemented, farmers would transition their operations further from traditional practices and move towards those that are more environmentally conscious. These practices could also be incentivized by the emerging carbon credit market. Recently, many corporations have pledged to work towards ‘net carbon zero emissions,’ and the main way they hope to achieve this is through purchasing carbon offsets from agricultural producers. It is believed that production agriculture can help these companies offset their carbon dioxide emissions through carbon sequestration (Paustian et al. 2009). To participate in the growing carbon market, farmers would have to adopt environmentally conscious farming practices to receive a payment based on the amount of carbon sequestered in the soil. Despite the excitement surrounding regenerative agriculture, to date, there is no analysis available to producers that show them if regenerative agriculture is economically viable for their operations.

Objectives

The purpose of this study was to evaluate the change in net cash income a farmer would experience for regenerative agriculture production practices. A secondary objective was to determine which practices would work best in different growing regions across Texas to help producers have quantitative information to make a decision.

Results

Each model was used to evaluate net cash income of four farms across Texas: Dawson County, Moore County, Hill County, and San Patricio County. For each farm, 2022 net cash income of different production practices was simulated. In each model, the dryland cotton operation of each farm was analyzed. This included 500 iterations of forecasted 2022 prices and yields used to determine producer profitability. The forecasted and historical cotton prices in this study were generated by FAPRI in April of 2022. The farm-level history was gathered using a combination of AFPC representative farms and National Agricultural Statistics Service (NASS) data. Costs that are typically considered fixed were converted to a variable cost through percentage of receipts of the total farm budget to reflect the changes dryland cotton experienced with a change in practice.

For each model in this analysis, Scenario 3 resulted in either the highest probability or one of the highest probabilities of positive net cash income. This is likely due to the equipment sold in this scenario, meaning that in most cases, the best chance to achieve positive net cash income is on a no-tillage system with equipment sold in the first year. For each model, except for the Hill County Farm, Scenarios 2,3, and 4 showed the lowest likelihood of a positive net cash income. Of these three, Scenario 5 proved to be the riskiest practice. The implementation of a no-tillage system without selling equipment (Scenario 2) proved to be a riskier option than Scenario 4. Conventional production (Scenario 1) resulted in the highest probability of positive net cash income in all models apart from the Hill County Farm.

Future Research

The profitability analysis developed in this study analyzed the profitability of production practices for 2022. In the future, projecting out more years of net cash income would be more beneficial to allow producers to make a more sound decision. This model could easily be adapted to simulate more years of production to estimate the impact of regenerative practices with a carbon market payment.

Future versions of this model could address the limitations found in this study that come from only simulating one year of production. One crop was analyzed in this model for the purpose of simplification; however, future work could expand the model to include additional crops. Also, only selling equipment in the first year could drastically impact the results of future projections because a producer would only sell equipment in the first year and not each subsequent year.

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