EVALUATING THE ECONOMICS OF INDUSTRIAL HEMP IN TEXAS

A Thesis

by

MEGAN LAUREL MOORE

Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
In partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Chair of Committee,	Joe L. Outlaw
Committee Members,	Henry Bryant
	Monty C. Dozier
Head of Department,	David J. Leatham

May 2020

Major Subject: Agricultural Economics

ABSTRACT

Farmers in the American agricultural system are working to make market receipts and government payments cover their cost of production. According to USDA Economic Research Service (ERS), "Net farm income, a broad measure of profits, is forecast to decrease $9.1 billion (12.1 percent) from 2017 to $66.3 billion in 2018, after increasing $13.8 billion (22.5 percent) in 2017." The decreasing profit margin has producers across the country looking for profitable cropping alternatives to diversify their operations with a profitable alternative.

Industrial hemp, Cannabis Sativa L. (Cannabacea), is a plant that was grown extensively in the United States prior to the enactment of the Controlled Substances Act of 1970. Industrial hemp was banned due to its genetic relationship to marijuana as hemp and marijuana share a botanical name. The difference between industrial hemp and marijuana is industrial hemp has a decreased delta-9 Tetrahydrocannabinol (THC) concentration (less than 0.3 percent on a dry weight basis) by law than marijuana (Congress, 115th, 2018). In comparison, industrial hemp has higher levels of CBD (cannabidiol) and marijuana has a much higher levels of THC. THC contains the psychoactive properties that has raised concerns.

The Agriculture Improvement Act of 2018 (2018 Farm Bill) changed federal policy concerning industry hemp, including the removal of hemp from the Controlled Substances list and directed the USDA Risk Management Agency (RMA) to develop crop insurance products for hemp. The bill legalized hemp with specific restrictions and expanded the definition of industrial hemp from the last 2014 Farm Bill. This allows the USDA Farm Service Agency (FSA) to potentially provide farmer support for growing hemp and gives insurance companies the ability to legally insure the crop. The 2018 Farm Bill policy change has many farmers excited about the possibility of growing hemp as a profitable cropping alternative. The 2018 Farm Bill legalized the commercial production of hemp and authorized states to submit state plans to administer hemp programs.

While the potential for a new basic crop for producers is very exciting, there remains fundamental questions. Producers do not have all of the necessary information needed to analyze whether this crop is a good financial decision. The primary objective of this thesis was to create Texas specific enterprise budgets for CBD, Fiber, and Grain production methods. These four types include, but are not limited to: CBD Vegetable Model, CBD Large Scale, Hemp grown primarily for Grain, and Hemp grown primarily for Fiber**.** A secondary objective was to incorporate risk in each of the budgets by simulating a range of realistic market assumptions to determine the likelihood or probability of an economic profit.

Information from pilot projects underway in Kentucky, Tennessee and South Carolina and discussions with industry leaders was used to develop the costs of production for growing hemp in Texas based on differences in climates and soils. Based on 2019 input and output prices, the average net revenue for the CBD Vegetable Model ($3,344.63/acre) and CBD Large-Scale Model ($8,175.51/acre) were both positive while the Grain Model (-$839.98/acre) and Fiber Model (-$1,225.64/acre) were negative. When considering risk, the only production system that is expected to generate a positive net revenue more than one-half of the time is the CBD Large-scale Model. Both the Hemp Grain and Hemp Fiber Models have less than a 6% chance of generating a positive net revenue.

The results of the risk analysis indicate that contracting with a reliable processor prior to planting is essential for Texas producers as experience thus far in other states indicates that producers have had more success growing hemp than they have had in getting paid for their hemp.

ACKNOWLEDGEMENTS

Thank you, **Lord**, for sustaining and growing me substantially though my time at Texas A&M. All glory, praise and honor be to you, God, from whom all blessings flow.

To My Husband: You are the Lord's greatest gift. I respect you. I love you. I choose you. You have led me by serving me throughout this process (Mark 10:45). You have loved me as Christ loves the church (Eph. 5:25). You have cared for me with humility, kindness, gentleness, and patience (Col. 3:12-17). I look forward to continuing the mission God has entrusted to us (Ps. 67; Matt. 28:18-20).

To My Family: The last few years have been the most wonderful and most challenging of my life thus far. Thank you for supporting me every step of the way from my teaching in Liberia to being taught in Texas. I will never be able to thank you enough for your love and support. I am grateful for this time to research the crop my great-grandfather grew for World War II.

To My Professors at University of Kentucky: Thank you for encouraging me professionally and personally throughout my undergraduate degree. Dr. Maynard, thank you for your encouragement and support in my undergraduate study abroad, quiz bowl, and encouraging me to pursue a Master's. I will remember many of our conversations for the rest of my life. Enjoy retirement. Dr. Mark thank you for being one of my supporters in my time in Liberia and being a wonderful support and mentor throughout my master's thesis. I am cheering you on as you continue research in this area and other areas. Dr. Davis, thank you for being the first academic

person to encourage me to pursue a Ph.D. Because of your encouragement, I have broadened my scope of thinking and thought more confidently about what my future could hold.

To Dr. Knapek: It has been a true honor to travel the country and learn about hemp alongside you. You have been a wonderful support and mentor to me during my time at Texas A & M. I am cheering you on as you continue research in this area and many other areas in the days to come.

To Dr. Outlaw and the Agricultural and Food Policy Center: Thank you, Dr. Outlaw, for the opportunity to travel the country and learn in depth about a topic. It has been an honor and a privilege. You and the entire policy center have been a wonderful support and encouragement through this entire process.

To Erin: Thank you for supporting me through this first year of marriage with everything from essential oils to how to clean up my house.

To Dr. Diane: I knew you would be a PhD by the end of my time at Texas A & M. I am cheering you on so loud! You are the ultimate includer of people. Your future learners will be lucky to know you and learn from you.

To My Liberian Students: I remember thinking while living among you in Liberia, “I will never take my educational opportunities for granted.” I hope this thesis makes you proud. You are smart. You are competent. You can do this.

CONTRIBUTORS AND FUNDING SOURCES

Contributors

This work was supervised by a thesis committee consisting of committee chair Dr. Joe L. Outlaw and committee member Dr. Henry Bryant of the Department of Agricultural Economics, and committee member Dr. Monty C. Dozier of the Department of Texas AgriLife Extension.

All work for the thesis was completed by the student, under advisement of Dr. Joe L. Outlaw of the Department of Agricultural Economics.

Funding Sources

Graduate study was supported by a fellowship from the Department of Agricultural Economics at Texas A & M University and funding provided by the Agricultural and Food Policy Center at Texas A & M University.

TABLE OF CONTENTS

LIST OF TABLES

TABLE **Page**

LIST OF FIGURES

FIGURE **Page**

CHAPTER I

INTRODUCTION

In 2019, farm debt is predicted to be $416 billion, a record high, with $257 billion in real estate debt and $159 billion in non-real estate debt (Newton, 2019). While farm income is projected to reach $88 billion which would be the highest since 2014, nearly 40% of farm income is related to trade assistance, disaster resistance, farm program payments and insurance indemnities. With record high debt and farmers experiencing cash flow problems, Chapter 12 farm bankruptcies are up 24% from 2018. Many farmers are contemplating alternatives that could save their farm.

In 2020, net farm income is forecasted to increase $3.1 billion to $96.7 billion while cash receipts for all commodities are forecasted to increase 10.1 billion which is a 2.7% increase in nominal terms over the previous year (Economic Research Service, USDA February 2020).

Federal and Texas Hemp Policies

The Agriculture Improvement Act of 2018 (2018 Farm Bill) legalized the commercial production of hemp and authorized states to submit state plans to administer hemp programs. In addition, the 2018 Farm Bill provides insurance companies the ability to develop insurance products and legally insure the crop. The 2018 Farm Bill policy change combined with very few profitable alternatives has many farmers excited about the possibility of growing hemp as a profitable cropping alternative.

On June 10, 2019, House Bill 1325 was signed into law by Texas Governor Greg Abbott. House Bill 1325 authorizes the production, manufacture, retail sale, and inspection of industrial hemp crops and products in Texas.

On October 31, 2019 the USDA Agricultural Marketing Service released an Interim Final Rule establishing the U.S. Domestic Hemp Production Program, with requests for comments, and the procedures for USDA to approve submitted plans (Agricultural Marketing Service, U., October 2019). According to the Interim Final Rule, States and tribes must submit plans to USDA for approval before farmers in a state or tribe can begin production. Texas submitted a Hemp Plan to USDA and on January 27, 2020, USDA approved The Texas Hemp Plan (Agricultural Marketing Service, U., January 2020). The next step is for the Texas Department of Agriculture (TDA) to adopt rules. Once rules are adopted, farmer licensing will begin. It is estimated this will be completed in early 2020 so farmers wanting to grow hemp can plant in the 2020 growing season (Texas Department of Agriculture, February 2020).

Objectives

While the potential for a new basic crop for producers is very exciting, there remains fundamental questions. Producers do not have all of the necessary information needed to analyze whether this crop is a good financial decision. The primary objective of this thesis is to create Texas specific enterprise budgets for CBD, Fiber, and Grain production methods. These four types include: CBD Vegetable Model, CBD Large Scale, Hemp grown primarily for Grain, and Hemp grown primarily for Fiber**.** A secondary objective would be to incorporate risk in each of the budgets by simulating a range of realistic market assumptions to determine the likelihood or probability of an economic profit.

Methodology

The preliminary results of pilot projects underway in Kentucky, Tennessee and South Carolina will be evaluated to determine the cost of production and any special considerations that need to be addressed when growing hemp in Texas. The methodology of this thesis is to create enterprise budgets specific for Texas on the four types of Industrial Hemp Production. Enterprise budgets which are a listing of all estimated revenues and expenses are the appropriate tool to use when evaluating a single commodity being produced (Kay, 1981). These four types include: CBD Vegetable Model, CBD Large Scale, Hemp grown primarily for Grain, and Hemp grown primarily for Fiber.

The newness and quickly changing nature of the hemp industry makes it difficult to obtain documented revenue and expense estimates for the construction of enterprise budgets. The budgets presented in this thesis are meant for educational purposes only. The enterprise budgets will represent the average income and expenses for a highly variable crop. The budgets are meant to represent hypothetical hemp production in Texas for 2019 which means that prices for outputs and inputs were obtained for 2019 and production practices and seed technology is of 2019. In 2019, hemp production was not legal in Texas, however, the budgets will reflect output and input prices for that crop year.

These budgets were created based on research on the hemp industry which included: attending the 1st through 3rd hemp colleges in Kentucky, Iowa, and Nevada respectively, visiting with current hemp producers in Colorado and Kentucky, attending a University of Kentucky hemp field day, visiting with hemp researchers from the West at the Western Agricultural Economics Association Annual Meeting, visiting with researchers from the South at the 2019 and 2020 Southern Agricultural Economics Association Annual Meetings and the 2019 Southern Extension Economics Committee, visiting with industry participants at the Multi-State hemp meetings (S1084), visiting processors in both Colorado and Kentucky, visiting retailers in Colorado, Kentucky, and Tennessee, and hearing the latest in research at the BIO World Conference. This information was compiled and applied to Texas growing conditions to produce the budgets.

The budgets are broken down into four production methods: CBD Vegetable Model, CBD Large-Scale Model, Hemp Grain, and Hemp Fiber. Again, it should be noted that production methods are highly varied with a high amount of volatility within each method. Unlike a more established crop enterprise budget, where there are generally accepted benchmarks of cost and revenues that serve as a reference point for creating budgets, the lack of publicly available information makes hemp budgeting a greater challenge.

2019 Texas Industrial Hemp Enterprise Budgets

The budgets for CBD are broken into two models, one for smaller scale (vegetable model) that is more labor-intensive production and another for larger acreage with mechanical harvesting. The vegetable model is currently used throughout the Southeast. This model is particularly prevalent in Kentucky and South Carolina where hemp is often seen as a replacement for tobacco production. CBD production decreases as males pollinate, pollen travels to females, and seed is produced. Seed production for producers growing for CBD is bad and can drastically bring down the CBD percentage. Ten percent CBD is the goal for CBD production (Mark, 2019). The vegetable model generally uses transplant production methods and hand harvesting. Thus, the CBD vegetable model has a strong reliance on hired labor.

The large-scale budget is meant to represent a grower with larger acreage which would make hand harvesting and planting transplants less feasible. The large-scale model includes planting seeds by drilling them with a planter containing modified vegetable seed plates and utilizing feminized seed. There is significant variability in the seed count/lb as it varies from 6,000 to 320,000. (Hutchens, 2019).

At this point, the seed and grain models appear to have a wide range of market potential and a large dependence on indsustry regulations. Hemp seed cannot be fed presently. However, the relatively high protein percentage has many in the agricultural industry intrigued. Seed protein for soybean is 44%, cotton is 25%, and industrial hemp is 34%. Hemp is also a good whole food as it has balanced amino acids. (Hutchens, 2019)

The fiber production sector of agriculture is expected to be the latest sector to develop. The standard planting practice is to drill the hemp seed into ground. As a standard, hemp grown for fiber typically contains a lower level of CBD (about 2%) than hemp grown for either seed or CBD.

The remainder of this thesis is organized as follows. Chapter II will go in-depth about the history and current status of industrial hemp in the United States. It will point out key areas of concern and producer risk in adopting industrial hemp in Texas. Chapter III will identify and discuss the data and methodology for developing industrial hemp budgets. Chapter IV will explain the enterprise budgets and analyze the impact of including risk in the analysis. Chapter V summarizes the research results from developing four alternative enterprise budgets, provides implications for producers, as well as, limitations and possible expansions of the research.

CHAPTER II

REVIEW OF LITERATURE

Hemp Industry Background

According to the USDA Economic Research Service (ERS), "Net farm income, a broad measure of profits, is forecast to decrease $9.1 billion (12.1 percent) from 2017 to $66.3 billion in 2018, after increasing $13.8 billion (22.5 percent) in 2017" (Economic Research Service, 2018). The decreasing profit margin has producers across the country looking for profitable cropping alternatives to diversify their operations and thus their farm risk.

Recent federal policy changes in combination with poor crop alternatives have increased producer interest in growing industrial hemp. Industrial hemp, Cannabis Sativa L. (Cannabacea), is a crop that was grown extensively in the United States prior to the enactment of the Controlled Substances Act of 1970. Industrial hemp was banned due to its genetic relationship to marijuana. Hemp and marijuana share a botanical name. The difference between industrial hemp and marijuana is industrial hemp has a decreased delta-9 Tetrahydrocannabinol (THC) concentration (less than 0.3 percent on a dry weight basis) by law than marijuana (Congress, 115th, 2018). In comparison, industrial hemp has higher levels of CBD (cannabidiol), while marijuana has much higher levels of THC. THC contains the psychoactive properties one might be concerned about considering the genetic relationship between the two (Anderson, 2018).

History

However, "new" as some might call it, industrial hemp is not new at all. Hemp is thought to be the first domestically cultivated plant as fabrics made from hemp date back to 8,000 years ago in Mesopotamia, now modern-day Turkey (Deering, et. al., October 2019).

Industrial hemp has been grown in the United States since colonial times. Originally, it was highly valued for the manufacture of rope and sails for ships. Hemp remained a valuable, although minor crop, through the industrial revolution and into the 20th Century. In the 1930s, hemp was viewed as a possible substitute for newspaper pulp and an impediment for growth of synthetic fibers, such as nylon for rope. These interests, and an increasing concern about the recreational and medicinal uses of marijuana, led to the passage of the Marihunana Tax Act, in 1937. The Act's name uses a spelling for marijuana which was common at that time.
With additional restrictions and taxation, interest in the crop further declined. Five years later, the loss of hemp imports from the Philippines during World War II, led to the government actively encouraging production of the crop. About 300,000 acres of hemp for fiber or seed were harvested from 1942 to 1945 (USDA, 1941-1946). U.S. production rapidly declined after World War II.

Over time the industry had many ups and downs. However, specific to the United States, it became a major player during World War II. The United States was dependent on hemp to meet the increased demand for fiber. Hemp fiber was used during this time period for fine cordage, commercial twines, threads, and packing. Domestic products such as brooms, brushes, mattresses, and upholstery and sail twine were made from hemp fiber material. "In the middle of the 19th century, production of hemp in the United States reached a high of approximately 75,000 tons, decreasing until less than 1,000 tons were produced in prewar years. During the five-year period 1929-1933 an average of only 500 tons was produced, increasing to about 3,308 tons in 1941. Then, due to increased demands for all types of fibers, production rose during World War II to 6,216 tons in 1942, 62,803 in 1943 and 30,130 in 1944. Estimates of production in 1945 and, 1946 were 2,232 and 1,715 tons, respectively" (Ash, 1948).

There was an article published in Popular Mechanics Magazine in 1938 calling industrial hemp “The Next Billion Dollar Crop” (Figure 2.1). At this time in history, industrial hemp was known mainly for the use of fiber. This article cites that in 1938 fiber machines in many states, including Texas, Illinois, and Minnesota processed fiber at production cost of half a cent per pound and were finding profitable markets for the byproduct of a stalk. Machine operators were making a profit among competition with foreign fiber while paying farmers $15.00 a ton for hemp fresh from the field. Even in 1938, hemp was known for yielding 3 to 6 tons per acre on good productive land that could grow corn, wheat, and oats.


NEW BILLION-DOLLAR CROP

AMERICAN farmers are promised a new cash crop with an annual value of several hundred million dollars, all because a machine has been invented which solves a problem more than 6,000 years old. It is hemp, a crop that will not compete with other American products. Instead, it will displace imports of raw material and manufactured products produced by underpaid coolie and peasant labor and it will provide thousands of jobs for American workers throughout the land.

The machine which makes this possible is designed for removing the fiber-bearing cortex from the rest of the stalk, making hemp fiber available for use without a prohibitive amount of human labor.

Hemp is the standard fiber of the world. It has great tensile strength and durability. It is used to produce more than 5,000 textile products, ranging from rope to fine laces, and the woody “hurds” remaining after the fiber has been removed contain more than seventy-seven per cent cellulose, and can be used to produce more than 25,000 products, ranging from dynamite to Cellophane.

Machines now in service in Texas, Illinois, Minnesota and other states are producing fiber at a manufacturing cost of half a cent a pound, and are finding a profitable market for the rest of the stalk. Machine operators are making a good profit in competition with coolie-produced foreign fiber while paying farmers fifteen dollars a ton for hemp as it comes from the field.

From the farmers' point of view, hemp is an easy crop to grow and will yield from three to six tons per acre on any land that will grow corn, wheat, or oats. It has a short growing season, so that it can be planted after other crops are in. It can be grown in any state of the union. The long roots penetrate and break the soil to leave it in perfect condition for the next year's crop. The dense shock of leaves, eight to twelve feet above the ground, chokes out weeds. Two successive crops are enough to reclaim land that has been abandoned because of Canadian thistles or quack grass.

Under old methods, hemp

(Continued to page 144A)

Top, sailing the seas with sails and rope made of hemp. Bottom, hemp fiber being delivered from machine ready for baling. Pile of pulverized hurds beside machine is seventy-seven per cent cellulose

238

Figure 2.1 Image from *Popular Mechanics* entitled “New Billion-Dollar Crop”: Reprinted from Popular Mechanics Magazine, 1938

Even prior to World War II, economists evaluated how profitable the crop would be.

“It cost Illinois farmers $21.19 a ton to produce and deliver hemp in 1943, according to R. H Wilcox, University of Illinois, College of Agriculture. This was the average cost on 112

Illinois farms picked at random in the hemp growing area of the State. The per acre cost for hemp of $55.02 was about double the cost of producing corn. But a hemp yield of 2.6 tons an acre at an average price of $42.90 per ton made the crop profitable" (Ash, 1948). In the publication entitled Producing Industrial Hemp in Illinois in 1943, Wilcox released a budget and explanation for the crop (Wilcox, 1944). Even though the budgets were profitable, farmers had the same questions that they do today. They doubted whether it would bring the same price compared to the same acres being allocated to corn. In addition, there were concerns about the unfamiliarity of the crop, its yield, the labor required, and the production costs (Marsh, 1967).

The Marihunana Tax Act was eventually replaced by the Controlled Substances Act of 1970. Hemp was classified as a Schedule I Drug. Drugs in this act were considered to have a high potential for abuse and are unsafe for use. This edict essentially led to industrial hemp's disappearance in the United States until recent legislative changes. The lapse of time has allowed for new time and opportunity, yet the same questions persist.

Industrial Hemp Markets

Industrial hemp has many uses. Currently, the production of industrial hemp is greatly dictated by its end use, be that for seed (food and replication), fiber, or cannabidiol (CBD). There is also the potential for a feed market, but currently it is not legal to feed hemp to animals that will be consumed by humans (Food and Drug Administration, 2020).

As of this writing, it is common practice to grow industrial hemp for one purpose (end market), but dual-purpose (seed and fiber, CBD and fiber, etc.) cropping is also being introduced in some areas. Each of these end markets will be examined in greater detail.

CBD or Cannabidiol

CBD is cannabidiol, one of the many cannabinoids, or chemical compounds, found in marijuana and hemp. Currently, the CBD market is garnering most of the attention and hemp planted acres in the United States. The popularity of CBD as a health supplement has exploded, and prior to 2019, the market was in a relative shortage situation. However, supply is quickly coming online as high returns to CBD production relative to other crop alternatives is attracting investment and acres. Prices for CBD have been falling, but it remains to be seen whether the rush to increase hemp acres will continue.

Part of the popularity of CBD has been its proponents claims of medicinal benefits. There are many claims that CBD cures a broad array of ailments. However, since hemp production has been illegal, there are very few scientific studies addressing the health benefits of CBD. Most proponents expound its usefulness for insomnia, anxiety, and chronic pain. However, at this point CBD has only one approved use. It is the active ingredient in Epidiolex, a Food and Drug Administration (FDA) approved drug used as a treatment for two types of children's epilepsy (Lennox-Gastaut syndrome (LGS) or Dravet syndrome (DS)). The 2018 Farm Bill explicitly states that the FDA continues to have jurisdiction over the regulation of indigestible and topical hemp products. The FDA has not been explicit on the regulatory future for CBD leaving considerable uncertainty for its future. Regulatory action could play a big role in increasing or decreasing demand for CBD and would substantially affect a farmer's profitability.

Fiber

The industrial hemp fiber market is really an industrial hemp stalk market (Riddle, 2019). Industrial hemp stalk is mainly composed of two sellable components, baste fiber and hurd (pith of the stalk). Both of these plant parts have multiple end markets, with the potential for greater development of end use products. Currently, one of the largest uses of industrial hemp hurd is in animal bedding (Riddle, 2019). Industrial hemp hurd animal bedding is attractive for its absorbency and long life. Hemp based animal bedding is marketed as more absorbent than wood chips, dust free and odor free. Industrial hemp fiber can be used in many products. Currently, hemp fiber is used in textiles, rope, and specialized paper. Many other end uses are possible, but will depend on cost and acceptance of consumers (Riddle, 2019)(Mark, et al., February 2020). Some potential uses include insulation, automotive parts, and as a replacement for petroleum based plastic.

From an economic perspective, hemp pulp is currently two to three times more expensive than wood pulp (Riddle, 2019). At current prices, it will be difficult for hemp pulp to compete with wood. However, consumer preferences for a biodegradable source of fiber could increase demand. The options in relation to plastic would be to making plastic from hemp or putting hemp in plastic. The potential to put hemp into plastic for use in parts in auto supply chain would be a huge potential market for the industry (Riddle, 2019). Another product that could have a lot of potential would be insulation as it is not an irritant like fiberglass (Riddle, 2019).

Seed (food and replication)

Industrial hemp seed has two purposes, replication and food. As the acres of industrial hemp grow, the need for seed for planting is also growing. It is likely that as the industrial hemp planted acres increase, seed dealers with specific genetics will appear. In the industrial hemp industry today, seed for planting can be hard to find (Smith, 2019). Currently most seed planted in the United States comes from Canada or overseas, depending on latitudinal relationship.

Industrial hemp seed can also be grown for food. In December 2018, the FDA completed its evaluation of hemp seed derived food ingredients. The FDA gave hulled hemp seed, hemp seed protein powder, and hemp seed oil a Generally Recognized As Safe (GRAS) designation. The seed can be hulled and sold raw or smoked/roasted seed. Additionally, industrial hemp seed can be further processed into protein powder or crushed for hemp oil. FDA has said that industrial hemp seed and oil are safe (Food and Drug Administration, February 2020). Nutritional content of hemp seeds is very comparable to other plant-based proteins.

Feed

Industrial hemp does have the potential to be used as a feed source. It is currently illegal to feed industrial hemp and its bi-products to food animals. According to industry contacts, the topic is being studied and regulations considered, however, there is currently no timeline as to when the regulations will be completed or from what hemp component the feed will be derived from. It would be economically useful if excess material from CBD production or refuse from seed processing could be used as a feed ingredient. There are questions regarding withdrawal dates on hemp derived feeds. Also, will the hemp feed come from the spent material from CBD, refuse from seed processing, or just the seeds?

Hemp Cultivation and Seed Types

While industrial hemp can grow in many environments, there are conditions it prefers. Hemp does not like to have "wet feet." This means that hemp prefers a well-drained soil such as a sandy loam and does not do as well in heavier clay.

Establishing a Hemp Crop

There are four different ways one may establish an industrial hemp crop:

1. Straight Run Seed. This is unsexed seed and will contain both male and female plants.

2. Started Seed or Transplants. These are seeds that have been planted in a tray and usually start germination and vegetative growth in a greenhouse. This type is often referred to as transplants.
3. Clones are clippings of a mother plant which is taken and put in a rooting solution. Clones range from $3-$6 per plant and have been as high as $11.50. Clones allow comfort in knowing what genetics you have in the plants (Lax, 2020).
4. Feminized Seed. This seed has had a process done to it that makes it only feminized seed. Some farmers have bought a seed labeled as "feminized seed," but they ended up being straight run seed (Mark, 2019) (Shepherd, 2019) (Lax, 2020). Due to pollination leading to lower CBD levels, farmers have had to pull up, remove, or kill about half of their crop (all of the males).

General Agronomy and Texas

While industrial hemp can grow everywhere, there are conditions it prefers. The general consensus is that hemp prefers a well-drained soil like a sandy loam and doesn't do as well in clay. Industrial hemp does like sand, but it needs to be irrigated. It does not hold the ground together well and leaves the soil loose which can leave the ground defenseless to erosion. The soil and irrigated maps for Texas are pictured in Figures 2.2 and 2.3. Latitude and longitude are a very important factor for this crop because day length has a great deal to do with the planting date and preferred growing method.

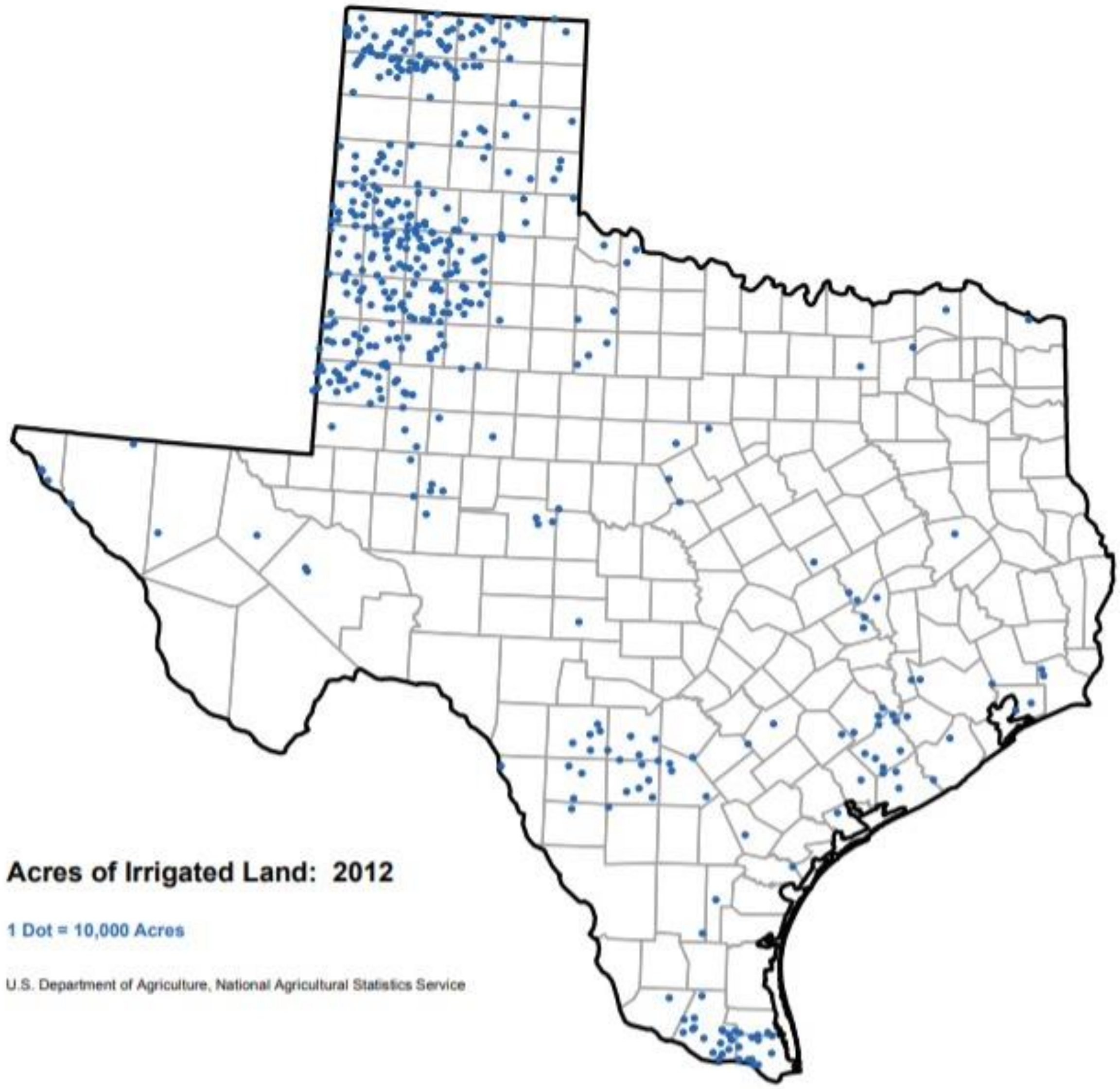

Figure 2.2 Acres of Irrigated Land: Adapted from United States of Agriculture, National Agricultural Statistics Service, 2012

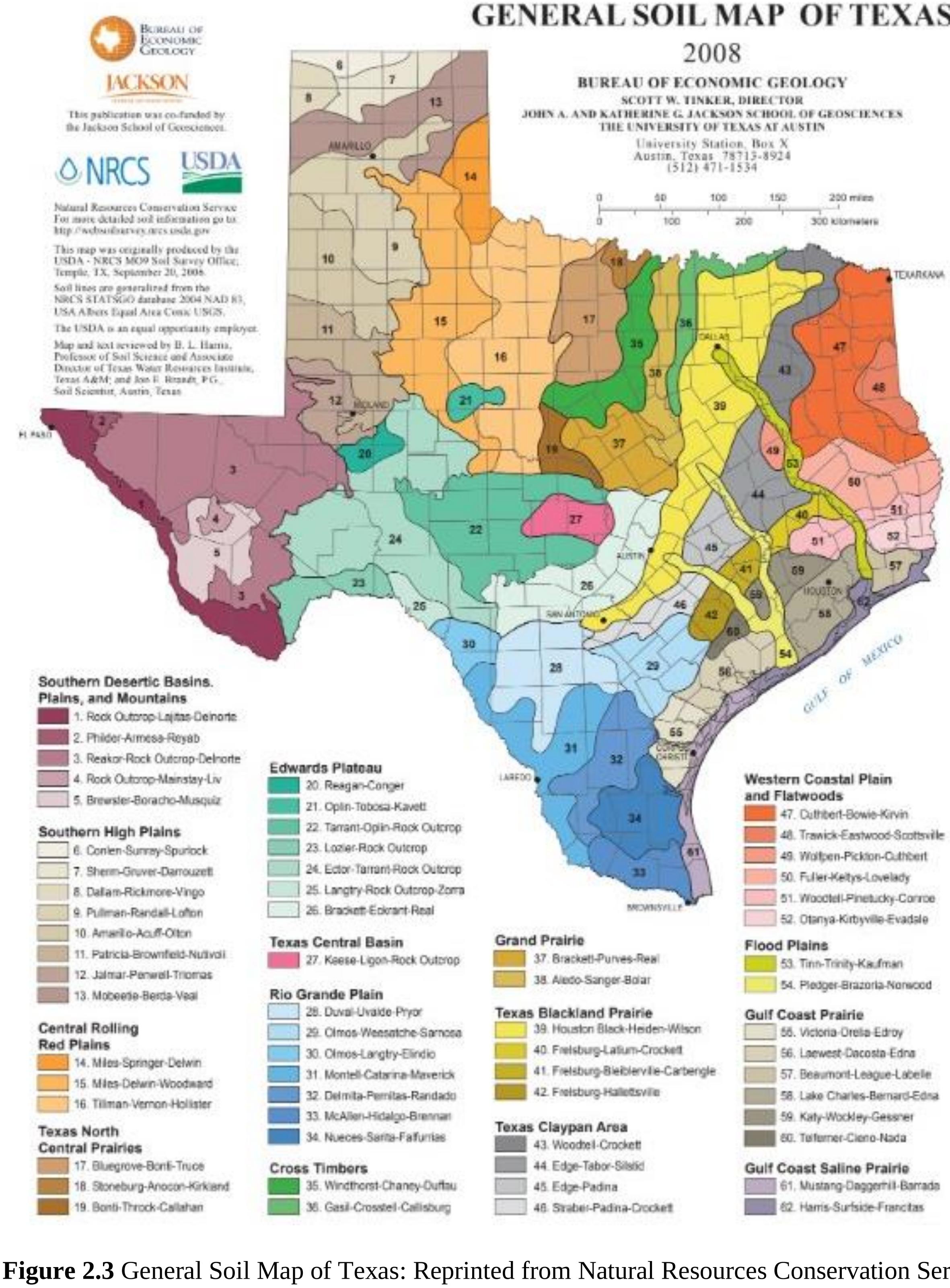

Figure 2.3 General Soil Map of Texas: Reprinted from Natural Resources Conservation Service and Bureau of Economic Geology, 2008

From an agronomic perspective, Industrial Hemp takes 90-100 days to grow. Seed germinates in 36 hours. A fourth season grower from western Kentucky said, "seed germinates and grows two times as fast as tobacco" (Sisk , 2019). No matter when it is planted, industrial hemp comes to maturity around equinox for the latitude (Furnish, 2019). Latitude and longitude are a very important factor for this crop because day length has a great deal to do with the planting date and preferred growing method. Hemp has developmental responses to lengths of daylight and darkness it experiences. Thus, it will know to start flowering based on sunlight almost regardless of when planted. Hemp requires more than 10 hours of darkness to initiate flowering. After days get shorter it knows fall is coming and seed is needed to drop. After June 21st the plants start going into reproductive phases, due to day length.

Planting depth is between .25" to .5". A farmer should check depth repeatedly. One should see some seeds on top of the surface. Seed germination rates are a huge issue. There will be less germination in the field than the greenhouse. The first thing to do when selecting seed is get a germination test prior to seeding it. There are lots of problems with stand failures (even if seed from last season) if you wait a year to plant the germination percentage can go down a lot. This is mainly due to genetics. Other crops have developed genetics to be sturdy and hardy seeds. This is not the case with industrial hemp genetics. Once a seed germinates it can tolerate higher temperatures and less favorable conditions. After planting, in 16-24 hours, radicals start to emerge. Seeded hemp seeds are more easily damaged than transplanted plugs. Immature genetic lines often lead to about to 30 percent die off within the first two weeks for no known reason.

Half an inch to an inch of water per week is needed at key times for this crop. Hemp requires between 10-15 inches of evenly spaced water in a crop year. While it is less than cotton, the timing is crucial. Due to the stress levels and plant adaptability in unfavorable environments, dryland is simply discouraged.

Once you start seeing weeds you could start working soil with cultivators. It is very important to stay ahead of the weeds. The first 30 days it is important to keep the weeds out. Palmer Amaranth or pig weed is a huge issue for both large-scale and small-scale growers. Most farmers are hand hoeing to keep the weeds out. Some are using mechanical weeders, but if it is too wet they cannot be used. According to growers, hemp likes nitrogen and has similar to 200 bushel corn fertilizer cost. Seed germination rates are least effected moving north than moving south. Thus, seed from Canada does not do as well in the United States as seed from the same latitude or from Southern latitude. (Furnish, 2019) It is better to go South to North with seed.

Currently there are no labeled herbicides, insecticides, or fungicides for industrial hemp.

Federal Hemp Policies

Most recognize the Agriculture Improvement Act of 2018 (2018 Farm Bill) as the piece of legislation that allowed farmers across the United States to begin legally growing industrial hemp. However, the Agricultural Act of 2014 (2014 Farm Bill) was actually the piece of legislation that allowed farmers to produce industrial hemp through state pilot programs. Furthermore, the 2014 Farm Bill (section 7606) authorized Departments of Agriculture in states that legalized hemp cultivation to create industrial hemp research pilot programs.

The 2018 Farm Bill changed federal policy concerning industrial hemp, including the removal of hemp from the Controlled Substances list and directing USDA Risk Management Agency (RMA) to develop crop insurance products for hemp. Hemp was such a large issue with the 2018 Farm Bill that the word “hemp” was mentioned seventy-two times in the final bill

(Congress, 115th, 2018). One of the law's major supporters was Senate Majority leader Mitch McConnell. Senator McConnell wrote on Twitter: "At a time when farm income is down and growers are struggling, industrial hemp is a bright spot of agriculture's future" (Tomashoff, 2019). The bill legalized hemp with specific restrictions and expanded the definition of industrial hemp from the 2014 Farm Bill (NCSL Energy, Environment, and Transportation, 2018).

Interest in industrial hemp had grown after the 2014 Farm Bill, setting the stage for legislative changes in the next farm bill. On December 20, 2018, President Trump signed into law the current farm bill, the Agricultural Improvement Act of 2018. Section 10113 of the 2018 Farm Bill provides for the cultivation, transport, and sale of hemp, a variety of Cannabis sativa that contains 0.3% tetrahydrocannabinol (THC) or less on a dry weight basis (Dunn, 2019). The law also expanded the definition of industrial hemp to the following:

> "The term hemp means the plant Cannabis sativa L. and any part of that plant, including the seeds thereof and all derivatives, extracts, cannabinoids, isomers, acids, salts, and salts of isomers, whether growing or not, with a delta-9 tetrahydrocannabinol concentration of not more than 0.3 percent on a dry weight basis." (Dunn, 2019)

A clearer understanding of the tie between the 2018 Farm Bill and industrial hemp is detailed below by Lowell Schiller of the U.S. Food and Drug Administration.

> In Section 7606 of the 2014 Farm Bill, states were given authority to implement laws allowing state departments of agriculture and universities to grow hemp for research or pilot programs. "The farm bill changed how cannabis is treated under the Controlled Substances Act (CSA)," says Lowell Schiller, U.S. Food and Drug

> Administration Associate Commissioner for Policy. "Among other things, this law removed a category of cannabis known as hemp from CSA's definition of marijuana, which means that hemp is no longer an illegal controlled substance under federal law. "The farm bill defines hemp as cannabis with no more than 0.3% by dry weight of the psychoactive compound delta-9-tetrahydrocannabinol, or THC. Cannabis plants and derivatives with higher THC content, including marijuana, are still under CSA" (Deering, et al., October 2019).

On October 31, 2019, the USDA Agricultural Marketing Service released an Interim Final Rule establishing the U.S. Domestic Hemp Production Program, also known as the Interim Final Rule with requests for comments, and the required provisions for USDA to approve submitted plans (Agricultural Marketing Service, U., October 2019). According to the Interim Final Rule, States and tribes must submit plans to USDA for approval before farmers in a state or tribe can begin production. The USDA framework for testing and sampling has been a point of contention for some hemp advocates.

While the specific details of how the USDA will regulate industrial hemp were yet to be made public as of the time of this publication, the 2018 Farm Bill does lay out the criteria that must be met by states and USDA for their industrial hemp plans. The following are the main components of the 2018 Farm Bill's language for USDA/state administered industrial hemp plans:

- Maintain the relevant information regarding the land on which hemp is produced;
- Develop a procedure for testing THC levels;
- Develop a procedure for disposal of:
  - Plants, whether growing or not, that are produced in violation;

  - Products derived from plants in violation;
- Develop a procedure to comply with enforcement procedures;
- Develop a procedure for conducting inspections of, at minimum, a random sample of hemp producers to verify that hemp is not produced in violation;
- Must license growers.

The Interim Final Rule has been under criticism. On January 30, 2020, the American Farm Bureau Federation (AFBF), the largest farm group in the U.S., released comments which summarize much of the industry's distrust (Nepveux, 2020). AFBF called for an increase in the legal THC level for industrial hemp to be raised from .03% to 1%. One of the other main concerns is with the rule calling for stricter THC testing than the 2018 farm bill. The Interim Final Rule kept the THC limit for industrial hemp at 0.3% with a 0.5% threshold for a "negligence" violation. The THC threshold (+/- .05) is a measurement of uncertainty. The term "measurement of uncertainty" is similar to a margin of error. Measurement of uncertainty means the actual THC concentration level is within the distribution or range when the reported THC concentration level is combined with the measurement of uncertainty. If a crop test result shows THC is beyond the measurement of uncertainty limit, the farmer is considered negligent and the crop must be destroyed. In the approved Texas Hemp Rules, destruction is at the license holder's expense which must be in accordance with DEA regulations and destruction will be without compensation (Texas Department of Agriculture, February 15, 2020).

There are several methods for testing the delta-9 THC concentrations in a hemp sample. The two most common are gas chromatography (GC) and high-performance liquid chromatography (HPLC) (Kight, 2019). HPLC testing reveals exactly the amount of delta-9 THC along with other cannabinoids, terpenes, and other molecules. THC-A as it undergoes a process of heating it experiences a chemical reaction called decarboxylation. However, the Interim Final Rule and Texas Department of Agriculture (TDA) Rules indicate the process of determining THC level by post-decarboxylation (Texas Department of Agriculture, February 2020). The term post-decarboxylation came from Congress in the 2018 Farm Bill. The term post-decarboxylation is not a scientific term and cannot objectively be determined. A test analyzing both THC and THC-A is looking at Total THC. As opposed to HPLC or decarboxylation, the GC testing method heats up a sample in order to separate out its constituent parts to measure them. The GC testing method creates the very molecule it is measuring. GC produces results with higher level of THC and an increased likelihood the sample will test "hot" (i.e. Delta-9 THC will exceed 0.3%) than HPLC (Kight, 2019).

The following excerpt is from the Oregon Industrial Hemp Farmers Association asking for growers to get involved politically:

> "While the 2018 Farm Bill defines hemp as 0.3% delta-9 THC, it also created a new testing standard that could change everything. The 2018 Farm Bill testing protocol calls for "post-decarboxylation or other similarly reliable methods". This would define hemp as 0.3% total THC instead of the current standard of delta-9 THC. Under a "total THC" testing standard, most CBD hemp genetics grown in the U.S. today would test above 0.3% total THC even though the delta-9 THC level is well below the 0.3% threshold meaning failed pre-harvest tests, noncompliance at maturity, and classification as Marijuana." (Oregon Industrial Hemp Farmers Association, 2019, July 27)

Furthermore, the Interim Final Rule requires testing of the flower which is the part of the plant with the highest THC content. The announcement also raises concern about the 15-day harvest time period. This time period includes THC sampling, testing, approval and harvest. The last concern raised by Farm Bureau is the limited number of DEA Testing labs. Figure 2.4 illustrates the reported DEA lab by state. Texas, the largest of the contiguous states, has 4 DEA laboratories. Finally, the Interim Final Rule requires the DEA or another authorized entity to handle and destroy crops that test too high in THC. This will most likely create high and costly burdens on farmers.

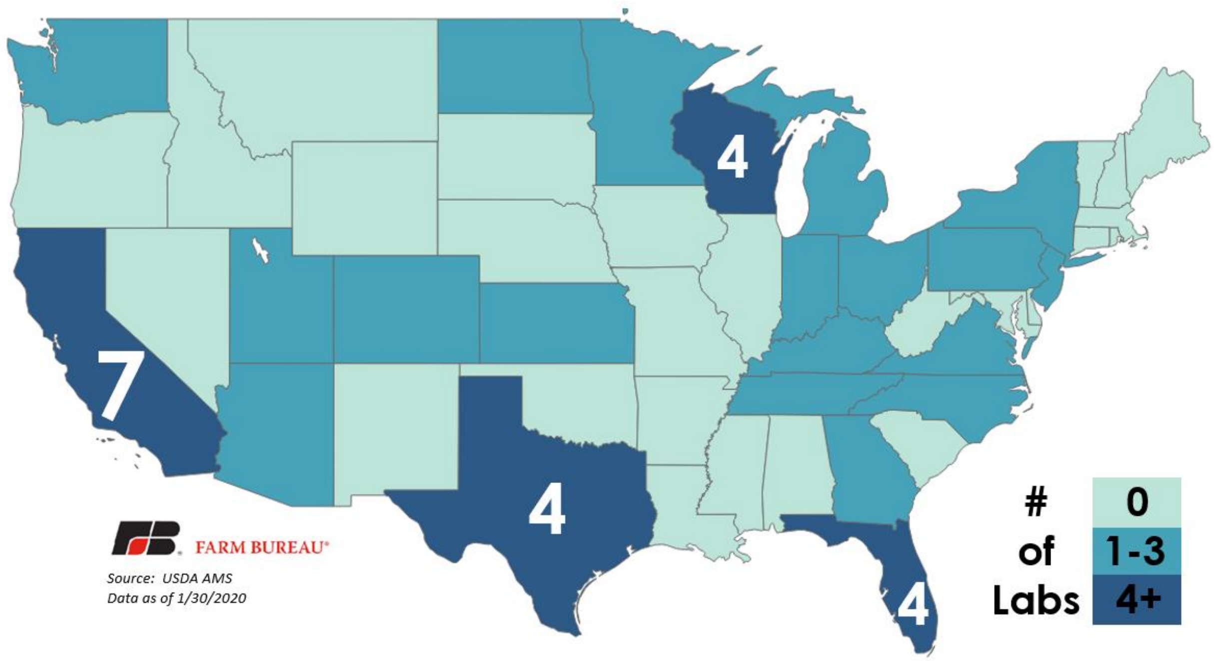

Figure 2.4 USDA Reported DEA labs by State: Adapted from Nepveux, 2020

Initially USDA released a 60-day public comment period (Agricultural Marketing Service, United States Department of Agriculture, October 2019) for the Interim Final Rule. On December 17, AMS announced it would be extending the public hearing period until January 29, 2020 (Agricultural Marketing Service, United States Department of Agriculture, December 2019).

On January 22, 2020, the Texas Department of Agriculture (TDA) held a public hearing on the Texas State Proposed Rule. Concerns were voiced from many Texans on a variety of issues surrounding the Texas State Proposed Rule. There are major concerns about the lack of DEA testing sites to process a massive influx of plant material to meet the 15-day harvest requirement. This issue becomes even more challenging because almost all farmers will be trying to get their samples tested at the same time. Sid Miller, Texas Commissioner of Agriculture, stated, "You have to take an official sample from an official licensed approved lab and get it tested for THC. Once that sample is pulled you have 15-days to harvest it. If you don't, you start over and you have to get another test and send it off. Looks like there is going to be plenty of labs available, I was a little worried about that. We (TDA) will not be pulling samples. You can contract with the lab or you can contract someone with the private sector, private industry to pull the samples. What we will do is we will do the training and certify those people that pull the samples." As indicated in Figure 1, the American Farm Bureau reports there are only 4 DEA certified labs in Texas (Nepveux, 2020). Other states such as Kentucky have state department officials come out to pull the samples (Sisk, 2019). The decision to not have TDA officials come out and sample puts more production risk on farmers. Other concerns from stakeholders include:

- the length of time from pulling sample to harvest (15-day day limit),
- the process by which THC level is tested, DEA certified labs must be recertified by TDA,
- having to certify every location seed can be stored including personal homes, and
- what rights it gives up as it includes "complete and unrestricted access", no industry standards (ex. TH % allowance, THC testing, CBD testing potency), short timeline to review applications and then approve lot permits for farms.

On January 27, 2020, USDA approved The Texas Hemp Plan (Agricultural Marketing Service, U., January 2020).

On February 19, 2020 the USDA Economic Research Service (ERS) released a study entitled, "Economic Viability of Industrial Hemp in the United States: A Review of State Pilot Programs" (Mark, et. el., February 2020). The study conducted the economic feasibility of Industrial Hemp based on state pilot programs which were started through the 2014 Farm Bill. The study states, "under the pilot programs, United States industrial hemp acreage reported by States increased from zero in 2013 to over 90,000 acres in 2018, the largest U.S. hemp acreage since the 146,200 acres planted in 1943." Currently, states with the largest hemp acreage are not leading producers of major field crops such as corn, soybeans, wheat, and cotton. "Switching from established field crops into a new minor crop like hemp is unlikely in the short run because of the difficulty of achieving economies of scale for input supplies, harvesting and planting equipment, and processing," said the report. "Specialty and minor crops are often agronomically suited to a limited geographic area or economically viable in only a few states."

This study also confirmed the need for basic data and information needed for decision-making and validated the inaccessibility. The limited objective information on regulatory issues and status and economic transparency has created continued challenges for decision makers or farmers. This study also outlined the relevant sections of the 2018 Farm Bill impacting the industrial hemp industry. It also graphically explained many country's (Canada, China, Europe, and Other) imports of raw hemp and process hemp between 1991 through September of 2019. However, none of the graphs depict the import of CBD oil into the United States which is currently the most viable market in the United States. This oversight does not provide hemp farmers with a clear picture about the global marketplace for the key product most farmers will be obtaining contracts.

Texas Hemp Policies

The 2018 Farm Bill legalized the commercial production of hemp and authorized states to submit state plans to administer hemp programs. On June 10, 2019, House Bill 1325 was signed into law by Texas Governor Greg Abbott. House Bill 1325 authorizes the production, manufacture, retail sale, and inspection of industrial hemp crops and products in Texas. This also includes products for consumable hemp products which contain cannabidiol (CBD), as well as other edible parts of the hemp plant.

Industrial hemp has garnered numerous headlines and attention. Successful Farming, an agriculture news website geared toward farmers, recently published a list of the Top 3 Most Read Articles of 2019, and all were focused around hemp. These articles were entitled: “What Farmers Need to Know About Growing Hemp;” “10 Common Questions About Hemp Farming;” and “Growing Hemp.” In Texas, interest in hemp increased rapidly after the passage of state legislation in June 2019, paving the way for the legalization of the crop. It is assumed that Texas will allow legal hemp production and processing beginning with the 2020 crop year. As of March 16, 2020, Texas Department of Agriculture opened up the online process for hemp growing license and permit application (Texas Department of Agriculture, March 2020). Farmers are expecting to make big investment decisions and there needs to be more reliable information available. The newness of the crop in the United States, and particularly to Texas, leaves many unknowns and magnifies the need for education on this industry.

Overall Hemp Industry

The industrial hemp industry is developing at a startling rate. There is very little government reported data on hemp cultivation and production. Traditionally one would not see Vote Hemp, a commodity advocacy organization, as a reliable source for planting and harvest data. However, the use of Vote Hemp as a reliable source by USDA for the interim rule demonstrates the limited nature of the data (Agricultural Marketing Service, 2019). Vote Hemp estimates over 511,442 acres were in industrial hemp production for 2019 season. This number is a 455% over 2018 licensed acreage. From their estimates and research, they predict 230,000 acres of the approved number will actually be planted. Of the planted acres, Vote Hemp predicts 50-60% of the 2019 crop which is planted will actually be harvested due to crop failure, non-compliant crops and other factors. Table 2.1 indicates hemp acreage has increased dramatically.

Table 2.1 State-Level Licensed Hemp Acreage: Adapted from Sterns, 2019

State	2017	2018	2019[a]
Colorado	12,042	21,578	80,000
Kentucky	12,800	16,100	58,000
Oregon	3,500	7,808	51,313
Montana	542	22,000	40,000
Tennessee	718	3,338	37,416
Wisconsin	0	1,850	16,100
North Carolina	1,930	3,184	11,572
Nevada	490	1,881	9,145
New York	2,000	2,240	5,000
North Dakota	3,100	2,778	2,175
Total	37,122	82,757	310,721

[a]2019 data are estimates, as of July 2, 2019.
Source: Hemp Industry Daily (2019), Cowee and Nichols (2019), and Nichols (2018).

PanXchange gathers data from industry stakeholders to develop a cash market price by state (PanXchange, 2020). It should be noted that PanXchangec collects pricing information via the PanXchange trading platform. It surveys market participants and does not allow participation from speculators or brokerage firms. Drastic cash market changes and an oversupply of hemp in the market without a contract has incentivized processors to not fulfill contracts and instead buy cheaper CBD biomass from producers without contracts at lower prices. Figure 2.5 below shows the midpoint biomass spot price trend among Colorado, Kentucky, and Oregon similarly over 2019.

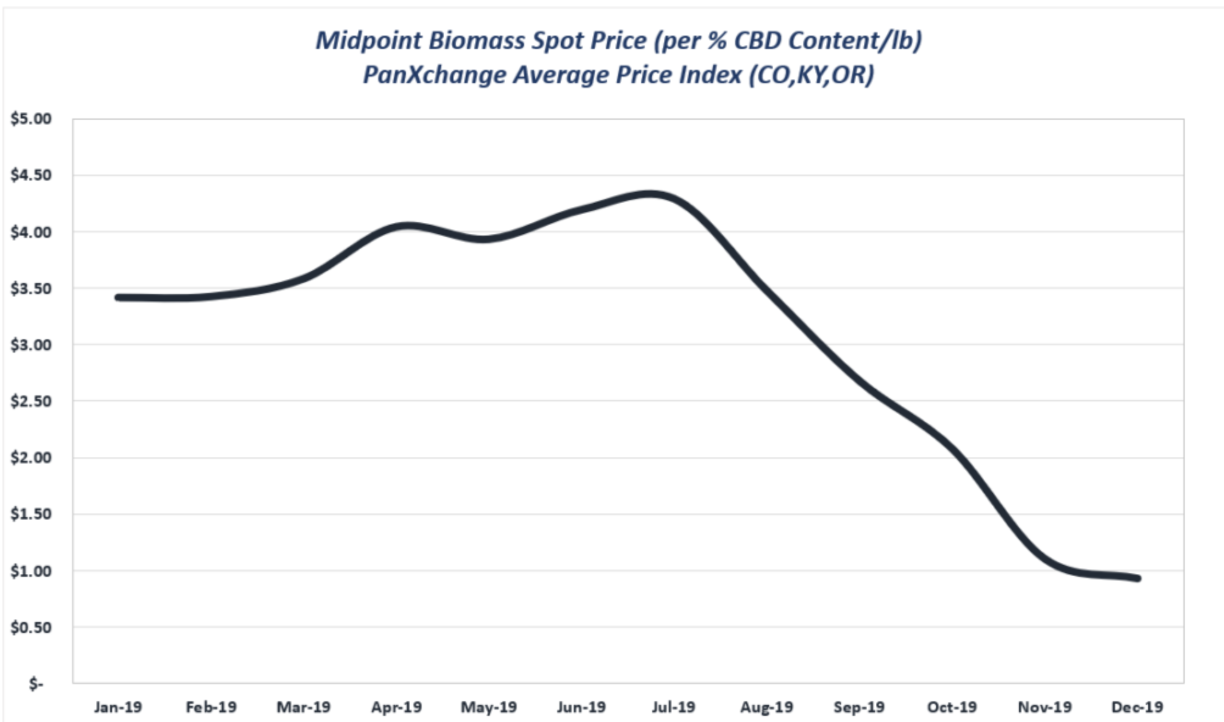

Figure 2.5 Midpoint Biomass Spot Price (per % CBD Content/lb) PanXchange Average Price Index: Reprinted from PanXchange, Inc., 2020

Per figure 2.6 January 2019, the CBD biomass per percentage point average cash price in Kentucky was $3.50, Colorado was $2.75, and Oregon was $4.00.

Biomass Spot Pricing - January 2019			
Region	Midpoint	Low	High
Colorado (per %)	$ 2.75	$ 2.50	$ 3.25
Kentucky (per %)	$ 3.50	$ 3.00	$ 4.00
Oregon (per %)	$ 4.00	$ 3.50	$ 4.50
Crude Spot Pricing - January 2019			
Region	Midpoint	Low	High
Colorado Winterized (per kg)	$ 6,250	$ 2,500	$ 10,000
Colorado Non-Winterized (per kg)	$ 2,950	$ 1,500	$ 4,400

Figure 2.6 Biomass Spot Pricing - January 2019: Reprinted from PanXchange, Inc., 2020

The following three figures in 2.7, 2.8, and 2.9 which show the progression of price falling around harvest.

Biomass Spot Pricing - November 2019 Source: PanXchange				
Region	Midpoint	▲	Low	High
Colorado (per % CBD Content/lb.)	$ 1.14	-47%	$ 0.93	$ 1.35
Kentucky (per % CBD Content/lb.)	$ 1.03	-53%	$ 0.80	$ 1.25
Oregon (per % CBD Content/lb.)	$ 1.13	-45%	$ 0.85	$ 1.40

Figure 2.7 Biomass Spot Pricing - November 2019: Reprinted from PanXchange, Inc., 2020

Figure 2.8 demonstrates spot price by December 2019 the CBD biomass per percentage point cash market price had fallen to an average of $0.98 in Kentucky, $0.95 in Colorado, and $0.85 in Oregon.

Biomass Spot Pricing - December 2019 *Source: PanXchange*				
Region	**Midpoint**	**▲**	**Low**	**High**
Colorado (per % CBD Content/lb.)	$ 0.98	-14%	$ 0.75	$ 1.20
Kentucky (per % CBD Content/lb.)	$ 0.95	-7%	$ 0.85	$ 1.05
Oregon (per % CBD Content/lb.)	$ 0.85	-24%	$ 0.60	$ 1.10
Refined Product Pricing - December 2019				
Product	**Midpoint**	**▲**	**Low**	**High**
Colorado Winterized Crude (per kg.)	$ 800	-22%	$ 600	$ 1,000
Colorado Full Spectrum Distillate (per kg.)	$ 2,200	-15%	$ 1,900	$ 2,500
Colorado Broad Spectrum Distillate (per kg.)	$ 4,050	-9%	$ 3,400	$ 4,700
Colorado Isolate (per kg.)	$ 2,250	-6%	$ 1,700	$ 2,800

Source: PanXchange, Inc.

Figure 2.8 Biomass Spot Pricing - December 2019: Reprinted from PanXchange, Inc., 2020

Prices continued to fall at the beginning of 2020 per Figure 2.11.

Biomass Spot Pricing - January 2020 *Source: PanXchange*				
Region	**Midpoint**	**▲**	**Low**	**High**
Colorado (per % CBD Content/lb.)	$ 0.72	-26%	$ 0.55	$ 0.89
Kentucky (per % CBD Content/lb.)	$ 0.74	-23%	$ 0.57	$ 0.90
Oregon (per % CBD Content/lb.)	$ 0.70	-18%	$ 0.50	$ 0.90
Northeast (per % CBD Content/lb.)	$ 0.73		$ 0.65	$ 0.80
Great Plains (per % CBD Content/lb.)	$ 0.62		$ 0.50	$ 0.74
Refined Product Pricing - January 2020				
Product	**Midpoint**	**▲**	**Low**	**High**
Colorado Winterized Crude (per kg.)	$ 550	-31%	$ 400	$ 700
Colorado Full Spectrum Distillate (per kg.)	$ 1,725	-22%	$ 1,250	$ 2,200
Colorado Broad Spectrum Distillate (per kg.)	$ 3,200	-21%	$ 2,400	$ 4,000
Colorado Isolate (per kg.)	$ 1,925	-14%	$ 1,400	$ 2,450

Source: PanXchange, Inc.

Figure 2.9 Biomass Spot Pricing - January 2020: Reprinted from PanXchange, Inc., 2020

Figures 2.6, 2.7 2.8, and 2.9 show the same price trend presented in Figure 2.5. Hemp benchmarks is another source for price data. This site works to develop a hemp spot price index (Hemp Benchmarks, 2020). This site is an independent Price Reporting Agency (PRA) and tries to be an unbiased source of wholesale market data. The site is a free information source of marketplace prices as opposed to other hemp information websites. Their goal is to create a fair and balanced hemp marketplace. Contributors to the pricing network must be validated and are assumed to be an industry stakeholder either in a form of a cultivator, seed producer, or hemp processor. The reported prices are voluntary information. Post-harvest prices have also declined over the past few months on Hemp Benchmarks. From November 2019 (Figure 2.10) and January 2020 (Figure 2.11), CBD biomass between 25K-100K changed from an assessed price of $1.79 to $1.31 each a % per CBD per pound in two months. This is a 36.6% decrease in two months. One might also notice the cost of industrial seeds, clones, and feminized seeds has stayed relatively the same over this same time period. Of course, the change in the market does not take into account the prices farmers contracted at the beginning of the season. Prices at the beginning of the season in Kentucky and Oregon were around $4 a % per CBD per pound, which is a price decline of -205.3%.

U.S. Region Products	Units	Assessed Price	Low	High
CBD Biomass (0-25k pounds)	$ / %CBD / pound	$1.81	$0.55	$2.90
CBD Biomass (25k-100k pounds)	$ / %CBD / pound	$1.79	$0.70	$2.70
CBD Biomass (100k-1M pounds)	$ / %CBD / pound	$1.73	$0.65	$2.50
CBD Biomass (1M+ pounds)	$ / %CBD / pound	$1.40	$0.75	$1.92
CBG Biomass	$ / %CBD / pound	$21.36	$13.15	$27.50
CBD Flower (Bulk)	$ / pound	$274	$60	$550
Clones	$ each	$4.44	$2.50	$5.50
Industrial Seeds	$ / pound	$4.57	$1.85	$10.84
CBD Seeds (Non-Feminized)	$ / pound	$2,360	$2,000	$2,500
CBD Seeds (Feminized)	$ each	$1.00	$0.60	$1.55
Crude Hemp Oil	$ / kilo	$936	$550	$1,483
Refined Hemp Oil	$ / kilo	$3,380	$1,600	$5,350
Distillate - THC Free	$ / kilo	$3,962	$2,850	$5,350
Distillate - Broad Spectrum	$ / kilo	$3,415	$2,500	$5,000
Distillate - Full Spectrum	$ / kilo	$2,920	$1,600	$5,000
CBD Isolate	$ / kilo	$2,437	$1,400	$4,000

Figure 2.10 Hemp Benchmarks November 2019 Prices: Adapted from Hemp Benchmarks, 2020

U.S. Region Products	Units	Assessed Price	Low	High
CBD Biomass (Aggregate)	$ / % CBD / pound	$1.00	$0.40	$2.50
CBD Biomass (0 - 25K pounds)	$ / % CBD / pound	$1.31	$0.70	$2.50
CBD Biomass (25K - 100K pounds)	$ / % CBD / pound	$1.14	$0.65	$1.75
CBD Biomass (100K - 1M pounds)	$ / % CBD / pound	$1.01	$0.60	$1.30
CBD Biomass (1M+ pounds)	$ / % CBD / pound	$0.55	$0.40	$0.75
CBG Biomass	$ / % CBG / pound	$14.80	$10.00	$20.00
CBD Flower (Bulk)	$ / pound	$226	$63	$675
CBD Clones	$ / each	$4.25	$3.00	$6.00
Industrial Seeds	$ / pound	$4.57	$3.72	$8.00
CBD Seeds (Non-Feminized)	$ / pound	$1,435	$475	$4,000
CBD Seeds (Feminized)	$ / seed	$0.93	$0.40	$1.25
Crude Hemp Oil	$ / kilogram	$668	$325	$1,200
Refined Hemp Oil (Aggregate)	$ / kilogram	$2,528	$750	$5,273
Distillate - THC Free	$ / kilogram	$3,120	$2,000	$5,273
Distillate - Broad Spectrum	$ / kilogram	$2,858	$1,400	$3,954
Distillate - Full Spectrum	$ / kilogram	$1,791	$750	$2,640
CBD Isolate	$ / kilogram	$1,624	$1,100	$4,000

Figure 2.11 Hemp Benchmarks January 2020 Prices: Adapted from Hemp Benchmarks, 2020

Contracts

Contracts have existed since the inception of the industrial hemp industry as we know it today. Most hemp is grown under contract with a processor (seed, CBD, or fiber). Producers wanting to grow hemp will have to make sure that they are comfortable with the contracts provided by the processors. It is recommended that a producer retain a lawyer to look over the contract before signing. As with any new business, there has been a number of new entrants to the industry. There have been numerous stories of processors going out of business or not having the money to pay their producers who are under contract. Currently, this is one of the biggest risks associated with growing industrial hemp. In discussions with farmers that are already growing hemp, all have suggested new producers should vet the processor very well before entering into a contract. It is recommended that producers actually physically visit the processing facility before signing a contract. Producers are going to want to have as many safeguards in their contracts to make sure that they get paid for the crop they grow.

Thus far, contracts have either paid a price per % CBD, lb of grain, or lb of fiber or the contract could mean that the processor takes a certain amount of the end product in exchange for processing(this is often called a 50/50 split). Processors have dictated price, delivery terms, pound requirements, production practices, and much more to farmers. As processors design the contracts, they place most of the production risks on producers (Sisk, 2019). Processors make the contracts to favor themselves rather than the farmer (Lax, 2020). In agriculture we know when there is an oversupply of a good, processors tend to become selective on the quality and quantity they choose to make payment. In some instances, where processors allegedly falsified results from quality tests so they could reject material that was contracted at a price higher than current market prices (Mulliken, 2020)(Lax, 2020).

While these farmers have followed their contracts to the letter, the market dropped significantly and there is an oversupply of hemp. Thus, the processor could buy hemp from other sources at a lower price than what they contracted at the beginning of the season. Some hemp companies have been known to put a non-disclosure agreement in the contract to forbid a farmer from speaking to others or contacting media outlets (Lax, 2020). This provision puts farmers in the position not able to speak out about fraud or unfulfilled contracts. The fear of some farmers is that while bad actors have been able to take advantage of farmers in states with more experience, the same investors can locate in new production states and take advantage of farmers new to the hemp industry.

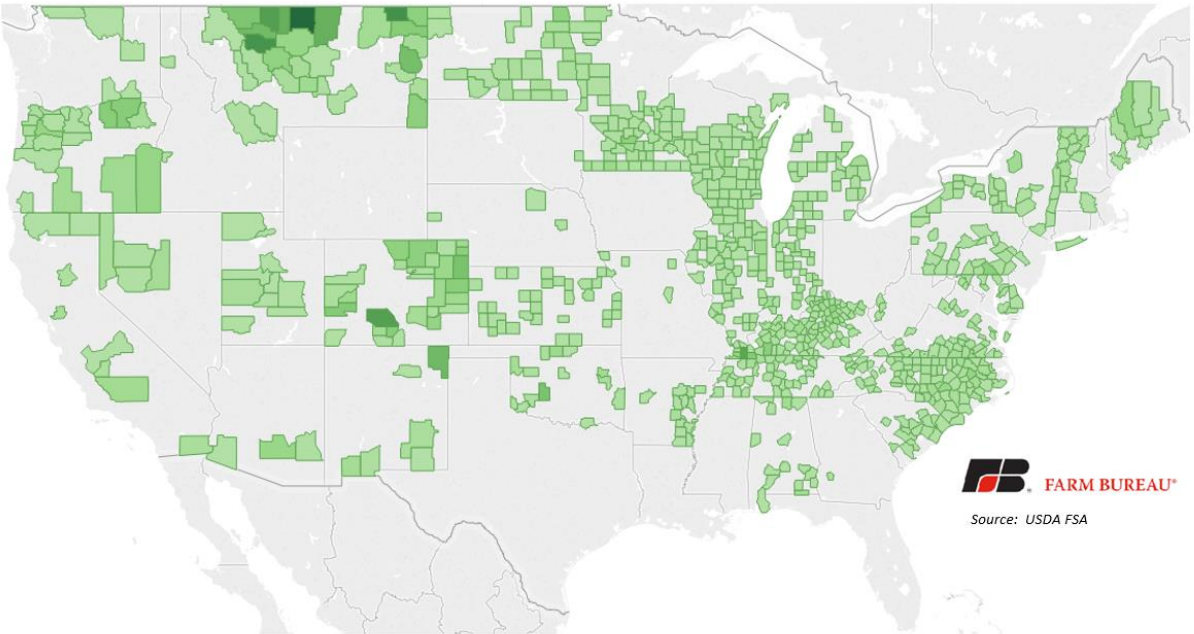

Figure 2.12 2019 USDA FSA Reported Hemp Acreage by County: Adapted from Nepveux, Michael from American Farm Bureau Federation, 2019

Lax works with many adult farmers in Calloway County, Kentucky. Calloway County is the only county in the state that is the darker shaded green (meaning more acres in hemp production) in Figure 2.12. Lax has seen many farmers take on tremendous risk by growing hemp since 2014 when Kentucky started with the State Pilot Program. Tim Lax says, "a few people are sort of going to make it (break-even), but most won't. If I had to guess I would say close to 1% of the farmers around here will actually be paid what they were promised by contract" (Lax, 2020). The biggest problem in Calloway County is the processor paying, not the process of being able to grow it; he went on to express, from his experience, those with contracts with smaller extractors are less likely to be paid. He says there are many, many fence rows in the county that are lined with storage bags of hemp and all of the growers he knows have a contract without a place for the hemp to go.

GenCanna is a leading hemp processor in Kentucky. At Farm Journal Hemp College in Iowa, Steve Bevan, the President and Executive Chair of GenCanna, sat on a panel and discussed their business operations. He said they currently have 40 million plants in the ground (Bevan, 2019). Forty million plants sums to over 70,000 acres. To put that into prospective, Canadian Hemp Trade Alliance (CHTA) predicted Canada to grow 50,000 acres in 2018 (Nicholason, 2019). As of February 6, 2020, GenCanna filed for Chapter 11 Bankruptcy (Schreiner, 2020).

Commonwealth Alternative Medicinal Options or CAMO, closed as of February 17, 2020 (Tierney, 2020). The CBD processing company was a major contractor near New Stanton, Pennsylvania. The company planned to expand production to 300 acres in 2019 from just 50 acres in 2018 (Hemp Industry Daily, February 2020). For perspective, in 2019 Pennsylvania hemp growers grew 4,000 acres. This means that CAMO contracted about 1 of every 8 Pennsylvania hemp acres. The company blamed the 75% price decrease in finished products for the collapse. The article went on to explain the supply increase far surpassed the demand for CBD. At least some, if not all hemp growers with contracts with CAMO are sitting on their product and are in need of another market outlet.

Some of the contracts have built in mechanisms to get out of payment on the part of the processor. It is critical that farmers have contracts looked at by a lawyer (Sisk, 2019). With many processors there are post-harvest discounts that can reduce the final price. For example, at Victory Hemp, which is a grain processor, if hemp does not come in at the correct moisture level a farmer must pay $.12 a percent to dry it (Victory Hemp, 2019). This is a common practice in feed grain production, for the farmer to pay an addition fee for drying. If Victory Hemp has to remove dust it costs $.06 a pound to clean it. There can also be a fee to store the hemp if the processor is not ready to process it yet.

Crop Insurance

Crop insurance provides protection from various types of loss for farmers of over 100 U.S. crops. Farmers have come to rely on indemnity payments being issued for a variety of causes of loss ranging from drought to flooding. Growing industrial hemp is not without production risk. This is especially true if the crop in grown in open fields, rather than greenhouse production. Like most plants, industrial hemp is susceptible to wind and hail, especially when it is young. As with most crops, dry conditions can be detrimental to plant size and yield. Thus, there is a need to protect the producer's investment in the growing crop.

The 2018 Farm Bill addressed this need and made industrial hemp eligible for federal crop insurance. It will likely take a few years before industrial hemp's breath of crop insurance products match those of other insured commodities. However, starting with the 2020 crop year, a Whole-Farm Revenue Protection (WFRP) policy will be available to industrial hemp growers nationwide (including Texas). Additionally, some private companies are selling a yield policy on hemp. AgriLogic a crop insurance development firm was tasked with developing the inaugural U.S. hemp insurance product. Traditional yield coverage insurance is available where pilot programs have been in place for a number of years. Unfortunately, Texas has not had a pilot industrial hemp program and growers in Texas are likely to be limited in their crop insurance choices for the 2020 crop year.

WFRP has an insurance liability cap of $8.5 million. Aspects of the WFRP eligibility include: growers complying with applicable state, tribal, or federal regulations, have a contract for purchase for the insured industrial hemp. Also, hemp that tests above the allowable level of THC is not an insurable loss. (Risk Management Agency, 2019)

Crop insurance is a major component of the producer safety net from the standpoint of covering production risk. The variability of the output price markets, concern about genetics, and general production uncertainties makes it difficult to insure. Whole-Farm Revenue Protection is available for hemp growers across the country (Risk Management Agency, 2019). Coverage will not be protected against the crop testing above the THC limit, white mold, quality deficiencies, not following the contract of processor, or poor genetics. The new 2020 coverage should assist farmers minimally for price risk and not for all production risks. The reality for producers is reliable coverage is coming, but it is not here yet, especially for Texans.

Recent Publications

In 2013, the University of Kentucky did a study on the estimated cost of production without having much production experience to base upon (Robbins, et. al., 2013). In 2015, there was a study of 10 hemp seed operations in Alberta, Canada (Laate, et.al., 2015). The University of Kentucky has published budgets based on 2016 survey data. Clemson has been working on a project to develop budgets from 2018 pilot program data (Smith, 2018). Clemson budgets have yet to be released as of January of 2020.

The following is from the study mentioned above in Alberta, Canada:

> Total production costs for hemp seed grown on dryland was estimated at $409 per acre or $0.38 per pound of hemp seed produced. Of this, approximately 75 per cent were variable costs and the remaining 25 per cent were capital or fixed costs. The corresponding costs for hemp seed grown on irrigated land was estimated at $574 per acre or $0.34 per pound. Of this, approximately 71 per cent were variable costs and the remaining 29 per cent were capital or fixed costs (Laate, et al., 2015).

The University of Kentucky released an economic impact paper that provided a significant amount of history and discussed the current status of hemp production (Robbins, et al., July 2013). Due to the CBD market in the U.S. being in its infancy, it was solely focused on seed, fiber, and a combination budget which would include cropping either for seed or fiber and selling the byproduct of the nonprimary crop. The paper did mention economic data and publications from already developed industrial hemp markets in Australia, Europe, and Canada. One of the most under researched areas of industrial hemp is labor. For these three production systems, labor costs were assumed to be covered by using custom machinery rates (Robbins, et al., July 2013).

An article written by Fortenbery and Bennett gives an overview of the subject. It says "The key to the long-term success of commercial hemp production appears to lie with the development of improved harvesting and processing technologies. The current technologies relative to harvesting, transporting, and processing hemp are quite labor intensive, and result in relatively high per unit production and processing" (Fortenbery & Bennett, 2001).

Enterprise Budgets

The term "enterprise budget" is used to describe an organization of revenue, expenses, and profit for a single enterprise typically based on some production input unit (Smith, et al., 2000). Each type of crop or livestock that can be grown is considered an enterprise (Kay, 1981). Enterprise budgets can be created for different levels or types of production or uses of technology, thus there can be more than one budget for a given enterprise. Complete enterprise budgets include costs that will be incurred only if this livestock or crop is produced. These include but are not limited to: operating and variable costs such as seed, fuel, machinery repairs, labor, land charge, and miscellaneous overhead (Kay, 1994).

The goal of an enterprise budget is to track all sources of income and expenses allocated to each enterprise (Minear, 1991). After an enterprise budget is complete, a manager can eliminate enterprises that in accounting terms generate inferior results and replace them with alternative enterprises should they become available. It is also used to look into alternative enterprises to analyze their viability.

Recent Enterprise Budget Publications

A USDA Agriculture Research Service (ARS) and Economic Research Service (ERS) publication, "Industrial Hemp and other Alternative Crops for Small-Scale Tobacco Producers" indicated there are few estimates available for modern production and processing costs (USDA, 1995). There have been several universities that have since released partial industrial hemp budgets including the University of Kentucky (Mark & Shepherd, 2019), the University of Tennessee (Cui & Smith, May 2019), North Dakota State University (Ripplinger, 2019), and the University of Missouri (Massey & Morrison, 2019).

The publication released from the University of Tennessee was solely for CBD production on a plasticulture production system for 1-acre of production. The budget does note there is significant variability in many areas from plant spacing to labor hours and to other input costs in the production of industrial hemp for extract (Cui & Smith, May 2019). Many farmers have moved away from this form of production.

In October of 2019, Missouri released hemp for grain and fiber budgets (Massey & Morrison, 2019). They released a budget generator spreadsheet and a paper explaining their budget. The budget in the paper is for a dual crop production system for both grain and fiber on a 40 acre field. The handout did make a disclaimer that the budgets were created from Kentucky, Tennessee, and North Dakota budgets and thus the numbers may not fit for Missouri production. There is a limited sensitivity analysis at the end of the publication.

North Dakota Budgets are the only hemp enterprise budgets out of the western United States (Ripplinger, 2019). The budgets are the most limited of the industrial hemp budgets. The budgets are labeled as Hemp Fiber and Hemp Oil. There are very few considerations included in the enterprise budget and exclude many production costs. The budget labeled Hemp Oil means hemp oil which is not CBD, but a derivative from the hemp hearts (Victory Hemp, 2019). The North Dakota Budgets do not clearly define if it is per field or per acre. Costs are allocated per ton, but do not indicate how many tons per acre. Hemp oil is also very vague; it is about a liquid unit but results in cost per pound instead of gallons.

Industrial Hemp Budgets released in 2019 by The University of Kentucky have been the most referenced and referred to budgets released. The USDA interim rule cited them. These enterprise budgets include: Hemp Grain, Hemp Fiber, CBD Row Crop Grain Harvested, CBD Row Crop No Grain, CBD Tobacco Model, and CBD Plasticulture. However, these budgets do not account for labor or equipment costs (Mark & Shepherd, 2019).

Simetar

Market and production risk will be incorporated using the *Simetar* add-in to Excel (Richardson, 2008). *Simetar* uses Latin Hypercube to simulate 500 iterations using a random number seed of 31517. Latin Hypercube is used opposed to Monte Carlo simulation, because Latin Hypercube draws random values using a systematic approach, sampling all regions of the probability distribution. *Simetar* calculates values for mean, standard deviation, covariance, minimum, and maximum of the 500 iterations for each of the key output variables, as well as a list of the 500 iterations.

The methodology of this study relies on the use of simulation using the excel add-in *Simetar*. In 2010, Isaac Olvera used *Simetar* to assess the economic implications of weight-based mediation in cattle (Olvera, 2010). More recently, *Simetar* was used to evaluate the Conservation Reserve Program (Bendavidez, 2016). This research will use *Simetar* to incorporate risk in the enterprise budgets.

There are parametric and non-parametric distributions (Richardson, 2008) (Maisashvili, 2019). Parametric distributions are fixed form and shape dependent on parameters. There are four major types of Parametric Distributions one might choose to use which are uniform, normal, beta and Bernoulli. Non-Parametric Probability Distributions are not a fixed form that is parameter dependent. Due to the variability, limited data, and constant change in this market this paper will assess risk using a Non-Parametric Probability Distribution. There are three key types of parameter dependent variables which are discrete uniform, empirical, and GRKS. The GRKS distribution was created to simulate random variables with limited data which means usually 10 or less observations. For GRKS parameters of minimum, middle, and maximum are generally set based on expert opinion and limited data. *Simetar* has a feature which simulates GRKS distributions. *Simetar* will be utilized in the risk analysis part of the analysis. This paper will make an enterprise budget to simulate cash flow, use GRKS to simulate risk, and then analyze the results.

This paper will assess the profitability of industrial hemp production in Texas. There are a few ways to look at profitability (Kay, 1981). The change in profit position should be considered in relationship to other changes in the firm (Barry, et al., 1988). Kay addresses the ways to analyze profitability as Net Farm Income, Return to Labor and Management, Return to Management, Rate of Return to Capital, and Rate or Return to Equity. Rational farmers would assess a new enterprise by looking at a net farm income. In this enterprise budget a farmer is looking at diversifying to take on a new avenue of revenue. Thus, management and equipment costs are not the primary point of interest, instead it is does this new enterprise make revenue.

Expansions and Limitations

Learning to grow a new crop alternative without a potential buyer and no expectations of profits is not realistic in the current economic environment. Despite the controversy surrounding this crop, industrial hemp might prove to be a dependable alternative for producers. Producers across Texas and the United States will benefit from the results of this study when completed. This research will be particularly useful to Extension educators tasked with providing economic information on the production of industrial hemp. The primary limitation of this research is that to-date hemp is not being grown in Texas under Texas growing conditions and soil types.

A recent study released from Cornell found genetics to be the key determinant of whether or not hemp will test hot that is above the THC legal ceiling (Toth, Jacob A., et al., 2020). The same study indicates that cannabis plants can have two CBD genes, two THC genes, or a gene of each gene that is CBD and THC. This new research gives the grower more information about what could affect a plant. Previously, it was thought that soil, plant stress, outside temperature, and other environmental elements had a larger influence on THC than genetics. Due to this new information, a logical hemp grower would lessen production risk of plants going hot by selecting plants with two CBD-producing genes. It should also be noted that while this research was being completed, the team also found that as many as two-thirds of the seeds they acquired of one hemp variety – which were all thought to be low-THC hemp – produced THC above legal limits.

Future Concerns and Issues

Currently the main production concerns have to do with the processing bottleneck and whether processor will pay for the plant material they contracted for. Basically, the processors have a time extensive process to take the harvested crop from the field to final product (Davies, 2019). Bob Hellman of Labyrinth Xtracts predicts there is not going to be enough processing for the 2019 hemp harvest and processing season (Davies, October 2019). He says at their extraction facility they are booked a year out and the bottleneck challenge is being faced everywhere.

Hellman says full-spectrum CBD oil, so called because it has a full range of cannabinoids, was selling a year ago for about $6,000 per liter, even reaching as high as $8,000 per liter. As of October 2019, the price was around $2,600 per liter. Due to the fall in prices, another hemp extraction facility, Delta Separations, in California predicts 90% of the hemp crop grown will not be processed. This would cost growers about $7.5 Billion in CBD lost sales. While Vote Hemp President, Eric Steenstra, finds the 90% to be quite high, he still estimates that only about 50 to 60% of hemp planted in 2019 will be harvested. An optimistic outlook holds the hope that in 2020 processors could get through the remaining unprocessed hemp, provided, of course, it's properly stored.

From seeing other commodity markets develop, farmers across the country grow specific crops that give them a comparative advantage. A comparative advantage means a crop can be grown in only limited areas because of specific soil and climate requirements (Kay, 1981). For example, corn and beans are predominately grown in the Midwest, livestock stockers are in the west. tobacco is grown in the North Carolina and Kentucky, etc. Due to there being three main reasons to grow hemp, one could guess as this market develops the different objectives will go toward areas of the country that give the comparative advantage.

As with any product there is concern of once the processing has caught up with farmer harvest, there will be an oversupply. In other words, the supply is above that which is demanded from consumers. Due to the processing bottleneck previously mentioned, it is currently unclear how large the demand will be.

There are no standards in the current marketplace. FDA is not regulating the CBD products sold on the market. There are no checks that products contain what they say they do. There is a myriad of ways farmers are growing hemp and harvesting it. There needs to be a more standards and consistency in the hemp industry for big companies to want to take part (Newhart, February 2020). This benchmark will be crucial for the market to fully develop. Standardization to open up other stability for markets and bigger companies.

> "As we work quickly to further clarify our regulatory approach for products containing cannabis and cannabis-derived compounds like CBD, we'll continue to monitor the marketplace and take action as needed against companies that violate the law in ways that raise a variety of public health concerns. In line with our mission to protect the public, foster innovation and promote consumer confidence, this overarching approach regarding CBD is the same as FDA would take for any other substance that we regulate," FDA principal deputy commissioner Dr. Amy Abernethy said. "We remain concerned that some people wrongly think that the myriad of CBD products on the market, many of which are illegal, have been evaluated by FDA and determined to be safe, or that trying CBD 'can't hurt.' Aside from one prescription drug approved to treat two pediatric epilepsy

> disorders, these products have not been approved by FDA, and we want to be clear that a number of questions remain regarding CBD's safety – including reports of products containing contaminants, such as pesticides and heavy metals – and there are real risks that need to be considered. We recognize the significant public interest in CBD, and we must work together with stakeholders and industry to fill in the knowledge gaps about the science, safety and quality of many of these products." (Feedstuffs, November 25, 2019)

In the report released on November of 2019 the United States Food and Drug Administration announced it "cannot conclude that CBD (cannabidiol) is generally recognized as safe among qualified experts for its use in human or animal food" because of a lack of scientific evidence (U.S. Food and Drug Administration, November 2019). "We remain concerned that some people wrongly think that the myriad CBD products on the market, many of which are illegal, have been evaluated by the FDA and determined to be safe, or that trying CBD 'can't hurt'…there are real risks that need to be considered," said Amy Abernethy, principal deputy FDA commissioner. "We recognize the significant public interest in CBD and we must work together with stakeholders and industry to fill in the knowledge gaps about the science, safety, and quality of many of these products." Under FDA rule CBD is still illegal as an ingredient. The only form of punishment the FDA has pursued so far is a few 'sternly worded' letters and an occasional occurrence of products being pulled from shelves (Newhart, 2020).

CHAPTER III

DATA AND METHODOLOGY

Hemp is a relatively new crop in the United States and is also a rapidly changing industry. There are very few detailed enterprise budgets for producers to use in decision-making. As mentioned in the Literature Review, there is a limited amount of reliable research available. Academic economists in the United States have not completed a recent or complete industrial hemp budget with labor and equipment costs. Some industry related sales sites have developed their own estimates, however, there is concern about a bias, accuracy and reliability. Due to there being limited data from government or university sources, websites supposedly having accurate information have emerged. Just in the last year, the Vote Hemp website has started asking for a $50 donation to acquire a full report listing of licensed acreage by state. Prior to that, the site was completely free with no fee to access information.

The budgets will be created from the limited available research on the hemp industry and also with information obtained from educational venues including:

- Attending Farm Journal Hemp Colleges in Kentucky, Iowa and Nevada where current producers, processors and industry representatives provided their perspective and information on the industry;
- Touring hemp operations in Colorado and Kentucky and learning from actual hemp producers;
- Attending the University of Kentucky hemp field day where hemp plots were toured and producers, processors and University economists, agronomists, engineers and entomologists discussed a wide range of production issues from bugs and weeds to alternative harvesting technologies;

- Attending Agricultural Economist's professional meetings to listen to the latest updates on hemp economics, production practices and product markets. Specifically attending the Western Agricultural Economics Association Annual meeting in 2019, the Southern Agricultural Economics Association Annual meetings in 2019 and 2020, the Southern Extension Economics Committee summer meeting in 2019, the Multi-State hemp meetings (S1084) in 2019;
- Visiting hemp processors in Colorado and Kentucky;
- Visiting retailers in Colorado, Kentucky, and Tennessee;
- Personal communications with university agricultural economists from Kentucky, South Carolina, Oregon and Tennessee who became involved with hemp after the 2014 Farm Bill established the hemp pilot program;
- Attending the BIO World Conference where industry participants provided their perspectives on costs, end uses and production practices in the hemp industry.

The information gained from all of these sources and the limited published research will be applied to Texas climate and growing conditions to produce the budgets.

It can't be stressed enough that these budgets are for 2019 crop year and are Texas specific. There was no industrial hemp production in Texas in 2019, so the hemp related numbers (such as revenue sources, genetics, etc.) come from other states, while Texas specific numbers come from Texas (ex. Land rent, irrigation, equipment costs, etc.).

Enterprise Budgets

The term enterprise budget is used to describe an organization of revenue, expenses, and profit for a single enterprise typically based on some production input unit (Smith, et al., 2000). Typically, an enterprise budget is developed on a small common unit such as 1 acre or 1 head of livestock. The enterprise budgets developed in this study will contain the costs and returns for one acre of hemp production. Enterprise budgets typically contain three sections: income, variable costs, and fixed costs and are for one specific time, such as a given crop year.

Enterprise budgets can be created for different levels or types of production or uses of technology, thus there can be more than one budget for a given enterprise. Complete enterprise budgets include costs that will be incurred only if this livestock or crop is produced these include but are not limited to: operating and variable costs such as seed, fuel, machinery repairs, labor, interest, land charge, profit or return to management, and miscellaneous overhead (Kay, 1994). While there are an unlimited number of output and input prices and quantities, generally average or expected prices are used, as well as, average costs for each of the cost components.

The goal of an enterprise budget is to track all sources of income and expenses allocated to each enterprise (Minear, 1991). After an enterprise budget is complete, a manager can eliminate enterprises that in accounting terms generate inferior results and replace them with alternative enterprises should they become available. It is also used to look into alternative enterprises to analyze their viability. Currently, the risks associated with growing industrial hemp are greater than for other more established crops.

As a rule, higher risk investments carry high expected returns (Barry., et al., 1988). If that is not the case, farmers could logically decide to not diversity their operations by growing industrial hemp.

Developing Hemp Budgets

The first step in creating enterprise budgets was to review all of the currently available research from agricultural economics, agronomy, entomology and agricultural engineering to ascertain how much information was available from published sources. Once this assessment was completed, the next step was to determine where hemp was already actively being grown in pilot program states, travel to the states and meet with researchers and farmers. The farm tours and conversations were generally focused on industry development, basic agronomics, cost of production, relationship with processors, political issues surrounding market and industry development, labor use, and equipment use. Meetings were held with processors to better understand their perspective and factors affecting processors.

Once all the data for the enterprise budgets had been gathered, information was sorted and data that were outliers were eliminated. While outliers are considered for the overall outlook for the industry, the enterprise budgets are aimed toward typical production. The focus is on the economics of hemp production at the farm level through the creation of budgets. These budgets are not meant to address every situation and condition. A major focus of this research is to help individuals considering entering this industry make informed decisions.

Once the research was compiled the information was analyzed with regard to climate and soil conditions in Texas, as well as the legal and regulatory environment, Texas specific hemp budgets could be developed.

Texas Hemp Legislation

Texas did not participate in the industrial hemp pilot program under the 2014 Farm Bill, so production of hemp in Texas is currently illegal. Therefore, Texas is behind some of the early adopters of industrial hemp such as Kentucky and Colorado in hemp production and processing. On June 10, 2019, House Bill 1325 was signed into law by Governor Greg Abbott authorizing the production, manufacture, retail sale, and inspection of industrial hemp crops and products in Texas. However, it should be noted, that until all the rules and regulations governing hemp are approved and in place, it still remains illegal to grow hemp in Texas. The Texas Department of

Agriculture (TDA) anticipates that the permit application process will begin in 2020 (Texas Department of Agriculture).

Though the specific rules and regulations overseeing the production of hemp are not available at the time of this publication, there are general rules outlined in House Bill 1325. The following points on hemp production in Texas are taken from the legislative language of House Bill 1325: Texas Fee Structure from the Submitted rules submitted to the Texas Register (Texas Department of Agriculture, February 2020)

- Application fee at least $100 for each license.
- Lot fee not to exceed $100 per location. This covers each facility, lot, and processor registration.
- Modification of location at least $500.
- Testing fee of $300 for each test performed by TDA.
- The license holder must also pay for fees payable to licensed sampler contracted with TDA.
- The license holder will also be responsible for all testing fees payable to the DEA laboratory.

The state also has the authority to perform annual inspections. In addition, all land and premises where industrial hemp is located consent to allowing representatives from TDA to enter land or premises with or without cause and with or without advance notice. A producer may not grow or handle hemp without a license. Additionally, anyone who has been convicted of a felony with regards to the Controlled Substance Act shall not grow hemp in Texas until after the 10 year anniversary of the conviction.

To apply for a license to grow, the statute outlines the grower must submit: the application, application fee, legal description and GPS coordinates of each plot of land intended for hemp production, and permission to allow state law enforcement and TDA employees on the property growing hemp. Licenses are good for one year.

Before harvest, the grower must notify TDA so that tests for THC levels can be performed. After the test, the grower will have 20 days to harvest. A grower cannot sell or use the hemp until the preharvest test results have been determined, but a grower can store and dry the material. If the test comes back with >0.3% THC, the grower has 15 days to request a post-harvest test. Falsifying lab reports is a third-degree felony. Seed used in hemp production must be certified for the production of hemp. TDA must provide a list of certified seed outlets. To transport hemp in Texas you must have a manifest, shipping document, or name and location where grown.

General Agronomy

As noted in the literature review, industrial hemp can grow everywhere, however, there are conditions it prefers. It does not like to have "wet feet" meaning the soil needs to drain well. The general consensus from discussions with industry participants is hemp prefers a well-drained soil like a sandy loam and doesn't do as well in clay or pan. Due to these considerations, all Texas specific input costs were for District two in the panhandle of Texas. Industrial hemp does like sand, but it needs to be irrigated. It does not hold the ground together well and leaves the soil loose which can leave the ground susceptible to erosion. The soil and irrigated maps for Texas contained in the literature review indicated that west Texas and the Panhandle areas of the State where irrigation is prevalent and sandy soils are present is the preferred area. Even on the preferred soils there are still problems with stands. Figure 3.1 Illustrates a poor stand on a farm that was visited in Colorado. At the same time, Figure 3.2 illustrates a very good stand on a nearby farm in Colorado.

Figure 3.1 Poor Stand of CBD Seed at Farm in Colorado (Moore, 2019)

Figure 3.2 Good Stand of CBD Seed at Farm in Colorado (Moore, 2019)

Seed production for producers growing for CBD can drastically bring down the CBD % percentage (Smith, 2019). Since the highest concentration of CBD is in the buds of the female plants, seed is unwanted in the CBD model and its presence leads to lower CBD yields. Ten percent CBD is the current genetic goal for CBD production. If the CBD percentage gets much higher the farmer is at risk for going hot (being above the THC threshold).

A study preformed by Robert Geneve & Derrick Davis says that the optimal germination is 21˚ C or 69.8 ˚ F. Concern about disease and pests increases when hemp is not grown in rotation with outher crops on the same land. Growers in Colorado and the Southeast have found that industrial hemp does well after soybeans or after alfalfa. Tom Keene has found that seed optimal planting depth is ¼ inch or less.

In Kentucky, Raul Villanueva talked of June Bugs being 3-4 times more prevalent than Japanese Beetles in industial hemp plant produciton. The Hemp Russet Mite is a huge problem in greenhouses. It is predicted there will be less Hemp Russet Mites in Texas and Colorado because of less humidity. Another issue in greenhouses would be with Pythium Root Rot which could live in styrofoam trays. A farmer could avoid this problem being a huge issue by using plastic trays and cleaning them very well after a growing season. Some farmers also advise cleaning the greenhouse thoroughly between growing seasons. Pythium affects the root tips and is most commonly seen as an issue in plugs or transplants. Cut worms are a big deal at planting (Hutchens, 2019). While European Corn Boar Worms are a big issue at harvest see Figure 3.3 Below.

Nicole Ward Gauthier, a plant pathologist from the University of Kentucky indicates the majority of the issues she has seen is Southern Blight or “White Mold.” It infects the xylem tissue. It takes water and nutrients up the plant. The other is Hemp Leaf Spot (Septoria leaf spot) which spreads abundantly throughout fields. It has been the talk of the hemp industry since 2014. Septoria Leaf Spot has been found in Texas in other species of plants including but not limited to Wheat (Lopez, 2015).

Figure 3.3 Corn Ear Worm Damage at Industrial Hemp Farm in Colorado (Moore, 2019)

Texas Enterprise Budgets

Texas industrial hemp production budgets will be developed for the three hemp end uses: CBD, seed/grain, and fiber. For all budgets, cash rent will be used. In addition, for certain costs such as harvesting, custom rates for the region will used to approximate the costs for the different types of harvesting methods.

The budgets for hemp grown for CBD production will be divided into two models: one for smaller scale with more labor-intensive production (CBD Vegetable Model) and another for larger acreage with mechanical harvesting (CBD Large-Scale Model). The CBD Vegetable Model is prevalent in the Southeastern United States. This model is particularly common in

Kentucky and South Carolina where hemp is often grown as a replacement for tobacco production.

The CBD Vegetable Model represents transplant production methods and hand harvesting. Thus, the CBD Vegetable Model has a strong reliance on hired labor. Conversely, the large-scale budget is meant to represent a grower with larger acreage which would make hand harvesting and planting transplants less feasible. The CBD Large-Scale Model includes planting seeds with a planter containing modified vegetable seed plates and mechanical harvesting. It is assumed that mechanical harvesting diminishes the CBD yield, although reports of how much vary greatly and may only be a very small amount. The figure below is an example of a plant grown for CBD.

Figure 3.4 Industrial Hemp for CBD Production (Moore, 2019)

CBD Vegetable Model

Revenue for a CBD crop is derived by multiplying the CBD percentage by the price per percent CBD by the pounds of dry matter yield. Therefore, a grower could increase revenue by increasing dry matter per acre and/or have a higher percent CBD. The highest price found in 2019 was $8 per percentage point of CBD. By the end of harvest, that number had fallen drastically to around $2.10 per percentage point of CBD. This research assumes prices at harvest for 2019.

There is much variation among recommendations of planting density from 1,000 to 10,000 plants per acre as farmers experiment with row and plant spacing within rows (Oakes, 2019). The CBD Vegetable Model assumes planting transplants via vegetable setter or tobacco setter. Thus, there is a cost for the plants themselves and having them custom set into the ground by a vegetable setter.

As previously stated, there are presently no chemicals approved for hemp production. Without the use of herbicides, weeds can be an issue which has led to high hand hoeing costs reflected in the budgets. Also, due to inconsistent genetics, it has been necessary to have someone go through fields and remove male plants. Due to Texas being a large state and not knowing the number or locations of processors, the budgets assume 120 miles to haul the crop to the processor.

While hemp doesn't require as much water as some crops like corn in order to produce a profitable yield, it does need some water, especially when the plant is young and being established. The budgets reflect the costs of pumping 15 acre-inches of water on the hemp crop. Certainly, rainfall during the growing season will play a big part on whether this number is lower or slightly higher.

Harvest cost reflects manual harvesting of the hemp stalk. Most producers in this model hand harvest and try to dry by hanging the green material in a barn or other similar location. There were no drying costs assumed due to the assumption as Texas will mostly dry in field. The drying costs in the budget are accounted for in the fixed costs section where a barn or other storage facility is expensed.

Plants are grown in this model in either a tobacco-based production method or a plasticulture production method (similar to vegetable model with plastic covering and drip tape).

Population in a field is 2,500 plants or transplants. From Canada to grower, the seed cost is about $2.50 lb + shipping (Hutchens, 2019). In 2018, processors paid between $3-$5 per percentage point of CBD. So, if you have a pound of hemp material that is 9% CBD, at $3 per percentage point of CBD that pound would be worth $27. From an experienced farmer who has grown his fourth crop of industrial hemp, an exceptional crop would be an 8 to 10 pound plant and 10 to 11% CBD at scale (Sisk, 2019).

In terms of planting for a CBD model, most farmers plant on a tobacco setter. With the tobacco setter you can plant 8 acres a day on a 1 row setter if there are no problems. They plant 40-inch rows with 2.5 ft between plants (Hutchens, 2019). Another farmer prefers 40 by 50 inch spacing and using a tobacco setter which is loaded from the front instead of a carousel setter (Furnish, 2019). Depending upon genetics and desired plant growth, some farmers prefer spacing from 30" spacing to 72" spacing (Smith, 2019). The cost for genetics is about $10,000 to $15,000 an acre. Nitrogen recommendation from farmers is 160-210 lbs. per acre. Depending on the present field makeup, the NPK recommendation is 200-150-150 NPK (Sisk, 2019). A farmer from Colorado dries CBD biomass using potato cellars to dry hemp (air system is important). Can go through 60-240 acres a day drying (Oakes, 2019). Other farmers in western Kentucky prefer using old tobacco barns to dry hemp. On the other hand, another believes CBD is not broken down by the sun. He prefers to dry out in field and rotate the sides of the plant in direct Sun. This method, to him, seems better to prevent mold (Sisk, 2019).

Sulfur input at 25 pounds came from Bryan Parr who is an agronomist for Legacy Hemp (Parr, 2019). The cost of Sulfur came from cost from 2019 Estimated Costs and Returns per Acre Irrigated Alfalfa South Plains Extension District 2 (Smith, 2019). Fees for fertilizer application came from Custom Fee for Wheat Grain Fertilizer Custom Application Fee taken from 2019

Estimated Costs and Returns per Acre Irrigated Wheat South Plains Extension District 2 for Fertilizer Application of Liquid Low and Liquid High (Smith, 2019). The soil test cost of $7, and the Tote Container cost of $35 dollars a tote came from the 2019 University of Kentucky Agricultural Economics Industrial Hemp Budgets (Mark & Shepherd, 2019). The $14.67 cost of pre-Sow plowing/preparing land came from 2018 Texas Agricultural Custom Rates (Finished Feb 2019) for Surface Chisel (3-8 inches) Rate per acre (Klose, et al., 2019). The cost for transplanting transplants was $259 from the UC Davis Transplanted Tomato Budget (Miyao, et al., 2017).

CBD Large-Scale Model

With the CBD Large-Scale Model, most costs match the CBD Vegetable Model. The two main differences occur in planting (seeds versus transplants) and harvesting expenses (mechanical versus manual). Similar to the CBD Vegetable Model, this budget also plans on some mechanical cultivation (with row crop cultivator), as well as, hand hoeing to reduce weeds. Mechanical harvesting assumes a sickle mower cutting it and then letting the plants dry in the field. Then the dried material would go through a modified combine to separate the stalk from the rest of the floral material. This is just one method of mechanical harvesting; thus, harvest costs could vary widely. One might note the CBD percentage being lower for Large-Scale Model than for CBD Vegetable Model. This calculation accounts for a lower CBD percentage due to mechanical harvesting as mentioned previously.

Feminized Seed costs at a minimum $1 per seed; comparatively, corn is $250 for roughly 80,000 seeds. Clones cost between $3 to $8 a plant (Shepherd, 2019). There is significant variability among the seed count per pound, varying from 6,000 seeds per pound to 320,000 seeds per pound (Hutchens, 2019). Because seed does so much poorer in the field than transplants, it is assumed that a higher number of plants are seeded than would be transplanted.

Labor and equipment costs are the most difficult thing to predict for this particular crop. Due to the strength and durability of the fiber, during harvest a typical combine can be easily damaged as the fibers are wrapped around the bearings and rotors. One extension faculty from Tennessee predicts a H2A labor cost not including infrastructure for laborers at $5,000 dollars an acre. (Cui, June 3, 2019)

Sulfur input at 25 pounds came from Bryan Parr who is an agronomist for Legacy Hemp (Parr, 2019). The cost of Sulfur came from cost from 2019 Estimated Costs and Returns per Acre Irrigated Alfalfa South Plains Extension District 2 (Smith, 2019). Fee for fertilizer application came from Custom Fee for Wheat Grain Fertilizer Custom Application Fee taken from 2019 Estimated Costs and Returns per Acre Irrigated Wheat South Plains Extension District 2 for Fertilizer Application of Liquid Low and Liquid High (Smith, 2019). The cost for water irrigation per ac inch and the cost of land rent came from the AFPC Representative Farms 2019 (Outlaw, 2019). The $14.67 cost of pre-Sow plowing/preparing land came from 2018 Texas Agricultural Custom Rates (Finished Feb 2019) for Surface Chisel (3-8 inches) rate per acre (Klose, et al., 2019). The planting with Sugar Beet plates cost of $22.08 came from the 2018 Texas Agricultural Custom Rates (Finished Feb 2019) for Planting Only No till: Drilling Rate per Acre (Klose, et al., 2019). The Cultivation cost for the CBD Large-Scale Model was from 2018 Texas Agricultural Custom Rates for Row Crop Cultivator Rate per acre (Klose, 2019). The custom harvest cost was from 2019 Estimated Costs and Returns per Acre Irrigated Sorghum Silage South Plains Extension District 2 Harvest and Haul Sorghum at $7 (Smith, 2019). The cost for pickup/General use equipment and irrigation equipment came from Irrigated

Cotton Pivot Budget District 2 (Smith, 2019). There was an assumption made that there would need to be some place to store the hemp at some point and overhead upkeep for machinery. This cost came from the University of Kentucky Dark Fired Tobacco Enterprise Budget as it was also considered for the more labor-intensive system (Galloway, 2019).

Hemp Seed/Grain Model

The Hemp Seed/Grain Model budget was designed specifically for the sale of seed for consumption (food and oil) and not for replication. For grain, farmers plant around 30 pounds of seed an acre. Hemp grown for seed is generally planted with a drill and much closer together than hemp grown for CBD. Most farmers recommend two to four applications of fertilizer. Due to the lack of listed herbicides, the goal for most seed and fiber farmers is to get the hemp plants planted early enough to achieve enough growth to choke out weeds. Because of the shading effect, the budget doesn't include the labor for hand hoeing or the custom charge for cultivation. In terms of spacing, 6 inches for seed/grain seems to be standard. In fact, a farmer from Colorado, has grown enough hemp canopy to choke out alfalfa (Oakes, 2019). The seed is harvested when the seed/grain goes to pollen (Furnish, 2019).

The Hemp Seed/Grain Model is similar to other commodities such as wheat. The harvested grain is the priority rather than the buds (which is the priority for CBD). In this budget model, it is assumed a farmer would harvest via modified combine to prevent fibrous hemp stems from wrapping around mechanical parts. It is also assumed freight on transporting the seed after harvest is paid by the processor, so no hauling charges are included in the budget.

The Hemp Seed/Grain Model also requires aeration. Within harvest you have 4-6 hours to get it to a grain bin which stores the grain properly and decreases the chance of molding (Victory Hemp, 2019). The budget assumed that the seed was harvested at moisture content low enough to not have to dry before storage. Due to hemp grain being consumed by humans, it is vital for post-harvest seed to be handled and cleaned appropriately, and a cleaning charge of $0.05/pound is included in the variable costs.

Grain seed cost ranges from $.80-$2 per pound (Oakes, 2019). Victory Hemp from Kentucky estimates seeds to cost betweeeen $2.50-$4 per pound (Victory, 2019). In Colorado, processors pay $.80-$1.50 pounds for harvested grain (Oakes, 2019). As of 2019 Victory Hemp paid $0.07 per pound for harvetsed grain (Victory Hemp 2019). Drying is assumed to be taking place in the field, but additional drying was assumed to be needed.

Previous work assisted with some of the expense assumptions for this model. Fees for fertilizer application came from Custom Fee for Wheat Grain Fertilizer Custom Application Fee taken from 2019 Estimated Costs and Returns per Acre Irrigated Wheat South Plains Extension District 2. for Fertilizer Application of Liquid Low and Liquid High (Smith, 2019). Field pre plant preparation came from 2018 Texas Agricultural Custom Rates for Land Tillage Operations including cost of operator, machine, and fuel for surface chisel (3-8 inches) rate per acre (Klose, et al., 2019). The cost of custom grain drill came from 2018 Texas Agricultural Custom Rates for Planting Only No till: Drilling Rate per Acre (Klose, et al., 2019). The cost of Combine Harvest Cost came from 2018 Texas Agricultural Custom Rates for Combining and Hauling Flat Rate (no extra charges) Corn Rate Per Bushel this includes operator, machine and fuel. Hauling per bushel which was given at $.48 a bushel (Klose, et al., 2019). Bryan Parr who is an agronomist with Legacy Hemp gave the cost for drying at $0.05 a pound (Parr, 2019). This budget assumes the entire harvest needs additional drying.

Hemp Fiber Model

Like grain production, the Hemp Fiber Model is seeded closer than hemp for CBD production and is usually planted with a grain drill. The closer planting space allows for more shading out of weeds, and thus, less need for hand hoeing. Additionally, a producer needs to plant seeds bred for fiber production. Ideal fiber plants are tall and do not have a thick stalk. Seed is typically planted at a rate of 50 pounds/acre (Riddle, 2019). The Hemp Fiber Model requires less fertilizer than for other end uses. Too much nitrogen can be a large issue for fiber genetics as higher rates of nitrogen do not allow cell walls to develop as the plants are growing too fast (Riddle, 2019). Generally, hemp grown for fiber typically contains a lower level of CBD (about 2%) than hemp grown for either seed or CBD.

To harvest, the hemp is cut, raked, and baled for an assumed custom rate of $210/acre. Hemp is dried in the field before baling and target moisture content is between 10 percent and 12 percent (Riddle, 2019). At 14% the load is discounted. Between 16-18% the load is rejected (Riddle, 2019). Hauling cost is assumed at $1.50/mile and hauling distance was assumed at 120 miles to get the fiber to processor. Proximity to the buyer/processing facility is a critical variable cost. The closer to the processor, the lower the transportation cost and the greater opportunity for profit.

Farmers prefer 5-7 ½ inch rows with the goal to shade out weeds. For fiber from Sundstrand Sustainable Materials, farmers are encouraged to plant 50 lbs seed an acre at $.80-$2/lb seed cost. Typically for fiber production, farmers should apply 50-100 units of nitrogen an acre. The Ph level is ideal between a 6 and 6.5 (Oakes, 2019).

Sulfur input at 25 pounds came from Bryan Parr who is an agronomist for Legacy Hemp (Parr, 2019). The cost of Sulfur came from cost from 2019 Estimated Costs and Returns per Acre

Irrigated Alfalfa South Plains Extension District 2 (Smith, 2019). The cost for the soil test was from the 2019 University of Kentucky Agricultural Economics Industrial Hemp Budgets (Mark & Shepherd, 2019). Fees for fertilizer application came from Custom Fee for Wheat Grain Fertilizer Custom Application Fee taken from 2019 Estimated Costs and Returns per Acre Irrigated Wheat South Plains Extension District 2 for Fertilizer Application of Liquid Low and Liquid High (Smith, 2019). Field pre plant preparation came from 2018 Texas Agricultural Custom Rates for Land Tillage Operations including cost of operator, machine, and fuel for Surface Chisel (3-8 inches) rate per acre (Klose, et al., 2019). The cost of custom Grain Drill came from 2018 Texas Agricultural Custom Rates for Planting Only No till: Drilling Rate per Acre (Klose, et al., 2019). Bryan Parr, an agronomist from Legacy Hemp, said the cost of raking hemp is 1-3 times that of hay (Parr, 2019). The cost to move bales to storage came from 2018 Texas Agricultural Custom Rates for Hay Hauling including operator, machine, and fuel in the category of Hauling hay (field to storage): Round Bales, over 1500 lbs. at a rate per bale (Klose, et al., 2019).

The crop found to be the most similar in terms of fixed costs to the needs of hemp fiber in District two was Guar. The Irrigated Guar Extension budget was consulted for the cost of Pick Up Equipment and General Use Equipment, Irrigation Equipment, Self-Propelled Tractor, and Implements. Irrigated Cash rent came from the 2019 AFPC Texas Representative Farms (Outlaw, et al., 2019). Overhead costs for storage and Infastructure depreciation, insurance, storage, interest on barns and machinery came from University of Kentucky Dark Fired Tobacco Enterprise Budget (Galloway, 2019). The Figure in 3.5 below is of a field for dual fiber and grain production.

Figure 3.5 Industrial Hemp for Fiber Production (Moore, 2019)

Other Costs and Budget Factors

There will fees associated with growing hemp in Texas that will have to be included in the budgets. There is an initial application fee of $100 to apply for license in TX (Texas Department of Agriculture, February 2020, Submitted Rules). If approved, one must pay $100 per facility and per lot permit or participation fee (Texas Department of Agriculture, January 2020, FAQ Handout). If a farmer wants to modify the facility fee during a one-year licensing period it is a $500 fee. A lab test fee of $300 an acre was assumed for each buget (Texas Department of Agriculture, February 2020). In 2018 there were 16,000 approved acres. In Kentucky, planted acres is about 40% of the acres approved. Harvested usually runs at about 37% of approved acres

(Mark, 2019). From a labor perspective CBD is ill advised to do without H2A workers especially more than an acre (Shepherd, 2019 June 3). Many farmers have hired a lawyer to examine contracts between growers and seed suppliers and growers and processors. They find that beyond genetics and labor, the greatest cost is legal fees. At $240 an hour, that adds up really quick (Farmer, 2019).

Incorporating Risk into Enterprise Budgets

Budgets will be presented in two ways. The first is a budget average costs and returns that does not incorporate risk. Then, risk will be incorporated into the enterprise budgets in two ways. The first simulation assumes there is price and yield risk for a farmer with fulfilled contracts. The second way risk will be incorporated is considering a counter-party risk or the risk processors do not pay farmers.

Typical enterprise budgets represent an average price and cost situation. To provide a more realistic evaluation of the profitability of an enterprise, economists have been including risk in their analyses (Richardson, 2008). There are three types of risk that will be incorporated into this research:

- Hemp prices
- Hemp yields
- Potential for nonpayment from processor.

Market and production risk will be incorporated using the *Simetar* add-in to Excel (Richardson, 2008). *Simetar* uses Latin Hypercube to simulate 500 iterations using a random number of seed of 31517. Latin Hypercube is used opposed to Monte Carlo simulation, because Latin Hypercube draws random values using a systematic approach, sampling all regions of the probability distribution. *Simetar* calculates values for mean, standard deviation, covariance, minimum, and maximum of the 500 iterations for each of the key output variables, as well as a list of the 500 iterations.

As indicated in the literature review, the GRKS distribution was created to simulate random variables with limited data which means usually 10 or less observations. For a GRKS distribution, parameters of minimum, mean, and maximum are generally set based on expert opinion and limited data. *Simetar* has a feature which simulates GRKS and will be used to incorporate risk into the enterprise budgets. GRKS was chosen due to the absence of historical data for industrial hemp. The GRKS distribution is a two-piece normal distribution with 50% of the weight below the middle value and 2.5% less than the minimum, and 50% above the middle value and 2.5% above the maximum. The distribution is used in place of a triangle distribution when one knows only minimum information about the random variable and the minimum and maximum are uncertain (Richardson et. al. 2006).

This research will assess profitability of industrial hemp production. There are several ways to look at profitability (Kay, 1981). The change in profit position should be considered in relationship to other changes in the firm (Barry, et al., 1988). Kay addresses the ways to analyze profitability as Net Farm Income, Return to Labor and Management, Return to Management, Rate of Return to Capital, and Rate or Return to Equity. Rational farmers would assess a new enterprise by looking at a net farm income. In this enterprise budget a farmer is looking at diversifying to take add a new business venture and source of revenue. Thus, management and equipment costs are not the primary point of interest, rather is the enterprise profitable.

The GRKS distribution is particularly useful in cases where historical data are non-existent and limited experimental data are available (Rezende & Richardson, 2015).

For this study, the minimum, middle point, and maximum values of CBD oil per percentage point are defined by the user based on limited experimental data. Due to a majority of hemp grown in the United States currently being for CBD production, risk will be based off of CBD budget numbers.

For these enterprise models prices for each budget will be put into a GRKS distribution. For prices the minimum will be 0 meaning the firm did not get paid. The middle number is derived from interviews and is the number which was assumed on the budgets. The maximum number for prices was a factor of the middle number. For prices it was 200% of the middle number.

For these models, the yields for each budget will be put into a GRKS distribution. For yields, the minimum will be 0 meaning the crop either failed due to environmental or genetic reasons. The mean is derived from interviews and is the number which was assumed on the budgets. The maximum number for prices was a factor of the mean. For yields, the maximum yield was 1.75 times the mid yield. Obtaining the 1.75 times the middle yield would be considered the optimal yield per acre.

Simulating the Effects of Risk on Yield

For these models yields per acre for each budget will be put into a GRKS distribution. For yields, the minimum will be 0 meaning the crop either failed due to environmental or genetic reasons. The middle number is derived from interviews and is the number which was assumed on the budgets. The maximum number for prices was a factor of the middle number. For yields, the maximum yield was 1.75 times the mid yield. Obtaining the 1.75 times the mid yield would be considered the optimal yield per acre. There were 4 intervals assumed for each standard deviation. Note the yield for CBD Vegetable Model and the CBD Large-Scale Model are the same. The difference in the mechanics of the two models was taken into account and is represented in the % of CBD per acre. The higher mechanism model (Large-Scale CBD Model) assumes a lower % of CBD production.

$$\text{Yield Industrial Hemp}_y = \text{GRKS (minimum, middle, maximum)}$$

The parameters used in the GRKS distribution are contained in Table 3.1.

Table 3.1 GRKS Distribution Yield Parameters Assumed in this Analysis.

	Minimum	Middle	Maximum
CBD Vegetable Model	0	1,200	2,100
CBD Large-scale Model	0	1,200	2,100
Hemp Grain Model	0	1,000	1,750
Hemp Fiber Model	0	9,000	15,750

Given per acre industrial hemp production, it is possible to simulate the amount of industrial hemp on an annual basis. Figure 3.6 provides a cumulative density function (CDF) of CBD yields on a pounds per acre basis for the Vegetable Model Enterprise Budget.

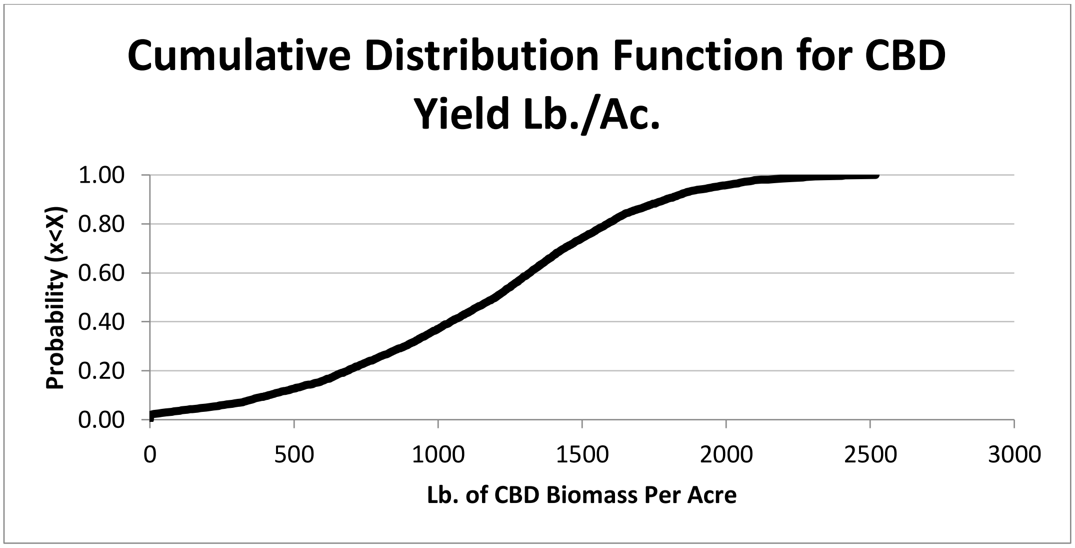

Figure 3.6 CDF for CBD Yield for Vegetable Model

Simulating the Effects of Risk on Price

Prices in each of the enterprise budgets described earlier will be simulated using a GRKS distribution to incorporate risk. The minimum will be 0 meaning the famer did not sell his crop on the market or an unfulfilled contract. The middle number is derived from interviews and is the number which was assumed on the budgets. The maximum number for prices was a factor of the middle number. For prices it was 200% of the middle number. Parameter information is contained in Table 3.2.

$$\text{Price Industrial Hemp}_y = \text{GRKS (minimum, middle, maximum)}$$

Table 3.2. GRKS Distribution Price Parameters Assumed in this Analysis.

	Minimum	Middle	Maximum
CBD Vegetable Model	$0	$2	$4
CBD Large-scale Model	$0	$2	$4
Hemp Grain Model	$0	$0.70	$1.14
Hemp Fiber Model	$0	$0.08	$0.16

Figure 3.7 is a cumulative density function (CDF) of CBD price on a pounds per acre basis for the Vegetable Model Enterprise Budget. The minimum one could be paid for a crop is 0. Although the maximum from the GRKS equation was $4 the simulation and distribution does make the max $4.89 a percent of CBD a pound.

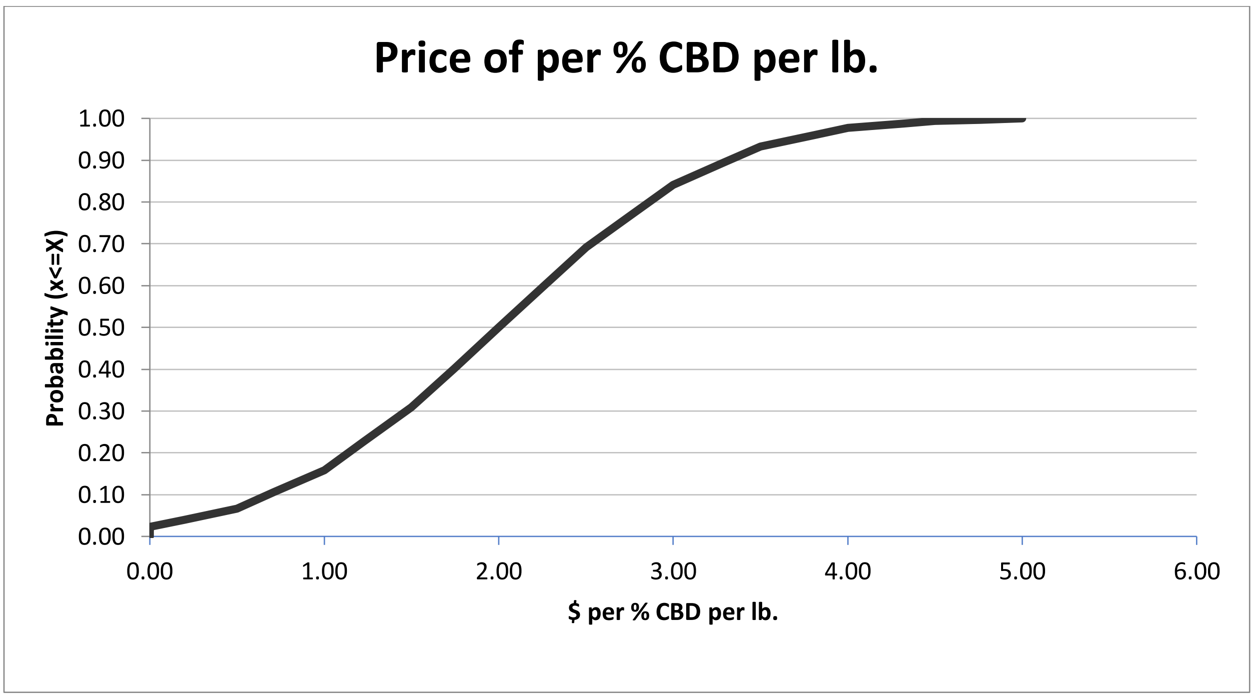

Figure 3.7 Price Per Percentage Point of CBD for the Vegetable Model CDF

Simulating the Effects of Risk on Farmer Profitability

The research used the most recent price and yield data incorporate risk into the enterprise budgets. In this model we will use the budgets created and simulate net income for each budget.

Simulating the Effects of Risk from Processors Not Paying Farmers

To simulate the likelihood of nonpayment this study would not use a continuous distribution, instead it would be assessed as a yes or no. The farmer was paid or not paid. This study will use a Bernoulli distribution to simulate the risk associated with nonpayment. Thus, every time the simulation is a 1 it would mean the farmer received payment. Every time the outcome was 0 it would mean the farmer would not receive payment. Some processors paid firms in installments. This would mean they might pay them a certain amount of money at the beginning of the season. Then, pay another installment at planting. Then, pay another installment midway through the season. Followed by, another payment at harvest. Lastly, they would pay a final and largest payment after harvest when all of the crop was processed.

This was modeled in a two-step process. First there was a Bernoulli equation for how often a farmer was paid by the processor. Then, to what extent a farmer was paid (ex. 25% of contract or 75% of contract) was then considered.

There were two scenarios in this study. The first is if the processor paid the farmer 50% of the time. This is represented by =Bernoulli(0.5). Then if the outcome of the first step was 1 (meaning there was payment) the Formula was =GRKS(25, 70, 100). This means the lowest amount assumed a farmer would make would be 25% of the contract. The mid payment would be 70% payment. The maximum payment would be the full contract of 100%.

The second scenario is intended to represent even less payment by processors and the impact on farmers. The second scenario is if the processor paid the farmer 10% of the time. This is represented by =Bernoulli(0.1). Then if the outcome of the first step was 1 (meaning there was payment) the Formula was =GRKS(10, 40, 100). This means the lowest amount assumed a farmer would make would be 10% of the contract. The mid payment would be 40% payment. The maximum payment would be the full contract of 100%.

Summary

Four Texas enterprise budgets for industrial hemp will be developed based on published research and actual information provided by current farmers, processors and industry participants. The budgets will incorporate risk so that realistic variability in enterprise profitability can be captured.

CHAPTER IV

RESULTS

These budgets were developed taking into consideration the latest information available from industry participants across the United States. The reader should be reminded of a few caveats and cautions. These budgets were developed for 2019 and while the costs contained in them are likely relatively close for 2020, due to the rapidly changing CBD market, the prices are likely high relative to market prices for 2020 and beyond. The budgets are intended to set a baseline for Texas production in the years going forward. Finally, it should be cautioned that production methods are highly varied with a great amount of volatility within each method. Unlike more established crop enterprise budgets – where there are generally accepted standards of cost and revenues that serve as a reference point for creating budgets – the lack of publicly available information on hemp makes budgeting a greater challenge.

The enterprise budgets in this section were developed after reviewing all available resources discussed in the literature review. These budgets are meant to represent hypothetical hemp production in Texas for the 2019 crop year. Even though this is a timeframe when hemp production was not legal in Texas, the budgets were developed for 2019 with known input prices for that year. Given the great amount of interest in the crop; at least some Texas producers will be growing hemp in Texas in 2020 once the rules and regulation have been established. These budgets will be a useful starting point for the 2020 crop year and producers can update output and input prices as those prices become known for 2020.

These budgets were developed by taking as much information from enterprise budgets available in other states and adjusting to climate and soil conditions in Texas. Since it is not known exactly how Texas producers will want to plant or harvest hemp, the budgets use current custom rates survey data as a reasonable proxy for what farmers might do where data is not currently available. These budgets in no way predict 2020 as the industry is continually changing and the regulations are not in place.

As outlined previously, there are several models for industrial hemp production. Enterprise budgets for each are discussed in the following section. The budgets are broken down into four production methods: CBD Vegetable Model, CBD Large-Scale, Hemp Grain, and Hemp Fiber. Unlike a more established crop enterprise budgets, where there are generally accepted benchmarks of cost and revenues that serve as a reference point for creating budgets, the lack of publicly available information makes hemp budgeting a greater challenge. Budgets will be presented in two ways. The first is a budget with average prices and costs. These budgets are seen below.

2019 Texas Industrial Hemp Enterprise Budgets

CBD Vegetable Enterprise Budget

The enterprise budget for the CBD Vegetable Model is in Table 4.1. The price at the end of 2019 was $2.10 a percent CBD per pound. The assumed CBD percentage is 9%. This is 2% greater than the assumed CBD percentage for the Large-Scale Model. This assumption is made to account for less loss when harvesting with hand labor relative to mechanical harvesting. The CBD yield per acre was 1,200 pounds of dry matter. These assumptions make the total revenue per acre $22,680.00. Seed and genetic costs per acre are the largest cost on the budget at $12,500. The variable costs total $16,834.12. The fixed costs total $2,501.25. The net return per acre is $3,344.63. It should be noted on the sensitivity analysis when the price drops below the $2 a % per CBD depending on an operations specific costs a farmer could be finding net revenue per acre.

Table 4.1 2019 Texas CBD Vegetable Enterprise Budget Model

2019 CBD Vegetable Model							
ITEM	**DESCRIPTION**	**QUANTITY**	**UNIT**	**PRICE**			**TOTAL**
			(#/AC)	**($/UNIT)**			
Gross Returns Per Acre							
	CBD%	**9.0%**					
	Price Per %	**$2.10**					
	Dry Matter Yield	**1,200**	lbs	**$18.90**			$22,680.00
Total Revenue							**$22,680.00**
Variable Costs Per Acre							
Genetics	Transplants	**2500**	plants	**$5.00**			$12,500.00
Fertilization	Nitrogen (Solid urea 46% N)	**200**	pound	**$0.46**			$69.00
	Phosphorous (P2O5)	**150**	pound	**$0.54**			$37.80
	Potassium (K2O)	**150**	pound	**$0.34**			$34.00
	Sulfur [1]	**25**	pound [2]	**$0.12**			$3.00
	Fertilizer Application Fee [3]	**1**	acre	**$8.25**			$8.25
	Chemicals (not available yet)	**1**	acre	**$ -**			$0.00
	Soil Test [4]	**1**	field	**$7.00**			$7.00
Growing	Cultivation (traditional) [5]	**1**	acre	**$10.89**	**# of Passes**	**2**	$21.78
	Irrigation (if required) [6]	**15**	ac in	**$6.50**			$97.50
Harvest	Drying Costs	**0**	lbs wet	**$1.50**			$0.00
	Tote Container [4]	**5**	acre	**$35.00**			$175.00
	Hauling Costs	**120**	miles	**$1.50**			$180.00
Custom Work	Pre-Sow plowing/preparing land [7]	**1**	acre	**$14.67**			$14.67
	Custom transplanting [8]	**1**	acre	**$259.00**			$259.00
	Roguing males Labor Cost	**5**	# of hours	**$13.50**			$67.50
	Weeding Labor Cost	**100**	# of hours	**$13.50**			$1,350.00
	Harvest Cost - Labor Cost [9]	**107.145**	# of hours [4]	**$13.50**			$1,446.46
	Interest on Operating Capital	**$18,772.21**	dollars	**6.00%**	**# of Months**	**6.0**	$563.17
Total Variable Costs Per Acre							**$16,834.12**
Planned Returns Above Variable Costs							**$5,845.88**
Fixed Costs Per Acre							
Equipment Fixed Costs	Pickup/General Use Equipment [10]	**1**	acre	**$1.25**			$1.25
	Irrigation Equipment [10]	**1**	acre	**$55.00**			$55.00
Overhead Costs	Management Fee, Owner/Operator Labor [11]	**1**	acre	**$165.00**	**$165.00**		$165.00
	Cash Rent [6]	**1**	acre	**$140.00**	**$140.00**		$140.00
	Whole Farm Insurance	**1**	acre	**$ -**			$0.00
	Crop Insurance (Not Available Yet)	**1**	acre	**$ -**			$0.00
	Application & License Fee [12]	**1**	acre	**$100.00**			$100.00
	Growing Fee [12]	**1**	per year	**$100.00**	**# of acres**	**1**	$100.00
	Lab Test [12]	**1**	# of test	**$300.00**	**# of acres**	**1**	$300.00
	Legal Expense [13]	**6**	# of hours	**$240.00**			$1,440.00
	Interest Barns, Machinery [11]	**1**	acre	**$200.00**	**$200.00**		$200.00
Total Fixed Costs							**$2,501.25**
Total Specified Costs							**$19,335.37**
Total Profit							**$3,344.63**

[1] The cost of Sulfur came from cost from 2019 Estimated Costs and Returns per Acre Irrigated Alfalfa South Plains Extension District 2 (Smith, 2019).

[2] Sulfur input at 25 pounds came from Bryan Parr who is an agronomist for Legacy Hemp (Parr, 2019).

[3] Fee for fertilizer application came from Custom Fee for Wheat Grain Fertilizer Custom Application Fee taken from 2019 Estimated Costs and Returns per Acre Irrigated Wheat South Plains Extension District 2. for Fertilizer Application of Liquid Low and Liquid High (Smith, 2019).

[4] The soil test cost of $7, and the Tote Container cost of $35 dollars a tote came from the 2019 University of Kentucky Agricultural Economics Industrial Hemp Budgets. The hours for harvest also came from the University of Kentucky Agricultural Economics Hemp Budgets. (Mark & Shepherd, 2019).

[5] The cost for cultivation per pass was $10.89 as per the 2018 Texas Agricultural Custom Rates for Row Crop Cultivator Rate per acre (Klose, et al., 2019).

[6] The irrigation cost per acre comes from AFPC Working Paper (Outlaw, Joe L., et. al., 2019)

[7] The $14.67 cost of pre-Sow plowing/preparing land came from 2018 Texas Agricultural Custom Rates for Surface Chisel (3-8 inches) Rate per acre (Klose, et al., 2019).

[8] The cost for transplanting transplants was $259 from the UC Davis Transplanted Tomato Budget (Miyao, et al., 2017).

[9] For a conservative estimate, cost of labor was increased from the List of Adverse Effect Wage Rates by State for 2020 (United States Department of Labor, 2019).

[10] Cost for Pickup/General Use Equipment and Irrigation Equipment are from Irrigated Cotton Pivot Budget District 2 (Smith, February 2019).

[11] Cost of Management Fee, Owner/Operator Labor and Interest Barns, Machinery was from University of Kentucky Tobacco Enterprise Budget (Galloway, February 2019).

[12] Cost of Application and License Fee, Growing Fee, and Lab Test costs are from Texas Hemp Proposal (Texas Department of Agriculture, February 2020).

[13] Contract Legal Fee Cost (Sisk, 2019).

[14] Cost of Management Fee, Owner/Operator Labor and Interest Barns, Machinery was from University of Kentucky Tobacco Enterprise Budget (Galloway, February 2019).

CBD Large-Scale Enterprise Budget

CBD Large-Scale Model is in Table 4.2. The price at the end of 2019 was $2.10 a percent CBD per pound. The assumed percentage was 7% CBD. This assumption is to account for a decreased CBD yield due to mechanical harvesting. The CBD yield per acre was 1,200 pounds of dry matter. These assumptions make the total revenue per acre $17,640.00. Seed and genetic costs per acre are the largest cost on the budget at $4,000. The difference in this cost in comparison to the previous budget is substantial. Seeding feminized seed is significantly cheaper than planting transplants. The variable costs total $6,963.24. The fixed costs total $2,501.25. The net return per acre is $8,175.51. The lower variable costs in this production system makes significant difference at the bottom line. This difference could signal the need for machinery specific for industrial hemp assisting in making CBD operations more profitable.

Table 4.2 2019 Texas CBD Large-Scale Enterprise Budget Model

2019 CBD Large-Scale Model							
Item	DESCRIPTION	QUANTITY	UNIT	PRICE	TOTAL	TOTAL	TOTAL
			(#/AC)	($/UNIT)	($/AC)	($/LB)	
Gross Returns Per Acre							
	CBD%	**7.0%**					
	Price Per %	**$2.10**					
	Dry Matter Yield	**1,200**	lbs	**$14.70**			$17,640.00
Total Revenue							**$17,640.00**
Variable Costs Per Acre							
Genetics	Feminized Seed Drilled	**4000**	seeds	**$1.00**			$4,000.00
Fertilization	Nitrogen (Solid urea 46% N)	**200**	pound	**$0.46**			$69.00
	Phosphorous (P2O5)	**150**	pound	**$0.54**			$37.80
	Potassium (K2O)	**150**	pound	**$0.34**			$34.00
	Sulfur [1]	**25**	pound [2]	**$0.12**			$3.00
	Fertilizer Application Fee [3]	**1**	acre	**$8.25**			$8.25
	Chemicals (Not Available Yet)	**1**	acre	**$0.00**			$0.00
	Soil Test [4]	**1**	field	**$7.00**			$7.00
	Irrigation (If Required) [5]	**15**	ac in	**$6.50**			$97.50
Harvest	Drying Costs	**0**	lbs wet	**$1.50**			$0.00
	Storage/Container Costs [4]	**5**	acre	**$35.00**			$175.00
	Hauling Costs	**120**	miles	**$1.50**			$180.00
Custom Work	Pre-Sow plowing/preparing land [6]	**1**	acre	**$14.67**			$14.67
	Planting with Sugar Beet Plates [7]	**1**	acre	**$22.08**			$22.08
	Cultivation (Traditional) [8]	**1**	acre	**$10.89**	**# of Passes**	**2**	$21.78
Labor	Roguing males Labor Cost [9]	**5**	hours	**$13.50**			$67.50
	Weeding Labor Cost [9]	**100**	hours	**$13.50**			$1,350.00
	Custom Harvest Cost	**1**	acre	**$600.00**			$600.00
	Interest on Operating Capital	**$9,188.83**	dollars	**6.00%**	**# of Months**	**6.0**	$275.66
Total Variable Costs Per Acre							**$6,963.24**
Planned Returns Above Variable Costs							**$10,676.76**
Fixed Costs Per Acre							
Equipment Fixed Costs	Pickup/General Use Equipment [11]	**1**	acre	**$1.25**			$1.25
	Irrigation Equipment [11]	**1**	acre	**$55.00**			$55.00
Overhead Costs	Management Fee, Owner/Operator Labor [12]	**1**	acre	**$165.00**	**$165.00**		$165.00
	Cash Rent [5]	**1**	acre	**$140.00**	**$140.00**		$140.00
	Whole Farm Insurance	**1**	acre	**$ -**			
	Crop Insurance (Not Available Yet)	**1**	acre	**$ -**			$0.00
	Application & License Fee [13]	**1**	acre	**$100.00**			$100.00
	Growing Fee [13]	**1**	per year	**$100.00**	**# of acres**	**1**	$100.00
	Lab Test [13]	**1**	# of test	**$300.00**	**# of acres**	**1**	$300.00
	Legal Expense [14]	**6**	# of hours	**$240.00**			$1,440.00
	Interest Barns, Machinery [12]	**1**	acre	**$200.00**	**$200.00**		$200.00
Total Fixed Costs							**$2,501.25**
Total Specified Costs							**$9,464.49**
Total Profit							**$8,175.51**

[1] The cost of Sulfur came from cost from 2019 Estimated Costs and Returns per Acre Irrigated Alfalfa South Plains Extension District 2 (Smith, 2019).

[2] Sulfur input at 25 pounds came from Bryan Parr who is an agronomist for Legacy Hemp (Parr, 2019).

[3] Fee for fertilizer application came from Custom Fee for Wheat Grain Fertilizer Custom Application Fee taken from 2019 Estimated Costs and Returns per Acre Irrigated Wheat South Plains Extension District 2 for Fertilizer Application of Liquid Low and Liquid High (Smith, 2019).

[4] The soil test cost of $7, and the Tote Container cost of $35 dollars a tote came from the 2019 University of Kentucky Agricultural Economics Industrial Hemp Budgets (Mark & Shepherd, 2019).

[5] The cost for water irrigation per acre inch and cost of land rent per acre comes from AFPC Working Paper (Outlaw, Joe L., et. al., 2019)

[6] The $14.67 cost of pre-sow plowing/preparing land came from 2018 Texas Agricultural Custom Rates (Finished Feb 2019) for Surface Chisel (3-8 inches) Rate per acre (Klose, et al., 2019).

[7] The planting with Sugar Beet Plates Cost of $22.08 came from the 2018 Texas Agricultural Custom Rates (Finished Feb 2019) for Planting Only No till: Drilling Rate per Acre (Klose, et al., 2019).

[8] The cost for cultivation per pass was $10.89 as per the 2018 Texas Agricultural Custom Rates for Row Crop Cultivator Rate per acre (Klose, et al., 2019).

[9] For a conservative estimate, cost of weeding and rouging (meaning the removal of males from the field) labor was increased from the List of Adverse Effect Wage Rates by State for 2020 (United States Department of Labor, 2019).

[10] The custom harvest cost was from 2019 Estimated Costs and Returns per Acre Irrigated Sorghum Silage South Plains Extension District 2 Harvest and Haul Sorghum at $7 (Smith, 2019). This was the closest to assumed equipment and process for Texas.

[11] Cost for Pickup/General Use Equipment and Irrigation Equipment are from Irrigated Cotton Pivot Budget District 2 (Smith, February 2019).

[12] There was an assumption made that there would need to be some place to store the hemp at some point and overhead upkeep for machinery. Cost of Management Fee, Owner/Operator Labor and Interest Barns, Machinery was from University of Kentucky Tobacco Enterprise Budget (Galloway, February 2019).

[13] Cost of Application and License Fee, Growing Fee, and Lab Test costs are from Texas Hemp Proposal (Texas Department of Agriculture, February 2020).

[14] Contract Legal Fee Cost (Sisk, 2019).

Hemp Grain Enterprise Budget

The enterprise budget for the CBD Hemp Grain Model is in Table 4.3. The grain price at the end of 2019 was $0.07 per pound of grain. The yield per acre is assumed at 1,000 pounds. These assumptions make the total revenue per acre $700.00. The variable costs total $518.73. The fixed costs total $1,021.25. The net return per acre is a loss of $839.98. The price for hemp grain needs to be $0.52 with a 1,000 pound yield just to cover variable costs.

Table 4.3 2019 Texas Hemp Grain Enterprise Budget Model

2019 Hemp Grain							
ITEM	**DESCRIPTION**	**QUANTITY**	**UNIT**	**PRICE**			**TOTAL**
			(#/AC)	**($/UNIT)**			
Gross Returns Per Acre							
	Hemp Grain	**1,000**	lbs	**$ 0.70**			$700.00
Total Revenue							**$ 700.00**
Variable Costs Per Acre							
Genetics	Seed	**30**	lbs	**$3.50**			$105.00
Fertilization	Nitrogen (Solid urea 46% N)	**150**	pound	**$0.46**			$69.00
	Phosphorous (P2O5)	**70**	pound	**$0.54**			$37.80
	Potassium (K2O)	**100**	pound	**$0.34**			$34.00
	Sulfur	**25**	pound	**$0.12**			$3.00
	Chemicals (Not Available Yet)	**1**	acre	**$ -**			$0.00
	Irrigation (If Required) [1]	**15**	ac in	**$6.50**			$97.50
Custom Work	Fertilizer Application Fee [2]	**1**	acre	**$8.25**			$8.25
	Field Preplant Preparation [3]	**1**	acre	**$14.67**	**# of Passes**	**2.0**	$29.34
Sowing	Soil Test [4]	**1**	field	**$7.00**			$7.00
	Custom Grain Drill [5]	**1**	acre	**$22.08**			$22.08
Harvest	Combine-Harvest Cost [6]	**22.73**	bushel	**$0.48**			$10.91
	Hauling Costs [6]	**-**	bu	**$ -**			$0.00
	Grain Cleaning [7]	**1,000**	lbs	**$0.05**			$50.00
	Drying Cost [7]	**1,000**	lbs	**$0.00**	**Points Removed**		$0.00
	Interest on Operating Capital	**$1,495.13**	dollars	**6.00%**	**# of Months**	**6.0**	$44.85
Total Variable Costs Per Acre							**$518.73**
Return Above Variable Costs Per Acre							**$ 181.27**
Fixed Costs Per Acre							
Equipment Fixed Costs	Pickup/General Use Equipment [8]	**1**	acre	**$1.25**			$1.25
	Irrigation Equipment [8]	**1**	acre	**$55.00**			$55.00
Overhead Costs	Management Fee, Owner/Operator Labor [9]	**1**	acre	**$25.00**			$25.00
	Cash Rent [1]	**1**	acre	**$140.00**			$140.00
	Whole Farm Insurance	**1**	acre	**$ -**			$0.00
	Infastructure Depreciation, Insurance, Storage [9]	**1**	acre	**$100.00**			$100.00
	Interest on Barns, Machinery [9]	**1**	acre	**$200.00**			$200.00
	Crop Insurance (Not Available Yet)	**1**	acre	**$ -**			$0.00
	Application & License Fee [10]	**1**	acre	**$100.00**			$100.00
	Growing Fee [10]	**1**	per year	**$100.00**	**# of acres**	**1.0**	$100.00
	Lab Test [10]	**1**	# of test	**$300.00**	**# of acres**	**1.0**	$300.00
Total Fixed Costs							**$1,021.25**
Total Specified Costs							**$1,539.98**
Total Profit							**-$839.98**
Breakeven Price to Cover Total Costs							**$1.54**
	Breakeven Yield at $0.7 /lb	**741**	**lb per acre to cover variable costs**				
	Breakeven Cost at 1000 lbs	**$0.52**	**/lb to cover variable costs**				

Previous work assisted with some of the expense assumptions for this model.

[1] The cost for water irrigation per acre inch and cost of land rent per acre comes from AFPC Working Paper (Outlaw, Joe L., et. al., 2019)

[2] Fee for fertilizer application came from Custom Fee for Wheat Grain Fertilizer Custom Application Fee taken from 2019 Estimated Costs and Returns per Acre Irrigated Wheat South Plains Extension District 2 for Fertilizer Application of Liquid Low and Liquid High (Smith, 2019).

[3] Field preplant preparation came from 2018 Texas Agricultural Custom Rates for Land Tillage Operations including cost of operator, machine, and fuel for Surface Chisel (3-8 inches) rate per acre (Klose, et al., 2019).

[4] The soil test cost of $7 came from the 2019 University of Kentucky Agricultural Economics Industrial Hemp Budgets (Mark & Shepherd, 2019).

[5] The cost of custom Grain Drill came from 2018 Texas Agricultural Custom Rates (Finished Feb 2019) for Planting Only No till: Drilling Rate per Acre (Klose, et al., 2019).

[6] The cost of Combine Harvest Cost came from 2018 Texas Agricultural Custom Rates (Finished Feb 2019) for Combining and Hauling Flat Rate (no extra charges) Corn Rate Per Bushel this includes operator, machine and fuel. Hauling per bushel which was given at $.48 a bushel (Klose, et al., 2019).

[7] Bryan Parr who is an agronomist with Legacy Hemp gave the cost for drying at $0.05 a pound (Parr, 2019). This budget assumes the entire harvest needs additional drying.

[8] Cost for Pickup/General Use Equipment and Irrigation Equipment are from 2018 Texas Agricultural Custom Rates (Finished February 2019) Guar District 2 Budget (Smith, February 2019).

[9] There was an assumption made that there would need to be some place to store the hemp at some point and overhead upkeep for machinery. Cost of Management Fee, Owner/Operator Labor, Infrastructure Depreciation, Insurance, and Storage, and Interest Barns, Machinery was from University of Kentucky Tobacco Enterprise Budget (Galloway, February 2019).

[10] Cost of Application and License Fee, Growing Fee, and Lab Test costs are from Texas Hemp Proposal (Texas Department of Agriculture, February 2020).

There was no lawyer fee assumed for this budget, however it should be considered for a farmer to look at a contract.

Hemp Fiber Enterprise Budget

The CBD Hemp Grain Model enterprise budget is contained in Table 4.4. The fiber price at the end of 2019 was $0.08 per pound. The fiber yield per acre is assumed at 9,000 pounds. These assumptions make the total revenue $720 per acre. The variable costs total $877.39. The fixed costs total $1,048.25. The net return per acre is a loss of $1,205.64. The yield per acre needs to be 10,967 to cover variable costs. The price for hemp fiber needs to be $0.10 at this yield to cover variable costs.

Table 4.4 2019 Texas Hemp Fiber Enterprise Budget Model

2019 Hemp Fiber							
ITEM	**DESCRIPTION**	**QUANTITY**	**UNIT**	**PRICE**			**TOTAL**
			(#/AC)	**($/UNIT)**			
Gross Returns Per Acre							
	Hemp Fiber	**9,000**	lbs	**$0.08**	**lbs**		$720.00
Total Revenue							**$720.00**
Variable Costs Per Acre							
Growing Crop	Seed	**50**	lbs	**$2.00**			$100.00
Fertilization	Nitrogen (Solid urea 46% N)	**150**	pound	**$0.46**			$69.00
	Phosphorous (P2O5)	**70**	pound	**$0.54**			$37.80
	Potassium (K2O)	**100**	pound	**$0.34**			$34.00
	Sulfur [1]	**25**	pound [2]	**$0.12**			$3.00
	Chemicals (Not Available Yet)	**1**	acre	**$ -**			$0.00
	Soil Test [3]	**1**	field	**$7.00**			$7.00
	Irrigation (If Required) [4]	**15**	ac in	**$6.50**			$97.50
Custom Work by Contractor	Fertilizer Application Fee [5]	**1**	acre	**$8.25**			$8.25
	Pre-sow plowing/preparing land [6]	**1**	acre	**$14.67**			$14.67
	Grain Drill [7]	**1**	acre	**$22.08**			$22.08
	Hemp Fiber Cutting, Raking, and Baling Cost [8]	**6**	bales per acre	**$35.00**			$210.00
	Hemp Raking Cost [9]	**1**	acre	**$7.00**	**# of rakings**	**2**	$14.00
	Moving Bales to Storage [10]	**4**	bales per acre	**$6.00**			$24.00
	Hauling Costs	**120**	miles [11]	**$1.50**			$180.00
	Interest on Operating Capital	**$1,869.55**	dollars	**6.00%**	**# of months**	**6**	$56.09
Total Variable Costs Per Acre							**$877.39**
Planned Return Above Variable Costs Per Acre							**-$157.39**
Fixed Costs Per Acre							
Equipment Fixed Costs	Pickup/General Use Equipment [12]	**1**	acre	**$1.25**			$1.25
	Irrigation Equipment [12]	**1**	acre	**$55.00**			$55.00
	Tractors/Self-Propelled [12]	**1**	acre	**$12.00**			$12.00
	Implements [12]	**1**	acre	**$10.00**			$10.00
Overhead Cost	Management Fee, Owner/Operator Labor [13]	**1**	acre	**$30.00**			$30.00
	Cash Rent [4]	**1**	acre	**$140.00**			$140.00
	Whole Farm Insurance	**1**	acre	**$ -**			$0.00
	Crop Insurance (Not Available Yet)	**1**	acre	**$ -**			$0.00
	Infastructure Depreciation, Insurance, Storage [14]	**1**	acre	**$100.00**			$100.00
	Interest on Barns, Machinery [14]	**1**	acre	**$200.00**			$200.00
	Application & License Fee [15]	**1**	acre	**$100.00**			$100.00
	Growing Fee [15]	**1**	per year	**$100.00**	**# of acres**	**1**	$100.00
	Lab Test [15]	**1**	# of test	**$300.00**	**# of acres**	**1**	$300.00
Total Fixed Costs							**$1,048.25**
Total Specified Costs							**$1,925.64**
Total Profit							**-$1,205.64**
Breakeven Price to Cover Total Costs							**$0.21**

Breakeven Yield at $0.08 /lb	**10967**	**lb per acre to cover variable costs**
Breakeven Cost at 9000 lbs	**$0.10**	**/lb to cover variable costs**

Previous work assisted with some of the expense assumptions for this model.

[1] The cost of Sulfur came from cost from 2019 Estimated Costs and Returns per Acre Irrigated Alfalfa South Plains Extension District 2 (Smith, 2019).

[2] Sulfur input at 25 pounds came from Bryan Parr who is an agronomist for Legacy Hemp (Parr, 2019).

[3] The soil test cost of $7 came from the 2019 University of Kentucky Agricultural Economics Industrial Hemp Budgets (Mark & Shepherd, 2019).

[4] The cost for water irrigation per acre inch and cost of land rent per acre comes from AFPC Working Paper (Outlaw, Joe L., et. al., 2019)

[5] Fee for fertilizer application came from Custom Fee for Wheat Grain Fertilizer Custom Application Fee taken from 2019 Estimated Costs and Returns per Acre Irrigated Wheat South Plains Extension District 2 for Fertilizer Application of Liquid Low and Liquid High (Smith, 2019).

[6] Field preplant preparation came from 2018 Texas Agricultural Custom Rates for Land Tillage Operations including cost of operator, machine, and fuel for Surface Chisel (3-8 inches) rate per acre (Klose, et al., 2019).

[7] The cost of custom Grain Drill came from 2018 Texas Agricultural Custom Rates (Finished Feb 2019) for Planting Only No till: Drilling Rate per Acre (Klose, et al., 2019).

[8] 2018 Texas Agricultural Custom Rates for Hay Cutting and Baling Operations including operator, machine, and fuel for round bales over 1500 lbs twine or wire tie rate per bale this found $27.50 for 4 bales (Klose, et al., 2019).

[9] Bryan Parr, an agronomist from Legacy Hemp, said the cost of raking hemp is 1-3 times that of hay (Parr, 2019).

[10] The cost to move bales to storage came from 2018 Texas Agricultural Custom Rates (Finished Feb 2019) for Hay Hauling including operator, machine, and fuel in the category of Hauling hay (field to storage): Round Bales, over 1500 lbs. at a Rate per bale (Klose, et al., 2019).

[11] 2019 University of Kentucky Agricultural Economics Industrial Hemp Budgets (Mark & Shepherd, 2019) distance was quadrupled to account for far distances in Texas.

[12] The crop found to be the most similar to the needs of hemp fiber in District two was Guar. Cost for Pickup/General Use Equipment, Irrigation Equipment, Tractors/Self-Propelled, and Implements are from 2018 Texas Agricultural Custom Rates Guar District 2 Budget (Smith, February 2019).

[13] There was an assumption made that there would need to be some place to store the hemp at some point and overhead upkeep for machinery. Cost of Management Fee, Owner/Operator Labor, was from 2018 Texas Agricultural Custom Rates Irrigated Alfalfa South Plains Extension District 2 (Smith, February 2019).

[14] There was an assumption made that there would need to be some place to store the hemp at some point and overhead upkeep for machinery. Infrastructure Depreciation, Insurance, and Storage, and Interest Barns, Machinery was from University of Kentucky Tobacco Enterprise Budget (Galloway, February 2019).

[15] Cost of Application and License Fee, Growing Fee, and Lab Test costs are from Texas Hemp Proposal (Texas Department of Agriculture, February 2020).

There was no lawyer fee assumed for this budget, however it should be considered for a farmer to look at a contract.

Assessing Risk on Production Systems

The budgets do not take into account movement of prices or yield once the crop is in production. Once the baseline budgets were created, risk was incorporated into the analysis two ways for the enterprise budgets. The first simulation assumes that there is price and yield risk for a farmer without a fixed price contract with the processor. The second way risk was incorporated is considering the counter-party risk or the risk processors do not pay farmers.

It is vital to investigate what the possible effect would be of changing prices or yield on the bottom line or net revenue for each production growing system. For this study, the minimum, middle point, and maximum values of CBD oil per percentage point were defined based on limited experimental data. These were discussed in Chapter 3. Due to a majority of hemp grown in the United States currently being for CBD production, risk will be based off of CBD budget numbers.

For each enterprise budget, prices and yields were simulated 500 iterations assuming a GRKS distribution drawing random prices and yields using Simetar. The input data for the GRKS distribution for yields and prices for each of the four budgets, the minimum, middle and maximum were presented in Table 3.1 and 3.2. The results are displayed as cumulative density functions (CDFs) that are an effective way to display the amount of risk in the budgets.

Budget Simulation with Assumed Payments from Processor

<u>CBD Vegetable Enterprise Budget Simulation</u>

The cumulative distribution for biomass yield of the Vegetable model is Figure 4.1. The mean of this distribution is 1,144.344 pounds of biomass per acre of CBD hemp production. The 0 yield of biomass would occur if there was a yield problem such as a hail storm that causes a complete failure of the hemp crop. The maximum pounds of CBD biomass for this simulation was 2,518.543 pounds per acre.

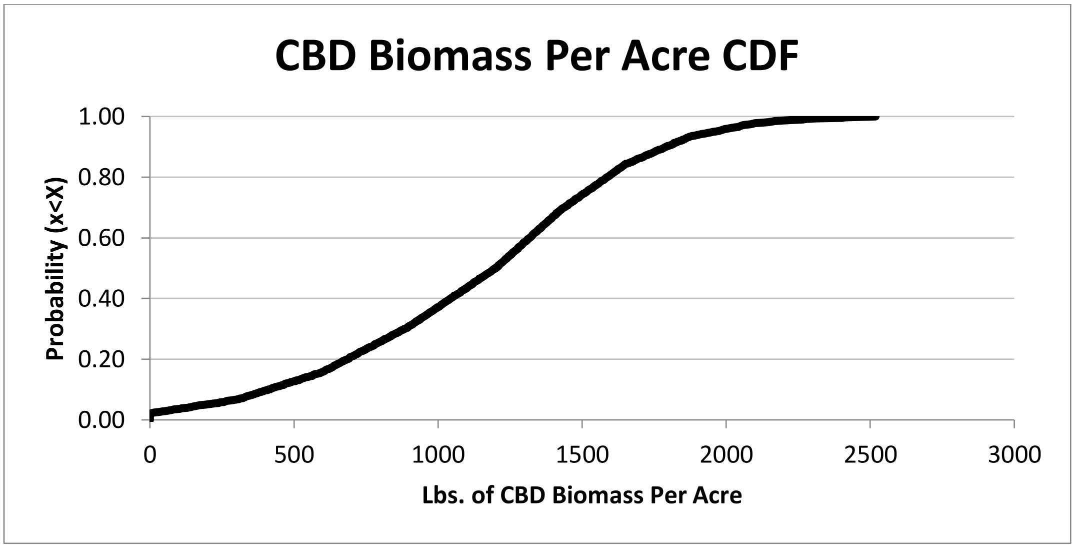

Figure 4.1 CBD Biomass Per Acre CDF

The cumulative distribution of CBD price per percentage point per pound of biomass of the Vegetable model is Figure 4.2. The mean of this distribution is $2.01 per percentage point per pound of biomass. The payment of $0 represents crop failure, no payment from processor, or not selling the crop as a spot price on the market without a contract. The maximum price of CBD for this simulation was $4.89 a percentage point per pound.

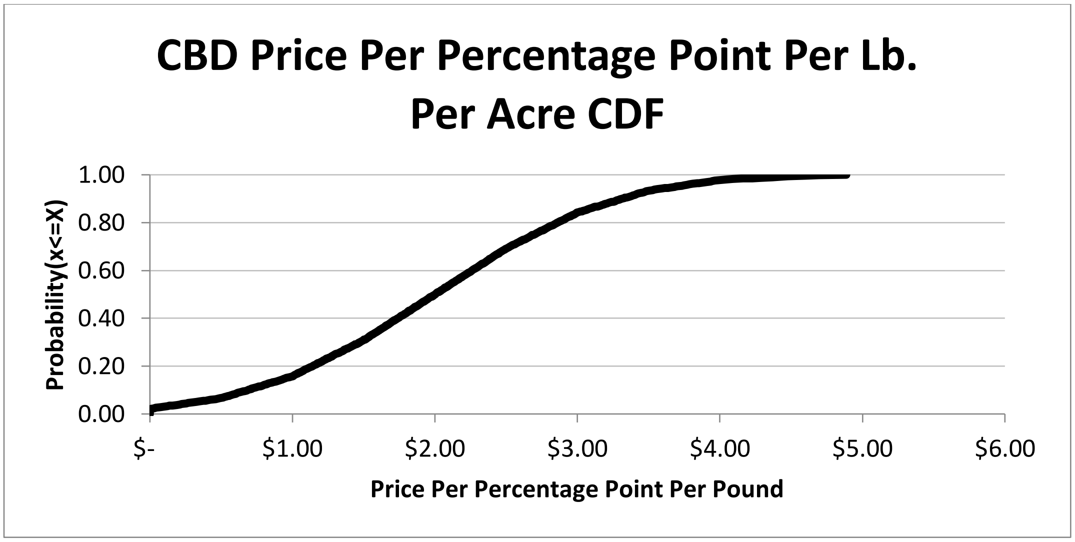

Figure 4.2 CBD Price Per Percentage Point Per Lb. Per Acre CDF

The CBD Vegetable Net Revenue simulation used the distributions from above in Figures 4.1 and 4.2. These distributions were put in place of the yield and price and thereby changed the net revenue output. The simulated results are presented in the cumulative distribution function in Figure 4.3. The mean net revenue is $1,368.04 dollars per acre. The most a farmer could lose per acre or highest simulated loss per acre was $19,335.37 dollars per acre. The maximum net revenue for a farmer is $60,746.71 dollars per acre. The probability a farmer will make $0 or less is 51.91%. Said another way, there is only a 48.09% change of making money with the CBD vegetable model.

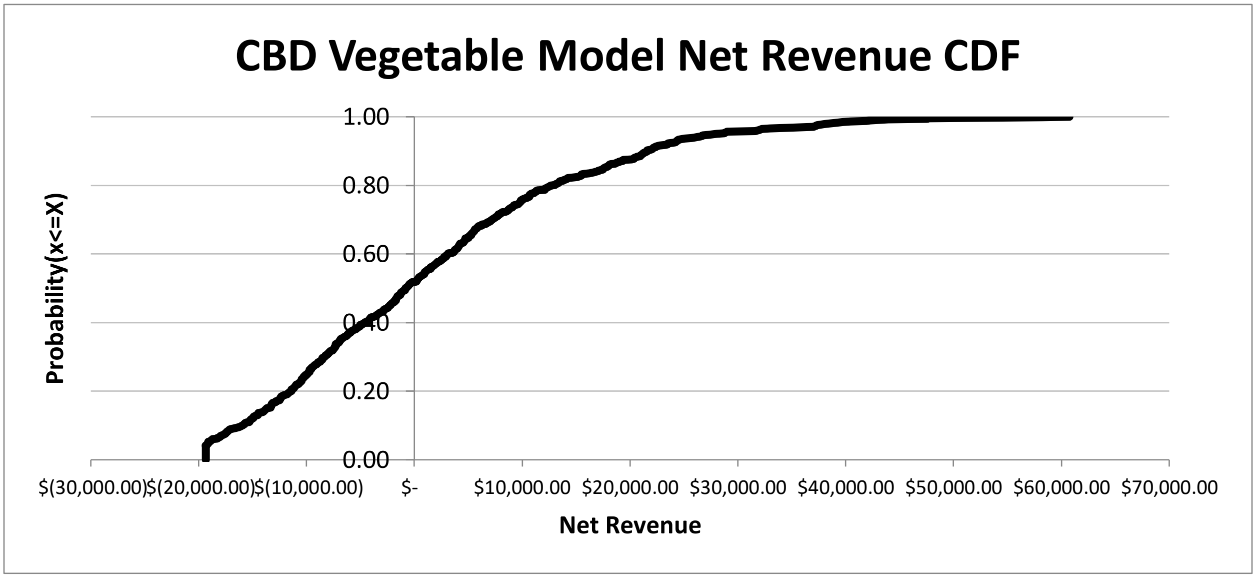

Figure 4.3 CBD Vegetable Model Net Revenue CDF

An example of one simulated outcome of the CBD Vegetable Model is in Table 4.5. In this example price is at $1.03 per percent of CBD per pound and yield of 968 pounds. This generates a total revenue of $8,934.67. The variable costs are $16,834.12. The fixed costs sum to $2,501.25. The net revenue for this budget is a loss of $10, 400.71 per acre. This assumes the processor paid the full contracted amount of $1.03 a % per CBD pound.

Table 4.5 One Simulated Outcome of the CBD Vegetable Enterprise Budget.

CBD Vegetable Model							
Item	DESCRIPTION	QUANTITY	UNIT	PRICE	TOTAL	TOTAL	TOTAL
			(#/AC)	($/UNIT)	($/AC)	($/LB)	
Gross Returns Per Acre							
	CBD%	9.0%					
	Price Per %	$ 1.03					
	Dry Matter Yield	968	lbs	$9.23			$8,934.67
Total Revenue							**$8,934.67**
Variable Costs Per Acre							
Genetics	Transplants	2500	plants	$5.00			$12,500.00
Fertilization	Nitrogen (Solid urea 46% N)	200	pound	$0.46			$69.00
	Phosphorous (P2O5)	150	pound	$0.54			$37.80
	Potassium (K2O)	150	pound	$0.34			$34.00
	Sulfur	25	pound	$0.12			$3.00
	Fertilizer Application Fee	1	acre	$8.25			$8.25
	Chemicals (not available yet)	1	acre	$ -			$0.00
	Soil Test	1	field	$7.00			$7.00
Growing	Cultivation (traditional)	1	acre	$10.89	# of Passes	2	$21.78
	Irrigation (if required -	15	ac in	$ 6.50			$97.50
Harvest	Drying Costs	0	lbs wet	$1.50			$0.00
	Tote Container	5	acre	$35.00			$175.00
	Hauling Costs	120	miles	$1.50			$180.00
Custom Work	Pre-Sow plowing/preparing lan	1	acre	$14.67			$14.67
	Custom transplanting	1	acre	$259.00			$259.00
	Roguing males Labor Cost	5	hours	$13.50			$67.50
	Weeding Labor Cost	100	hours	$13.50			$1,350.00
	Harvest Cost - Labor Cost	107.145	hours	$13.50			$1,446.46
	Interest on Operating Capital	$18,772.21	dollars	6.00%	# of Months	6.0	$563.17
Total Variable Costs Per Acre							**$16,834.12**
Planned Returns Above Variable Costs							**-$7,899.46**
Breakeven Price to Cover Variable Costs							
Fixed Costs Per Acre							
Equipment Fixe	Pickup/General Use Equipment	1	acre	$1.25			$1.25
	Irrigation Equipment	1	acre	$55.000			$55.00
Overhead Cost	Management Fee, Owner/Oper	1	acre	$ 165.00	$165.00		$165.00
	Cash Rent	1	acre	$140.00	$140.00		$140.00
	Whole Farm Insurance	1	acre	$ -			$0.00
	Crop Insurance (Not Available Y	1	acre	$ -			$0.00
	Application & License Fee	1	acre	$ 100.00			$100.00
	Growing Fee	1	per year	$100.00	# of acres	1	$100.00
	Lab Test	1	# of test	$300.00	# of acres	1	$300.00
	Legal Expense	6	#hours	$240.00			$1,440.00
	Interest Barns, Machinery	1	acre	$200.00	$200.00		$200.00
Total Fixed Costs							**$2,501.25**
Total Specified Costs							**$19,335.37**
Net Revenue							**-$10,400.71**

CBD Large-Scale Enterprise Budget Simulation

The cumulative distribution for biomass yield for the Large-Scale CBD model is presented in Figure 4.4. The mean of this distribution is 1,144.344 pounds of biomass per acre of CBD hemp production. The 0 yield of biomass would occur if there was genetic or environmental failure of the hemp crop. The maximum pounds of CBD biomass for this simulation was 2,518.543 pounds per acre.

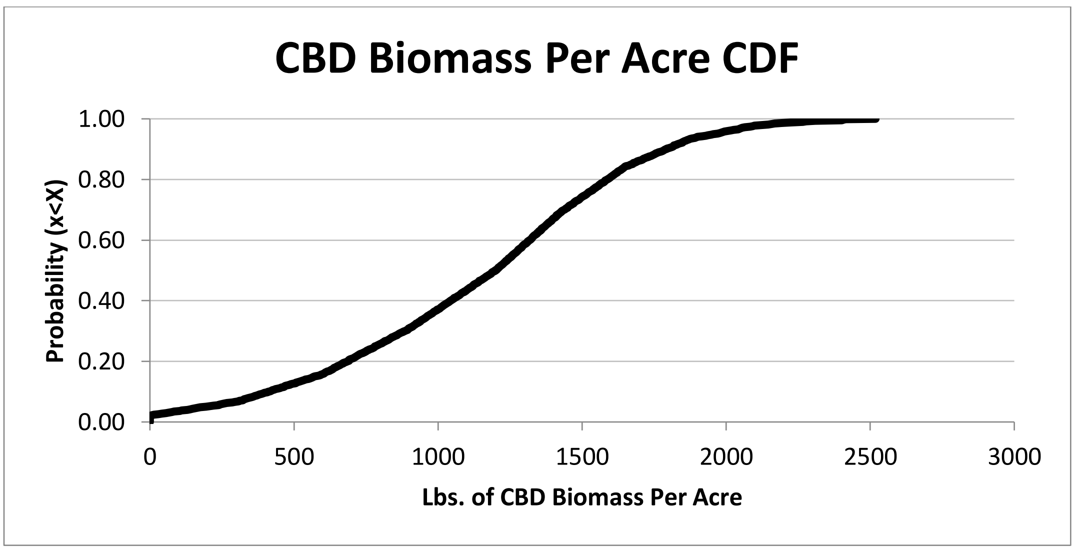

Figure 4.4 CBD Biomass Per Acre CDF

The cumulative distribution of CBD price per percentage point per pound of biomass of the Large-Scale CBD model is Figure 4.5. The mean of this distribution is $2.01 a percentage point per pound of biomass. The payment of $0 represents crop failure, no payment from processor, or not selling the crop as a spot price on the market without a contract. The maximum price of CBD for this simulation was $4.89 a percentage point per pound.

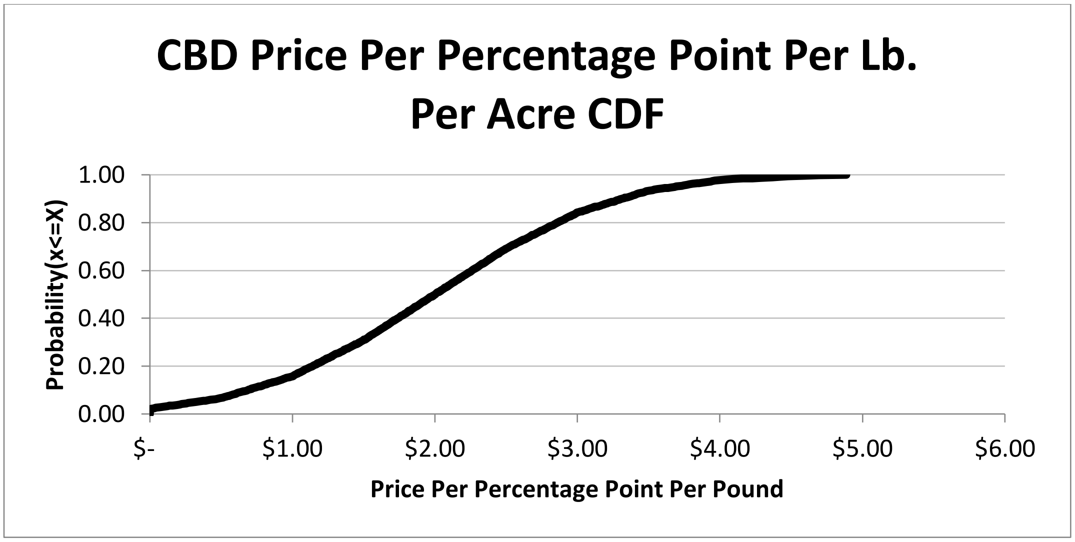

Figure 4.5 CBD Price Per Percentage Point Per Lb. Per Acre CDF

The Large-Scale CBD Model net revenue simulation used the distributions from Figures 4.4 and 4.5. These distributions were put in place of the yield and price and simulated generating 500 outcomes and is represented in the CDF in Figure 4.6. The mean net revenue is $6,638.16 dollars per acre. The minimum net revenue simulated per acre was ($9,464.49) dollars per acre. The maximum net revenue for a farmer is $52,821.57 dollars per acre. The probability a farmer will make $0 or lose money is 33.96%.

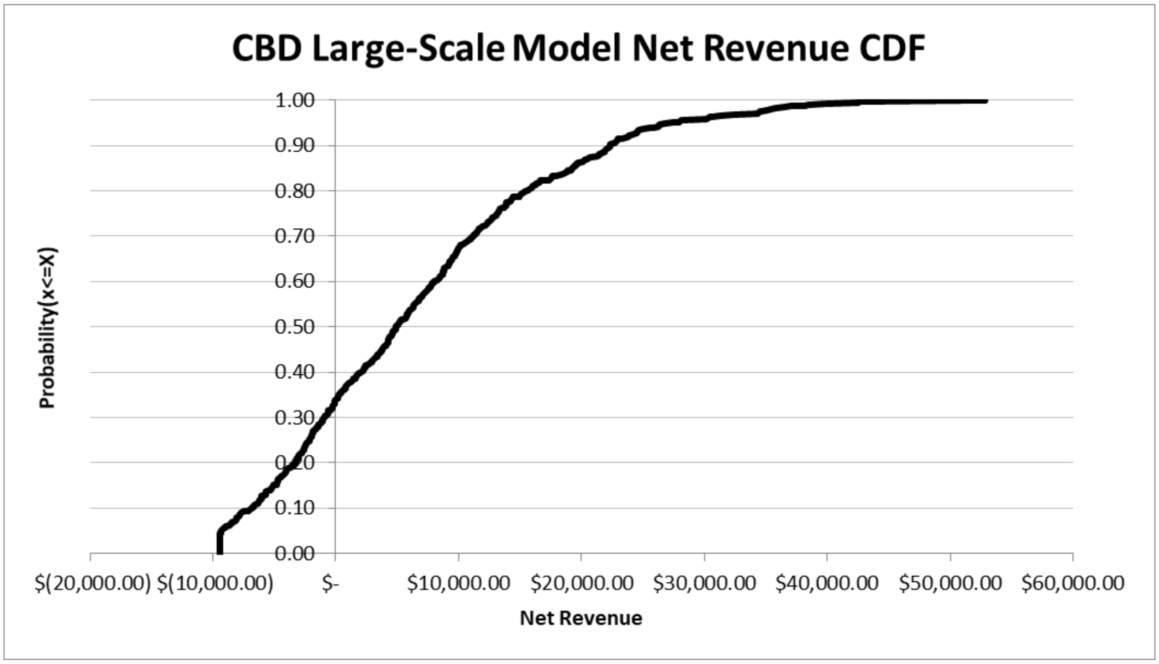

Figure 4.6 Large-Scale CBD Model Net Revenue CDF

An example of one simulated outcome of a CBD Large-Scale Enterprise Budget is in Table 4.6. In this example price is at $0.72 per percent CBD per pound and yield of 942 pounds. This make Total Revenue $4,724.15. The variable costs are $6,963.24. The fixed costs sum to $2,501.25. The net revenue for this budget is a loss of $4,740.34 per acre. This assumes the processor paid the full contracted amount of $0.72 a percent per CBD pound. With a price this low there is a significant loss to the operation.

Table 4.6 One Simulated Outcome of a CBD Large-Scale Enterprise Budget.

CBD Large-Scale Model							
Item	DESCRIPTION	QUANTITY	UNIT	PRICE	TOTAL	TOTAL	TOTAL
			(#/AC)	($/UNIT)	($/AC)	($/LB)	
Gross Returns Per Acre							
	CBD%	7.0%					
	Price Per %	$ 0.72					
	Dry Matter Yield	940	lbs	$5.03			$4,724.15
Total Revenue							**$4,724.15**
Variable Costs Per Acre							
Genetics	Feminized Seed Drilled	4000	seeds	$1.00			$4,000.00
Fertilization	Nitrogen (Solid urea 46% N)	200	pound	$0.46			$69.00
	Phosphorous (P2O5)	150	pound	$0.54			$37.80
	Potassium (K2O)	150	pound	$0.34			$34.00
	Sulfur	25	pound	$0.12			$3.00
	Fertilizer Application Fee	1	acre	$8.25			$8.25
	Chemicals (not available yet)	1	acre	$ -			$0.00
	Soil Test	1	field	$7.00			$7.00
	Irrigation (if required -	15	ac in	$ 6.50			$97.50
Harvest	Drying Costs	0	lbs wet	$1.50			$0.00
	Storage/Container Costs	5	acre	$35.00			$175.00
	Hauling Costs	120	miles	$1.50			$180.00
Custom Work	Pre-Sow plowing/preparing lan	1	acre	$14.67			$14.67
	Planting with Sugar Beet Plates	1	acre	$ 22.08			$22.08
	Cultivation (traditional)	1	acre	$10.89	# of Passes	2	$21.78
Labor	Roguing males Labor Cost	5	hours	$13.50			$67.50
	Weeding Labor Cost	100	hours	$13.50			$1,350.00
	Custom Harvest Cost	1	acre	$600.00			$600.00
	Interest on Operating Capital	$9,188.83	dollars	6.00%	# of Months	6.0	$275.66
Total Variable Costs Per Acre							**$6,963.24**
Planned Returns Above Variable Costs							**-$2,239.09**
Breakeven Price to Cover Variable Costs							
Fixed Costs Per Acre							
Equipment Fixe	Pickup/General Use Equipment	1	acre	$1.25			$1.25
	Irrigation Equipment	1	acre	$55.000			$55.00
Overhead Cost	Management Fee, Owner/Oper	1	acre	$ 165.00	$165.00		$165.00
	Cash Rent	1	acre	$140.00	$140.00		$140.00
	Whole Farm Insurance	1	acre	$ -			
	Crop Insurance (Not Available Y	1	acre	$ -			$0.00
	Application & License Fee	1	acre	$ 100.00			$100.00
	Growing Fee	1	per year	$100.00	# of acres	1	$100.00
	Lab Test	1	# of test	$300.00	# of acres	1	$300.00
	Legal Expense	6	#hours	$240.00			$1,440.00
	Interest Barns, Machinery	1	acre	$200.00	$200.00		$200.00
Total Fixed Costs							**$2,501.25**
Total Specified Costs							**$9,464.49**
Net Revenue							**-$4,740.34**

Hemp Grain Enterprise Budget Simulation

The CDF of Hemp Grain yields is presented in Figure 4.7. The mean of this distribution is 953.5956 pounds of hemp grain production per acre. The maximum pounds of CBD biomass for this simulation was 2,072.515 pounds per acre.

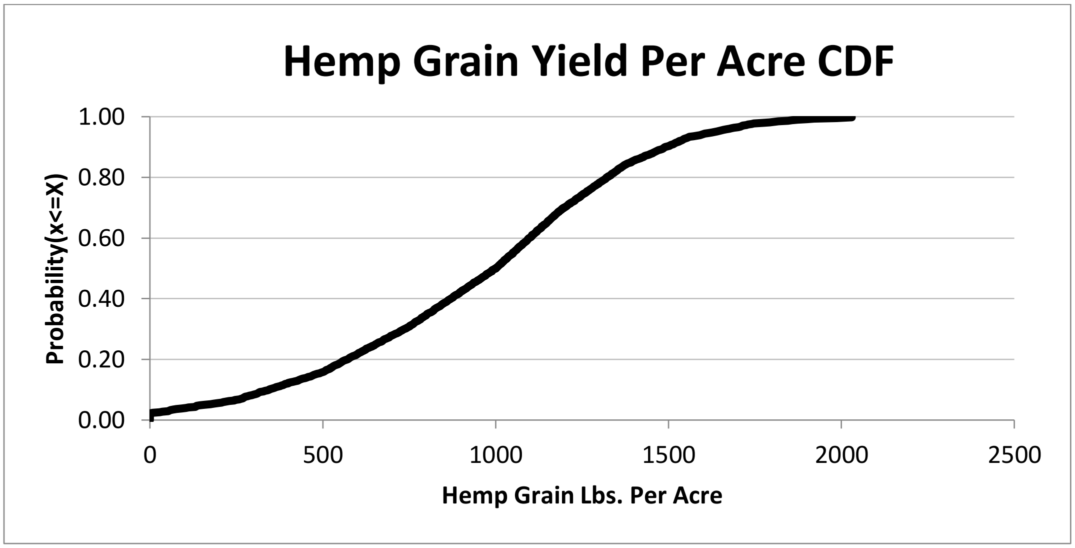

Figure 4.7 Hemp Grain Yield Per Acre CDF

The cumulative distribution of hemp grain price per pound for the Grain model is presented in Figure 4.8. The mean of this distribution is $0.70 per pound of grain. The payment of $0 represents crop failure, no payment from processor, or not selling the crop as a spot price on the market without a contract. The maximum price of CBD for this simulation was $1.70 per pound of grain.

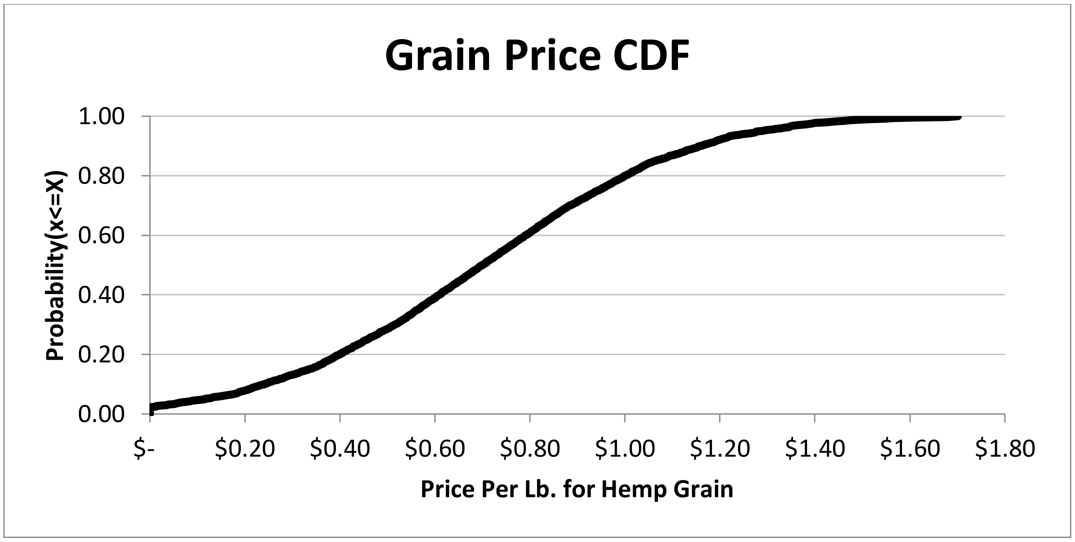

Figure 4.8 Grain Price CDF

The Grain net revenue simulation used the price and yields distributions shown in Figures 4.7 and 4.8. These distributions were put in place of the yield and price and thereby changed the net revenue output. The budget was then simulated, and the outcome of the simulation is represented in the CDF in Figure 4.9. The mean net revenue is a loss of $857.04 dollars per acre. The most a farmer could lose was $1,560.82 dollars per acre. The maximum net revenue for a farmer is $909.43 dollars per acre. The probability a farmer will make $0 or lose money is 94.27% or only 5.73% chance of making a profit.

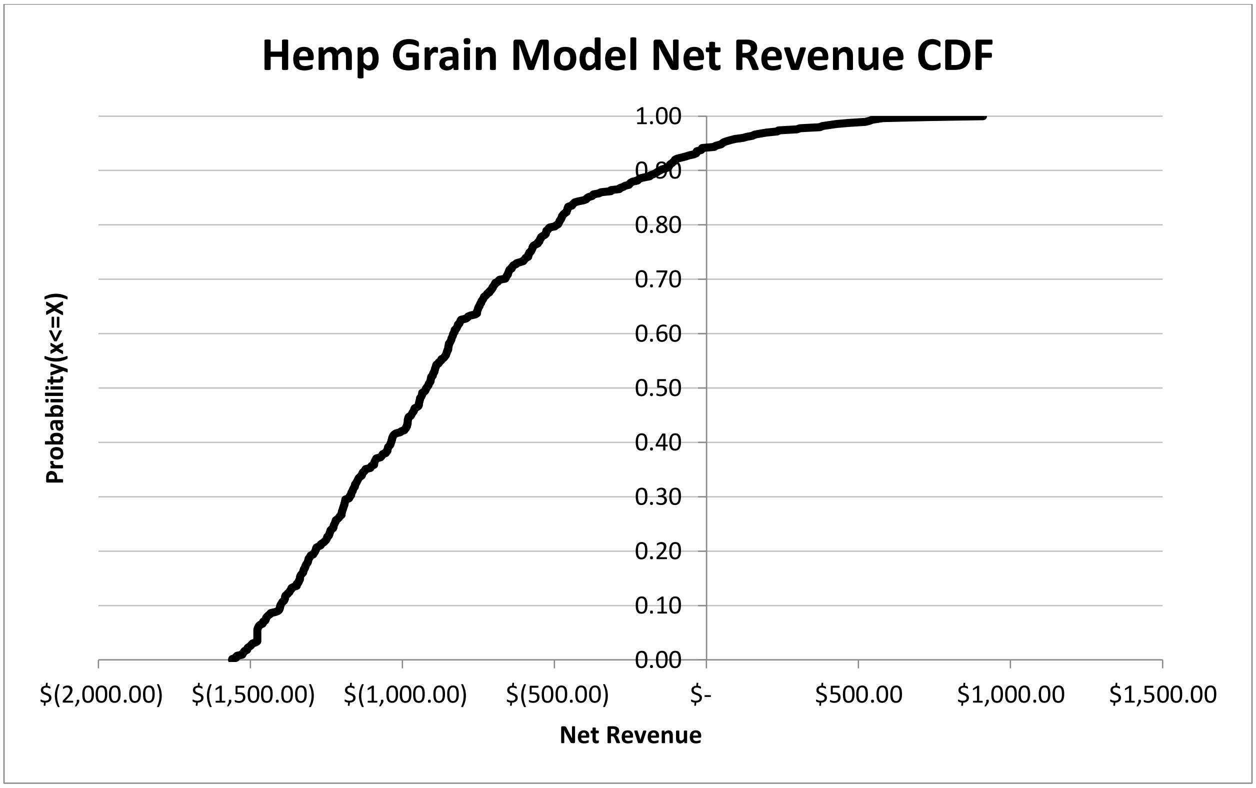

Figure 4.9 Hemp Grain Model Net Revenue CDF

One can see an example of one simulated outcome visually in the budget presented in Table 4.7. The price for this particular outcome was $.82. The yield on the acre was 1,532 pounds. The input costs of Combine Harvest Cost and Grain Cleaning Costs adjusted the yield amount and thus increased from the budget model example. The Net Revenue of this example was a farmer loss of $319.51. It should be noted that while price and yield were above average assumptions made for 2019 the farmer did not generate a positive profit, but instead lost $319.51 dollars on the acre.

Table 4.7 One Simulated Outcome of a Hemp Grain Enterprise Budget.

Hemp Grain							
Item	DESCRIPTION	QUANTITY	UNIT	PRICE	TOTAL	TOTAL	TOTAL
		Quant.	Unit	Price			Total
Gross Returns Per Acre							
	Hemp Grain	1,532	lbs	$ 0.82			$1,253.86
Total Revenue							$ 1,253.86
Variable Costs Per Acre							
Genetics	Seed	30.00	lbs	$ 3.50			$105.00
Fertilization	Nitrogen (Solid urea 46% N)	150	pound	$0.46			$69.00
	Phosphorous (P2O5)	70	pound	$0.54			$37.80
	Potassium (K2O)	100	pound	$0.34			$34.00
	Sulfur	25	pound	$0.12			$3.00
	Chemicals (Not Available Yet)	1	acre	$ -			$0.00
	Irrigation (If Required)	15	ac in	$ 6.50			$97.50
Custom Work by Contractor	Fertilizer Application Fee	1	acre	$8.25			$8.25
	Field Preplant Preparation	1	acre	$14.67	# of Passes	2.0	$29.34
Sowing	Soil Test	1	field	$ 7.00			$7.00
	Custom Grain Drill	1	acre	$ 22.08			$22.08
Harvest	Combine-Harvest Cost	34.82	bushel	$ 0.48			$16.72
	Hauling Costs	-	bu	$ -			$0.00
	Grain Cleaning	1,532.23	lbs	$ 0.05			$76.61
	Drying Cost	1,532	lbs	$ 0.00	Points Removed		$0.00
	Interest on Operating Capital	$1,527.55	dollars	6.00%	# of Months	6.0	$45.83
Total Variable Costs Per Acre							$552.12
Return Above Variable Costs Per Acre							$ 701.74
Breakeven Price to Cover Variable Costs							$ 0.36
Fixed Costs Per Acre							
Equipment Fixed Costs	Pickup/General Use Equipment	1	acre	$ 1.25			$1.25
	Irrigation Equipment	1	acre	$ 55.00			$55.00
Overhead Costs	Management Fee, Owner/Operator Labor	1	acre	$ 25.00			$25.00
	Cash Rent	1	acre	$ 140.00			$140.00
	Whole Farm Insurance	1	acre	$ -			$0.00
	Infastructure Depreciation, Insurance, Storage	1	acre	$ 100.00			$100.00
	Interest on Barns, Machinery	1	acre	$ 200.00			$200.00
	Crop Insurance (Not Available Yet)	1	acre	$ -			$0.00
	Application & License Fee	1	acre	$ 100.00			$100.00
	Growing Fee	1	per year	$ 100.00	# of acres	1.0	$100.00
	Lab Test	1	# of test	$ 300.00	# of acres	1.0	$300.00
Total Fixed Costs							$ 1,021.25
Total Specified Costs							$ 1,573.37
Net Revenue							$ (319.51)
Breakeven Price to Cover Total Costs							$ 1.03

Breakeven Yield at $0.82 /lb 675 lb per acre to cover variable costs

Breakeven Cost at 1532 lbs $0.36 /lb to cover variable costs

Hemp Fiber Enterprise Budget Simulation

The CDF of yield for the Hemp Fiber model is in Figure 4.10. The mean of this distribution is 8,581.72 pounds of hemp fiber production per acre. The maximum pounds of fiber for this simulation was 18,744.4 pounds per acre.

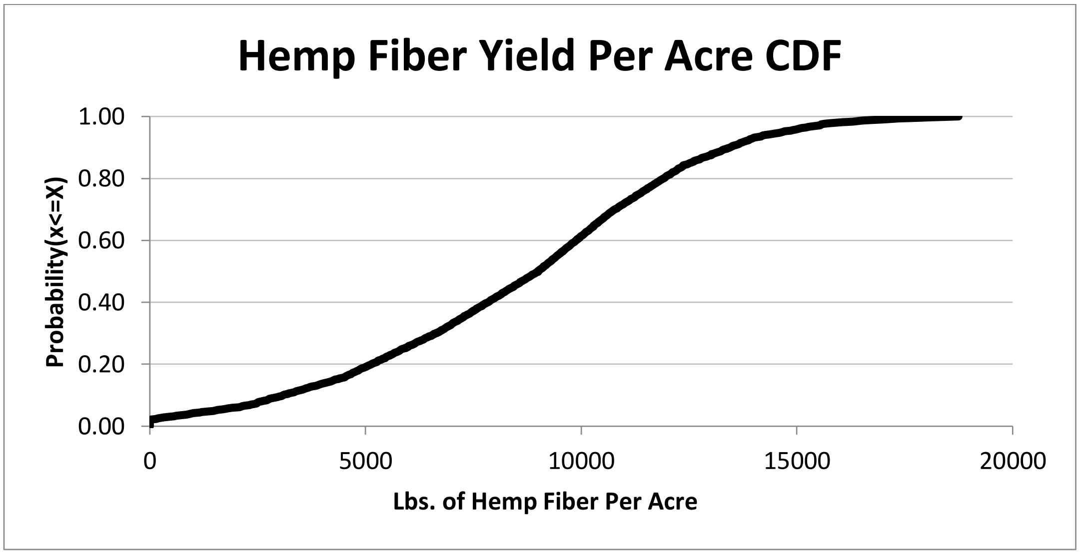

Figure 4.10 Hemp Fiber Yield Per Acre CDF

The CDF of hemp fiber price per pound of hemp fiber model is presented in Figure 4.11. The mean of this distribution is $0.08 per pound of fiber. The payment of $0 represents crop failure, no payment from processor, or not selling the crop as a spot price on the market without a contract. The maximum price of fiber for this simulation was $0.20 per pound of fiber.

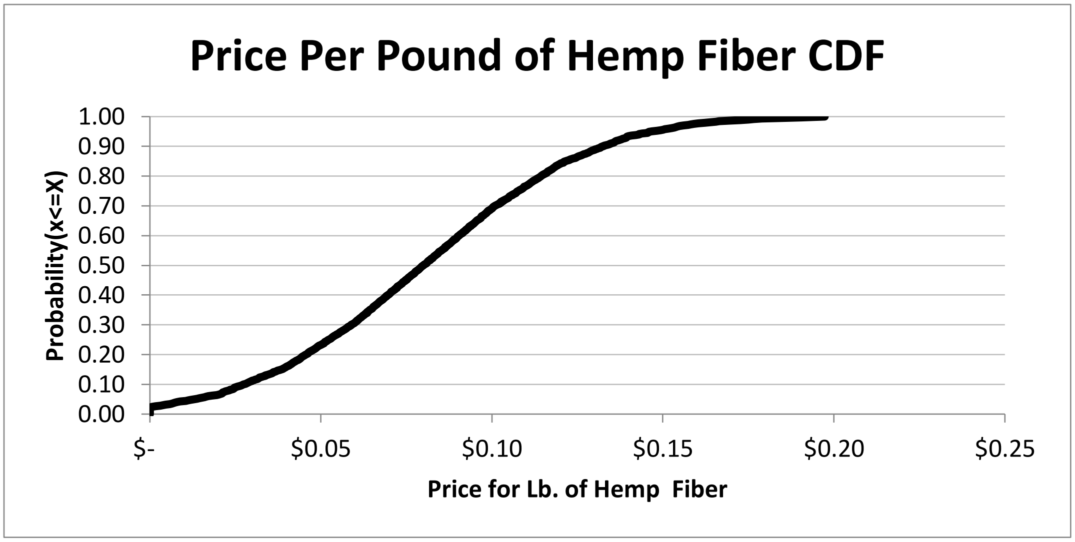

Figure 4.11 Price Per Pound of Hemp Fiber CDF

The Fiber net revenue simulation used the price and yield distributions from Figures 4.10 and 4.11. These distributions were put in place of the yield and price and thereby changed the net revenue output. The budget was then simulated, and the outcome of the simulation is represented as the CDF of net revenue in Figure 4.12. The mean net revenue is a loss of $1,215.07 dollars per acre. The most a farmer could lose per acre or highest simulated loss per acre was $2,087.18 dollars per acre. The maximum net revenue for a farmer is $693.03 dollars per acre. The probability a farmer will make $0 or lose money is 98.63%.

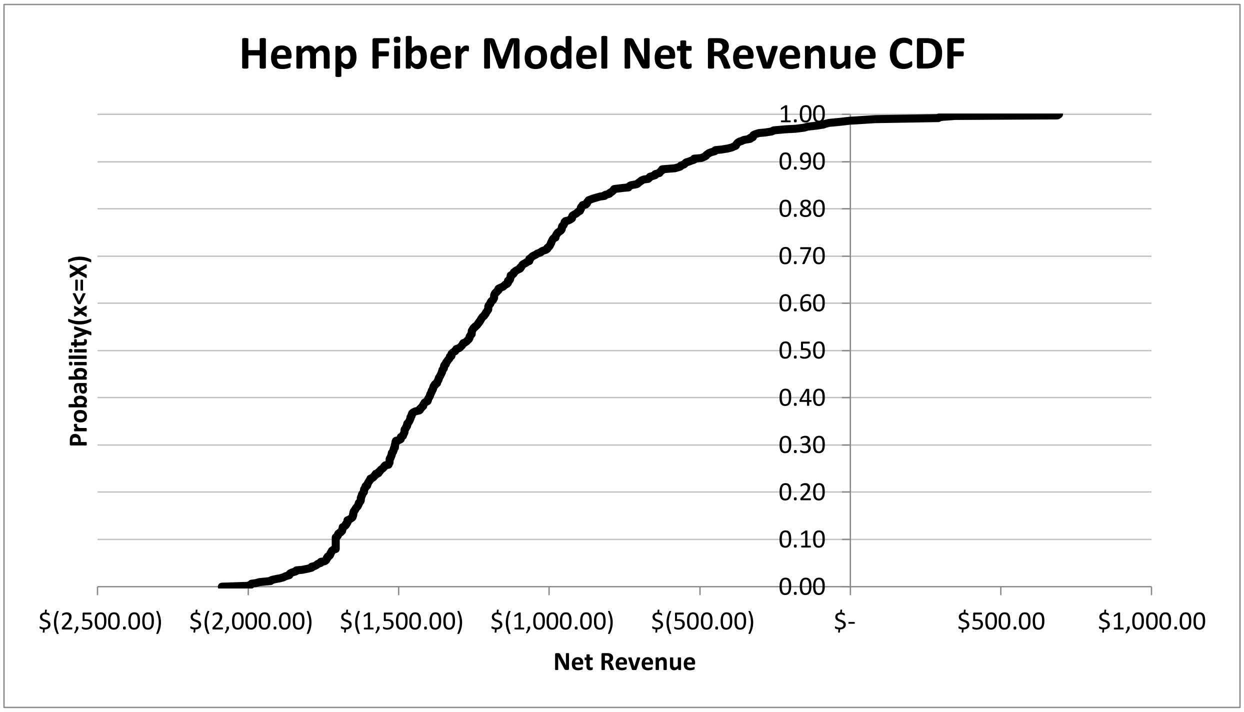

Figure 4.12 Hemp Fiber Model Net Revenue CDF

An example of one simulated outcome of a Hemp Fiber Enterprise Budget is in Table 4.8. In this example price is at $0.11 a pound of fiber and yield of 9,979 pounds. This makes total revenue $1,145.59. The variable costs are $900.92. The fixed costs sum to $1,048.25. The net revenue for this budget is a loss of $803.58 per acre. The breakeven price to cover total costs for this simulated yield and costs is $0.20 a pound.

Table 4.8 One Simulated Outcome of a Hemp Fiber Enterprise Budget.

Hemp Fiber							
Item	DESCRIPTION	QUANTITY	UNIT	PRICE	TOTAL	TOTAL	TOTAL
		Quant.	Unit	Price			Total
Gross Returns Per Acre							
	Hemp Fiber	9,979	lbs	$0.11	lbs		$1,145.59
Total Revenue							$1,145.59
Variable Costs Per Acre							
Growing Crop	Seed	50.00	lbs	$2.00			$100.00
Fertilization	Nitrogen (Solid urea 46% N)	150	pound	$0.46			$69.00
	Phosphorous (P2O5)	70	pound	$0.54			$37.80
	Potassium (K2O)	100	pound	$0.34			$34.00
	Sulfur	25	pound	$0.12			$3.00
	Chemicals (not available yet)	1	acre	$ -			$0.00
	Soil Test	1	field	$7.00			$7.00
	Irrigation (if required - water)	15	ac in	$6.50			$97.50
Custom Work by Contractor	Fertilizer Application Fee	1	acre	$8.25			$8.25
	Pre-Sow plowing/preparing la	1	acre	$14.67			$14.67
	Grain Drill	1	acre	$ 22.08			$22.08
	Hemp Fiber Cutting, Raking, ar	6.65	Bales per a	$35.00			$232.84
	Hemp Raking Cost	1	acre	$7.00	Number of	2	$14.00
	Moving Bales to Storage	4	bales per a	$6.00			$24.00
	Hauling Costs	120	miles	$1.50			$180.00
	Interest on Operating Capital	$1,892.39	dollars	6.00%	# of Month	6	$56.77
Total Variable Costs Per Acre							$900.92
Planned Return Above Variable Costs Per Acre							$244.67
Fixed Costs Per Acre							
Equipment Fixed Costs	Pickup/General Use Equipmen	1	acre	$ 1.25			$1.25
	Irrigation Equipment	1	acre	$ 55.00			$55.00
	Tractors/Self-Propelled	1	acre	$ 12.00			$12.00
	Implements	1	acre	$ 10.00			$10.00
Overhead Cost	Management Fee, Owner/Ope	1	acre	$ 30.00			$30.00
	Cash Rent	1	acre	$140.00			$140.00
	Whole Farm Insurance	1	acre	$ -			$0.00
	Crop Insurance (Not Available	1	acre	$ -			$0.00
	Infastructure Depreciation, Ins	1	acre	$ 100.00			$100.00
	Interest on Barns, Machinery	1	acre	$ 200.00			$200.00
	Application & License Fee	1	acre	$100.000			$100.00
	Growing Fee	1	per year	$100.00	# of acres	1	$100.00
	Lab Test	1	# of test	$300.00	# of acres	1	$300.00
Total Fixed Costs							$ 1,048.25
Total Specified Costs							$ 1,949.17
Net Revenue							$ (803.58)
Breakeven Price to Cover Total Costs							$ 0.20

Breakeven Yield at $0.11 /lb	7848	lb per acre to cover variable costs
Breakeven Cost at 9979 lbs	$0.09	/lb to cover variable costs

Effects of Risk from Processors Not Paying Farmers Simulation

The second way this thesis simulated risk was by considering a counter-party risk or the risk processors do not pay farmers. To simulate the likelihood of nonpayment this study would not use a continuous distribution, instead it would be assessed as a yes or no. The farmer was paid or not paid. This study used a Bernoulli distribution to simulate payment. Thus, every time the simulation is a 1 it would mean the farmer received payment. Every time the outcome was 0 it would mean the farmer would not receive payment. Some processors paid firms in installments. This would mean they might pay them a certain amount of money at the beginning of the season. Then, pay another installment at planting. Then, pay another installment midway through the season. Followed by, another payment at harvest. Lastly, they would pay a final and largest payment way after harvest when all of the crop was processed.

This was modeled in a two-step process. First there was a Bernoulli equation for how often a farmer was paid by the processor. Then, to what extent a farmer was paid (ex. 25% of contract, 75% of contract etc.)

There were two scenarios evaluated. The first is if the processor paid the farmer 50% of the time. This is represented by =Bernoulli(0.5). Then if the outcome of the first step was 1 (meaning there was payment) the Formula was =GRKS(25, 70, 100). This means the lowest amount assumed a farmer would make would be 25% of the contract. The mid payment would be 70% payment. The maximum payment would be the full contract of 100%.

The CDF of Scenario 1 is in Figure 4.13. The mean of this simulation was 69.92; meaning if the farmer was paid by a processor, they would be paid 69.92% of their contract. The minimum of this simulation was 3.907; meaning if the farmer was paid, the minimum they would be paid would be 3.907% of their contract. The maximum a farmer would be paid would be 100% of their contract.

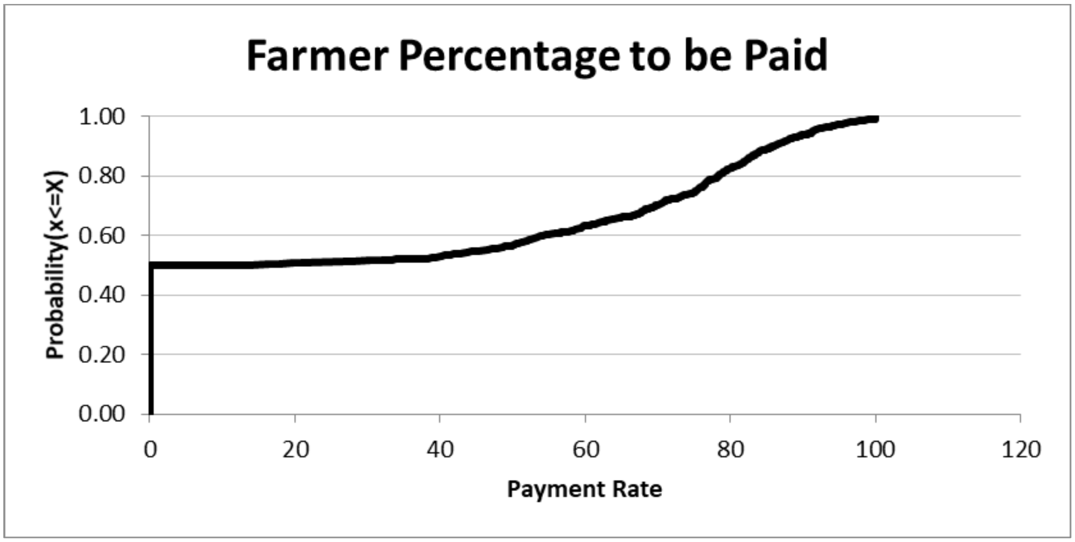

Figure 4.13 Scenario 1 Farmer Percentage to be Paid CDF

Table 4.9 Scenario 1 Net Revenue Outcome

	Mean Net Revenue	Mean Payment Percentage	Net Revenue With Percentage Payment Outcome
CBD Vegetable Model	$1,368.04	69.92%	$956.54
CBD Large-scale Model	$6,638.16	69.92%	$4,641.40
Hemp Grain Model	($857.04)	69.92%	($599.24)
Hemp Fiber Model	($1,215.07)	69.92%	($849.574)

If the means of Scenario 1 were applied to the net revenue means of the budgets the farmer payment per acre would be still be positive net revenue for the CBD Vegetable and CBD Large-scale models and negative for the Hem Grain and Fiber Models (Table 4.11).

The second scenario is intended to represent the impact of even less payment by processors on farmer net revenue. The second scenario is if the processor paid the farmer 10% of the time. This is represented by =Bernoulli(0.1). Then if the outcome of the first step was 1 (meaning there was payment) the Formula was =GRKS(10, 40, 100). This means the lowest amount assumed a farmer would make would be 10% of the contract. The mid payment would be 40% payment. The maximum payment would be the full contract of 100%.

The CDF of Scenario 2 is presented in Figure 4.14. The mean of this simulation was 45.85; meaning if the farmer was paid by a processor, they would be paid 45.85% of their contract. The minimum of this simulation was 0; meaning if the farmer was selected to be paid, they would not be paid any of their contract. This is due to the pseudo minimum assumption of the GRKS distribution. The maximum a farmer would be paid would be 100% of their contract.

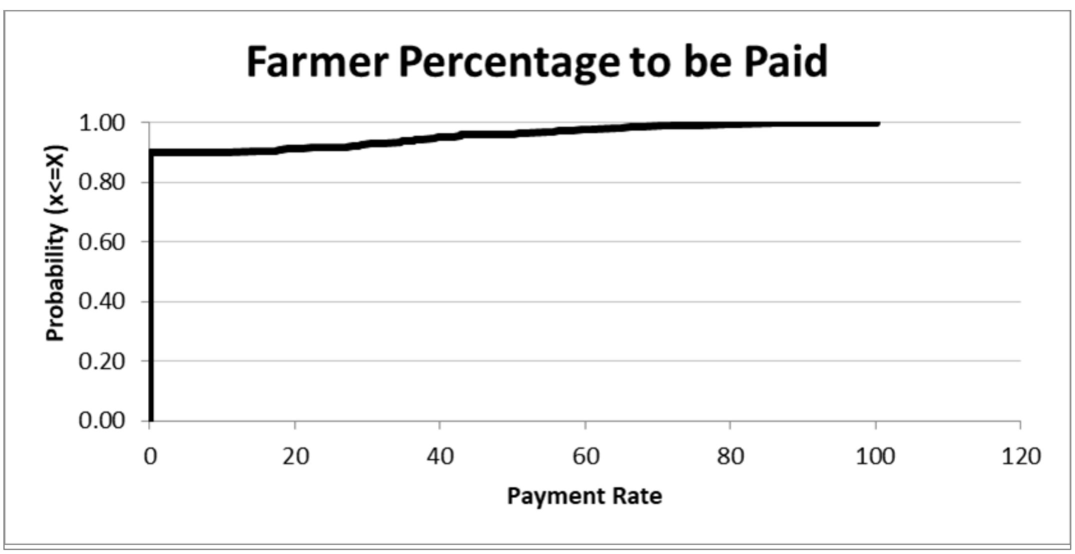

Figure 4.14 Scenario 2 Farmer Percentage to be Paid CDF

If the means of Scenario 2 were applied to the net revenue means of the budgets the farmer payment per acre would result in slightly lower net revenue than scenario 1 (Figure 4.12).

Table 4.10 Scenario 2 Net Revenue Outcome

	Mean Net Revenue	Mean Payment Percentage	Net Revenue With Percentage Payment Outcome
CBD Vegetable Model	$1,368.04	45.85%	$627.25
CBD Large-scale Model	$6,638.16	45.85%	$3,043.60
Hemp Grain Model	($857.04)	45.85%	($392.95)
Fiber Model	(1,215.07)	45.85%	($557.11)

The inclusion of price and yield risk into enterprise budgets is a first for this industry. No agricultural economist has published any simulation of the economics of hemp. The greatest simulated mean net revenue is from the CBD Large-Scale Model. This is impactful because the difference among the CBD models is the equipment, labor and assumed CBD percentage for harvest. Thus, CBD Large-Scale has more machine mechanization, less labor, and a lower assumed % of CBD. The results of the scenario payment simulations confirm the importance of processor payment for the CBD models. The simulation results indicate a wide variation in the probability of generating a positive net revenue. Table 4.13 provides the average simulated net revenues and the probability of a farmer achieving a positive net revenue for each of the four models.

Table 4.11 Simulated Average Net Revenue and Probability of Positive Net Return for the Four Models.

	Simulated Average Net Revenue	Probability of Positive Net Revenue
CBD Vegetable Model	$1,368.04	48.09%
CBD Large-scale Model	$6,638.16	66.04%
Hemp Grain Model	-$857.04	5.73%
Hemp Fiber Model	-$1,215.07	1.37%

Data Limitations and Future Research

In development of the enterprise budgets, the reader is reminded of several caveats and cautions:

These budgets are for the year 2019 only. They are intended to be setting a baseline for Texas production in the years going forward. Given the great amount of interest in the crop; at least some Texas producers will be growing hemp in Texas in 2020 once the rules and regulation have been established. These budgets will be a useful starting point for the 2020 crop year and producers can update output and input prices as those prices become known for 2020.

It should be cautioned that production methods are highly varied with a great amount of volatility within each method. Unlike more established crop enterprise budgets – where there are generally accepted standards of cost and revenues that serve as a reference point for creating budgets – the lack of publicly available information on hemp makes budgeting a greater challenge.

These budgets were developed by taking as much information from enterprise budgets available in other states and adjusting to climate and soil conditions in Texas. Since it is not known exactly how Texas producers will want to plant or harvest hemp, the budgets use current custom rates survey data as a reasonable proxy for what farmers might spend where data is not currently available. There are a few key concerns that could be considered in future research.

Contracts

Most hemp grown today is under contract with an end product processor (seed, CBD, or fiber). Contracts are a vital part of hemp production for many reasons, including the fact to qualify for crop insurance on hemp, a producer must have a contract on the insured production. Producers growing hemp need to make sure that they are comfortable with the contracts provided by the processors. A producer may want to have their lawyer look over a contract before signing. As with any new industry, there has been a number of entrants to the industry. There are numerous stories of processors going out of business or not being able to pay their producers who are under contract. Presently, this is one of the greatest risks of growing industrial hemp. Producers should vet a processor, including physically visiting a processing facility, before entering into a contract. Producers should negotiate safeguards into their contracts to make sure that they get paid for the crop they grow.

In the words of Tom Shipley, Iowa State Senator, “Hemp is not going to save nobody” (Farm Journal, 2019). Low farm payments in other commodities has many producers searching for alternatives that would leave the balance sheet in black instead of red, this is not your crop. In the words of a fellow researcher from Colorado “Hemp is at best unpredictable. Sometimes it likes tissue culture. Sometimes it doesn’t. Sometimes it likes ...” The best economic advice for farmers is “one should not invest more in industrial hemp than they can stand to lose.”

Markets/overproduction

There are many possible uses for hemp, particularly hemp fiber. Industrial uses include: clothing, insulation, and automobile parts. For example, in Europe, hemp has been used in automobile molding and other parts for some time (Karus & Vogt, 2004). In fact, according to Karus and Vogt in 2002, the market share of hemp fibers used in the automotive sector amounted to about 15% – compared to less than 1% in 1996. Hemp shives which is a byproduct of the fiber production system has established a long-standing commercial use in Europe. While most of these markets do appear to have potential in the United States, they are still in their infancy. To develop fully, additional hemp products will have to be less costly than current products or perform a function better than an alternative. Until these markets are fully developed, the ability of the supply of raw hemp inputs provided by a greater number of planted acres to overwhelm the market is real issue.

Processing

Currently, the CBD processing portion of the hemp industry is in a bottleneck. However, more processors are popping up daily and efficiency is improving. As many new processors are entering the industry as growers. The learning curve is steep and sound financial practices must be followed.

Hemp fiber and seed processing in the United States is also presently limited. This is expected to change, but it should be noted that to grow fiber, it is ideal to be as close to the processing plant as possible. Otherwise, profits margins are squeezed by transportation costs incurred moving the bulky hemp stalks.

The seed and grain model at this point seems to have a wide range of market potential and a large dependence on indsustry regulations. Again, hemp seed cannot be fed presently to animals. However, the protein percentage has intrigued interest from many agriculturalists. Canola oil is high in Omega 3 and Omega 6. Soybean has high levels of estrogen and unbalanced amino acids. Hemp is good as whole food as it has balanced amino acids (Hutchens, 2019).

The fiber production sector of agriculture is likely the longest-term and latest-term sector to develop. From an economic perspective hemp pulp is 2 to 3 times more expensive compared to wood pulp. Hemp may be more absorbent than wood. Currently, it will be difficult to compete with wood at $25/ton. However, consumer preferences for a biodegradable source of fiber could drive up demand. The options in relation to plastic would be to making plastic from hemp or putting hemp in plastic. The potential to put hemp into plastic for example using hemp for car parts in auto car supply chain would be a huge area for the industry. An example would be using hemp for car parts in the auto car supply chain. Another product that could have a lot of potential would be insulation as it is not an irritant as fiberglass is (Riddle, 2019).   Hemp based animal bedding is more absorbent dust free and odor free. Hemp chipped bedding biodegrades faster than wood chipped animal bedding which makes it better for the environment.

Cross Pollination

For hemp varieties grown for a higher content for CBD, it is imperative that there are not male plants in the vicinity that can cross pollinate. Such plants would cause the percentage of CBD to decrease. Removing males from a feminized seed field can be very costly, depending on the purity and quality of the seed. There is the thought that hemp grown for grain or fiber could pollenate hemp grown for CBD if planted close enough for the pollen to drift into neighboring fields. The highest concentration of CBD in a hemp plant is in the floral material. Thus, having female plants go from flowering to seed could present issues for a CBD grower. Cross pollination does not seem to be a big issue for seed or fiber production.

Seeds

As discussed previously, there is a great variation in hemp seed size and quality. There are also many reports of poor germination percentages with the crop. The reason for this has not been sufficiently studied, but there are likely a number of factors at play.

In 2019, the lack of availability of seed for planting was a huge obstacle for growers. Hemp seed also commanded relatively high prices. Even when a producer was able to procure seed, getting a stand was sometimes a struggle. With other crops such as corn and cotton, there are decades of breeding and technology introduced into the seed stock. This is not true for hemp. Thus, hemp seed may have issues with germination and emergence until the breeding programs get established.

FDA/Market Regulation

It has been observed that the hemp market has gotten ahead of regulation. So, the industry has had its issues with fraud. This is probably true for most new and fast-growing industries. Many in the industry seem to be eager for more regulations so as to not disenfranchise a group of consumers. The USDA will hopefully provide some clarity when they finish their rules and regulation for growing hemp. One of the questions that would need to be covered includes standardized testing procedures for THC content. Currently there are many ways of testing. For example, what part/parts of the plant is being tested, how many cuttings are taken, and what testing procedure is used. One can see how altering any of the metrics that go into testing could lead to variance in test results.

The consumer products side of the hemp industry has also been plagued by a lack of quality control, consistency, and unregulated CBD claims. Since 2015, FDA has issued almost 50 letters warning firms that they were making unverified claims about products containing CBD or the products themselves were found to not contain the level of CBD claimed (FDA, 2019).

Additionally, a recent study reported that a test of 84 CBD products found “a wide range of CBD concentrations.” Additionally, “Of the tested products, 26% contained less CBD than labeled, which could negate any potential clinical response (JAMA, 2017).”

Lastly, the 2018 Farm Bill explicitly states that the FDA will maintain jurisdiction over ingestible and topical products made from hemp. This includes CBD. How the FDA handles its regulation of the product which is currently driving the hemp industry in the United States will have vast implications going forward with the potential to drive even more demand for CBD or change the industry entirely.

CHAPTER V

SUMMARY AND CONCLUSIONS

In 2019, farm debt is predicted to be $416 billion, a record high, with $257 billion in real estate debt and $159 billion in non-real estate debt (Newton, 2019). While farm income is projected to reach $88 billion which would be the highest since 2014, nearly 40% of farm income is related to trade assistance, disaster resistance, farm program payments and insurance indemnities. With record high debt and farmers experiencing cash flow problems, Chapter 12 farm bankruptcies are up 24% from 2018. Many farmers are contemplating alternatives that could save their farm.

The Agriculture Improvement Act of 2018 (2018 Farm Bill) legalized the commercial production of hemp and authorized states to submit state plans to administer hemp programs. In addition, the 2018 Farm Bill provides insurance companies the ability to develop insurance products and legally insure the crop. The 2018 Farm Bill policy change combined with very few profitable alternatives has many farmers excited about the possibility of growing hemp as a profitable cropping alternative.

On June 10, 2019, House Bill 1325 was signed into law by Texas Governor Greg Abbott. House Bill 1325 authorizes the production, manufacture, retail sale, and inspection of industrial hemp crops and products in Texas.

Objectives

While the potential for a new basic crop for producers is very exciting, there remains fundamental questions. Producers do not have all of the necessary information needed to analyze whether this crop is a good financial decision. The primary objective of this thesis is to create Texas specific enterprise budgets for CBD, Fiber, and Grain production methods. These four types include, but are not limited to: CBD Large Scale, CBD Vegetable Model, Hemp grown primarily for Grain, and Hemp grown primarily for Fiber. A secondary objective would be to incorporate risk in each of the budgets by simulating a range of realistic market assumptions to determine the likelihood or probability of an economic profit.

Methodology

There is a limited amount of reliable research available for industrial hemp. University-based economists in the United States have not completed recent or complete industrial hemp budgets with labor and equipment costs. Therefore, a major portion of the data collection for the thesis was visiting past and current producers, processors, and individuals involved in the industrial hemp industry. This information combined with previous research was used to create enterprise budgets specific for Texas on the four types of Industrial Hemp Production: CBD Large Scale, CBD Vegetable Model, Hemp grown primarily for Grain, and Hemp grown primarily for Fiber. These budgets were developed by taking as much information from enterprise budgets available in other states and adjusting to climate and soil conditions in Texas. To achieve the secondary objective, risk was incorporated into the budgets using the Excel add-in Simetar.

Results

The hemp budgets will serve as a key decision tool for Texas farmers, as well as, extension professionals. The net revenue for each budget gives an indication about the expected profit margin for each production system. The bottom-line average profitability for each of the four types of production and probability of each generating a positive net return are contained in Table 5.1. Given the assumed prices and production costs, only the CBD systems would be expected to generate a positive profit. The hemp grain model and fiber-grain models would lose $809.39 and $1,215.07 per acre. When considering risk, the only production system that is expected to generate a positive net revenue more than one-half of the time is the CBD Large-scale Model. Both the Hemp Grain and Hemp Fiber Models have less than a 6% chance of generating a positive net revenue.

Table 5.1 Simulated Average Net Revenue and Probability of Positive Net Return for the Four Production Systems.

	Simulated Average Net Revenue	Probability of Positive Net Revenue
CBD Vegetable Model	$1,368.04	48.09%
CBD Large-scale Model	$6,638.16	66.04%
Hemp Grain Model	-$857.04	5.73%
Hemp Fiber Model	-$1,215.07	1.37%

The simulation of yield, price, and net revenue gives a clearer picture of possible net revenue outcomes for farmers. It should be noted the CBD production models while have the highest positive net return, still have a significant probability of a farmer losing money. The simulation and risk scenarios could be useful in evaluating and determining areas of weakness for individual farms. With processors in financial difficulty, this study could mean that if farmers are not going to be paid it could put them in a situation where they could be insolvent.

The inclusion of risk in enterprise budgets is the first for the hemp industry. The highest simulated mean net revenue is from the CBD Large-Scale Model. This is significant because the biggest difference among the CBD models is the equipment, labor and assumed CBD percentage at harvest. Thus, CBD Large-Scale has more machine mechanization, less labor, and a lower assumed percentage of CBD. The CBD Large-Scale and CBD Vegetable Models net revenue risk simulation signals the advantage on the bottom-line return with hemp specific machinery and moving away from the more hand labor dependent model of CBD Vegetable model. This difference signals the need for machinery specific for industrial hemp assisting in making CBD operations more profitable.

The results of the scenarios simulating differing amounts of processor payments to producers confirms the importance of processor payment in this industry.

Data Limitations and Future Research

In development of the enterprise budgets, the reader is reminded of several caveats and cautions:

These budgets are for the year 2019 only. They are intended to be setting a baseline for Texas production in the years going forward.

Finally, it should be cautioned, production methods are highly varied with a great amount of volatility within each method. Unlike more established crop enterprise budgets – where there are generally accepted standards of cost and revenues that serve as a reference point for creating budgets – the lack of publicly available information on hemp makes budgeting a greater challenge. Since it is not known exactly how Texas producers will want to plant or harvest hemp, the budgets use current custom rates survey data as a reasonable proxy for what farmers might do where data is not currently available.

Future research could strengthen this research by conducting producer surveys of their production costs, contract prices and yields to provide additional fine tuning for the budgets. Also, as equipment is modified for use in the different hemp production systems specific costs of both the equipment and modifications would allow for better estimates of fixed costs.

REFERENCES

Abaca Bill is Signed: U.S. to Continue Production of Fiber for Hemp. (1950, Aug 12). New York Times (1923-Current File)

Abbott, Chuck (November 2019) FDA Won't Endorse CBD as "Generally Recognized as Safe." Successful Farming. https://www.agriculture.com/crops/hemp/fda-won-t-endorse-cbd-as-generally-recognized-as-safe?hid=b1fc66597004000304cb1b20cc7e3af2178cf5a9&did=464134-20191127&utm_campaign=todays-news_newsletter&utm_source=agriculture.com&utm_medium=email&utm_content=112719&cid=464134&mid=26946761521

Abbott, Chuck (February 2020) Future of Industrial Hemp Clouded By Economic Uncertainties. Successful Farming. https://www.agriculture.com/news/business/future-of-industrial-hemp-clouded-by-economic-uncertainties?did=492668-20200220&utm_campaign=todays-news_newsletter&utm_source=agriculture.com&utm_medium=email&utm_content=022020&cid=492668&mid=29935095703

Agricultural Marketing Service, United States Department of Agriculture. (October 2019). Establishment of a Domestic Hemp Production Program . Washington, D.C. : Agricultural Marketing Service billing Code 3410-02 P.

Agricultural Marketing Service, United States Department of Agriculture. (2019, December 17). USDA Extends U.S. Domestic Hemp Production Program Interim Final Rule Comment Period to January 29. Washington, D.C. : https://www.ams.usda.gov/content/usda-extends-us-domestic-hemp-production-program-interim-final-rule-comment-period-january

Agricultural Marketing Service, United States Department of Agriculture. (2020) USDA Approves Seven State, Tribal Hemp Production Plans, Washington, D.C. : Agricultural Marketing Service https://www.ams.usda.gov/content/usda-approves-seven-state-tribal-hemp-production-plans

AgriLogic, (2019) Company Headquarters. Personal Communication. College Station, Texas.

Agriculture, U. S. (2018, November 30). Highlights From the November 2018 Farm Income Forecast. Retrieved from United States Department of Agriculture Economic Research Service: https://www.ers.usda.gov/topics/farm-economy/farm-sector-income-finances/highlights-from-the-farm-income-forecast

Anderson, Robert David (2018). "Effects of Nitrogen Fertilizer Rate, Timing, and Herbicide Use on Industrial Hemp (Cannabis Sativa)." Masters Theses & Specialist Projects. Paper 2100. https://digitalcommons.wku.edu/theses/2100

Ash, A.L. Hemp—production and utilization.(1948). Econ Bot 2, 158–169

Barry, Peter J., Hopkin, John A., and Baker, C. B. (1988). Financial Management in Agriculture. Fourth Edition. Copyright 1988 by The Interstate Printers & Publishers, Inc. Library of Congress Catalog Card No. 88-80270

Benavidez, Justin Reynaldo (2016). The Conservation Reserve Program Choice. Master's thesis, Texas A & M University.

Bevan, Steve (2019, September 17). The Green Rush: Market Opportunities for CBD, Fiber, Seed and More: Panel

Brady, T. (2003). The Argument for the Legalization of Industrial Hemp. San Joaquin Agricultural Law Review, 13, 85-108.

Campbell, J., Campbell, B., & Rabinowitz, A. (2019, June 3). Consumer Perception of Hemp and Hemp Products. Nashville: Southern Extension Economics Committee.

Coinnews Media Group LLC (Coin News). (2018, November 18). US Inflation Calculator. Retrieved from Historical Inflation Rates 1914-2018: https://www.usinflationcalculator.com/inflation/historical-inflation-rates/

Congress, 115th. (2018, December 20). H.R.2 - Agriculture Improvement Act of 2018. PUBLIC LAW 115–334—DEC. 20, 2018. Washington, D. C., United States of America: Authenticated U.S. Government Information GPO. Retrieved from Congress.Gov: https://www.congress.gov/bill/115th-congress/house-bill/2/text

Cui, I. (2019, June 3). Industrial Hemp Extract Production Budget and Hemp Economics. Nashville: Southern Extension Economics Committee.

Cui, X. I., & Smith, S. A. (May 2019). 2019 Industrial Hemp Extract (CBD) Production Budget. Knoxville, TN: University of Tennessee Extension Institute of Agriculture.

Dallas News. (2019). Texas Debates Hemp Bills As State Takes It Off List of Dangerous Drugs. How Might Marijuana, CBD laws Change? Dallas: The Dallas Morning News.

Deering, J., Funk, J., Martin, A., & Zienkiewic, M. (October 2019). Cannabis Breaks Free. Seed World, 26-27.

Dempsy, J.M. (1975). Hemp. Fiber Crops. University of Florida. Pg. 46–89.

Davies, Steve (October 2019) Hemp Growers May Find Processing Bottleneck. AgriPulse Communications, Inc.

Dunn, A. D. (2019, July 25). Testimony of Alexandra Dapolito Dunn, Esq. Assistant Administrator, Office of Chemical Safety and Pollution Prevention U.S. Environmental

Protection Agency before the Senate Committee on the Agriculture, Nutrition and Forestry.

Economic Research Service, United States Department of Agriculture (2018). U.S. Cash Receipts for Selected Crops, 2014-18F. Washington, D. C.: USDA.

Economic Research Service, United States Department of Agriculture (February 5, 2020). 2020 Farm Sector Income Forecast

Farm Journal. (2019). Tom Shipley Senator. September 17, 2019 in Altoona, Iowa.

Feedstuffs (2019, November 25). FDA issues warning on cannabidiol-containing products.

Food and Drug Administration. (2018). "FDA Responds to Three GRAS Notices for Hemp Seed-Derived Ingredients for Use in Human Food." Washington, DC: FDA, December 20, 2018. Available online at https://www.fda.gov/food/cfsan-constituent-updates/fda-responds-three-gras-notices-hemp-seed-derived-ingredients-use-human-food.

Food and Drug Administration (2019). "Warning Letters and Test Results for Cannabidiol-Related Products." Washington, DC: FDA, Content current as of 07/24/2019. Available online at https://www.fda.gov/news-events/public-health-focus/warning-letters-and-test-results-cannabidiol-related-products

Food and Drug Administration (February 2020). FDA Regulation of Cannabis and Cannabis-Derived Products, Including Cannabidiol (CBD) Content Current as of 2/13/2020. Under Public Health Focus.
https://www.fda.gov/news-events/public-health-focus/fda-regulation-cannabis-and-cannabis-derived-products-including-cannabidiol-cbd

Fortenbery, R. T. (2014). Industrial Hemp: Opportunities and Challenges for Washington. Pullman, WA: Washington State University.

Fortenbery, R. T., & Bennett, M. (2001). Is Industrial Hemp Worth Further Study in the U.S.? A Survey of the Literature. Madison, Wisconsin: University of Wisconsin-Madison.

Furnish, B. (2019, August 22). Industrial Hemp Industry. Personal Communication. Cythiana, Kentucky.

Galloway, Alan (February 2019) Dark Fired Tobacco Budget for 2019 Estimated Contracted Tobacco Costs and Returns for Kentucky and Tennessee.

Gauthier, Nicole W., (2019) UK Hemp Field Day Presentation in Industrial Hemp. August 21, 2019. University of Kentucky.

Geneve, Robert and Davis, Derrick. (2019). UK Hemp Field Day Presentation in Industrial Hemp. August 21, 2019. University of Kentucky.

Global Hemp. (1997, October 15). North American Industrial Hemp Council Industrial Hemp Facts Sheet. Peoria, Illinois, United States of America.

Green Market Report. (2019). Texas Continues to Take Baby Steps Towards Legalization. New York, New York: Green Market Report.

Hemp Benchmarks (2020). “Hemp Spot Price Index”. Site visited by Megan Moore on February, 18, 2020.

Hemp Industry Daily. (2019, February 7). “USDA chief questions hemp’s use in animal feed, gives not to plant’s mounting interest.” Hemp Industry Daily. Available online at https://hempindustrydaily.com/usda-chief-hemp-suitability-cattle-feed-remains-to-be-seen/

Hemp Industry Daily (2020, February 18) Pennsylvania hemp processor closes, citing falling hemp and CBD prices. Hemp Industry Daily.

https://hempindustrydaily.com/pennsylvania-hemp-processor-closes-operations-citing-falling-hemp-cbd-prices/?mc_cid=74a7331f1c&mc_eid=352a982d05

Hutchens, T. (2019, June 6). President of Kentucky Hemp Seed R & D and Director of Research at Atalo Processing Facility located at Hemp Research Campus. Personal Communication. Winchester, KY.

JAMA. (2017). "Labeling Accuracy of Cannabidiol Extracts Sold Online." JAMA 318(78): 1708, November 7, 2017.

Jeliazkov, V. D., Noller, J., Angima, S., Rondon, S. I., Roseberg, R. J., Summers, S., Jones, G., and Sikora, V. (2019). What is Industrial Hemp?. Oregon State University Extension Service.

Karus, Michael & Vogt, Dominik. (2004). European hemp industry: Cultivation, processing and product lines. Euphytica. 140. 7-12. 10.1007/s10681-004-4810-7.

Kay, R. D., & Edwards, W. M. (1994). Farm management / Ronald D. Kay, William M. Edwards. In McGraw-Hill series in agricultural economics (Vol. 3rd ed). New York : McGrawHill, c1994.

Kay, R. D. (1981). Farm Management: planning, control, and implementation / Ronald D. Kay. In McGraw-Hill publications in the agricultural sciences. New York : McGraw-Hill, c1981.

Kight, Rod. (2019). What is "Total THC" and Does it Matter? https://cannabusiness.law/what-is-total-thc-and-does-it-matter/ Visited February 28, 2020.

Kim, G., & Mark, T. (2018). Who Are Consuming Hemp Products in the U.S.? Evidence for Nielsen Homescan Data. Lexington, KY: SSRN.

Keene, Tom (2020) UK Hemp Field Day Presentation in Industrial Hemp. August 21, 2019. University of Kentucky.

Klose, S., Smith, J., Waller, M., Thompson, B., Zapata, S., and Keeling, W., (February 2019) 2018 Texas Agricultural Custom Rates. Custom Rates Survey Conducted and Compiled by Texas A & M AgriLife Extension Service Department of Agricultural Economics.

Laate, E. A., Graham, L.-J., Breland, P., & Jackson, K. (2015). Industrial Hemp Seed Production Costs and Returns in Alberta, 2015. Alberta: Alberta Agriculture and Forestry.

Lax, Tim (February 2020). Hemp Grower and Adult Farmer Educator in Calloway County Kentucky. Personal Communication. Murray, Kentucky.

Lopez J.A., Rojas K., Swart J. (2015) . The economics of foliar fungicide applications in winter wheat in Northeast Texas. Crop Protection, 67 , pp. 35-42.

Maisashvili, Aleks (2019). Agribusiness Analysis and Forecasting. Univariate Probability Distributions. Texas A & M University Agricultural Economics Course AGEC 622 Spring Semester

Mark, Tyler. (2019, June 3). Kentucky Industrial Hemp. Personal Communication. Owensboro, Kentucky.

Mark, Tyler, & Shepherd, Jonathan. (2019). Hemp & Enterprise Model CBD Budget Model . Lexington Kentucky: University of Kentucky Agricultural Economics Department.

Mark, Tyler, Jonathan Shepherd, David Olson, William Snell, Susan Proper, and Suzanne Thornsbury. (February 2020). Economic Viability of Industrial Hemp in the United States: A Review of State Pilot Programs, EIB-217, U.S. Department of Agriculture, Economic Research Service.

Marsh, R. (1967). The Illinois Hemp Project at Polo in World War II. Journal of the Illinois State Historical Society (1908-1984),60(4), 391-410.

Massey, Ray, & Morrison, Chase (October 2019). Industrial Hemp for Grain and Fiber Planning Budget. Columbia, Missouri: University of Missouri Extension.

Massey, Ray & Morrison, Chase (2019). Industrial Hemp Budget Generator. Columbia, Missouri: University of Missouri Extension.

McCarty, Tanner (2019). "What Regional Economic Factors Drive Feedstock Cost for Cannabinoid Hemp Processors in the United States?," Journal of Agricultural Hemp Research: Vol. 1 : Iss. 1 , Article 6.

Miller, Sid whom is serving as the Texas Commissioner of Agriculture (January 2020). Public Hemp Hearing. (Observed hearing M. Moore) Texas Department of Agriculture

Minear, Kelly Don (1991). Enterprise budget development and production cost allocation. Master's thesis, Texas A&M University.

Miyao, G., Aegerter, B., Sumner., D., Stewart, D., (2017) Sample Costs to Produce Processing Tomatoes. Sub Surface, Drip Irrigated (SDI) in Sacramento Valley & Northern Delta. University of California Cooperative Extension Agriculture and Natural Resources Agricultural Issues Center. UC Davis Department of Agricultural and Resource Economics.

Moore, Dale (2019). Farm Bankruptcies Surge. American Farm Bureau Federation Executive Vice President interviewed by Michel Martin. Released via NPR Podcast on All Things Considered on November 10, 2019.

Moore, Megan (2019). Images Taken on October 2, 2019 on a Farm in Wiggins, Colorado.

Mulliken, Jacob (2020). Hemp Farmers Say Local Processor Not Fulfilling Contracts. Messenger-Inquirer

Natural Resources Conservation Service and Bureau of Economic Geology (2008). General Soil Map of Texas. Map and text reviewed by Harris, B.L., Professor of Soil Science and Associate Director of Texas Water Resources Institute, Texas A & M and Brandt, Jon. E., P. G., Soil Scientist. http://legacy.lib.utexas.edu/geo/pics/gensoiltxpg1clean.pdf

NCSL Energy, Environment, and Transportation. (2014, July 25). What's All the Hype About Hemp? National Conference of State Legislatures, Washington, D.C., United States of America.

NCSL Energy, Environment, and Transportation. (2018, August 8). State Industrial Hemp Statues. Retrieved from National Conference of State Legislatures: http://www.ncsl.org/research/agriculture-and-rural-development/state-industrial-hemp-statutes.aspx

Nepveux, Michael (2020). Changes Needed to Hemp Interim Final Rule as Comments Are Due. American Farm Bureau. https://www.fb.org/market-intel/Changes-Needed-to-Hemp-Interim-Final-Rule-as-Comments-Are-Due.

New Mexico, Farmer (2019, September 20). Hemp Production 2019. Unnamed upon request. Personal Communication. New Mexico.

Newhart, Beth (2020, February 6). Does CBD Have a Place in Dairy?. Dairy Reporters.com https://www.dairyreporter.com/Article/2020/02/06/Does-CBD-have-a-place-in-dairy?mc_cid=520273d9d0&mc_eid=352a982d05

Newton, John (2019, October 30). Chief Economist. Farm Bankruptcies Rise Again. Chapter Filings Increase 24% Compared to Year-Ago Levels. https://www.fb.org/market-intel/farm-bankruptcies-rise-again

Nicholson, Marcy (2019, June 26). Cannabis Professional Reporter. Canada's 2019 Hemp Crop to surge on CBD demand, but pricing will be tricky. The Globe and Mail.

Niemeyer, Liam (2020, February 10). Over-Hyped Hemp? Amid Price Drop and A Big Bankruptcy, Some Farmers Feel Burned. Ohio Valley ReSource. https://wfpl.org/over-hyped-hemp-amid-price-drop-and-a-big-bankruptcy-some-farmers-feel-burned/

Oakes, D. (2019, June 19). How to Grow Hemp: A Farmer's Perspective. Presentation at Hemp College. Lexington, Kentucky. Colorado Farmer.

Olvera, Isaac Daniel (2010). Statistical and Economic Implications Associated with Precision of Administering Weight-based Medication in Cattle. Master's thesis, Texas A&M University.

Oregon Industrial Hemp Farmers Association (Cyrus, Matt., Tombe, Justin., Norton, Jerry,.) (2019, July 27). Letter to Oregon Hemp Growers and Handlers. Available online at: https://oregonhempfarmers.com/delta-9-vs-total-thc-could-your-hemp-crop-be-worthless-2/ Pacific Northwest Hemp Industries Association.

Outlaw, Joe L., George M. Knapek, J. Marc Raulston, Henry L. Bryant, Brian K. Herbst, David P. Anderson, Steven L. Klose, and Peter Zimmel. (2019) "Representative Farms Economic Outlook for the January 2019 FAPRI/AFPC Baseline." Texas A&M AgriLife Research, Texas A&M AgriLife Extension Service, Texas A&M University, Department of Agricultural Economics, AFPC Working Paper 19-1. April 2019.

Palma, M.A., Richardson, J.W., Roberson, B.E., Ribeira, L.A., Outlaw, J., Munster, C., (2011).

Economic feasibility of a mobile fast pyrolysis system for sustainable bio-crude oil production. Int. Food Agribusiness Management Review 14 (3), 01–16.

PanXchange, Inc. (2020). PanXchange Hemp: Benchmarks & Analysis January 2019, November 2019, December 2019, January 2020. Average Price Index. https://panxchange.com/panxchange-hemp-benchmarks-analysis

Parr, Bryan (2019) Hemp College by Farm Journal in Altoona, Iowa. September 17, 2019. Agronomist.

Popular Mechanics Magazine (February 1938). New Billion-Dollar Crop Volume 69. NO. 2

Quarles, R. (2019, June 19). Kentucky Hemp. Welcome Speech. Lexington, Kentucky.

Rawson, Jean M. (1992). Growing Marijuana (Hemp) for Fiber: Pros and Cons. Report 92-510, Congressional Research Service, Washington, DC.

Rezende, Marcelo L. and Richardson, James W., (2015) Economic feasibility of sugar and ethanol production in Brazil under alternative future prices outlook, Agricultural Systems, Volume 138, 2015, Pages 77-87, ISSN 0308-521X, https://doi.org/10.1016/j.agsy.2015.05.004.

Rezende, Marcelo L. and Richardson, James W., (2017) Risk analysis of using sweet sorghum for ethanol production in southeastern Brazil, Biomass and Bioenergy, Volume 97, 2017, Pages 100-107, ISSN 0961-9534, https://doi.org/10.1016/j.biombioe.2016.12.016.

Richardson, James (2008). Simulation for Applied Risk Management with an Introduction to Simetar. College Station, TX: Texas A & M University.

Richardson, J. W., Herbst, B. K., Outlaw, J. L., & Gill, R. C. (2007). Including risk in economic feasibility analyses: the case of ethanol production in Texas. Journal of Agribusiness, 25(345-2016-15144), 115-132.

Richardson, J. W., Johnson, M. D., & Outlaw, J. L. (2012). Economic comparison of open pond raceways to photo bio-reactors for profitable production of algae for transportation fuels in the Southwest. Algal Research, 1(1), 93-100.

Richardson, J, W., Klose, Steven L., and Gray, Allan W., (2000). An Applied Procedure for estimating and simulating multivariate empirical (MVE) probability distributions in farm-level risk assessment and policy analysis. *Journal of Agricultural and Applied Economics* 32(2), 299-315

Richardson, J. W., and Mapp Jr., H. P., (1976). Use of probabilistic cash flows in analyzing investments under conditions of risk and uncertainty. *Southern Journal of Agricultural Economics* 8, 19-24

Richardson, J. W., Schumann, K., and Feldman, P., (2006). Simetar: Simulation for Excel to analyze risk. Unnumbered staff report, Department of Agricultural Economics, Texas A & M University, College Station, Texas

Riddle, Trey (2019, June 7). Chief Executive Officer of Sunstrand Sustainable Materials Fiber Company. Personal Communication. Louisville, Kentucky.

Ripplinger, D. (2019). Industrial Hemp. Fargo, North Dakota: North Dakota State University.

Risk Management Agency, United States Department of Agriculture. (2019). USDA Announces Pilot Insurance Coverage for Hemp Growers. Washington, D.C., Dec. 23, 2019

Risk Management Agency. (2020). "Hemp Crop Insurance Coverage Available for 2020." Washington, DC: USDA Risk Management Agency. Available online at https://www.rma.usda.gov/en/News-Room/Press/Press-Releases/2019-News/Hemp-Crop-Insurance-Coverage-Available-for-2020

Robbins, L., Snell, W., Halich, G., Maynard, L., Dillon, C., & Spalding, D. (July 2013). Economic Consideration for Growing Industrial Hemp: Implications for Kentucky's Farmers and Agricultural Economy Department of Agricultural Economics. Lexington, Kentucky: University of Kentucky.

Schäfer, T.; B. Honermeier, (2006). Effect of sowing date and plant density on the cell morphology of hemp (Cannabis sativa L.), Ind Crops Prod, 23 (2006), pp. 88-98

Schreiner, Bruce (2020, February 6). Leading Kentucky Hemp Processor files for bankruptcy. Associated Press. Kentucky Today News.

Semuels, Alana (2019, November 27). 'They're Trying to Wipe Us Off the Map.' Small American Farmers Are Nearing Extinction. Time. https://time.com/5736789/small-american-farmers-debt-crisis-extinction/

Serecon Management Consulting. Inc. (2012). Alberta Hemp Cost of Production and Market Assessment-Final Report.

Shepherd, J. (2019, June 3). Industrial Hemp Industry in Kentucky. Personal Communication. Lexington, Kentucky.

Shepherd, J. (2019, June 3). Economics of Hemp Production. Nashville: Southern Extension Economics Committee.

Sisk, Joseph (2019, June 5). 4th Season Hemp Grower Experience. Personal Communication. Owensboro, Kentucky.

Smith, Jackie; McCorkle, Dean; and Outlaw, Joe. (2000). Making Decisions with Enterprise Budgets College Station, Tex.]: Texas Agricultural Extension Service, Texas A&M University System, 4 unnumbered pages. 28 cm.

Smith, Jackie (February 2019) 2019 Estimated Costs and Returns per Acre Irrigated Alfalfa South Plains Extension District 2. Professor and Extension Economist, Texas A&M AgriLife Extension.

Smith, Jackie (February 2019) 2019 Estimated Costs and Returns per Acre Irrigated Sorghum Silage South Plains Extension District 2 Harvest and Haul Sorghum. Professor and Extension Economist, Texas A&M AgriLife Extension.

Smith, Jackie (February 2019) 2019 Irrigated Cotton Pivot Budget District 2. Professor and Extension Economist, Texas A&M AgriLife Extension.

Smith, Jackie (2019) 2019 Estimated Costs and Returns per Acre Irrigated Wheat South Plains Extension District – 2. Custom Fee for Wheat Grain Fertilizer Custom Application Fee taken from for Fertilizer Application of Liquid Low and Liquid High. Professor and Extension Economist, Texas A&M AgriLife Extension.

Smith, Jackie (2019) 2019 Estimated Costs and Returns per Acre Irrigated Guar South Plains Extension District – 2. Professor and Extension Economist, Texas A&M AgriLife Extension.

Smith, Nathan (2019, February 5). Risk Management Considerations For South Carolina Industrial Hemp Pilot Program. Personal Communication. Birmingham, Alabama.

Smith, N. B. (2018, September 6). What Does an Extension Ag Economist Do? College Station, TX, USA.

Smith, Stephen (2019, October 2). Personal Communication. Wiggins, Colorado.

Sterns, J.A. (2019). "Is the Emerging U.S. Hemp Industry Yet Another Boom–Bust Market for U.S. Farmers?" Choices. Q 3rd Quarter 2019 Choices Magazine. Available online: www.choicesmagazine.org/choices-magazine/submitted-articles/is-the-emerging-us-hemp-industry-yet-another-boombust-market-for-us-farmers

Texas Department of Agriculture. (2019). “Hemp Regulations.” Austin, TX: TDA, Content current as of 10/16/2019. Available online at https://www.texasagriculture.gov/RegulatoryPrograms/Hemp.aspx

Texas Department of Agriculture (January 2020). Public Hemp Hearing. (Observed hearing M. Moore)

Texas Department of Agriculture (January 2020) Texas Hemp Program FAQ. Handout at Public Hemp Hearing. Last updated 1/21/2020

Texas Department of Agriculture (February 2020). Website viewed February 10, 2020. Hemp Regulation. https://www.texasagriculture.gov/RegulatoryPrograms/Hemp.aspx.

Texas Department of Agriculture (February 2020). The Texas Department of Agriculture Proposed Hemp Plan for Texas. Website viewed February 10, 2020. Hemp Regulation. https://www.texasagriculture.gov/RegulatoryPrograms/Hemp.aspx. Approved by USDA January 27, 2020

Texas Department of Agriculture (February 2020). Submitted Rules (Texas Register). Website viewed February 15, 2020. Hemp Regulation. *Disclaimer: these rules have not been finally adopted. https://www.texasagriculture.gov/RegulatoryPrograms/Hemp.aspx.

Texas Department of Agriculture (March 2020). Submitted Rules (Texas Register). Website viewed March 20, 2020. Hemp Regulation. https://www.texasagriculture.gov/RegulatoryPrograms/Hemp.aspx.

Tierney, Jacob (2020, February 17) New Stanton area hemp processor CAMO closes, stranding farmers. Published on TRIB Live. https://triblive.com/local/westmoreland/new-stanton-area-hemp-processor-camo-closes-stranding-farmers/ Commonwealth Alternative Medicinal Options.

Tomashoff, C. (2019). Hyping Hemp. Centennial Spotlight entitled "Marijuana Goes Mainstream", 40-43.

Toth, Jacob A., Stack, George M., Cala, Ali. R., Carlson, Craig H., Wilk, Rebecca L., Crawford, Jamie L., Viands, Donald R., Philippe, Glenn, Smart, Christine D., Rose, Jocelyn K.C., Smart, Lawrence B. (2020, January 10). Development and validation of genetic markers for sex and cannabinoid chemotype in Cannabis sativa L. GCB Bioenergy Published by John Wiley & Sons Ltd.

United States Department of Agriculture (1941-1946). USDA. Crop Report Annual Summary, Washington, DC: USDA, Bureau of Agricultural Economics, Crop Reporting Board, various 1941 – 1946.

United States Department of Agriculture, Agricultural Research Service and Economic Research Service (ERS) for Karl Stauber, Under Secretary for Research, Education, and Economics, Industrial Hemp and other Alternative Crops for Small-Scale Tobacco Producers (1995).

United States Department of Agriculture, National Agricultural Statistics Service (2012). Acres of Irrigated Land, 2012. Map Atlases for the 2012 Census of Agriculture.

United States Food and Drug Administration (November 2019). FDA warns 15 companies for illegally selling various products containing cannabidiol as agency details safety concerns. FDA News Release. November 25, 2019 https://www.fda.gov/news-events/press-announcements/fda-warns-15-companies-illegally-selling-various-products-containing-cannabidiol-agency-details.

Agriculture, U. S. (2018, November 30). *Highlights From the November 2018 Farm Income Forecast*. Retrieved from United States Department of Agriculture Economic Research Service: https://www.ers.usda.gov/topics/farm-economy/farm-sector-income-finanes/highlights-from-the-farm-income-forecast/

United States Department of Labor (2019) List of Adverse Effect Wage Rates by State for 2020. https://www.foreignlaborcert.doleta.gov/adverse.cfm. December 31, 2019.

Wilcox, R. H. (1944). The Cost of Producing Hemp in Illinois in 1943 Urbana, Ill., pgs. 1-16

Villanueva, Raul. (2019). UK Hemp Field Day Presentation in Industrial Hemp. August 21, 2019. University of Kentucky.

Victory Hemp (2019, August 22). Hemp Grain Growing Basics. Fiber Processor. Handout

Vote Hemp (2019). 2019 U.S. Hemp License Report. Handout