ECONOMIC EVALUATION OF THE IMPACT OF REGENERATIVE AGRICULTURE ON FARMER RISK

A Thesis

by

COLTON ROY RUSSELL

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Chair of Committee,	Joe Outlaw
Committee Members,	David Anderson
	Monty Dozier
Head of Department,	David J. Leatham

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ABSTRACT

The U.S. agriculture industry has seen decades of changes through both technological and cultural innovations. Regenerative agriculture has become the topic at the center of today's changes within the industry. Regenerative agriculture, very similar to the soil health movement, includes a range of practices with the intention of improving the condition and rigor of the soil. The primary regenerative practices, reduced or no-till and cover cropping, have picked up momentum lately with even the Biden administration focusing upon them. While the assertions made by supporters of these movements sounded hopeful, there remained a need for an economic analysis within regions of Texas specifically.

The first objective of this study was to determine if regenerative practices increased yields and/or reduced yield risk enough to offset potentially higher production costs. The secondary objective was to determine whether these impacts were different for farms in different production regions of Texas.

Farms throughout four regions of Texas were modeled, with the focus of the study built into each simulation. Each regenerative practice was run through the models, and compared to each farm's conventional base practices. For two of the representative farms, no-till practices resulted in a higher net present value on average than conventional operations for this five-year analysis. However, for the other two farms conventional practices resulted in the highest average net present value. One constant result throughout the analysis of all four farms was the cover cropping scenario receiving the lowest mean net present value.

The models were created to economically assess the effects of transition to regenerative practices. These may be helpful to Texas producers debating on transitioning from conventional practices themselves. Texas farm operations may also benefit from the use of this model as it is updated to make decisions on transitioning in the future as well.

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Contributors

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The data analyzed was contributed by the Agricultural and Food Policy Center (AFPC). All analyses performed were done so with the help of Simetar, provided by Dr. Joe Outlaw.

All other work for the thesis was completed by the student independently.

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CHAPTER I

INTRODUCTION

Regenerative agriculture and the practices it encompasses have become the focus of many producers, agricultural analysts, and even the Biden Administration. Regenerative agriculture, very similar to the soil health movement, includes a range of practices with the intention of improving the condition and rigor of the soil. This would include adding practices such as cover crops and removing or reducing several conventional tillage practices, among other practices. Proponents have stated that these techniques will greatly improve the soil's ability to hold water, consequently lessening the influences of droughts on crops, as well as, potentially reducing fertilizer requirements (Kaye & Quemada 2017). There are also assertions that these techniques will decrease production costs, and even improve yields over years of application (Soil Health Institute 2021). Recently, one of the major proponents has stated they believe that producers who adopt these practices would decrease production risk, therefore justifying a crop insurance premium discount (Agree 2021). Other proponents have echoed this proposition, stating that the Federal Crop Insurance Act (FCIA) has existing power to alter insurance rates for fields and farms encapsuled in these practices (Sharma *et al.* 2022). The crop insurance industry has stated that APH yields would already take this change into consideration. Regardless, there remains the question of whether regenerative agriculture practices actually increase yields and/or decrease yield risk.

Objectives

The primary objective of this study is to determine if regenerative practices increase yields and/or reduce yield risk enough to offset potentially higher production costs. A secondary objective would be to determine whether these impacts are different for farms in different production regions of Texas.

CHAPTER II

REVIEW OF LITERATURE

Regenerative agriculture has become a recent focus within the agricultural industry, specifically regarding the row crop sector. Regenerative agriculture can be defined as “a system of farming principles and practices that increases biodiversity, enriches soils, improves watersheds, and enhances ecosystem services” (Regenerative Agriculture Collection, 2021). Though this new movement seems to have gained extraordinary momentum using the ideas of sustainability and rejuvenation, its overall definition can be seen as quite vague to those within the industry itself. Until the USDA releases official guidelines as to what falls under the label of regenerative agriculture, one must suffice with a broad ideology comprised of the definitions of various sources.

Regenerative agricultural practices are those that have been claimed to better the overall long-term health of the soil to create more sustainable and therefore economically beneficial crops for farmers. Much of this is claimed to be done through the minimization of disturbance within the soil, and keeping the soil naturally covered as much as possible. Most of the producers who adopt regenerative agriculture will do so by installing one of the following practices: cover crop inclusion, no-till or reduced-till integration, rotational grazing (livestock integration), and maximizing optimal crop rotations (Payne, 2020). The level of participation in each of these practices does vary from producer to producer and will impact the level of success they will see from the adoption of regenerative agriculture practices. Although there are numerous claimed possibilities for these practices to help the physical state of the soil, this analysis will focus solely on the economic incentives and results of practices such as cover crops being implemented.

Cover Crops

Cover crops can be defined as a "plant that is used primarily to slow erosion, improve soil health, enhance water availability, smother weeds, help control pests and diseases, [and] increase biodiversity" (Clark, 2015). Cover crops can be divided into two main classes: legumes and non-legumes.

Legume cover crops are used for the same purposes as non-legumes, except for fixing nitrogen within the soil for the primary crop's use. The most common examples of cover crops are "winter annuals, such as crimson clover, hairy vetch, field peas, [and] subterranean clover" (Sustainable Agriculture Research and Education, 2007).

Non-legume cover crops do not provide the same nitrogen benefit as the legume class of cover crops, but are still useful for "scavenging nutrients, providing erosion control, suppressing weeds and producing large amounts of residue that adds soil organic matter" (Clark, 2015). The most used non-legume cover crops are wheat, rye grass, barely, and oats. Non-legumes are normally planted to help with excess nutrients within a field, such as nitrogen.

No-till & Reduced-till

No-till and reduced-till are the practices in which producers eliminates or severely reduces the amount of plowing or disking performed in the field. Although these practices are commonly referenced, there are numerous categories of conservation tillage. The practices contained within the term conservation tillage are no-till and the separate components of reduced-till. Ridge-till, mulch-till, and strip-till can all be referenced as reduced-tillage practices.

No-till is the end point of the spectrum of these practices, resulting in an absence of field operations that "leaves the soil undisturbed from harvest to planting" (Janssen and Hill, 1994). This practice removes the disruption of the soils natural state, allowing for organic matter to remain in place. Planting into an un-plowed field requires a "no-till planter to create a narrow furrow just large enough for the seed to be placed" (Duyck and Petit, 2018). Due to the lack of weed management from physical force, no-till results in a heavily herbicide dependent operation.

Ridge-till falls under the reduced-till category. Ridge-till requires a seedbed to be prepared on ridges, hence the name. The seed can then be planted into the seedbed, and the ridges are reconstructed during cultivation (Janssen and Hill, 1994). Other than the seedbed, the rest of the soil remains undisturbed.

Mulch-till, like ridge-till, is a form of the reduced-tillage practices. Mulch-till uses "chisel plows, field cultivators, disks, sweeps, or blades to till the soil before planting" (Janssen and Hill, 1994). This practice results in the desired texture and clots within the soil without turning it over completely.

Strip-till tends toward the conventional tillage sector of this spectrum. Strip-till is "a field tillage system that combines no-till and full tillage to produce row crops" (Nowatzki and Endres, 2017). This combination of the seemingly contrary categories of tillage practice is achieved by leaving as much of the soil surface undisturbed except for tilled strips six to twelve inches wide. This minimum disturbance allows for most of the field to continue to be covered by crop residue.

Economics of Regenerative Agriculture

There is a strong need for an analysis of the benefits and costs of regenerative agriculture to educate producers so that they may decide whether to adopt these practices. The need for this study stems from the claims that the improvement of soil health through regenerative agriculture is responsible for, and able to, increase crop yields long term while decreasing yield variability. If these claims can be substantiated and prove that regenerative agriculture practices reduce producers' yield risk, then the crop insurance payments should decrease as well (Agree, 2021). With less risk assumed within the production cycle, crop insurance companies should charge lower premiums and expect to pay indemnities less often. This would reduce the amount the government spends to subsize farmers' insurance purchases.

It has been suggested that these government incentives could be in the form of increased subsidies towards crop insurance payments for those producers engaging in regenerative agricultural practices (Sharma *et al*., 2022). A potential concern with this method of compensation would be the possible unintended consequence to the actuarial values within the crop insurance industry (Halcrow, 1949). The current methodology for calculating a producer's premium and risk level is constructed by taking the individual's average production history (APH) which is calculated by the farmer's past ten-year rolling average of yields, then combined with the county's risk assessment to determine the producers risk level (Bryant, 2022). Due to this, participation in these regenerative practices would require a county-wide adoption to influence the premium rate. The regenerative practices could, however, positively impact a producer's premium costs by increasing, or even just steadying, the producers APH over time (Bryant, 2022).

In a study performed by Plastina et al., (2018) there is a development and comparison of partial budgets accrued from a statewide survey in Iowa, aimed at measuring the profitability of cover crops. These surveys collected data on factors such as how cover crops were terminated, the producer's number of years working with cover crops, tillage practices, and planting method. Plastina et al., (2018) found that only producers who integrated livestock grazing on the cover crops had a positive short term net return. The partial budget analysis of this study will be similar to that performed by Plastina et al., with specific regard to the variables used to run the partial budget analysis. While there have been studies aimed at a cost-benefit analysis of these practices, many of these studies have been performed in the midwest where average rainfall is much higher than that of the southern region of the United States, Texas specifically. These analyses provide potential methodology to be used but the results are not accurate for Texas producers due to the location of the research, such as Lichtenberg (2004) and the Soil Health Institute (2021).

Bertgold et al. (2005) performed an analysis of cover crop profitability in Alabama, a more similar terrain and climate to that of Texas. Bertgold et al. also examined risk levels associated with the cover crop practices used in two-year rotations of corn and cotton. The study was conducted on a 24-acre coastal plain field at Smith

Research and Extension Center and assumed cost-share as a factor for the cover crops under the EQIP program when considering the costs. Bertgold et al. found that:

> The use of alternative mixtures of high-residue cover crops, while being more costly to plant than more traditional cover crops, can increase crop yields and decrease the risk of obtaining lower crop yields and net returns in drought years. Given the conservation system with cover crop used was relatively immature; we would expect that these benefits would become more evident over time (2005).

The claimed time factor to realizing returns from this practice are significant in the realization that an analysis on the financial effects of cover cropping would need to evaluate numerous consecutive years.

Though the two previously mentioned papers provide insightful context, the first has little in common regionally and the second was performed on a research farm rather than observing and comparing the finances of actual productions within the area.

To better educate producers in the state of Texas on the financial benefits and consequences of these practices, a per acre regional analysis must be performed. Myers et al. found through their research that cover crop seed will range from $10 to $50 an acre. Myers et al. also found a $5-$18 an acre cost of seeding the field with the cover crops, and a $0-$10 cost of termination, altogether giving a range of $15-$78 per acre cost of cover cropping. The Sustainable Agriculture Research and Education Annual Report for 2019-2020 found that most of the farmers studied (63.5%) spent $6-$20 per acre on their cover crop seed, with 47.6% spending $11-$20 per acre.

While adopting the practices of cover crops involves an initial investment, no-till and reduced tillage practices are normally implemented with the expectation of an initial cost savings from the operations. These perceived savings are normally due to the reduction in expense categories associated with tillage practices such as tractor depreciation, diesel, labor, and tillage machinery depreciation. A Kansas State University study performed by Ibendahl (2016) found the opposite of this however, stating that "the trade-off between chemical weed control and tillage means that it is difficult to predict which system will have the lowest expenses." Ibendahl only labeled farms as no-till practices if they have been practicing no-till for at least five years on all their crop acreage. The study divided the state of Kansas into three regions and analyzed each region's financial situation with both no-till and conventional tillage practices. For the North Central Region of Kansas in 2014 it was found that the average total expenses for no-till and conventional tillage were $305 and $280 per acre respectively. In the South-Central Region of Kansas the total expenses per acre for no-till and conventional tillage in 2014 were ~$287 and ~$257 respectively. In the Northeast Region the total expenses per acre for no-till and conventional tillage was ~$475 and ~$361 respectively (Ibendahl, 2016). This study serves the same relevance as that performed by Plastina et al. but shares the same lack in similar regionality and climate as Texas.

A study performed by the Soil Health Partnership (2021) collected responses from growers in the Midwest, attempting to build a per acre assessment of the differences in budgets between conventional practices, no-till practices, and no-till practices with cover crop implementations. This study found that for corn, the labor per acre cost was the same ($33.19/acre), therefore the assumption can be made labor was a fixed cost and employees were salary. Fuel did vary however, with a $27.81/acre, $13.70/acre, and $15.82/acre cost associated with conventional, no-till, and no-till/cover crop operations respectively (Soil Health Partnership, 2021). Surprisingly, and very curiously, this study did not find that herbicide costs rose with the adoption of no-till practices, even without cover crops keeping the soil covered. Instead, this study claims herbicide costs decreased with the transition from conventional ($32.45/acre) to no-till ($26/acre), and only saw herbicide costs rise with the inclusion of cover crops to the no-till practices ($33.66/acre) (Soil Health Partnership, 2021). This study questions it's analysis of yield outcomes due to the insignificant yield increase resulting from no-till and cover crop practices by calling into question its small sample size and geographic focus on the Midwest. These same concerns could possibly explain the cost per acre results.

A single year partial budget analysis performed by Hoelscher (2022) analyzed the financial influences of regenerative agriculture on cotton farms within Texas. This study gave the regional specific analysis needed for farmers in Texas to begin to consider the implications of transitioning. Hoelscher's study, however, only looked at the economic effects of regenerative agriculture compared to the base conventional for a single year. The purpose for this study is to take the findings of Hoelscher and project them long-term to give a more comprehensive understanding of these economic implications involved with the transition to practices such as no-till and cover cropping.

Cotton will also be the focused commodity of this study due to its predominance throughout the state (Texas Almanac 2021).

In an economic comparison, Ribera et al. assumed a 30% reduction in fuel, lubricants, and labor from the conventional budgets to reflect the conversion to a no-till operation (2004). This same percentage reduction was used in this analysis as well. Ribera et al. also found that there were no statistically significant crop yield differences between conventional and no-till operations (2004). This finding was also conveyed through a study performed by Buman et al. (2005). This analysis will build these percentage-based changes into the model to speculate the long-term influences they may have.

The previously referenced Myers et al. (2019) study to collect the budget data of farmers participating in cover cropping practices will also be used to in a similar method. These ranges will be used to implement the same percentage base changes as those mentioned above for no-till practices.

The review of literature on the benefits and consequences of transitioning from conventional to regenerative agricultural practices showcase the need for a long-term Texas specific regional study on this topic. While there have been many analyses performed on the increase in quality of soil due to these practices, little has been done to uncover the financial assets or burdens of the transition long term. The purpose for this study is to fill the void of regionality and economic focus within this topic, and to hopefully give producers the necessary information to make an educated and confident decision on whether to transition to regenerative practices or not.

CHAPTER III

METHODOLOGY

This study first required estimates on a partial budget analysis comparing the financial implications of regenerative practices compared to those of conventional operations. These estimates broke down the benefits and cost to farmers who adopted the regenerative practices into their operations. This evaluation was performed by analyzing four representative farms' financial data provided by the Agricultural and Food Policy Center (AFPC). Cotton was the main crop assessed in this analysis due to its large influence throughout the state. Cotton can also be found throughout the most regions of the state as compared to other crops (Texas Almanac, 2021).

Farm Models

The four farms chosen for the analysis were spread geographically across Texas focusing on the state's main row crop producing regions. These regions include the Northern Plains, Southern Plains, Central Texas, and the Coastal Bend of Texas. The total cotton acreage of these farms ranges from 500 to 2000 acres each.

Once the needed farm data was collected, this data was organized by individual farm. A spreadsheet containing the data was created, and a complete financial model was created to analyze the cotton production operations on each individual farm. These models were designed to include stochastic risk within the farms' financial operations, and then compared conventional operations to each of the individual proposed scenarios representing regenerative agriculture practices. Change in net present value at the end of a five-year period was used as the determining factor, the key output variable, to signify results within each type of operation.

The model used for all four farms was designed to analyze all financial components of the non-irrigated cotton production system. Sheets to calculate needed figures such as financing options for land and equipment, as well as an income tax calculator were included to make for a robust and inclusive model. The first year simulated was 2022, and a discount rate of .05 was assumed for this analysis. The owned cropland, pastureland, and cash on hand as of January 1^{st} were collected for each representative farm. The data on leased cropland was also collected, and all cropland was sorted into the categories of irrigated and non-irrigated. The value paid for cash rent, and the value of farm buildings and machinery were also collected. The machinery replacement fraction was assumed at .12, signifying a replacement of 12% of the operations machinery every year for financial purposes.

Values such as all land and machinery debt were collected to be incorporated into the financing calculations. The interest rates used for land loans, operating loans, equipment loans, and savings were gathered from the representative farms' data as well. This includes the length of loans for land and equipment in years, as well the length of the operating loan in months.

Another included component of this model is the other cost variables a farm incurs. These were included using the variables of dividends earned annually, farmer withdrawals for a living wage, and other income tax deductions. These were included into the model in order to provide a more accurate and realistic model.

The category of fixed costs was provided by the representative farm data, although a few of the fixed costs were converted partially or fully to variable per acre costs. This conversion was done to perform percentage-based increases or decreases to each of these cost categories based on the effects of transitioning to regenerative agricultural practices according to previous literature. This was done by first analyzing the number of commodities grown on each operation, and then conducting a percentage of receipts evaluation to ensure that each resource was allocated proportionately to each commodity. This is done because some commodities within an operation may consume more resources than others, and that the two divisions of irrigated and non-irrigated within a commodity will also have differing cost per acre. Once the percentage of receipts analysis was performed, the fixed costs could then be allocated more accurately to each commodity on a per acre basis. By this method the proper percentage fixed costs such as of labor, fuel, and repairs per acre could be dispersed per acre and per crop.

The cost categories that were converted to a variable per acre basis were: fuel and lube, labor (hourly), repairs, maintenance, and supplies. For labor only, the given non-salary cost was transferred to a variable cost, as it was assumed that non-salary labor would be the first to be changed in the event that no-till or cover cropping practices reduce or increase needed labor in comparison to conventional operations.

The percentage increases and decreases in each were found within the previously referenced studies conducted. These changes in cost categories could then be implemented into the financial simulation through the “=SCENARIO” function within Excel. This function allows for scenarios which include variables that the program recognizes as changeable and implements variations of these variables within analysis according to the user's request.

Aside from the fixed costs that were converted, in order to account for transition to regenerative agriculture, the following fixed costs in Table 3.1 were gathered and used to construct this model.

Table 3.1 Fixed Cost Categories

Fixed Costs
Fixed cost, Salary Labor ($/yr)
Fixed cost, Real Estate Taxes ($/yr)
Fixed cost, Accounting & Legal ($/yr)
Fixed cost, Trucks, Equip. & Liability Insurance ($/yr)
Fixed cost, Miscellaneous ($/yr)
Fixed cost, Phone, Utilities & Internet ($/yr)

The variable costs used for this model are included in Table 3.2. These include the three converted fixed costs.

Table 3.2 Variable Cost Categories

Variable Costs
VC Seed ($/ac)
VC Nitrogen Fertilizer ($/ac)
VC Potash & Phosphorous ($/ac)
VC Herbicide ($/ac)
VC Insecticide ($/ac)
VC Fungicide ($/ac)
VC Defoliant ($/ac)
VC Growth Regulator ($/ac)
VC Applications ($/ac)
VC Boll Weevil Eradiation ($/ac)
VC Scouting & Consultants ($/ac)
VC Ginning ($/lb)
VC Fuel & Lube ($/ac)
VC Non-Salary Labor ($/ac)
VC Repairs, Maintenance, & Supplies ($/ac)

With the mentioned assumptions in place and the fixed costs broken down into per acre incremental variable costs, it was then possible to build a partial budget to analyze the economic change in transitioning from conventional to regenerative agricultural practices. The partial budget performed in this study was modeled and formatted after the examples found in Farm Management by Kay and Edwards 1994. Partial budgeting allows for an analysis of costs and benefits directly influenced by a change within a business operation (Dhoubhadel & Stockton 2010). The original budget used to form the partial budget was created through the collection of the financial data for AFPC's representative farms and the state of Texas' enterprise budget for dryland cotton. After this baseline for conventional costs and returns was established, the effects of transitioning to regenerative agriculture were applied to create the partial budget.

To realistically create a profitability analysis for the partial budgets, the entire financial simulation was analyzed for each farm with the four scenarios. Similarly, Hoelscher (2022) created a one year, one crop, budget analysis providing the net change in ending cash as a result of the regenerative practices included into operation. This study took Hoelscher's approach to a single year budget change and then modeled the effects over five years to include a longer-term evaluation of regenerative agriculture (Sharma *et al.* 2022) (Hoelscher 2022).

Due to the inclusion of the =SCENARIO function within Excel, one of the variables that could be altered to represent regenerative agricultural practice effects was yield. The yields could be lowered or raised on a percentage basis, just as was performed with the cost. This would allow for a determination of necessary yield increases or even decreases for a regenerative operation to have a similar budget with conventional operators in the same circumstances. To incorporate the change in costs due to the implementation of the regenerative practices with the claimed increase in yield and yield stability over time (Sharma et al. 2022), the factors were combined in a model that allowed each to influence the financial outcome of the operation.

Stochastic Prices and Yields

These models were constructed using a simulation model within Excel known as Simetar (Richardson et al. 2008). Stochastic simulation allowed for an accurate analysis of decisive variables over a realistic range of possible outcomes (Fischer 2016). Stochastic simulation also allowed for a range of the necessary offset costs, or increased yields, for transition to regenerative practices. This method can then be interworked with the process of partial budgeting to reduce the level of uncertainty in the result of the transition (Dhoubhadel & Stockton 2010). This specific model allowed for an analysis of the partial budget comparison for one year with one primary crop production. Within Simetar, the sampling method chosen for each of the random values was the Latin Hypercube Sampling (LHS). This was due to LHS's ability to layer all input dimensions simultaneously, compared to simple random sampling (Loh 1996).

In order to generate stochastic random draws for non-irrigated cotton prices, historical price data was collected from the Food & Agricultural Policy Research Institutes (FAPRI) baseline projections (FAPRI 2021). To generate the random stochastic draws for cotton yield, historical yields were collected from each of AFPC's representative farms. For years in which AFPC representative farm data was not available, a yield index was created using National Agricultural Statistic Service (NASS) yield data to fill in the missing years. The cotton lint price, cotton seed price, and yield data from 2021 until 1998 was gathered and analyzed. This data was combined with each individual farm's own yield data throughout the years to provide a more accurate regional representation. The data was then checked for stationarity using a Dickey Fuller test. As it was found that the farms' data sets were not stationary, the model then required the generation of historical U and Z values through the "PERCENTRANK.INC" and "NORMSINV" excel functions respectively. A linear correlation matrix was then created, and used to generate CUSD values for yield, lint price, and seed price. Finally, a joint stochastic draw was created with the CUSD values, and combined with the projected mean yield, lint price, and seed price for each farm giving stochastic values to be implemented into the model. These stochastic values were projected for five years, from 2022 to 2026.

Comparative Scenario Analysis

To build the previously mentioned scenarios, the stochastic variables were simulated with changes in cost and yield percentages depending on the transition in question. As stated in previous literature (Ribera et al., 2004), no-till operations had an assumed 30% reduction in fuel, lubricants, and hourly labor from the base conventional operations. Previous literature had also found that there were no statistically significant changes in yield, however, increases and decreases in the yield were applied to determine if one would be needed to help financially justify transitioning from conventional to regenerative practices. Due to the lack of mechanical weed control, herbicide use had to be greatly increased for the no-till scenarios. This study assumed an herbicide increase rate of 50% to compensate for the absence of physical weed deterrence. Another aspect to the no-till scenarios is the possible need for a new planter, or to retrofit the farmer's current planter to be able to work within a no-till field. However, in personal communications with producers, it was found that most newer planters in Texas are already capable of planting into a field without tillage. Due to this the cost of retrofitting a planter, or purchasing a new planter entirely, was not included into the no-till scenarios.

For the second no-till scenario which includes the gradual sell of tillage equipment, an assumed 4.94% of equipment was sold per year to simulate a gradual transition. This was performed by including a "Machinery Sold" variable within the scenario functions. The percentage was then multiplied by the total machinery worth to find the income from selling mentioned equipment. This dollar amount was then added to the income for the no-till scenario in which a producer sells off equipment.

For cover cropping, a new variable cost category was implemented to represent the cost of cover crop seed. For this value there can be a great range of dollar per acre increments, mostly dependent on which crop producers choose for their cover crop. Based on the literature review for economic analysis of cover cropping (Myers et al., 2019), this value was placed at $9 per acre and a cover crop of rye grass (*Lolium Perenne*) was assumed. As referenced previously, the average cost for seeding cover crops found by Myers et al. (2019) was used to increase the categories of fuel, lubricants, and hourly labor by 10%. Since cover cropping requires the termination of the cover crop, the cost of an extra pass of herbicide was added to both the cover crop and the no-till and cover crop scenarios. This resulted in a 25% increase in the herbicide cost for both referenced scenarios (Myers et al., 2019).

The scenario including the implementation of both the no-till and cover cropping practices, the sum percentage change in each cost category was applied. For instance, fuel use was assumed to decrease 30% with no-till implementation and increase 10% with cover cropping. These two practices implemented together would result in a net cost decrease of 20% in fuel for the referenced scenario.

Final Farm Financial Analysis

Once the factors for each scenario were in place, and the stochastic price and yield forecasts were created, the total financial simulation of each farm was undertaken. The number of planted non-irrigated cotton acres for each farm was inserted into each model. This variable was then multiplied by the stochastic yield per acre draws to find a total production yield. For cotton seed production, the model assumed a variable of 0.0004 for tons of cottonseed per pounds of cotton lint. This variable was then multiplied by the stochastic random draw for cotton yield per acre to find the cottonseed yield per acre. As with the lint, this was then simply multiplied by the total non-irrigated planted acres for a total cottonseed production figure. This was done for all five years, each year using its respective stochastic draw for yield as calculated by the Multivariate Empirical function within Simetar.

As the main justification for this study was to provide a regionally specific economic analysis for regenerative practices and the transition to them, this model incorporated price wedges to more accurately reflect the local price received for the products. The price wedge for each farm was provided within the financial data collected from AFPC. This could also be calculated by taking the price received for the cotton lint and cotton seed at the local level and subtracting the national average price.

Next, the landlord share of the total production was found by simply multiplying the landlord's share percentage of the crop by the total production, leaving the remaining production to be sold by the producer. This production was then applied to the stochastically drawn prices to give the market receipts. This was performed for the cotton lint, as well as the cottonseed, and then summed to give the total market receipts.

Inflation on variable and fixed costs were also included into the model to increase its accuracy. This inflation was performed by taking the base years cost for each, and then applying FAPRI's price index forecasts. The price index for each cost category and year were applied respectively to accurately account for inflation. The dividends received by the producers and the owner withdrawals were also inflated by the Consumer Price Index. This same methodology was applied to update the value of assets such as farm buildings, machinery, and owned cropland.

A value of machinery purchased annually was assumed at .12 or 12%. To calculate the value of machinery purchased every year this value was multiplied by the value of farm machinery consecutively from year to year. The deprecation rate for the farm machinery was assumed at .125. This allowed for the depreciation of machinery to be calculated by multiplying this variable to the respective years value of purchased machinery. This process was also done consecutively from the year 2022 to 2026, allowing for a result of sum depreciation of all machinery.

The depreciation of farm buildings was calculated by applying the assumed depreciation value of 0.125 to the value of farm buildings. This calculation was performed only once however, and depreciation was assumed to be linear, thereby distributing the same value for depreciation to each of the five years.

An income statement was then generated. The first step of this process was summing the inflated fixed and variable costs. This gave a value for the total operating cost, which was then applied to the interest of operating loans given previously to receive the operating interest costs. This same process was performed to calculate the land and machine loan interest costs. If the ending cash calculation was negative, then the interest cost for carrying over the loan to the next year was calculated and implemented into the model as well. The net farm income was then created by subtracting the entire total cash expenses from the total cash receipts. This process was repeated for each of the five years.

The net farm income was then used in conjunction with the dividends from off farm investments, interest on cash reserves, and beginning cash (if ending cash in the previous year is positive) to create the total cash inflows. The cash outflows were created from the payments of cash flow deficits from the previous years (if any), principal payments on land and machinery loans, farm owner's withdrawal, federal income taxes, and the replacement of machinery. By subtracting the total cash outflows from all cash inflows, the ending cash as of December 31st for each year was calculated.

To configure the ending net worth, a balance sheet was constructed. All assets were updated to market value per each respective year using the FAPRI inflation rates and Consumer Price Indexes. This included owned cropland, owned pastureland, farm buildings, machinery, and cash reserves (if positive). Liabilities were then calculated, including land and machinery debt, and cashflows if ending cash is negative. Total liabilities were subtracted from total assets to create the ending net worth for each of the projected five years. The calculation of total assets and total liabilities also allowed for a debt to asset ratio to be created for each of the years within each representative farm.

One of the final calculations necessary was the present value of ending net worth. This was calculated by multiplying the ending net worth of the fifth year with the ending fifth year result of the present value discount rate factor. Each year's present value discount rate factor was created with the following formula:

$$\boldsymbol{Present\ Value\ of\ Discount\ Rate\ Factors} = \frac{\mathbf{1}}{(\mathbf{1} + \boldsymbol{Discount\ Rate})^{\boldsymbol{Previous\ Year}}}$$

Finally, the key output variable for this analysis was able to be created, the farm's net present value. This was performed by taking the negative of the beginning net worth, adding the sum of the present values of withdrawals and the present value ending net worth. The final result, a stochastic net present value for each of the five years dependent on the scenario chosen. Then, using the simulation function within Simetar, the net present value for each individual scenario was simulated for 500 iterations. The mean net present value at the end of the fifth year for each of the scenarios were collected and compared.

SERF Risk Analysis

The Simetar function SERF (Stochastic Efficiency with Respect to a Function) was used to analyze these net present value results and compare the risks within each scenario. This function allowed for a certainty equivalent to be portrayed based upon each individual farm's risk assessment. These risk assessments were influenced by each farm's beginning net values.

Scenario Yield Increments

Throughout the entire budget scenario analysis performed above, the yields for each scenario were assumed to be that of the conventional budgets. For the final portion of this study, the models were reworked to find the yield increases or decreases which would give approximately the same net present value as the conventional baseline operation. This process was performed by implementing yield changes within the scenario variable "yield percentage" in each farm's model. This final component of the study was not included to predict these changes, but to rather show what incremental yield adjustments would be required for each scenario to set the producer in their original financial situation.

CHAPTER IV

RESULTS

The four farm models were developed into an excel spreadsheet as mentioned, with the stochastic cotton yields, lint prices, and cottonseed prices created by the program Simetar®. Each model was developed according to its designated representative farm. The required formulas for calculating the financial state of the farms for years one through five were influenced by the stochastic variables, allowing for a more realistic approach for this analysis. Each of the four farms were included to cover the different cotton producing regions of the state and create a more robust overall model and study. These individual models all contained five possible scenarios to create an understanding of the risks and rewards associated with transitioning to regenerative practices.

Results from the partial budget study for the four regional representative farms within the state are conveyed in this chapter. The ending net present value for the five-year analysis period is the key output variable representing each operation's financial health. The purpose of providing stochastically drawn variables for yields and prices were to include risk into this analysis, and to increase its utility to producers debating upon transitioning between conventional and regenerative practices.

The budget scenarios analyzed for each representative farm were:

Scenario 1: Conventional practices based upon the representative farm's original data;

Scenario 2: No-till practices based upon literature;

Scenario 3: No-till practices with the gradual liquidation of tillage equipment;

Scenario 4: Cover cropping practices based upon literature; and

Scenario 5: A combination of no-till and cover cropping practices.

The 500 stochastic draws for prices are based upon mean values and projections from FAPRI. The stochastic draws for yields are based upon representative farm data from AFPC. Due to the inclusion of the stochastic component to this study, all results of net present value at the end of the five-year duration are contained within a given distribution. This distribution gives the potential net present values for each farm along with each scenario, the range of possible outcomes.

Due to these resulting distributions, the Cumulative Distribution Function (CDF) within Simetar® was used to demonstrate the variability and risk with the net present values. This function graphs the 500 iterations of the potential net present values for 2026, the end of the five-year study period. The net present values are presented on the x-axis and the respective probabilities of each x-value are located on the y-axis.

In order to isolate the budget effects of transitioning to regenerative practices, variables such as the acres planted remained constant. Yields per acre for the analyses were held constant for the scenario analysis as well. These do, however, include insignificant differences found in FAPRI's data which are likely attributed to the gradual genetic improvements of seed.

After the profit and risk scenario assessments were completed, the scenario yields were evaluated to find the percentage change in yields for each that would be needed to equal the net present value of that farm's conventional budget. These increments in yield percentage change needed to prevent the change in a farm's net present value were calculated with each models' assumptions and parameters.

Southern Plains Representative Farm Results

The five partial budget scenarios were run through the Southern Plains farm model to evaluate the resulting net present values at the end of the year 2026. The net present value summary statistics for the 500 stochastic iterations are outlined in Table 4.1. Of the five scenarios, the largest standard deviation in net present value was from the operation with cover cropping practices. The scenario operation with the smallest standard deviation value was no-till with the selling of tillage equipment. It should be noted, however, that selling equipment cannot be a permanent stream of income and should rather be seen as a liquidation of already invested capital.

Table 4.1 Southern Plains Net Present Value Summary Statistics

Net Present Value Summary Statistics		
Southern Plains	**Conventional**	
Mean	$	348,305.84
Standard Deviation	$	190,029.67
CV	$	54.56
Minimum	$	(29,998.85)
Maximum	$	893,629.29
Southern Plains	**No-Till**	
Mean	$	368,123.22
Standard Deviation	$	189,938.46
CV	$	51.60
Minimum	$	(12,114.22)
Maximum	$	939,077.12
Southern Plains	**No-Till with Selling Equip.**	
Mean	$	389,513.76
Standard Deviation	$	190,525.80
CV	$	48.91
Minimum	$	6,500.05
Maximum	$	992,373.22
Southern Plains	**Cover Crops**	
Mean	$	289,202.37
Standard Deviation	$	190,732.04
CV	$	65.95
Minimum	$	(86,207.95)
Maximum	$	819,617.38
Southern Plains	**No-Till & Cover Crops**	
Mean	$	337,132.83
Standard Deviation	$	190,121.62
CV	$	56.39
Minimum	$	(40,409.26)
Maximum	$	868,950.39

The results from the 500 iterations of net present value under the parameters set for each scenario (Figure 4.1). The CDF allows for a visual representation of the differing possibilities contained within each operational scenario.

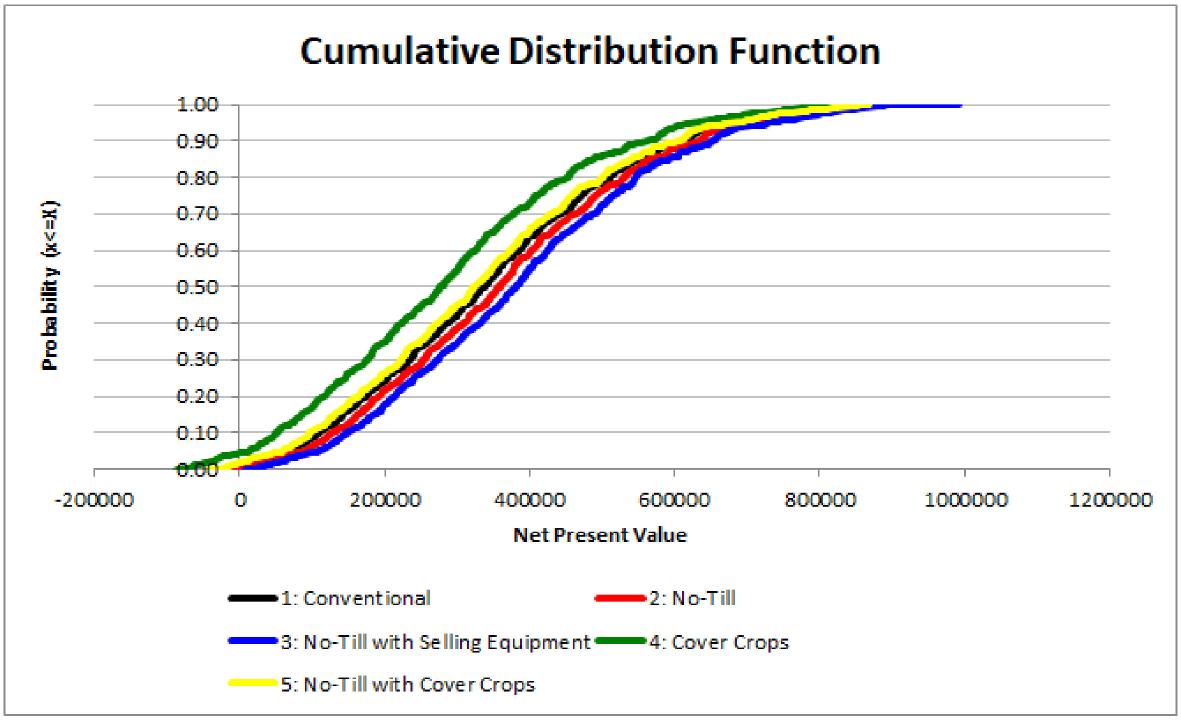

Figure 4.1 Southern Plains Cotton Farm Net Present Value CDF

With the previous scenario parameters set, no-till with the selling of equipment has the best probability of returning the highest net present value over the five-year analysis period, with a mean of $389,513 for the Southern Plains representative farm. As previously mentioned though, this should not be seen as a long-term budget operation as the liquidation of tillage equipment will eventually cease once all equipment has been cleared. The scenario in which the farm transitions to no-till practices without selling equipment has the second highest probability of returning the best net present value, with a mean of $368,123. The conventional scenario, which was set as the base control for this study, had the third highest mean net present value for this farm at $348,305. Both scenarios involving cover cropping resulted in the two lowest net present value returns, $289,202 for cover cropping and $337,132 for cover cropping with no-till. The operational scenarios involving cover cropping practices had the highest standard deviation variables for net present value as well.

To analyze risk the Simetar® Stochastic Efficiency with Respect to a Function (SERF) was utilized. Figure 4.2 demonstrates the exponential utility weighted risk of the five scenarios, using scenario one as the baseline. The figure reiterates the analysis to this point, showing no-till practices alone to have the less associated risk compared to conventional and cover cropping practices.

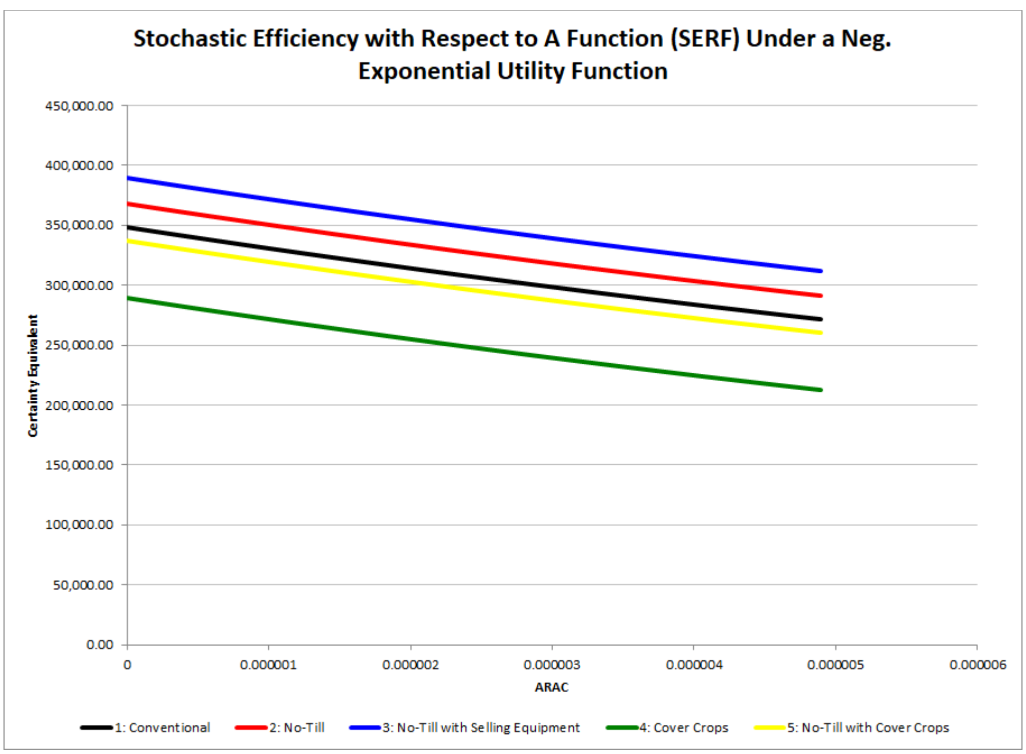

Figure 4.2 Southern Plains Cotton Farm SERF Table

The changes in yield increments for each regenerative scenario were found by inserting possible increments to the models' built in yield adjuster until the net present value of each regenerative practice was reasonably close to that of the conventional scenario. The model found that the no-till scenario could have a reduction in yield of approximately 3% and still have a comparatively close net present value. The yields for the no-till while selling equipment scenario could decrease even lower, by 7%, and still see a reasonably similar net present value. The cover cropping scenario, however, required a 9.8% yield increase approximately to offset the costs of this practice. The last regenerative scenario, no-till with the inclusion of cover crops, required a slightly smaller yield increase at approximately 2%. Table 4.2 displays these percentage changes in yield needed for each practice in the Southern Plains model.

Table 4.2 Approximate Changes in Yield Percentage while Holding NPV Constant for Southern Plains

Approximate Changes in Yield Percentage while Holding NPV Constant				
	No-Till	No-Till with Selling Equipment	Cover Cropping	No-Till and Cover Cropping
Southern Plains	-3%	-7%	9.80%	2%

Central Texas Representative Farm Results

As with the previous region, the five scenarios were once again run through simulation through Simetar®. Each scenario's unique cost and benefit percentages were given the influence over the ending net present value in the final year of the analysis, 2026. The 500 iterations for the key output variable were generated, and the summary statistics for these simulations were compiled into Table 4.3. As in the Southern Plains, scenario 2 involving no-till practices with the liquidation of no-till equipment gradually over the five-year period showed the highest mean net present value. Unlike the Southern Plains, however, for this representative farm the second highest mean net present value occurred in the conventional scenario. The no-till practice scenario received the third highest net present value, followed by no-till with cover crops and solely cover crops respectively.

Table 4.3 Central Texas Net Present Value Summary Statistics

Net Present Value Summary Statistics		
Central Texas	**Conventional**	
Mean	$	623,236.78
Standard Deviation	$	41,575.28
CV	$	6.67
Minimum	$	540,923.29
Maximum	$	753,020.59
Central Texas	**No-Till**	
Mean	$	622,871.57
Standard Deviation	$	41,584.94
CV	$	6.68
Minimum	$	540,553.38
Maximum	$	752,728.36
Central Texas	**No-Till with Selling Equip.**	
Mean	$	629,705.66
Standard Deviation	$	41,391.16
CV	$	6.57
Minimum	$	547,486.22
Maximum	$	758,205.30
Central Texas	**Cover Crops**	
Mean	$	612,443.49
Standard Deviation	$	41,818.73
CV	$	6.83
Minimum	$	530,017.23
Maximum	$	744,404.80
Central Texas	**No-Till & Cover Crops**	
Mean	$	619,672.52
Standard Deviation	$	41,667.84
CV	$	6.72
Minimum	$	537,314.41
Maximum	$	750,169.58

The cumulative distribution function (CDF) was created for the Central Texas model results to better illustrate the comparative risks of these scenarios. The CDF gave a more visual perspective of the operations in relation to one another.

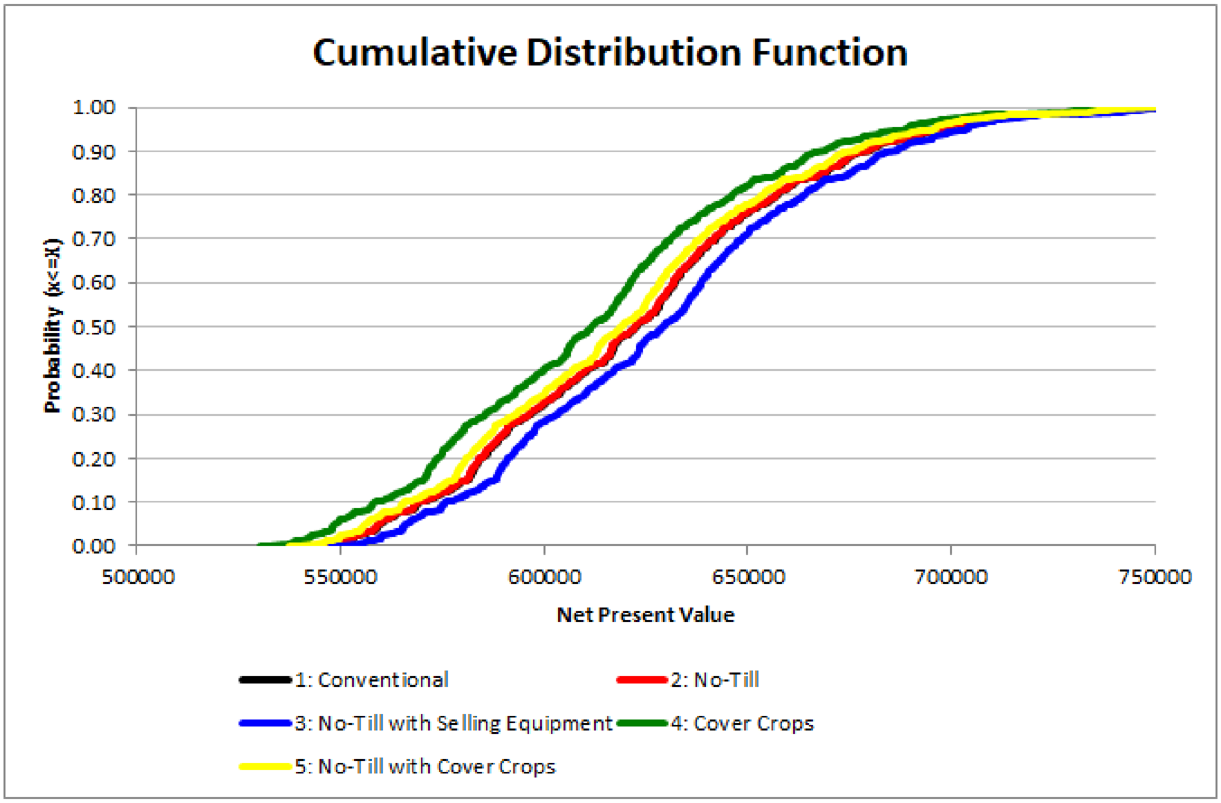

Figure 4.3 Central Texas Cotton Farm Net Present Value CDF

With the scenario percentage increases and reductions in place, the scenarios with the highest standard deviations in Central Texas were both of those which involved implementations of cover crops. The lowest standard deviation was associated with the implementation of no-till alongside the liquidation of tillage equipment. Both practice scenarios also received the lowest minimum and maximum variables for net present values.

The Simetar® tool SERF was utilized to measure differing levels of risk between all the possible scenarios. Unlike within the Southern Plains study, conventional agricultural practices proved to contain less of a risk component within this analysis than that of the no-till scenario.

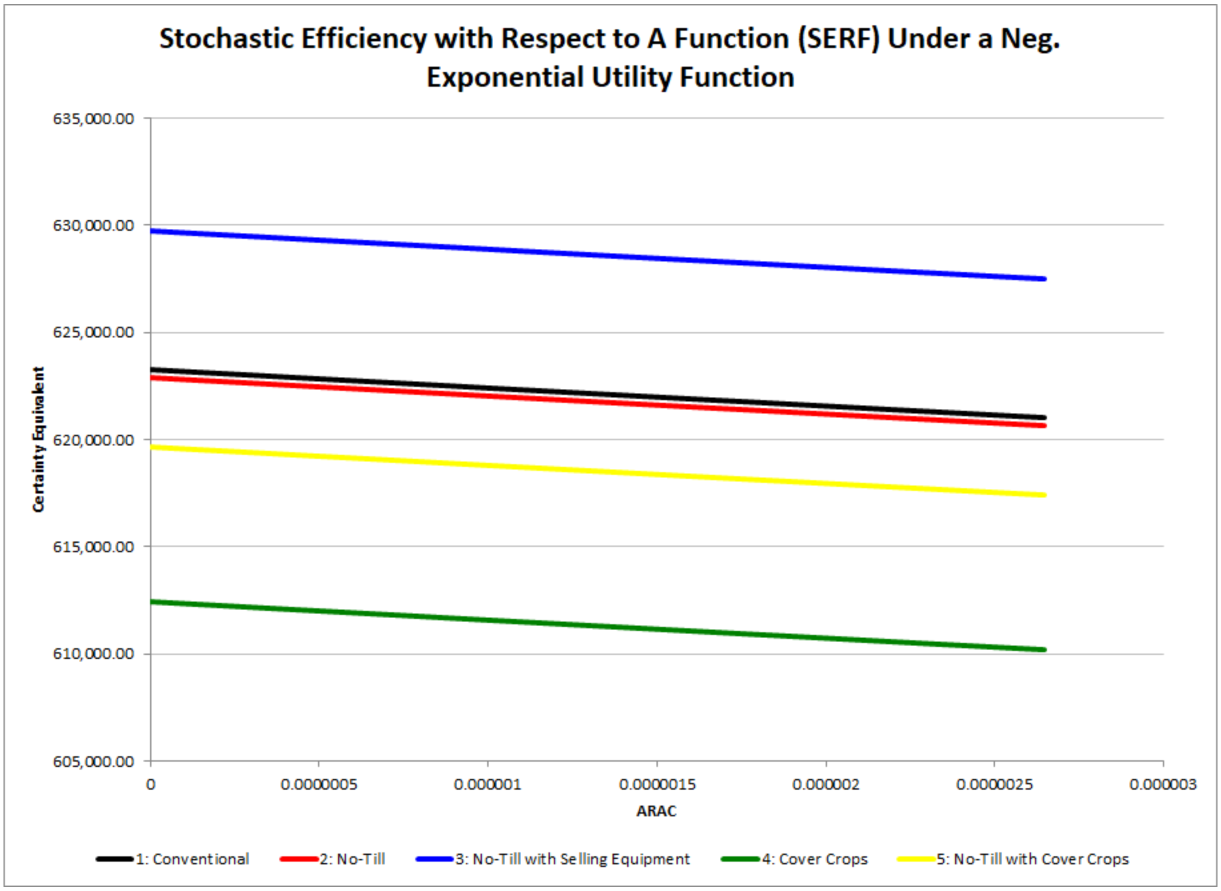

Figure 4.4 Central Texas Cotton Farm SERF Table

The changes in yield required by each regenerative scenario to achieve a net present value statistically similar to that of the conventional base scenario were once again calculated. The yields for the no-till scenario would need to experience a 0.5% increase, in order to create a similar financial status to that of the conventional practices. The no-till with the selling of tillage equipment could experience an approximate 3.5%

decrease in yields before the net present value fell below that of the conventional. The cover cropping scenario would need an approximate 6% yield increase to equate the baseline scenario. Finally, the no-till with the inclusion of cover crops would require an approximate 2% increase in yields according to the parameters of this model. Table 4.4 displays these percentage changes in yield needed for each practice in the Central Texas model.

Table 4.4 Approximate Changes in Yield Percentage while Holding NPV Constant for Central Texas

Approximate Changes in Yield Percentage while Holding NPV Constant				
	No-Till	No-Till with Selling Equipment	Cover Cropping	No-Till and Cover Cropping
Central Texas	0.50%	-3.50%	6%	2%

Northern Plains Representative Farm Results

As with the previous two regional analyses, the five scenarios and their parameters were run through simulation for the Northern Plains representative farm. This farm's specific budget data justified the need for multiple representative farms within this study. The summary statistics for the 500 iterations of simulated net present value are outlined in Table 4.5. For this representative farm, the conventional scenario had the highest mean net present value as well as the lowest standard deviation for the same variable.

Table 4.5 Northern Plains Net Present Value Summary Statistics

Net Present Value Summary Statistics		
Northern Plains	**Conventional**	
Mean	$	1,310,225.30
Standard Deviation	$	22,724.78
CV	$	1.73
Minimum	$	1,275,554.64
Maximum	$	1,393,111.52
Northern Plains	**No-Till**	
Mean	$	1,304,769.53
Standard Deviation	$	22,765.25
CV	$	1.74
Minimum	$	1,270,086.81
Maximum	$	1,388,791.94
Northern Plains	**No-Till with Selling Equip.**	
Mean	$	1,306,515.02
Standard Deviation	$	22,752.23
CV	$	1.74
Minimum	$	1,271,836.08
Maximum	$	1,390,173.86
Northern Plains	**Cover Crops**	
Mean	$	1,302,119.32
Standard Deviation	$	22,780.63
CV	$	1.75
Minimum	$	1,267,432.24
Maximum	$	1,386,694.83
Northern Plains	**No-Till & Cover Crops**	
Mean	$	1,305,222.10
Standard Deviation	$	22,761.87
CV	$	1.74
Minimum	$	1,270,540.35
Maximum	$	1,389,150.24

The Northern Plains representative farm was also the first in the study to have a higher mean net present value for the no-till with cover cropping scenario than the solely no-till scenario. As with the previous simulations, no-till with the liquidation of equipment had the highest of the four regenerative agriculture scenarios. The budget parameters of the Northern Plains representative farm allowed the conventional budget to return a higher net present value, and by a much greater margin than the highest net present value scenarios of other farms.

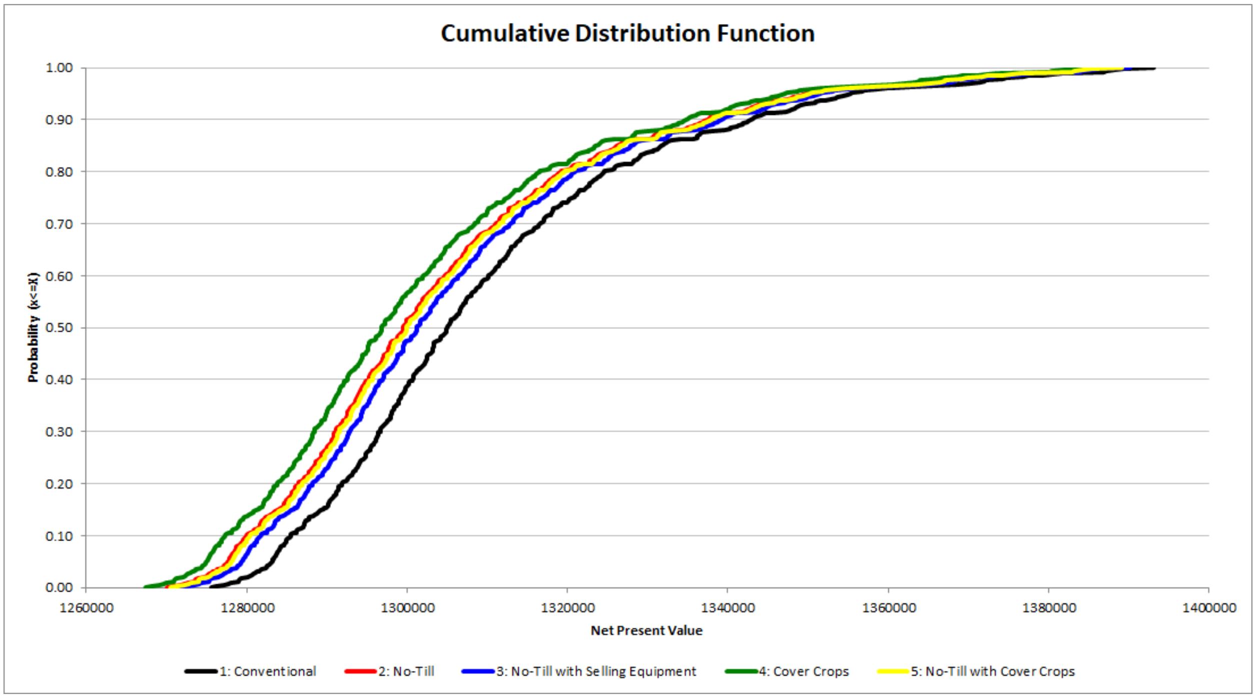

Figure 4.5 Northern Plains Cotton Farm Net Present Value CDF

The SERF analysis was calculated for the Northern Plains model to provide a risk assessment for the five proposed scenarios. As with the net present value mean, the conventional budget had the lowest risk assessment of the five scenarios. The cover crop scenario was the highest risk practice of the five analyzed for this model with the given parameters.

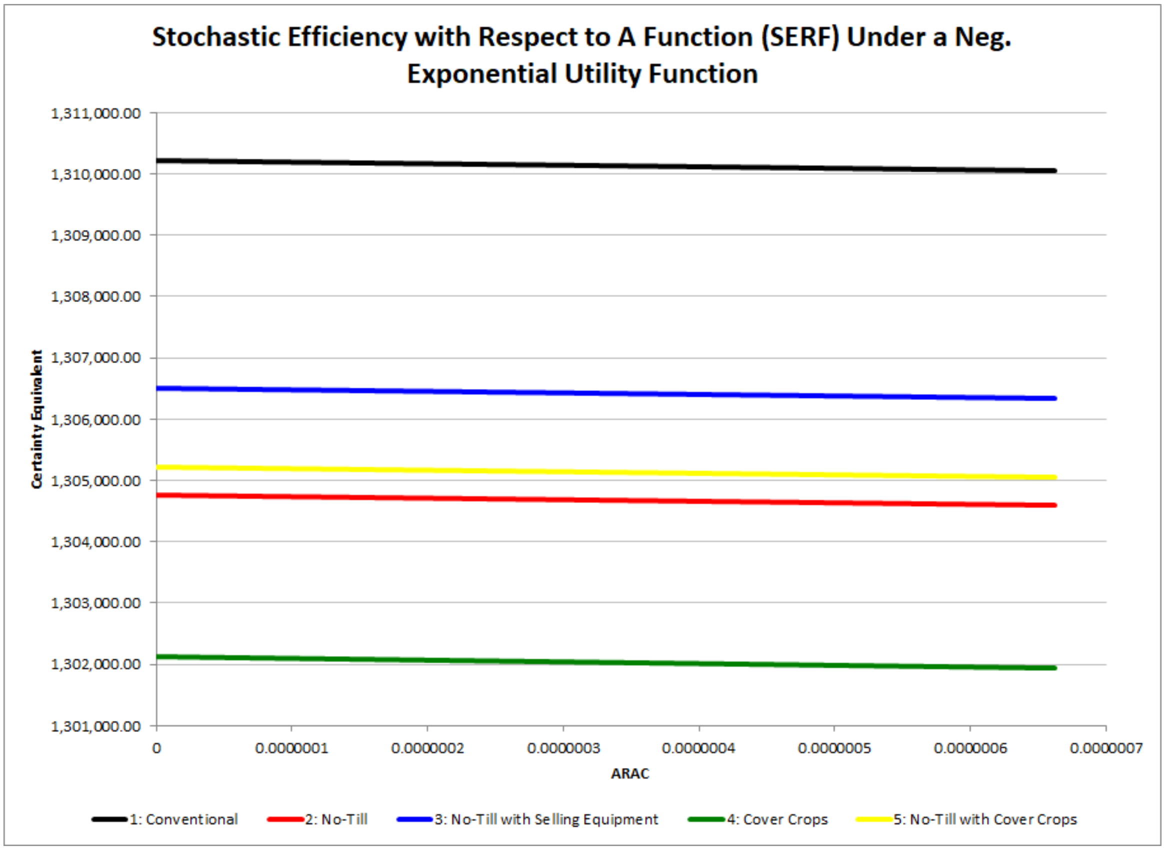

Figure 4.6 Northern Plains Cotton Farm SERF Table

After the financial analysis of the budgets with yields held constant were conducted, the yield change increments needed for each regenerative practice to equal approximately that of the conventional practices were found for the North Texas region. The percentage yield increments for this representative farm were much lower than the previously studied models. The no-till scenario and no-till with selling equipment scenarios both required approximate increases of 9% and 6% respectively. The cover crop scenario required an approximate 12% yield increase to match the net present value of the conventional scenario, and the cover crop with no-till required an approximate increase of 8%. Table 4.6 displays these percentage changes in yield needed for each practice in the Northern Plains model.

Table 4.6 Approximate Changes in Yield Percentage while Holding NPV Constant for Northern Plains

Approximate Changes in Yield Percentage while Holding NPV Constant				
	No-Till	No-Till with Selling Equipment	Cover Cropping	No-Till and Cover Cropping
Northern Plains	9%	6%	12%	8%

Coastal Bend Representative Farm Results

Finally, the five scenarios were programmed into the budget parameters for the Coastal Bend representative farm. The summary statistics for the 500 iterations of the simulation are found in Table 4.7. The baseline for this analysis, conventional practices, proved to have the highest net present value within this simulation. Following the trend of the Northern Plains, the next highest net present values within the model were no-till with the liquidation of tillage equipment and no-till, respectively. The lowest net present variables came from the scenarios involving cover crops once again, with cover cropping alone receiving the smallest net present value.

Table 4.7 Coastal Bend Net Present Value Summary Statistics

Net Present Value Summary Statistics		
Coastal Bend	**Conventional**	
Mean	$	1,197,786.07
Standard Deviation	$	438,963.18
CV	$	36.65
Minimum	$	422,983.20
Maximum	$	3,275,766.04
Coastal Bend	**No-Till**	
Mean	$	1,162,643.48
Standard Deviation	$	429,113.41
CV	$	36.91
Minimum	$	406,719.53
Maximum	$	3,225,878.31
Coastal Bend	**No-Till with Selling Equip.**	
Mean	$	1,172,450.05
Standard Deviation	$	432,158.41
CV	$	36.86
Minimum	$	410,841.82
Maximum	$	3,240,224.90
Coastal Bend	**Cover Crops**	
Mean	$	1,090,074.50
Standard Deviation	$	409,176.33
CV	$	37.54
Minimum	$	370,798.49
Maximum	$	3,116,763.09
Coastal Bend	**No-Till & Cover Crops**	
Mean	$	1,152,655.61
Standard Deviation	$	426,529.55
CV	$	37.00
Minimum	$	401,769.22
Maximum	$	3,211,158.94

As before, the CDF was created using the 500 iterations of each scenario (Figure 4.7). In this farm model's case the CDF allows for the demonstration of how close the scenarios came in respect to eachothers net present value probabilities.

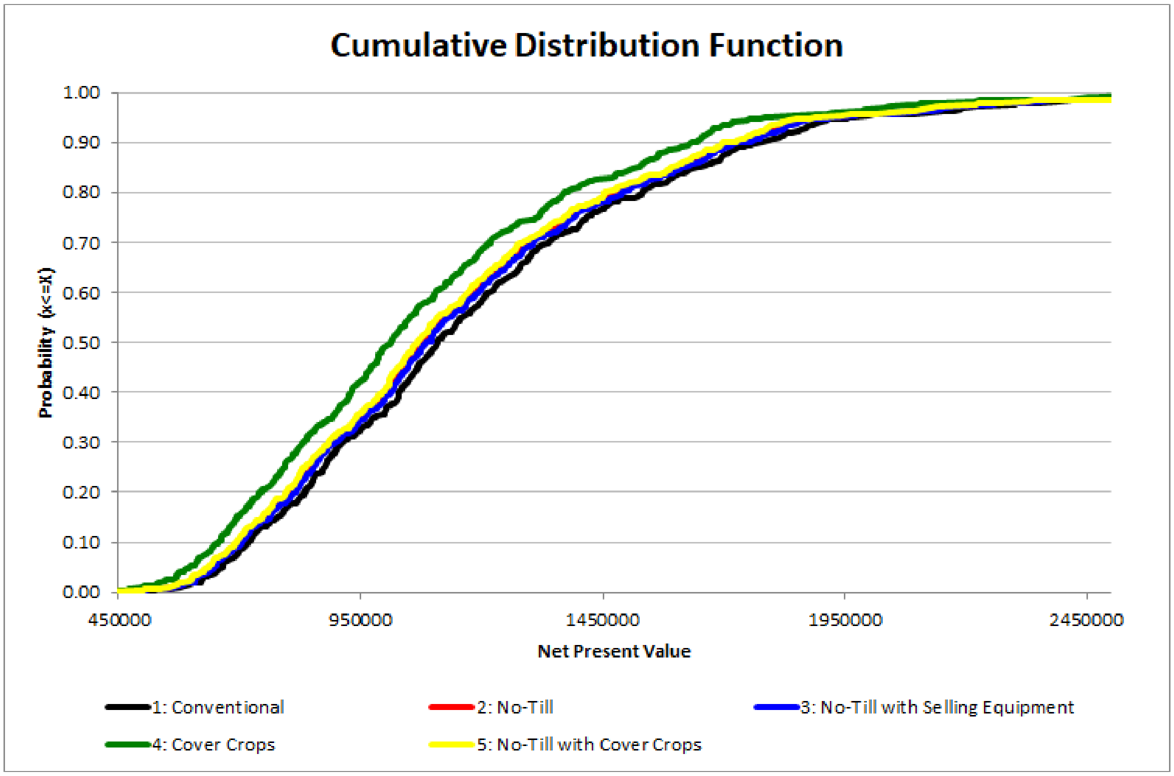

Figure 4.7 Coastal Bend Cotton Farm Net Present Value CDF

The SERF analysis for the Coastal Bend (Figure 4.8) demonstrated once again the conventional scenarios lower risk level. This graph also assisted in depicting the comparison between the risk levels of the four regenerative practice scenarios in their entirety. No-till with the liquidation of equipment received the second lowest risk score, followed by no-till alone, then no-till with the inclusion of cover cropping, and finally cover cropping alone.

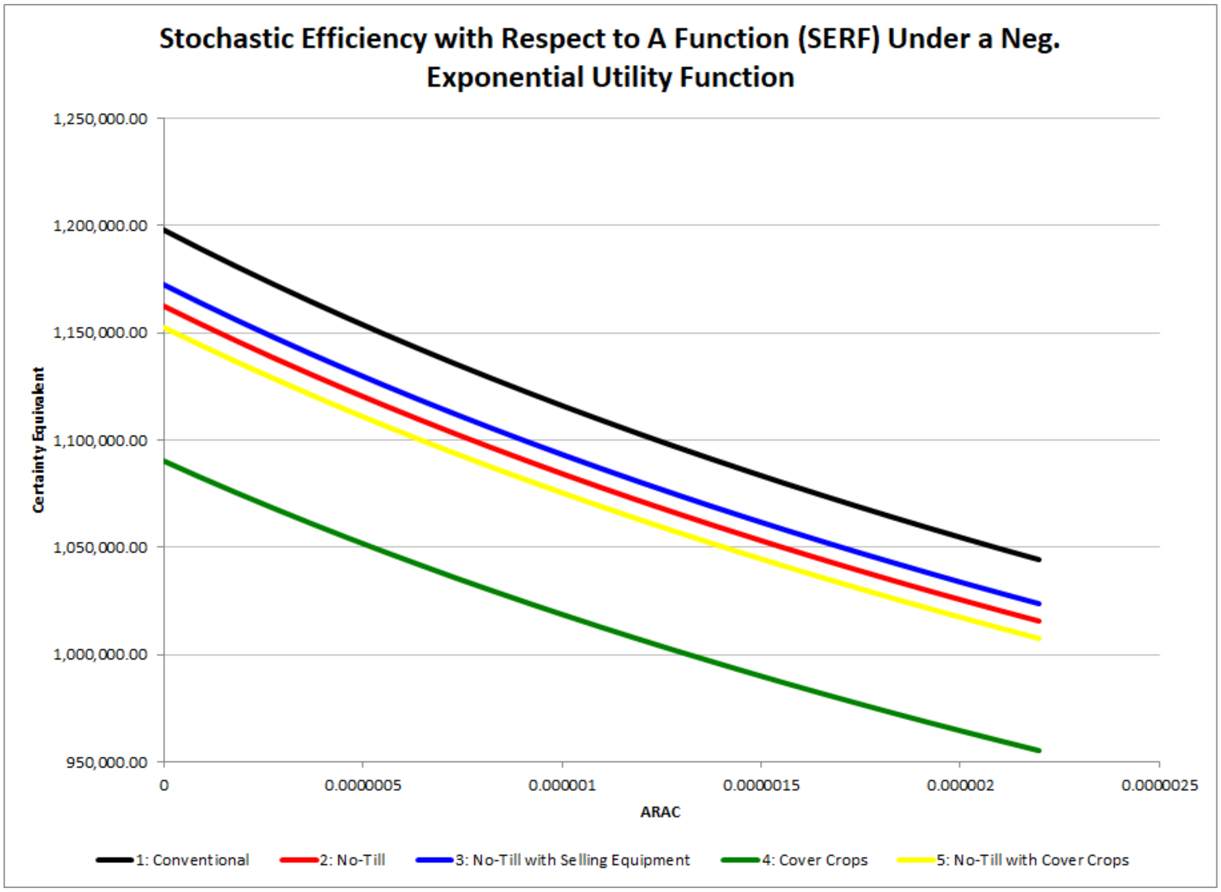

Figure 4.8 Coastal Bend Cotton Farm SERF Table

Finally, the last yield incremental changes needed to level the scenarios' net present value were calculated. The no-till and no-till scenario with the liquidation of previously mentioned equipment required yield increases of approximately 1.55% and 1.1% respectively. The scenario with cover cropping alone required an increase of 4.95% to offset the costs of the practice. The final scenario, no-till with cover cropping, needed an increase of yield at approximately 2% according to the parameters set. Table 4.8 displays these percentage changes in yield needed for each practice in the Coastal Bend model.

Table 4.8 Approximate Changes in Yield Percentage while Holding NPV Constant for Coastal Bend

Approximate Changes in Yield Percentage while Holding NPV Constant				
	No-Till	No-Till with Selling Equipment	Cover Cropping	No-Till and Cover Cropping
Coastal Bend	1.55%	1.10%	4.95%	2%

Summary of Results

The transition to regenerative agricultural practices such as no-till and cover crops will have a range of effects on each differing operation. The results of these transitions will largely depend on the producers' original levels of the study influenced inputs in their conventional scenarios, such as herbicide. For the Southern Plains and Central Texas representative farms, no-till practices resulted in a higher net present value on average than conventional operations for this five-year analysis. However, conventional practices resulted in the highest average net present value for the Northern Plains and Coastal Bend representative farms. One constant result throughout the analysis of all four farms was the cover cropping scenario receiving the lowest mean net present value. The no-till and cover cropping scenario received the second lowest net present value on average for all farms except the Northern Plains. For potential changes in yield percentages, cover cropping was found to need an increase in yield ranging from 4.8%-12% to receive approximately the same net present value as the conventional operation. The potential yield changes for no-till to receive the same net present value as the base operation were not always positive. The Southern Plains was the only farm which could experience a decrease in yield (3%) within the no-till scenario and still receive a comparative net present value. The rest of the farms required ranges of yield increases from .5%-9% to establish an approximately equal net present value.

CHAPTER V

CONCLUSIONS

Regenerative agriculture and the practices it encompasses have become the focus of many producers, agricultural analysts, and even the Biden Administration. Regenerative agriculture, very similar to the soil health movement, includes a range of practices with the intention of improving the condition and rigor of the soil. This would include adding practices such as cover crops and removing or reducing several conventional tillage practices, among other practices. Proponents have stated that these techniques will greatly improve the soil's ability to hold water, consequently lessening the influences of droughts on crops, as well as, potentially reducing fertilizer requirements. With the assertion that these techniques could decrease production costs and risk levels, producers may find themselves in need of a comprehensive financial analysis on the effects of transitioning to these practices. While there is a source of literature for analysis such as this, few if any have focused regionally on Texas and its crop operations.

Objectives

The primary objective of this study was to determine if regenerative practices increased yields and/or reduce yield risk enough to offset potentially higher production costs. The secondary objective was to determine whether these impacts were different for farms in different production regions of Texas. Risk was incorporated into the model through the inclusion of historical yield and price data. This data allowed for an accurate distribution, which allowed for the creation of stochastic price and yield variables. With the use of these stochastic variables, net present value for each scenario within each farm was simulated through 500 iterations. These 500 iterations gave a realistic range from which an analysis could be performed.

Results

The transition to regenerative agricultural practices such as no-till and cover crops will have a range of effects on each differing operation. The results of these transitions will largely depend on the producers' original levels of the study influenced inputs in their conventional scenarios, such as herbicide. For the Southern Plains and Central Texas representative farms, no-till practices resulted in a higher net present value on average than conventional operations for this five-year analysis. In all four farm models, no-till with the selling of tillage equipment received a higher net present value on average than the no-till without the selling of equipment. It can be noted that this added income from the selling of this equipment is the liquidation of a prior investment rather than a newfound income. Although, it should also be noted that the removal of this equipment from the operation also removes maintenance and eventually replacement costs for these pieces of machinery.

Conventional practices resulted in the highest average net present value for the Northern Plains and Coastal Bend representative farms. One constant result throughout the analysis of all four farms was the cover cropping scenario receiving the lowest mean net present value. The no-till and cover cropping scenario received the second lowest net present value on average for all farms except the Northern Plains. For potential changes in yield percentages, cover cropping was found to need an increase in yield ranging from

4.8%-12% to receive approximately the same net present value as the conventional operation. The potential yield changes for no-till to receive the same net present value as the base operation were not always positive. The Southern Plains was the only farm which could experience a decrease in yield (3%) within the no-till scenario and still receive a comparative net present value. The rest of the farms required ranges of yield increases from .5%-9% to establish an approximately equal net present value. These required changes in yield percentage for each practice on each farm are presented in Table 5.1.

Table 5.1 Approximate Changes in Yield Percentage while Holding NPV Constant

Approximate Changes in Yield Percentage while Holding NPV Constant				
	Southern Plains	Central Texas	Northern Plains	Coastal Bend
No-Till	-3%	0.50%	9%	1.55%
No-Till with Selling Equipment	-7%	-3.50%	6%	1.10%
Cover Cropping	9.80%	6%	12%	4.95%
No-Till and Cover Cropping	2%	2%	8%	2%

Future Research

The partial budget-based model developed in this analysis evaluated the financial effects of transitioning to regenerative practices on an operations' net present value over a five-year period. The model which was constructed for this study can be adjusted to reflect future years as time progresses. With many inputs seeing significant inflation on their costs at the time of this writing, a future study could attempt to incorporate this inflation to give producers a more accurate outlook by updating this model.

Another direction for the furtherment of this research could be the inclusion of more representative farms from sub-regions within the state. While this study attempted to analyze the majority of the large crop producing regions of Texas, there are some areas which could also be included to help create a more robust model.

Furthermore, assumptions were made for variables such as cover crop seed type and cost, and percentage changes on inputs such as herbicide, labor, and fuel. Future studies could rework these assumptions and their percentages to cover a broader spectrum of how producers may choose to integrate into regenerative practices.

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