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Factors of Profitable Field Crop Selection

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FACTORS OF PROFITABLE FIELD CROP SELECTION

by

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Abstract

Methods of crop selection are varied, depending on a variety of factors, including resources, climate, soil type, and potential marketability of the crop. This study utilizes a theoretical farm of one thousand farmable acres to estimate the costs and returns as well as the resources associated with cultivating, planting, irrigating, harvesting and selling the crop products. The theoretical farm is situated in southwest Idaho in any of the counties of Ada, Canyon, Elmore, Owyhee and Payette. The crops grown are typical of the area; the crops examined are field corn (*Zea mays*), alfalfa (*Medicago sativa)* and sugarbeets (*Beta vulgaris*). Each is examined for yield potential, and market value. Timeliness of production practices are important for best management, so field capacities are determined and machinery needs are calculated. Input costs for fertilization, irrigation and pest control are analyzed and contrasted between each crop. Market data and prices of each crop are used to determine profitability and feasibility of the theoretical farm. Finally, the use of Global Positioning System (GPS) is discussed with respect to each crop and any potential benefits of using GPS are examined.

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Area of Interest

This study will focus on the southwest region of the State of Idaho, specifically the counties of Ada, Canyon, Elmore, Owyhee and Payette. These counties have a diverse range of landscapes, the southwest portion of Owyhee county forms rugged cliffs and valleys, primarily range land for cattle, while other regions feature arable land suitable for crop production. According to the United States Department of Agriculture's Census of Agriculture, Ada County in 2012 consisted of 144,049 acres in agricultural production which was divided between 1233 farms. Canyon County was similar in farm number, with 2331 farms in 2012 and 303,836 acres were devoted to farming. Elmore County had fewer numbers of farms, 349, but the farms were of larger size, 988 acres on average. The total number of acres in farms was 344,820 in 2012. Owyhee County also had a comparatively small number of large acre farms, with 578 farms in 2012 at an average size of 1295 acres. The total area in farms for Owyhee County was 748,771 acres. Payette County had 157,090 acres divided between 655 farms for an average of 240 acres per farm in 2012. This information is summarized in Table 1, along with 2007 and 2002 census data.

With the large number of farms, there are a large number of agricultural products sold. The USDA census reported the counties in the southwest region of Idaho range in value of crop sales from $44,599,000 in 2012 for Ada County to $272,381,000 in Canyon County. The other counties have crop sales of $50,270,000 for Payette County, $93,770,000 for Owyhee County and $94,142,000 for Elmore County. These values are just the crop sales, rather than the total agricultural products, the percentages for the crop sales of the total agricultural products range from 20 percent in Ada County to 53 percent in Canyon County, with values of 21 percent

(Payette County), 27 percent (Elmore County) and 32 percent (Owyhee County) in between. See Table 1 for a summary of these numbers, as well as values for the 2007 and 2002 Census data and average crop values for those three census.

Table 1: County Profiles, from 2012, 2007, 2002 USDA Census of Agriculture

County	Year	Agricultural Production (acres)	Number of Farms	Average Farm Acreage	Value of Agricultural Products	Crop Sale Value	Average Crop Sale Value
	2002	223,388	1420	157	$126,729,000	$42,974,000	
Ada	2007	191,477	1323	145	$156,031,000	$45,029,000	$44,200,667
	2012	144,049	1233	117	$220,989,000	$44,599,000	
	2002	271,992	2233	122	$268,949,000	$133,556,000	
Canyon	2007	260,247	2368	110	$420,928,000	$174,070,000	$193,335,667
	2012	303,836	2331	130	$513,723,000	$272,381,000	
	2002	346,034	364	951	$292,854,000	(N/A)	
Elmore	2007	346,550	381	910	$284,628,000	$72,016,000	$83,079,000
	2012	344,820	349	988	$350,583,000	$94,142,000	
	2002	571,051	571	1000	$126,773,000	$37,161,000	
Owyhee	2007	569,305	620	918	$206,552,000	$52,262,000	$61,064,333
	2012	748,771	578	1295	$291,557,000	$93,770,000	
	2002	154,562	639	242	$106,715,000	$25,250,000	
Payette	2007	166,179	678	245	$146,454,000	$28,523,000	$34,681,000
	2012	157,090	655	240	$236,243,000	$50,270,000	

The climate of the region is affected by elevation and topography, with elevations ranging from 2000 feet in the valleys to over 9700 feet in the mountains. The majority of the crop production is completed in the lower elevations, where a mild climate during winter is conducive to a long, warm growing season of anywhere from 90 to more than 150 frost free days. However, in some parts of Owyhee County, the rising elevation pushes the number of frost-free days down to as low as 60. The long growing season is suitable for a variety of fruit and vegetable crops. However, many of the valleys in this region experience less than 10 inches of precipitation annually (Climate of Idaho, 2016). A few select towns in Owyhee and Payette

Counties show similar 30-year average temperatures and precipitation totals as seen in Figures 1 and 2.

Statistic	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Minimum Temperature	°F	21.4	25.5	30.8	37	44.9	51.7	56.3	53.9	44.7	35.4	27.9	20.8	37.53
Maximum Temperature	°F	38.4	47.2	57.7	66.1	74.5	83	90.7	89.8	79.3	66.5	49.5	38.3	65.08
Heating Degree Days		1088	802	642	410	199	64	11	20	146	437	790	1100	475.75
Cooling Degree Days		0	0	0	6	34	135	275	234	56	0	0	0	61.67
Monthly Precipitation	inches	0.64	0.57	0.79	0.66	0.85	0.66	0.25	0.22	0.59	0.51	0.78	0.59	0.59

Figure 1: Average Climate Data for Grand View, Idaho (Owyhee County)

Statistic	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Minimum Temperature	°F	19.5	24.9	31.8	37.7	45.9	53.2	58.9	57.3	48.1	37.1	28.6	21.3	38.69
Maximum Temperature	°F	36.7	45.8	57.7	66.1	74.3	82.4	90.8	89.6	80.1	67.6	50.1	38.7	64.99
Heating Degree Days		1145	830	628	396	179	50	8	11	107	395	769	1085	466.92
Cooling Degree Days		0	0	0	2	28	134	313	272	80	2	0	0	69.25
Monthly Precipitation	inches	1.46	1.24	1.1	0.8	0.97	0.73	0.32	0.32	0.46	0.63	1.43	1.6	0.92

Figure 2: Average Climate Data for Payette, Idaho (Payette County)

Figures 3 and 4 show the first and last frost dates for the two towns as well.

First Frost			Last Frost		
10%	50%	90%	10%	50%	90%
SEP 15	SEP 30	OCT 14	APR 17	MAY 07	MAY 27

Figure 3: Frost data for Grand View, Idaho

First Frost			Last Frost		
10%	50%	90%	10%	50%	90%
SEP 15	OCT 02	OCT 18	APR 12	MAY 06	MAY 31

Figure 4: Frost data for Payette, Idaho

The first frosts describe the chance that the first frost occurs before the specific date, according to 50 years of data (Idaho Climate Charts, 2016). For Grand View, the average percentage that the first frost occurs before September 15th is 10 percent, this is the same percentage in Payette as well. There is a 90 percent chance that the first frost will occur before October 14th in Grand View and October 18th in Payette. The last frost is similar, the 10 percent chance on April 17th in Grand View means that there is a 10 percent chance that the last frost occurred before the 17th, and a 90 percent chance there will be frosts after this date. In Grand

View there is a 90 percent chance that the last frost will have occurred before May 27th and in Payette the last frost occurs before May 31st 90 percent of the time (Idaho Climate Charts, 2016).

Study Introduction

This study uses a theoretical farm, with 1000 acres of farm ground to be split between three different crops. This size farm is similar to average farm size in Elmore or Owyhee county. These crops are common crops in southwest Idaho, and have markets in the area. The crops are alfalfa, field corn, and sugarbeets, 300 acres of each field corn and alfalfa and 400 acres of sugarbeets. The crops are rotated between specific fields, but since this study is purely theoretical the individual fields cannot be modeled, though there will be 100 acres of alfalfa planted, as if it was rotated out of a different crop.

The farm is established, but may need to update or buy new equipment for the production of these crops. Cultural practices, such as planting, and harvesting methods will be similar to other operations in the area. The prices and markets for the crops will be analyzed using recent market data for the area and prices of inputs such as fertilizer and pesticides will be gathered from recent data. Though these numbers are accurate, a farm may experience different circumstances that are difficult to replicate, unexpected losses may occur due to freak accidents, such as fire, insects or weather events. That is difficult to model and will not be demonstrated in this study.

Crops of Interest

It is important to understand the crops being grown to cater to each ones strengths and attributes. On the study farm the crops of corn, alfalfa and sugarbeets are grown for different purposes, the corn is grown for dried grain, to be sold for a variety of uses, such as animal feed.

Alfalfa is primarily grown for animal feed, and depending upon the quality of the alfalfa it can be sold as an export to foreign markets. Sugarbeets are raised for their sugar content; they are shipped to a processing plant where their sucrose is extracted and then processed into sugar, the remaining pulp can be used for animal feed or applied to roadways as a deicer.

Corn (*Zea mays)* is a member of the grass family *Poaceae*, which is one of the largest plant families and consists of cereal grains, forage species, and plants such as rice, sugar cane and bamboo. This family has a large number of species that are economically important to the world in order to feed the human population, feed animals, and accomplishing other tasks such as building structures and oil production. Corn has a C_4 photosynthesis pathway, meaning the plant produces a four carbon compound first in photosynthesis. These plants are most productive in warmer climates that are frost-free. Corn produces well in warm climates, but is also grown in temperate climates as well. The corn plant completes its life cycle in one year, making it an annual plant. Corn grows tall and consists of a heavy stem that produces aerial roots to aid in supporting the plant. "The plant bears separate male and female inflorescences" (Langer & Hill, 1991, 119). The male inflorescence, called a tassel, is a shoot that grows from the top of the plant. This shoot is branched and contains florets which drop pollen down to the female inflorescence. The pollen can be carried by the wind or insects to the female inflorescence, or the cob. The silks of the corn cob are the styles of the female inflorescence and this is where the pollen grains are deposited.

The separation of male and female inflorescences allows for cross breeding to be accomplished fairly easily between plants. For agricultural purposes, this cross breeding is used to produce "hybrid vigor". If two kinds of corn are inbred for multiple generations, the successive generations would have decreased vigor and production. If these two kinds of corn were bred together, the resulting generation would display greater vigor than the parent generation. (Langer & Hill, 1991, 121) "Even better results are obtained by including two further inbred lines which are eventually crossed, and this is followed by the production of a so-called double hybrid from the two initial crosses" (Langer & Hill, 1991, 121-122). To control the cross breeding of corn plants, there will be two different lines of corn planted in close proximity. The desired female parent plant will be planted in rows with the desired male parent plant. When the plants are mature and begin to flower, the tassels of the female parent plant are removed so only the male plants can pollinate the cobs of the female plants.

For corn to produce best, it should be planted in soils that meet certain conditions. "The best plant growth occurs on soil with pH levels from 6.0 to 7.0 and moderate to high fertility. Over half of the N[itrogen] and P[hosphorus] and 80% of the K [potassium] for best growth is required before the reproductive stage" (Jones Jr, 2003, 26). Fertilizer requirements are loosely based upon the soil, as well as previous crops. If a nitrogen-fixing legume is grown before the corn crop is planted, the needed nitrogen is reduced. Soils samples will determine what the soil holds for mineral matter and how much fertilizer is to be applied. One such nitrogen-fixing crop is alfalfa.

Alfalfa (*Medicago sativa*) is a member of the *Fabaceae* family, which are commonly known as the legumes. The *Fabaceae* family is also a large plant family and consists of three subfamilies. The three subfamilies are the Mimosoideae, the Caesalpinioideae, and the Faboideae. The first two are commonly found in tropical regions and hold minimal economic importance. The last, Faboideae is "the largest subfamily, and by far the most important in terms of agricultural production" (Langer & Hill, 1991, 217).

No matter which sub family they are in, the majority of legumes have "the ability to fix atmospheric nitrogen in their roots in a symbiotic association with bacteria of the genus *Rhizobium*" (Langer & Hill, 1991, 219). The *Rhizobium* bacteria can be found in the soil or it may be applied by the farmer. The bacteria enter the plant through the root hairs and forms nodes on the plant roots. Nitrogen fixation is dependent upon a few factors: the specific strain of the bacteria can affect some plants. Some plants require a certain strain, while others will fix nitrogen with a large variety of *Rhizobium* strains. Different bacterial strains also differ in their persistence in the soil, "some rhizobia cannot survive for long in soils in the absence of the host plant, while others can survive for many years" (Langer & Hill, 1991, 220). Other factors of bacterial survival include the pH of the soil, acidic soils kill certain strains of the bacteria, and basic soils kill others (Langer & Hill, 1991, 220).

Alfalfa is a perennial plant that grows upright and produces blue flowers. The leaves of the alfalfa plant are trifoliate in nature, meaning there are three leaflets per leaf. The central leaflet is "slightly elevated on a short petiolule" (Langer & Hill, 1991, 237). Each leaflet is oblong in shape and serrated along the upper third of the leaf. When alfalfa is produced for seed, bees must trip the flower to expose the stigma and the anther is subsequently tripped as well. "Following fertilisation [sic] *sativa* lucerne[alfalfa] produces a spirally coiled dark-brown to black pod containing usually three to four seeds" (Langer & Hill, 1991, 237). The seeds are very small, about 2-2.5 mm, and sometimes have difficulty geminating because they are hard.

Germinating occurs best in soils with a pH of around 6 or higher. The seeds may be coated with a variety of substances to promote growth, from inoculant for successful nodulation, to lime for acidic soils. A mature alfalfa plant produces a deep tap root that sustains the plant during times of drought, but the seeds should be planted to allow growth and maturation before the dry months of the summer. Once established, alfalfa will out-compete weeds, but before maturity weeds can have an effect on the productivity of the alfalfa stand for years to come (Merrick, 2006). To reduce weed competition the stand should be sprayed with an herbicide to cut down on the weed population (Merrick, 2006). Alfalfa produces readily and does well when irrigated, but a high water table that covers the roots will cause the roots to rot and productivity will be lost. Production can also be lost if alfalfa is over-utilized, this is due to the activity of the crown of the plant. The crown is the part of the plant right above the level of the ground. This area of the plant is where new shoots come from when the top of the plant is cut or grazed. Though the crown is usually inactive, it starts producing new shoots when the plant starts to produce flowers, so if the top is cut or harvested, there will be new shoots ready to begin growing.

The final crop produced on the farm will be sugarbeets (*Beta vulgaris*). Sugarbeets are part of the Chenopodiaceae family, which only has a single species that is important to agriculture. That species is *Beta vulgaris*, which can be spread into three separate subspecies. The subspecies consist of plants like the garden or silver beet, which have large leaves which are consumed. Another plant of the subspecies is the beetroot, in which the hypocotyl region of the plant is enlarged. The last subspecies is one "in which both the hypocotyl and taproot are enlarged as in the fodder and sugar beet" (Langer & Hill, 1991, 197).

The sugarbeet, like the other beet subspecies is a biennial plant, with mostly vegetative growth occurring the first year, and reproductive growth occurring the second year. Though beets are somewhat susceptible to frost and cold weather, they require lower temperatures in order to vernalize for the winter. After the plant recovers from winter, a long shoot, called a bolt, grows and develops flowers. This bolt will produce the seeds, which are about 2mm in diameter and black. The seeds develop in clusters, so as they develop, multiple seeds may be encased in a group. This produces a "multigerm" seed, which, if planted, would produce multiple seedlings from a single seed. For agricultural purposes, this is undesirable because these plants could crowd each other and result in lower yields and production. However, methods of singling out the seeds have been developed, mechanically and genetically. Mechanical methods can be breaking up the seed cluster before planting, or by thinning the crop after planting and germination. A genetic solution is artificially selecting for plants that do not produce flowers in clusters. Langer and Hill write "considerable success in this direction has been achieved, particularly in sugar beet" (Langer & Hill, 1991, 201).

The sugarbeet has been cultivated and selected to yield a large amount of sugar. The sugarbeet has a large, swollen taproot. Only a small part of the root shows above the soil, and is cut off during harvest. The widest part of the plant is where the highest concentration of sugar is (Langer & Hill, 1991, 205). In some areas a sugar content as high as 20% is possible, but is not constant and often results in decreased yield (Langer & Hill, 1991, 205). Typically, a larger beet root will have low sugar content, and a smaller beet will have larger sugar content; though some cultivars are found in the middle of this rule of thumb (Langer & Hill, 1991, 205). "Traditionally, plant breeders have concentrated on cultivars averaging 13-18% sucrose which were shown to produce the greatest total yield of sugar per unit area" (Langer & Hill, 1991, 205). However, this trend has moved to cultivars with higher sugar content, in order to process fewer beets.

Producers generally plant their sugarbeets as early in the year as possible, though planting too early could have an adverse effect on the crop. If the beet crop sustains a frost, or cold weather, there may be a few plants that undergo vernalization, these plants can then produce a bolt, and have a reduced yield due to their reproductive growth. Weed control is important for sugarbeets as they are sensitive to competition from other plants during growth. Ideal pH is from 5.8 -7.0 (Jones, Jr., 2003, 175) and fertilizer aids the plant a great deal, especially nitrogen and potassium fertilizers. Sugarbeets are susceptible to a number of plant pests and diseases, so resistant varieties are important. Varieties are often determined by local committees to help producers in the area use cultivars that will meet standards of resistance and yield. Proper plant spacing is important to allow for maximum growth and yield. Typical row spacing is 22 to 30 inches, though 22 inches predominates. Too much space gives weeds room to grow in between the sugarbeets, and too little space creates competition among the sugarbeets. Within rows a spacing of approximately 8 inches is ideal (Creech, 2015). This spacing is accomplished using a precision planter, and is much easier to accomplish with monogerm seeds.

Irrigation is essential to sugarbeets as they do not tolerate drought. Though, "near-harvest moisture stress increases percent of beet sugar content" (Jones, Jr., 2003, 175). Harvest is accomplished using a variety of specialized machines to top the beets, and then lift the beets into a truck. The beet harvest occurs over the course of a few weeks in late fall.

Machinery

In order for the most efficient operations possible, machinery is used to increase the number of acres in production operations. Before any crop is planted, the ground must be prepared and cultivated properly to allow for adequate contact between the soil and seed, and to also allow water to infiltrate the soil properly. As stated in the book *Farm Power and Machinery Management,* "tillage absorbs well over half the power expended on the farms in the nation" (2001, 100). This power expenditure relates to expenditure of fuel, labor, and other expenses. This tillage is also critical to plant growth and development. Tillage management and knowledge is critical for Conventional tillage consists of a variety of operations to break up the soil in order to allow new plants to grow. These operations can be broken up into primary tillage and secondary tillage.

Primary tillage is the operations that primarily work the soil more than 5 inches below the surface. Tillage of this depth creates a lot of draft force, which is a pulling force over a distance in a span of time. The larger the draft force, the larger the required horsepower since horsepower is a measure of work divided by time. Examples of this primary tillage would be plowing, or perhaps ripping the ground. Ripping is typically the deepest tillage method, and is seldom used, it is primarily used to break up a hard pan, or plow pan. The plow pan is a layer of soil beneath the level of the plow, as the plow is moved through the soil it tends to compress the layer of soil beneath it. The compressed soil will act to block water from infiltrating the soil and will sit on top of the hard pan rather than moving deeper into the ground. Roots of some plants will also have a hard time moving through this hard pan and can suffer in productivity and vigor.

Following these primary tillage operations is secondary tillage, which works the soil from 3-5 inches. Secondary tillage is more focused on the final use of the field, which seeds are to be planted and what kind of seed bed is needed. Some operations include disking the field, which can break up the soil, and chop up previous plant growth. Often, primary tillage leaves large clods of soil that must be broken up to allow for the desired seedbed a disk or similar implement serves to break up these clods. Many different implements can be used, and various combinations of implements can be found for a specific operation.

Previously described is commonly referred to as "conventional tillage" with a large amount of energy expended working the soil and possibly leading to erosion of the soil. To reduce both erosion and resources spent, there are a number of other ways to prepare the soil for the seedbed. Some methods are "reduced tillage" or "conservation tillage," which both reduce the energy spent on tilling the soil. Reduced tillage can be "combining operations into a once-over trip, strip tilling only the planned rows, and tilling only as deep as is productive" (Hunt, 2001, 99). Strip tilling can be used to reduce erosion in susceptible soils by leaving crop residue in the ground, and only working the soil where the new crop will be planted. Conservation tillage is accomplished in a number of ways, one of them being a no-till operation. No-till only disturbs the soil a small amount, and leaves the crop residue intact. The equipment used for no-till is heavy and durable to allow for planting into a less-than-desirable seedbed. The equipment allows the operator to plant directly into previous crop stubble, thus saving time and energy on tillage.

The final seedbed preparation can be accomplished in a number of ways, such as by using a spring toothed harrow to finish breaking up the soil, or by using a roller harrow to prepare the soil for the seed. Different types of crops or farms may require a variety of seedbed preparations.

If a row crop such as corn or sugarbeets is to be watered from a concrete ditch, the seedbed may be prepared into "beds" for the crop. These beds are raised beds that allow water to flow between the rows and tractors and other machines can drive through the furrow, rather than over the plant or on the seedbed.

Planting the crop is almost as varied as the types of crops available for planting. The type of seed largely determines the method used. The three crops focused on here will be alfalfa, corn and sugarbeets. First, alfalfa: this plant produces very small seeds which can be planted in a couple of ways, either by broadcasting the seed across the surface of the ground and then using an implement to disturb the soil to incorporate the seed into the ground, or by drilling the seed into the ground using a grain drill with an alfalfa box. The alfalfa box is a smaller box on the front of the grain drill that has small openings to allow only a selected rate of alfalfa seeds out at a time. The theoretical farm of this paper utilizes this method.

Corn is a row-crop plant and is planted using a row crop planter, but there are a number of variations of this planter. Some variations use a disk with certain size of holes to grab a seed and deposit it into the ground, while others use air to create either pressure or a vacuum to deposit the seed into the ground. No matter the method, each seed is metered to allow for maximum control when planting. This allows to optimum plant spacing and population density. A row spacing of thirty inches is preferred for corn to allow for growth and machinery specifications.

Sugarbeet seeding is similar to that of corn, it also uses a row crop planter and if the planter is capable of modifying the row spacing, the same planter could be used for both crops. A row spacing of twenty-two inches is preferred for sugar beets to allow for maximum plant yield (Creech, 2015).

Following planting there are a variety of operations performed. For alfalfa there are a limited number of operations performed besides planting and harvesting. But for the fields that are flood irrigated from a concrete ditch, the field is corrugated to allow for adequate water flow to all parts of the field. Corrugation is done in the spring before the crowns of the alfalfa plant have produced shoots that could be damaged. The theoretical farm scenario consists of fifty acres of alfalfa that is irrigated in this fashion.

When the corn and sugarbeets are planted in a field irrigated using a concrete ditch they are planted in beds to ensure proper irrigation. The beds are created before planting and don't usually need to be reestablished. The same machine can be used to create these beds; it just needs to be mechanically adjusted for each row spacing. To save time in the spring, these beds can be created in the fall following harvest operations.

Once these operations are complete, the crops are planted, and the summer begins. Throughout the growing season there are a number of chemical applications that take place, pesticides or fertilizers may be applied. Some could be applied through irrigation systems, but the majority are applied with a sprayer. The pesticide and fertilizer are explained in more depth later in the paper, but the sprayer of this study is mounted on the 250 horsepower tractor. Depending upon the year, there are a number of applications that are made, for this study 2100 acres are calculated, to account for multiple applications for each crop. This number may deviate, but if 15 days throughout the summer are used for spraying, the sprayer width must be approximately 46 feet. However, there are many sprayers with booms that are 45 feet wide or 60 feet wide. A 45 foot wide boom would take a bit longer to spray the field than the 60 foot boom.

Alfalfa is harvested four times throughout the summer. The harvest begins with cutting the alfalfa. Cutting is accomplished with the use of a swather, which can be of a couple types. A rotary swather uses rotating blades to cut, while the sickle bar swather has one or two bars used to cut the alfalfa. A rotary swather can achieve greater working speeds, but requires greater horsepower and higher initial cost.

Two sicklebar swathers are used for the three hundred acres of alfalfa on the hypothetical farm of this study. They make a 12 foot swath and average 5 miles an hour, so they will be able to swath the alfalfa in 5 days. After swathing, the alfalfa is dried for a number of days. Once dried adequately, (approximately 16% moisture (Shewmaker, 2007, 38)) windrows are raked together with a basket rake and left to dry one more day. Two basket rakes are utilized to rake the acres cut in one day.

Following raking, the windrows are baled using a large rectangular baler. This operation is performed with dew to ensure adequate moisture in the bale so it does not lose quality. The dew serves to retain the leaves which are fragile when dry, but are essential to the quality of the hay. Two balers are used to bale the sixty acres per day. Following the baling, the bales are stacked and taken to a stackyard to await sale.

This procedure is repeated each time the alfalfa is harvested. However, there may be differences, such as drying time in the middle of summer may be less, also, available baling time may be affected by the dew that is present. Generally, there is a loss in quality for the second cutting due to the higher temperatures, which lead to faster growth and higher fiber content of the hay.

After the last alfalfa harvest, the sugarbeet harvest takes place in October. Sugarbeet harvesters are a specialty machine that lifts the beet up out of the ground and then delivers in into the bed of a truck or trailer. Before the beets are lifted out of the ground, the foliage must be removed. Foliage removal is accomplished using another specialty tool called a beet defoliator, or more commonly, a beet topper. This machine uses some type of flail to remove the leafy tops from the beet plants. After the tops are removed a sharp edge is used to remove the rest of the crown from the beet. Any foliage left on the beet could result in leaf growth and rotting (Cattanach, Dexter, & Oplinger, 2016).

The beet harvest or lifter uses rotating disks that run along under the ground to squeeze the beet up and out of the soil, then a series of rollers carry the beets up into a holding bin while simultaneously cleaning dirt from the beets. As the beets are lifted they are usually dumped into a truck that follows beside the lifter. A number of trucks are needed for continuous operation of the harvester.

Beet toppers and harvesters both come in a variety of sizes and styles. Sizes of 4 to 12 rows are available depending upon timeliness, acreage and resources available. Harvesters can be of a couple varieties, one being a wheel type, or a straight elevator type. These different types describe how the machine elevates the beets from the bottom of the machine into the holding bin. Each type is equally effective, and is used according to the preference of the farmer.

The size and types of machines used on the theoretical farm are both twelve row machines. The topper is 12 rows and requires a tractor of anywhere from 150 horse power (Amity Technology, 2014) to 250 horsepower (Parma Company, 2015). The beet harvester is also a twelve row and is the conventional, straight elevator type. The tractor size required of this machine is from 250 horsepower (Amity Technology, 2014) to 320 horsepower (Parma Company, 2015).

The last farming operation of the season is harvesting the corn. There are a number of ways corn can be harvested. The whole plant can be harvested for animal feed as corn silage. The whole plant is chopped by a chopper machine and then stored in a pit or similar structure where it is fermented and then fed to animals. The corn cob can be also be harvested for human consumption, a corn picker machine strips the cob from the rest of the corn stalk and the cob is deposited in a bin for transport to a processing facility. One other way to harvest corn is to wait until the corn kernels are hard and ripe and then use a combine harvester to strip the cob from the stalk, then thresh the kernels from the cob. The kernels are then processed in a number of ways for animal feed or human consumption. Though corn is used for all these purposes, the corn plants are not all the same. Different varieties or types of corn are used for each.

The theoretical farm of this study utilizes a combine to harvest the ripened, dried corn kernels from the cob. This type of corn is a field corn that is normally harvested late in the year, such as late October or November depending upon the time of planting and days to maturation. A 6 row corn header is used on a combine to harvest the grain corn.

All of these field operations are presented in Appendix I along with Theoretical Field Capacity calculations using information from *Introduction to Agricultural Engineering Technology* shown in Appendix II. The draft calculations are shown in Appendix III using data from *Farm Power and Machinery Management* and *Introduction to Agricultural Engineering Technology* in Appendix IV and Appendix V. There is also a calendar of field operations in Appendix VI.

Inputs

Alfalfa, corn and sugarbeets all have various needs, from water to nutrients to pest control. They also need these inputs at various times throughout the year. The University of Idaho Extension publishes a summary of input prices annually titled the *Idaho Crop Input Price Summary*. The latest edition was published in 2014; current prices could have various effects on budgets. The input prices included in this summary are "herbicides, fungicides, insecticides/nematicides, fertilizers, seeds, interest rates, labor, fuel, water assessments, and custom rate charges for chemical and fertilizer applications."

One of the largest input costs is incurred at the beginning (see Appendix VI) of the growing season, the cost of the seed. According to the 2014 Summary alfalfa seed is priced per pound. For roundup ready alfalfa seed the price per pound in southwest Idaho is between $7.00 and $7.50. A conventional planting rate is between 8 and 12 pounds of pure live seed per acre. Pure live seed is certified by seed distributors and is certified to have a certain germination percentage and live seed percentage. For the 100 acres that are being planted into alfalfa on the theoretical farm that equates to 800 to 1200 pounds of alfalfa seed, though this number could be slightly higher depending on the percentage of pure live seed. The range of prices for 800 to 1200 pounds of alfalfa seed at the prices of $7.00 and $7.50 would be between $5600 and $9000. This represents a significant input cost.

The input cost of corn seed is also significant. According to different sources within the University of Idaho extension a seeding rate of between 28,000 and 36,000 kernels per acre is common (Painter, Neufeld, Rimbey & Patterson, 2013). A bag of seed contains approximately 80,000 kernels, so that corresponds to between .35 and .45 bags per acre. To plant 300 acres of corn on the study farm, a total of 105 bags to 135 bags of corn kernels. The 2014 Input Cost Summary shows that a bag of corn in Southwest Idaho costs between $200 and $250 for Roundup Ready Corn. In addition, Roundup Ready corn with resistance to either Corn Borer or Rootworm costs from $240 to $265. If just Roundup Ready corn seeds are planted on the 300 acres the seed cost would be from $21,000 to $33,750. If corn borers or rootworms were a problem, then $25,200 to $35,775 would cover the cost of the resistant seeds.

Sugarbeet seeds are planted on a basis of units, which consist of 100,000 seeds. A typical seeding rate of sugarbeets is .5 units per acre (Patterson, 2013) or 50,000 seeds per acre. The theoretical farm of this study plants 400 acres of sugarbeets. Four hundred acres of sugarbeets at .5 units per acre is 200 units. According to the University of Idaho Extension the range of seed costs in Southwestern Idaho is from $285 to $445; though a typical cost is from $340 to $350. This cost consists of the raw seed cost, as well a few different fees on top of the raw seed. The fees included are a Roundup ready technology fee, a nematode resistance fee and a seed treatment. These fees add considerable value to the seed. The cost of seed for 200 units has a wide range, but using the typical range of seed costs, the total cost range for the 400 acres is from $68,000 to $70,000.

Table 2 shows the Total Seed cost per acre for each of the crops.

Table 2
Total Seed Cost

Crop		Quantity / acre	Unit	Cost / Unit	Total Cost / Acre
Alfalfa					
	Roundup Ready Seed	12	Pounds	$ 7.50	$ 90.00
Corn					
	Roundup Ready Seed	0.45	Bags	$ 250.00	$ 112.50
	RR + Corn Borer	0.45	Bags	$ 265.00	$ 119.25
	RR + Rootworm	0.45	Bags	$ 265.00	$ 119.25
			(Bag contains about 80,000 seeds)		
Sugar beets					
	Roundup Ready Seed	0.50	Unit	$ 350.00	$ 175.00
			(Unit contains about 100,000 seeds)		

Though some seed is bred with insect resistance. there are some insects and other pests that need to be dealt with in other ways. Pest management is handled in a variety of ways, from cultivation and mechanical processes, to chemical control. Insects are not the only form of pests that are present in agricultural production. Weeds, insects, snails, disease are all different forms of plant pests. The best way to handle pests is by preventing them. This can be done by buying certified seeds that are weed free to prevent the weeds from entering the field or area. Insects are harder to prevent than weeds. In either case, the pest needs to be monitored to determine the level of damage or population size. This information can be used to determine the desired method of action. If the pest is not causing a significant level of damage to the crop, it would not be economical to take action. However, if the pest is lowering yield or reducing quality to an economically significant level, action must be taken. This action can include a number of different approaches. Cultivation can be used to control weeds in a row crop, though the effectiveness depends upon the timing and type of plant. For some pest problems a biological control could be used. Biological controls are a pest's natural enemy, such as another insect that preys upon a pest insect. However, caution must be used with biological control agents can become a pest themselves in some situations. Some cultural practices that can prevent certain pests are things like selecting the proper plants for an area, rotating crops, mowing or irrigating properly. Healthy plants are more resistant to disease, and are more vigorous and out-compete weeds. If the wrong species of crop is planted in an environment that isn't suitable, the crop will not be as vigorous and healthy, so it will be susceptible to many different plant pests.

A popular and effective method of pest control is to use pesticides. Pesticide is the overarching term for a number of chemical products, such as herbicides, insecticides, fungicides and many others. When used effectively a pesticide controls the pest and is beneficial for the crop. However, there are a number of ways pesticides can be used inefficiently. The pesticide label should always be followed and care must be taken to ensure proper application. Roundup resistant varieties of many crops are available to make herbicide application more effective, as the entire field can be sprayed with the herbicide *Roundup* and everything but the crop should be killed. Additional fees are incorporated into the price of the seed for the herbicide resistance. There are many varieties of pesticides used and are found to be effective for different reasons. Pesticides can be applied in a number of ways, but a sprayer of some sort is common. The sprayer can be a self-propelled type, it may be mounted on a tractor or truck, or the sprayer could be mounted on a trailer and pulled behind a tractor. The sprayer will have a large tank where the pesticide is mixed. The pesticide comes in concentrated forms, in a variety of sizes and forms. This pesticide concentrate is mixed with water to form the final pesticide that is applied.

Over application or improper application can result in a variety of issues. Improper application of certain herbicides could have a detrimental effect on field crops. Symptoms such as stunted growth, necrosis, or even plant death could occur if the wrong herbicide is applied or applied at levels higher than recommended by the herbicide label. Applying at rates that are higher than specified on the label is against the law and could lead to severe legal problems. To ensure proper application and legality, an applicator should be properly licensed and be aware of procedures and laws of applying pesticides. Licenses are issued by the state after the applicator passes a test to certify they know the material. The cost for this test and other certifications range in amount, but are not unreasonable.

Pesticide cost is highly variable depending upon brand and form of the pesticide. For this analysis, the pesticides applied will be those shown in the enterprise budgets published by the University of Idaho Extension for alfalfa, sugarbeets, and field corn (Painter, 2013, Painter, Neufeld, Rimbey & Patterson, 2013, Patterson, 2013). The pesticides listed for alfalfa hay are Velpar Alfamax DG and Furadan 4F. These are applied at 2 pounds and 1 quart per acre, respectively, and cost $15.15 per pound of Alfamax DG and $20.10 per quart of Furadan 4F. Sugarbeet pesticides are listed as Poncho Beta Seed Treatment, which is included in the seed cost, Roundup Power Max 4.5, Ammonium Sulfate and Tilt. Roundup Power Max 4.5 is applied at 54 fluid ounces per acre and costs $.20 per fluid ounce. Ammonium sulfate is applied at 2.4 pounds per acre at no cost. Tilt costs $3.65 per fluid ounce and 4 fluid ounces are applied per acre. Corn pesticides are as follows: Micro-tech, Counter 15G L-N-L, Roundup Power Max 4.5 and AMS. Micro-tech is applied at 2 quarts per acre and costs $7.30 per quart. Counter 15 G L-N-L costs $3.00 per pound and 8 pounds are applied per acre. Forty fluid ounces of Roundup Power Max 4.5 are applied per acre at a cost of $.20 per fluid ounce. AMS costs $.39 per pound and 2 pounds are applied per acre. The total costs of these pesticides are calculated and tabulated in Table 3:

Table 3
Total Pesticide Costs

Crop		Quantity / Acre	Unit	Cost / Unit	Total Cost / Acre
Alfalfa					
	Velpar Alfamax DG	2	Pounds	$ 15.15	$ 30.30
	Furafan 4F	1	Quarts	$ 20.10	$ 20.10
Sugarbeet					
	Roundup Power Max 4.5	54	Fluid Ounces	$ 0.20	$ 10.80
	Ammonium Sulfate	2.4	Pounds	$ -	$ -
	Tilt	4	Fluid Ounces	$ 3.65	$ 14.60
Corn					
	Micro-Tech	2	Quarts	$ 7.30	$ 14.60
	Counter 15G L-N-L	8	Pounds	$ 3.00	$ 24.00
	Roundup Power Max 4.5	40	Fluid Ounces	$ 0.20	$ 8.00
	AMS	2	Pounds	$ 0.39	$ 0.78

In addition to the input of pesticides, fertilizer is also a large input for the crops. Fertilizer is used to bring nutrient levels to the proper levels for each crop, it "is defined as an 'organic or inorganic material of natural or synthetic origin (other than liming materials) that is added to a soil to supply one or more elements essential to the growth of plants'" (Jones Jr., 2003, 253). These nutrients include nitrogen, potassium, phosphorus, magnesium, and sulfur as well as a number of other micronutrients. These nutrients are depleted be plants, by runoff, and breakdown in the soil. Many methods are used to replace the nutrients that are depleted by the plants. Applying animal manure, composting, a previous crop or synthetic fertilizers are common methods to replace nutrients into the soil. However, it is important to apply the proper amount of nutrients, over applying nutrients can be just as detrimental as not having enough nutrients. The soil nutrient content should be determined before applying fertilizer.

The primary way to determine the nutrient content of a soil is to conduct a soil test. A soil sample takes cores from a number of spots throughout a field. These cores should provide a "representative sample" of the field. An area that is not typical for the field, such as an area with more organic matter or particularly rocky or sandy area should be skipped or sampled separately. These non-typical areas could skew the soil sample in a number of ways. They may require different amounts of nutrients or may have a different soil order, which would lead to different results for the test. Soil test results typically show the soil texture, pH, salinity, phosphorus, potassium, nitrogen and other essential elements as well as the percent organic matter. Each of these provides insight for different aspects of the soil. Soil texture can show characteristics of the soil in addition to the kind of capacity the soil has for holding nutrients as well as water. For example, "sandy soils (sand, loamy sand, sandy loam) have lower water and nutrient holding capacities, whereas high clay soils (clay, silty clay, clay loam, silty clay loam) tend to be poorly drained and are subject to compaction" (Cardon, Kotuby-Amacher, Hole, & Koenig, 2008, 3).

This measurement allows the manager to determine the amount and timing of irrigation and fertilizer applications. The "pH indicates the acidity or alkalinity of soil" (Cardon, Kotuby-Amacher, Hole, & Koenig, 2008, 3). The pH of the soil can determine what plants should be planted in a specific area. While "most plants grow well in soils with pH values between 6.0 and 8.0" (Cardon, Kotuby-Amacher, Hole, & Koenig, 2008, 3) other plants grow better in higher or lower pH soils. Matching the soil pH with the needs of the crop optimizes yields and quality.

Also related to the yield and quality of the soil is the salinity of the soil. The "salinity indicates the amount of soluble salt in the soil" (Cardon, Kotuby-Amacher, Hole, & Koenig, 2008, 3). High salinity levels have a negative effect on how the plant grows and responds to fertilizers. The measure of salinity is ECe, or the electrical conductivity of the soil measured in decisiemens per meter (dS/m). According to the Utah State University Extension an ECe of 0 to 2 has slight effects on plants. Sensitive plants start to show decreased yields at ECe measures of 2 to 4, ECe measures of 4 to 8 many plants are affected. Salinity levels of 8 to 16 restricts plant growth to only the plants that are tolerant of salt, and with levels higher than 16 only really hardy plants are able to grow.

Phosphorus, potassium and nitrogen are shown in parts per million or mg/kg. These numbers correlate to the amount of nutrients available to the plants as they are growing. The interpretation from the Utah State University Extension ranks the levels of nutrients as very low, low a, low b, marginal, adequate/marginal, high and very high. These various rankings are used to provide recommendations for applying the nutrient. In the case of phosphorus and potassium very low or low values indicate that in order to provide adequate nutrition for the crop more phosphorus or potassium must be applied. A high level of phosphorus can "indicate excessive fertilizer or manure application and may lead to nutrient imbalances in plants, or negative environmental impacts to nearby water sources" (Cardon, Kotuby-Amacher, Hole, & Koenig, 2008, 3). A high level of potassium has not been shown to have detrimental effects. Nitrogen measures are shown to be important, because "nitrogen is the most important, and generally the most limiting plant nutrient in the soil system" (Cardon, Kotuby-Amacher, Hole, & Koenig, 2008, 4). So for this reason, fertilizer applications are generally matched to the plant need. The plant need also includes expected yield, for example, the nitrogen recommendation for a grain corn yield of 160 bushels is 200 pounds of nitrogen per acre, while for a 140 bushel per acre yield goal, 170 pounds of nitrogen per acre is recommended (Cardon, Kotuby-Amacher, Hole, & Koenig, 2008, 9).

After a soil test is taken, the fertilizer should be applied. However, it is impossible to interpret results from a theoretical farm, so the values presented in the University of Idaho's enterprise budgets will be used to serve as a base for the theoretical farm. The fertilizer applied to the field corn is dry nitrogen, dry P2O5, and K2O as well as sulfur. Dry nitrogen is applied at a rate of 210 pounds per acre and costs $0.66 per pound. Dry P2O5, which serves as a source of phosphorus, costs $0.53 per pound and is applied at 80 pounds per acre. K2O is applied for its potassium content at a rate of 100 pounds per acre, and it costs $0.50 per pound. Sulfur costs $0.25 per pound and is applied 30 pounds per acre.

Sugarbeets require the same application as corn, in addition to liquid nitrogen, liquid P2O5 and additional micronutrients. The prices for dry nitrogen, dry P2O5, K2O and sulfur are the same as previously, but application rates are modified for sugarbeets. The application rates for sugarbeets are 115 pounds per acre of nitrogen, 40 pounds per acre of P2O5, 60 pounds per acre of K2O and 20 pounds of sulfur per acre. Liquid nitrogen costs $0.82 per pound and is applied at 10 pounds per acre. Liquid P2O5 is applied at 35 pounds per acre and costs $0.76 per pound. The sugar beet micronutrients are applied per acre and cost $14 per acre.

Alfalfa requires less nitrogen than the other crops due to its ability to fix atmospheric nitrogen for most of its nitrogen requirement. Oftentimes nitrogen isn't applied since it may inhibit nodulation of the young plants; though it is sometimes applied at low quantities, as it is in the alfalfa enterprise budget. For this budget, dry nitrogen is applied at 15 pounds per acre, dry P2O5 is applied at 75 pounds per acre, K2O is applied at 80 pounds per acre and sulfur is applied at 40 pounds per acre. Prices are all the same as previously stated. See Table 4 for a breakdown of all the fertilizer costs.

Table 4
Fertilizer Cost

Crop		Quantity / Acre	Unit	Cost / Unit	Total Cost / Acre
Corn					
	Dry Nitrogen	210	Pounds	$ 0.66	$ 138.60
	Dry P2O5	80	Pounds	$ 0.53	$ 42.40
	K2O	100	Pounds	$ 0.50	$ 50.00
	Sulfur	30	Pounds	$ 0.25	$ 7.50
Sugar beets					
	Dry Nitrogen	115	Pounds	$ 0.66	$ 75.90
	Dry P2O5	40	Pounds	$ 0.53	$ 21.20
	K2O	60	Pounds	$ 0.50	$ 30.00
	Sulfur	20	Pounds	$ 0.25	$ 5.00
	Liquid Nitrogen	10	Pounds	$ 0.82	$ 8.20
	Liquid P2O5	35	Pounds	$ 0.76	$ 26.60
	Micronutrients	1	Acre	$ 14.00	$ 14.00
Alfalfa					
	Dry Nitrogen	15	Pounds	$ 0.66	$ 9.90
	Dry P2O5	75	Pounds	$ 0.53	$ 39.75
	K2O	80	Pounds	$ 0.50	$ 40.00
	Sulfur	40	Pounds	$ 0.25	$ 10.00

Machinery costs are also included in the costs of operating the farm. The machinery costs include more than just the purchase price. A machine requires lubrication and fuel as well as maintenance to maintain its performance and efficiency. Fuel costs are dependent upon the efficiency of the individual machine, but are also correlated with the amount of load that is applied to the machine. A higher load could mean that the machine will be using more fuel per hour or more fuel per acre, for specific tractor fuel consumption, the University of Nebraska-Lincoln Nebraska Tractor Test Laboratory conducts tests on different brands and tractor makes to determine horsepower at different engine loads as well as fuel consumption (HP·hr/gal) at these loads. Two different sources describe fuel consumption in different manners. The first comes from Farm Power and Machinery Management which shows fuel efficiency as a result of percent of load applied to the engine. Though this table is calculated and figured for new tractors, older tractors will have different values. The table mentioned can be seen below:

Table 5: Fuel Efficiency, kW·hr/L [HP·hr/gal] *Farm Power and Machinery Management*

			Diesel		
Loading, % max.	Gasoline	LP Gas	Nat. aspirated	Turbo	Turbo and cooled
100	2.17 [11.01]	1.78 [9.06]	2.90 [14.72]	3.07 [15.58]	3.09 [15.68]
80	1.96 [9.95]	1.68 [8.55]	2.84 [14.41]	2.82 [14.31]	2.86 [14.52]
60	1.63 [8.30]	1.47 [7.50]	2.60 [13.19]	2.55 [12.94]	2.59 [13.15]
40	1.28 [6.45]	1.17 [5.95]	2.13 [10.81]	2.10 [10.66]	2.15 [10.91]
20	0.83 [4.20]	0.83 [4.20]	1.38 [7.00]	1.36 [6.90]	1.42 [7.21]

The previous table shows how much fuel is used at different load percentages, so to calculate a hypothetical maximum for the largest tractor on the farm, a 345 horsepower tractor, the following calculation is used:

$$345HP \times \frac{1\ gal}{15.68\ HP \cdot hr} = 22.002\frac{gal}{hr}$$

Another method of estimating the fuel consumption of the tractor is by the gallons per acre consumed during various field operations. The Virginia Cooperative Extension of Virginia Tech and Virginia State University provide an article on *Predicting Tractor Diesel Fuel Consumption*, included in this article is a table showing the values of average fuel consumption in gallons per acre for tillage, fertilizer application, chemical application, planting, cultivation and harvest. See Appendix VII for this table. According to the *Diesel fuel consumption for field operations* table, the primary tillage operation of plowing consumes an average of 1.81 gallons per acre.

According to the 2014 Crop Input Summary fuel prices for bulk delivery of off-road diesel was $3.55 per gallon. That relates to $78.11 per hour ($3.55/gallon x 22.002 gallon/hour) using the data from the *Farm Power and Machinery Management* book. It also corresponds to $6.43 per acre ($3.55/gallon x 1.81 gallons per acre) from the Virginia Cooperative Extension publication.

Though engines do not consume oil as quickly as fuel, there is a measurable amount of oil consumed in engines. This consumption needs to be replaced and that oil replacement costs money. Though the consumption is not just what is used during operation, according to *Farm Power and Machinery Management*, "consumption includes both the amount of oil used up in an engine and the amount of oil drained from the engine" (Hunt, 2001, 55). The following table (Table 6) is included for reference. The data was "developed from Nebraska Tractor Test data and manufacturers' recommended oil change periods. The recommended oil change periods vary widely" (Hunt, 2001, 55). Table 6 assumes a 150 hour oil change interval.

Table 6: Oil Consumption. *Farm Power and Machinery Management*

		Type of Engine											
		Gasoline				Diesel				LP Gas			
Maximum PTOP		Sump Capacity		Consumption		Sump Capacity		Consumption		Sump Capacity		Consumption	
kW	[HP]	L	[gal]	L/hr	[gal/hr]	L	[gal]	L/hr	[gal/hr]	L	[gal]	L/hr	[gal/hr]
0-15	[0-20]	2.6	[0.7]	0.017	[0.005]	5.3	[1.4]	0.035	[.009]				
15-30	[20-40]	5.7	[1.5]	0.038	[0.010]	5.9	[1.6]	0.039	[0.011]				
30-45	[40-60]	6.2	[1.6]	0.041	[0.011]	7	[1.8]	0.047	[0.012]				
45-60	[60-80]	7.5	[2.0]	0.05	[0.013]	9	[2.4]	0.06	[0.016]				
60-75	[80-100]	8.4	[2.2]	0.056	[0.015]	11.4	[3.0]	0.076	[0.020]	7.6	[2.0]	0.05	[0.013]
75-100	[100-134]	11.4	[3.0]	0.076	[0.020]	15	[4.0]	0.1	[0.027]	9.1	[2.4]	0.06	[0.016]
100-150	[134-200]					16.6	[4.4]	0.111	[0.029]	9.8	[2.6]	0.07	[0.017]
150+	[200+]					20.2	[5.3]	0.135	[0.035]				

Oil prices vary, so it is difficult to determine a total cost of the oil consumption.

In addition to fuel and oil costs, another variable cost is the repair and maintenance of the machines. "Repair costs are the expenditures for parts and labor for (1) installing replacement parts after a part failure and (2) reconditioning renewable parts as a result of wear" (Hunt, 2001, 85). The repair costs are "highly uncertain," though use will wear out items like cutting bars, chains and gears. Effective measures of repairs costs are repair rates, these rates are the machine's list price divided by the amount of use. This rate is multiplied by the purchase price, to give the repair costs per hour. This can be multiplied by the number of hours the machine is used per year to give a yearly repair cost for the machine. The table of Repair and Maintenance costs can be found in Appendix VIII.

There are alternatives to these machinery input costs however. One of these alternatives is to hire a custom operator to perform field operations such as harvest or spraying. The University of Idaho Extension has a publication showing custom rates for different parts of Idaho as well as methods of calculating custom rates. As stated by this publication, "the equipment needed for a modern farming operation is expensive and often specialized" (Patterson & Painter, 2015, 1). If this equipment isn't used very often it is hard to justify spending the money to buy it. Owning the machinery leads to additional costs, such as maintenance, fuel, storage, insurance and other costs. Depending upon the cost of ownership, "custom services can sometimes be hired at a cost lower than that of owning and operating farm equipment, particularly on smaller farms" (Patterson & Painter, 2015, 2). The point at which these costs intersect is called the breakeven cost, and will typically be communicated in number of acres. The University of Idaho Extension publication gives a formula to allow producers to calculate breakeven acre:

$$Breakeven\ Acreage = \frac{Annual\ Ownership\ Cost}{(Custom\ Rate\ per\ Acre - Operating\ Cost\ per\ Acre)}$$

For example, custom rates in southwest Idaho for swathing range from $18 per acre to $25 per acre, with an average of $20.34. Using the data from the theoretical farm and ownership costs from the University of Idaho Extension (Appendix IX), the equation for breakeven acreage shows:

$$Breakeven\ Acreage = \frac{\$17246}{(\$20.43 - \$4.03)} = 822.413\ acres$$

This shows the breakeven acreage for swathing alfalfa to be about 822 acres. If the farm swathed less than 822 acres, it would be more economical to hire a custom operator to harvest the alfalfa. However, since the farm harvests the alfalfa at least three times per year, which equates to about 900 acres or 1200 acres if the alfalfa is harvested four times. So it is more economical for the farm to own the swather.

Markets

There are a lot of costs associated with operating a farm, and very few forms of income in comparison. Most income comes from the selling of the crop at the end of the growing season. According to the National Agricultural Statistics Service of the United States Department of Agriculture, the United States produced grain corn that valued more than $62 billion in 2013, $53 billion in 2014, and $49 billion in 2015. Those values correspond to production of approximately 13.8 billion bushels of grain in 2013, 14.2 billion bushels in 2014 and 13.6 billion bushels in 2015. The state of Idaho produced 20.8 million bushels of grain in 2013 valued at $102 million, 16 million bushels valued at $66 million in 2014 and 14.5 million bushels in 2015 valued at $68 million. Those relate to a price of $4.91 per bushel in 2013, $4.16 in 2014, and $4.70 in 2015. These prices are the result of a diverse market for grain corn. Grain corn is used in a plethora of ways, both in the United States and other countries. The Economic Research

Service of the United State Department of Agriculture states that "the United States in the world's largest producer and exporter of corn" (ERS USDA). The export market produces a large demand for American producers, which is important for domestic prices and markets. The markets of corn are numerous since "corn has food, seed, and industrial uses" (ERS USDA). That includes food for both animals and humans, and a growing industrial use in ethanol production. Figure 5 shows three categories for corn use in the United States in billions of bushels for a number of years from 1980 to 2015.

Feed use is associated closely with the amount of corn that is fed to animals, which derives from the animal inventory at any given time. This category fluctuates over time, depending upon prices and other variables, but has not had a sharp growth in recent years. Alcohol for fuel use on the other hand, has had distinct growth from the early 2000s. If this growth continues, the demand for corn will also increase. So prices and inventory will also increase.

Sugar production comes from two main sources, sugarbeets and sugarcane. Both of these crops produce in different climates, so they do not compete for acreage. This contributes to the United States being "among the world's largest sugar producers," this is due to the

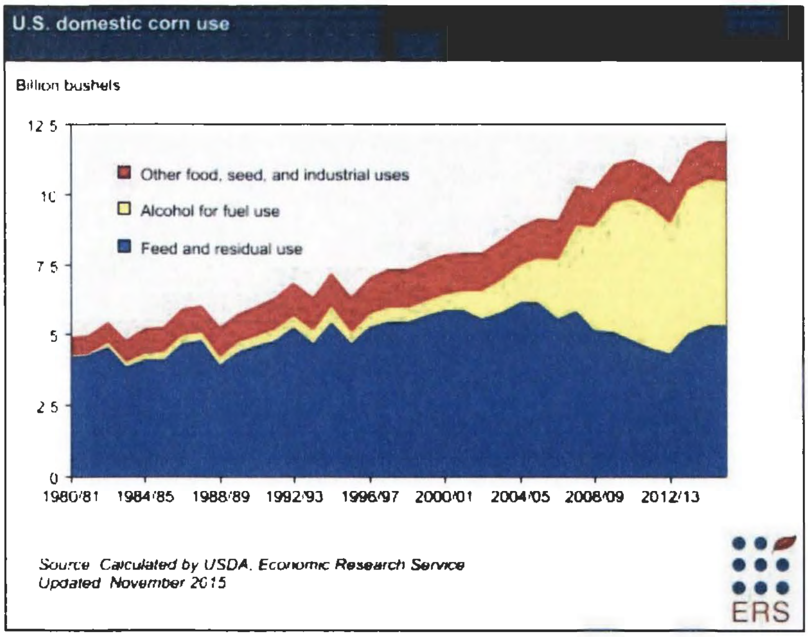

Figure 5: U. S. Domestic Corn Use

"United States [having] both large and well-developed sugarcane and sugar beet industries" (United States Department of Agriculture, Economic Research Service, 2015). Sugar production is not shared equally between the two crops however, sugarbeets account for about 55 percent (United States Department of Agriculture, Economic Research Service, 2015) of the United States production, while sugarcane is accountable for the remaining 45 percent of production. The 55 percent of United States sugar production equates to 32.7 million tons of sugar beets in 2013, worth $1.5 billion, 31.2 million tons worth $1.4 billion in 2014 and 35 million tons in 2015 (United States Department of Agriculture, National Agricultural Statistics Service, 2016). The value of 2015 production has not been published at the time of this study. Idaho accounts for a large portion of the countries sugarbeet production, with 6.2 million tons harvested in 2013, 6.3 million tons in 2014 and 6.4 million tons in 2015. The value of that production was $251 million in 2013 and $283 million in 2014 (United States Department of Agriculture, National Agricultural Statistics Service, 2016). In Idaho the average yield per acre was 36.2 tons in 2013, 37.3 tons in 2014 and 38.1 tons in 2015, with a price of $40 dollars per ton in 2013 and $45 dollars per ton in 2014, the average value per acre was $1448 in 2013 and $1678.5 in 2014. Using those prices for 2015 production equals a value of between $1524 and $1714.5 per acre if the 2015 sugar beet price was in the $40-$45 range per ton of sugar beets.

Alfalfa hay is a productive feed for animals; it is fed to horses, dairy cattle, beef cattle, and other ruminants. Though, the quality of the hay is a large determining factor for both price received and the market the hay goes to. Quality standards are broken down into 5 quality grades as stated by the Hay market report which is compiled by the USDA Market News Service. The five grades given to alfalfa hay are supreme, premium, good, fair, and utility. The quality differences of each can be seen in Figure 6.

Table 1. Alfalfa guidelines (for domestic livestock use and not more than 10% grass)					
Quality	ADF	NDF	*RFV	**TDN (100%)	CP
Supreme	<27	<34	>185	>62	>22
Premium	27 to 29	34 to 36	170 to 185	60.5 to 62	20 to 22
Good	29 to 32	36 to 40	150 to 170	58 to 60	18 to 20
Fair	32 to 35	40 to 44	130 to 150	56 to 58	16 to 18
Utility	>35	>44	<130	<56	<16

*RFV calculated using the Wisconsin/Minnesota formula
**TDN calculated using the Western formula
Quantitative factors are approximate and many factors can affect feeding value. Values based on 100% dry matter.
Guidelines are to be used with visual appearance and intent of sale (usage).

Figure 6: Alfalfa Quality Grades, From Forage and Hay Grower

The grades are used to market hay to buyers. The quality is determined by a hay test using samples collected and then sent to a lab to determine nutrient content. For industries like the dairy industry it is important to have high quality feeds and sufficient nutrient content for high milk production. It is for this reason that high quality alfalfa hay receives premium prices compared to lower quality alfalfa. Figure 7 shows a breakdown of price comparisons for different states and different hay grades on March 1, 2016 These prices fluctuate and change with different seasons and different years, but the trends remain the same.

Alfalfa hay prices reported to USDA from selected states.			
	Forage Quality Grade		
Location	Premium+	Good	Fair
	$ per ton		
California	160-250(d)	160(d)-170	145(d)
Colorado	200	N.A.	N.A.
Idaho	150	110	80-90
Illinois	190-320(d)	160-240	90-120
Iowa	195	115-155	82-110
Kansas	155-210	140-160	65-85
Minnesota	N.A.	N.A.	80-115
Missouri	150-200	120-160	100-120
Montana	150-200	130-150	90-130
Nebraska	180-200	75-165	85-90
Oklahoma	120-150	70-110	80-100
Oregon	170-240	180	N.A.
Pennsylvania	190-290	165-200	130-145
South Dakota	95-118	65-150	40-120
Texas	190-333	155-250(d)	150
Utah	120-180	100-140	85-120
Washington	265	140	120
Wisconsin	120-145	60-112	55-80
Wyoming	N.A.	100-120	75-85

Figure 7: Alfalfa Hay Prices March 1, 2016, from Forage and Hay Grower

Alfalfa's ability to grow in a

variety of areas leads to a large amount of production in many areas of the United States. As a whole, the United States produced 57 million tons of alfalfa and alfalfa mixtures in 2013, 61 million tons in 2014 and about 59 million tons in 2015. That production was worth $10.6 billion, $10.5 billion, and $8.7 billion in 2013, 2014, and 2015. The average price per ton was $199 in 2013, $196 in 2014 and $163 in 2015. Idaho's prices per ton were below the national average in 2013 at $193, but above average in 2014 and 2015 at $200 and $175, respectively. With those prices, and a production of about 4.2 million tons in each of the three years, the value of production was $821 million in 2013, $850 million in 2014 and $735 million in 2015. Idaho producers averaged a yield of 3.8 tons per acre in 2013, 3.9 tons per acre in 2014 and 4 tons per acre in 2015. So if a producer had average yields per acre and received the average price per ton the producer would receive $733.40 per acre in 2013, $780 per acre in 2014 and $700 per acre in 2015. On average for those three years alfalfa brought $737.80 per acre.

The market for alfalfa production is not limited to the United States however. Overseas markets are importing American alfalfa to feed their animals as well. This leads to more demand for producers to meet. Foreign markets include Japan, China, United Arab Emirates, Korea, and other countries. The total exports to these countries hit a high in 2013 before dropping in 2014 after a number of circumstances including a drop in demand from China after more stringent testing for genetically modified alfalfa was implemented. However, the export total bounced back in 2015 to similar levels as

Table 7: Total Yearly Hay Exports (2006-2015), from Progressive Forage

Year	Metric Tons (million)	Tons (millions)	Value ($ million)
2006	0.809	0.89	165.2
2007	0.749	0.83	171.2
2008	0.919	1.01	215.2
2009	1.547	1.71	354.3
2010	1.452	1.60	339.4
2011	1.619	1.78	400.6
2012	1.759	1.94	500.2
2013	1.975	2.18	586.8
2014	1.685	1.86	536.5
2015	1.939	2.14	641.3

Table 8: Leading 2015 Alfalfa Hay Markets, from Progressive Forage

Country	Metric Tons	Tons	Value ($ million)
China	868,595	957,462	294.8
Japan	463,412	510,824	167.8
UAE	222,900	245,705	58.8
South Korea	183,264	202,014	57.5
Saudi Arabia	71,492	78,806	23.4

2013 (Table 7). A table of the leading exporters in 2015 is shown in Table 8. Even though China was concerned with the genetically modified crops from the U.S. they were still the leading exporter of American alfalfa hay.

Following China was Japan and then the United Arab Emirates. South Korea and Saudi Arabia are the last on this list, but not the last exporters, there are more countries that export from America.

GPS Use

There are many ways for an operation to become more efficient, from proper maintenance of equipment to prevent breakdown, to timely operations and other strategies. But as stated by Donnell Hunt in *Farm Power and Machinery Management*, "a manager of equipment may be quite knowledgeable about machine and power performance; but unless the machine operator's performance also is high the total system performance may be low" (2001, 63). This means that even if a manager is doing everything possible to be efficient, if the operators of the tractors and combines and other machinery are not being efficient, then the other methods of improving efficiency would be useless. Though operating machinery is not physically intense labor, the operator must be aware and alert of a number of things. The larger the machine is and more complicated it is, the more alert the operator must be. Individual operators have a lot to do with efficiency, one operator may have more skill and experience than another, so that may lead to more attentiveness or it may lead to the operator being lazy since they have "seen it all."

The operator performance is difficult to measure, but there are ways to reduce distractions and demands on the operator. One way to reduce operator fatigue is by use of automatic systems that follow furrows or ridges or rows and reduce the need for the operator to constantly monitor and steer the machine. Instruments also aid the operator by displaying pressures, temperatures, speeds, and other functions to maximize efficiency and reduce fatigue. These are not the only ways to reduce fatigue however. The use of global positioning systems (GPS) allow for high levels of efficiency for the farm operation. GPS can be used in a variety of ways, such as producing yield maps, or variable rate planting or spraying, or the GPS can guide the operator around the field. Some systems will also take control of the machine to drive it on a predetermined path or row. This technology is essential for row crops that plant into beds or furrows. By following the same path used by the bedding machine, the planter can deposit seeds into the proper locations. There are varying levels of accuracy and costs associated with this technology. Higher accuracy systems can come as close as 1 inch from pass to pass (Adamchuk, 2008).

Though important for operator fatigue, global positioning systems also serve as an advantage for "input savings from more precise field application of seed, fertilizers, chemicals, fuel, and labor" (Groover & Grisso, 2009). According to the article from the Virginia Cooperative Extension, costs can range from "less than $2,000 for a light bar navigation system with an accuracy of approximately one foot to $40,000 or more for autopilot systems with 1-inch accuracy" (Groover & Grisso, 2009). This article uses a $6,500 system to approximate annual costs if the system is spread out over 5 years with an interest rate of .1 and repair costs of $130.

The study reports an annual cost of $1845 for a mechanical steering system and guidance system. A reported 2-7% savings per acre are possible with this GPS set up. Depending upon the costs per acre, the savings will vary. An example breakeven acreage chart is shown in Figure 8 assuming an annual cost of $1845 for the GPS system and an average farm cost of $154 per acre. The bottom axis shows varying rates of savings and the left axis shows the requisite acreage required for each savings percentage. The 1000 acre farm of this study would break even for all percentage of savings except 1%.

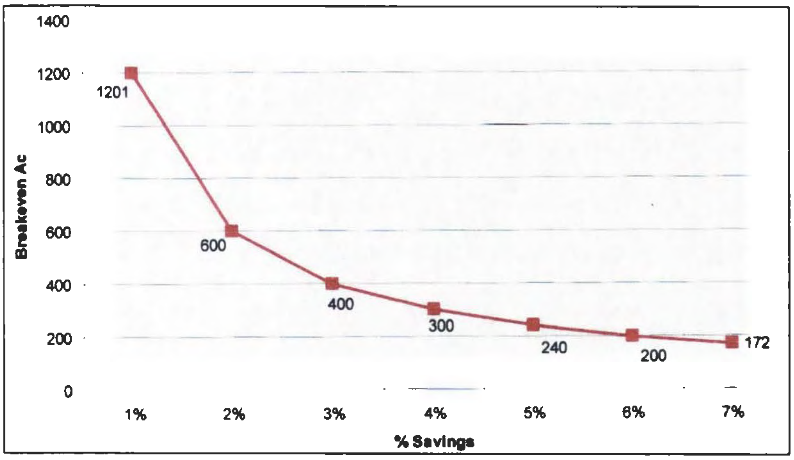

Figure 8: GPS Breakeven Acreage

All of these factors, the costs of tillage, planting, cultivating, harvesting, and chemical applications and the revenue from grain, sugarbeets, and hay come together to provide the farm's net income. The enterprise budgets for alfalfa, sugarbeets, and corn are found in Appendices X, XI and XII.

Conclusion

A farm is just like any other business; it must ensure it spends less money than it makes. But unlike other businesses its income doesn't come throughout the year. For the most part, the income is acquired after the harvest. Usually in the fall, so that creates an interesting dynamic for most farms. They have to ensure the income from the fall lasts through tillage, planting, cultivation, irrigation and until the next harvest. All of the operations, and the inputs required are determined from the previous year's crop yields and prices. This can be hard to simulate for the purposes of this study, but included in the enterprise budgets of each of the three crops are ranging analysis for a variety of yields and prices. These factor in the calculated operating costs and total costs and compare those to the revenue from different crop prices and yields. The costs are calculated on a per acre basis. See Table 9 for an example of these ranging analyses for alfalfa (Appendix XII).

Table 9: Alfalfa Ranging Analysis

Price ($/ton)	Return above Total Costs										$ 789.81
	Yield (ton/acre)										
Alfalfa Hay	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8
$ 145.00	$ (354.81)	$ (282.31)	$ (209.81)	$ (137.31)	$ (64.81)	$ 7.69	$ 80.19	$ 152.69	$ 225.19	$ 297.69	$ 370.19
$ 155.00	$ (324.81)	$ (247.31)	$ (169.81)	$ (92.31)	$ (14.81)	$ 62.69	$ 140.19	$ 217.69	$ 295.19	$ 372.69	$ 450.19
$ 165.00	$ (294.81)	$ (212.31)	$ (129.81)	$ (47.31)	$ 35.19	$ 172.69	$ 200.19	$ 282.69	$ 365.19	$ 447.69	$ 530.19
$ 175.00	$ (264.81)	$ (177.31)	$ (89.81)	$ (2.31)	$ 85.19	$ 172.69	$ 260.19	$ 347.69	$ 435.19	$ 522.69	$ 610.19
$ 185.00	$ (234.81)	$ (142.31)	$ (49.81)	$ 42.69	$ 135.19	$ 227.69	$ 320.19	$ 412.69	$ 505.19	$ 597.69	$ 690.19
$ 195.00	$ (204.81)	$ (107.31)	$ (9.81)	$ 87.69	$ 185.19	$ 282.69	$ 380.19	$ 477.69	$ 575.19	$ 672.69	$ 770.19
$ 205.00	$ (174.81)	$ (72.31)	$ 30.19	$ 132.69	$ 235.19	$ 337.69	$ 440.19	$ 542.69	$ 645.19	$ 747.69	$ 850.19
$ 215.00	$ (144.81)	$ (37.31)	$ 70.19	$ 177.69	$ 285.19	$ 392.69	$ 500.19	$ 607.69	$ 715.19	$ 822.69	$ 930.19
$ 225.00	$ (114.81)	$ (2.31)	$ 110.19	$ 222.69	$ 335.19	$ 447.69	$ 560.19	$ 672.69	$ 785.19	$ 897.69	$ 1,010.19
$ 235.00	$ (84.81)	$ 32.69	$ 150.19	$ 267.69	$ 385.19	$ 502.69	$ 620.19	$ 737.69	$ 855.19	$ 972.69	$ 1,090.19

The total costs for alfalfa are shown in the top right hand corner, at $735.79 per acre. This includes input costs such as seed, fertilizer, pesticide, and fuel, as well as ownership costs of the machinery and farm. A range of prices, from $145 per ton to $235 per ton are calculated with a variety of yields from 3 tons per acre to 8 tons per acre. As the table shows, if a farmer is only obtaining a yield of 3 tons per acre, he will lose money no matter what the price of hay is. At 3.5 and 4 tons per acre he can lose money or gain money depending upon the price of hay. If his alfalfa produces more than 5.5 tons per acre the costs will be covered and large amounts of revenue are possible per acre. If the alfalfa produced a yield of 4.5 tons per acre throughout the year and was of high enough quality to receive a price of $185 per ton the farmer could record a profit of $42.69 per acre or $12,807.75 total for the 300 acres of alfalfa.

Similar tables for sugarbeets and grain corn can be found in Appendix XIII and XIV. Sugarbeets have a higher total cost, in large part due to seed cost and increased pesticide requirements. Total cost for sugarbeets is $1430.79. So the ranging analysis shows prices per ton of $40 to $60 along with sugarbeet yields of 28 tons per acre to 48 tons per acre. At any of these crop yields there is opportunity to make a profit on the crop, at 36 tons per acre, all of these prices would result in profit. If the farmer had yields of 33 tons per acre and received $44 per ton his net returns would be $21.21 per acre, or for the entire crop of 400 acres, the total net return would be $8483.40.

The corn crop is more difficult to turn a profit with. The total cost per acre is $1122.83. The yields of 135 to 235 bushels per acre and prices of $3.75 to $6.25 are combined to show a significant loss of money for a lot of price and yield combinations. For any yields lower than 185 bushels per acre the farmer would lose money unless he decreased his total costs. Even at 235 bushels per acre he would need to receive a price greater than $4.75 per bushel to gain a profit on his crop. At an average yield of 205 bushels per acre and a price of $4.75 he would make a profit of $4.67 per acre, or $1,399.65 for the entire 300 acres of grain corn.

What these numbers show is that it is critical for a farm to have good management and sound financial practices in order to produce the most amount of crop possible to keep up with a volatile market. Prices in agricultural products can range in value a great deal from year to year, so the farmer needs to be able to adapt and keep up with the current markets and technology to increase his profits as well as reduce his costs.

Word Count: 1,220

Reflection

Research was never part of my plan as I started college. I wanted to complete my degree and get a job in the agricultural industry. But as I started at Utah State I learned that research and working with faculty and professors is a large part of the Honor's Program. So as I began my Junior year at Utah State I started my Honors Contracts, I worked with a few different professors in my major of Agricultural Systems Technology as well as in the Plants, Soils and Climate Department. I researched various topics in agriculture including precision agriculture, increased emission standards, hay quality and field crop selection. These contracts prepared me for the research I would have to do for my capstone project.

Though my contracts had prepared me for the writing and research required by the Honors Capstone project, deciding what to do for my capstone project was really difficult. I wanted to research a topic that was applicable to my future plans. I talked with a few different people about what would be good to research and I had a variety of topics presented, such as a case study on a farm I was working at to help the farmer be more efficient. This was a good idea, but I wasn't sure how I would conduct my research. That got me thinking about a project that dealt with a farm as a whole. I want to be a farm manager, so a research project that could benefit me in this pursuit would be ideal. As I was going to work the summer before my senior year I was driving through the farm ground outside of town and a though struck me. There is something that farmers have to do every year and is something that can have a large impact on the farm.

Selecting crops to grow and sell can make or break the farm. Different crops require many different inputs, such as different machinery, different soil types, different fertilizers, and different markets. All of this contributes to the selection of a crop for a farm to grow. I knew this, but I didn't know how a farmer would go about selecting crops for his farm. So I decided this was what I wanted to research.

I had the project, now I just needed a mentor to help me structure and refine my research. There were a few people who came to mind, Dr. Michael Pate, who I had worked with numerous times, or I could work with another professor in the same department. But since Dr. Pate is the Departmental Honors Advisor for Applied Sciences, Technology and Education, I figured he would be a part of the capstone project anyway. Since I decided not to work with Dr. Pate I thought it might be best to look into the Plants, Soils and Climate Department, since my capstone project had a lot to do with field crops.

My search in the PSC department led me to Dr. Ralph Whitesides, who taught Forage Production and Pasture Ecology and Field Crops. I took Field Crops the first semester of my senior year, and decided to complete my final contract in that class with Dr. Whitesides. For this contract I did a literature review of field crop selection, as a prelude to my capstone project. I had taken Forage Production and Pasture Ecology from him, so I knew him but I had never worked with him before. However, he was happy to work with me as I talked with him at the start of the fall semester. He agreed to mentor me through the contract and then the final capstone project as well. His support was great throughout the process and I was happy to work with him.

One of the harder parts of the Capstone process was finished. I found a project that I found interesting and was really applicable to my post-graduation plans. I found a professor I knew and liked in Dr. Whitesides, and I also had Dr. Pate to talk to as well. Both of these professors helped me throughout the process and great mentors. But the next step of researching and writing my paper was still somewhat daunting.

I started researching in the fall before graduation, which was really helpful; I was able to get a jump on the project. Some of my peers didn't really start on the research until the spring semester, which really caused them a lot of stress and work their last semester. If I was to do anything different I would have started my contracts the first semester of my sophomore year, so I could have had my four contracts finished by my senior year, so I could put my full attention into the capstone project for the entirety of my senior year. I made it work but I would encourage others to start their contracts sooner.

I finished my preliminary research for my capstone in December, then after a break for Christmas I started writing in January, when I started back into school. All of the writing seemed really daunting to begin with, but I thought it would be best to take it in chunks at a time. So I took the time to write an outline for a few reasons. The first reason was to get my ideas about my paper into a solid plan that I could follow, the second reason was the outline allowed me to take specific sections only focus on that section at a time. Focusing on a small section at a time was helpful because I would finish that section and feel good about it, rather than thinking how much I still had left of the paper as a whole. Plus, the outline served as a great Table of Contents later on when I was formatting my paper. Though I have made outlines for other papers I found that this paper almost required an outline for me to get all of my thoughts down and to be able to focus on the writing.

The writing took me a number of months, and there is really no way to get around it, the paper has to get written. But I kept at it, I would write a little bit most every day. But the great part about starting early was I didn't have to pull all-nighters or miss out on fun stuff like basketball games or other stuff. So it is definitely a big plus to start as soon as possible to avoid the stress of "having" to get it done. I was able to take my time and write (what I think is) a quality paper.

When I was done I sent it to my mentor who made some suggestions and I went through a few drafts before I was finished. But after those drafts I felt like I had a good paper that I could be proud of. I had put a lot of work into it and a lot of time. I also came out of this experience with some knowledge that could help me or others in the future. That knowledge was to start early, both on contracts and the capstone project (or any large paper), make an outline, and to take small chunks at a time so you aren't overwhelmed.

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Appendix I

Theoretical Field Capacity Calculation: $C_s = (V \times w \times E_f) / 8.25$ $w = (8.25 \times C_s) / (V \times E_f)$

Operation:	Crop:	Acres:	Days to Complete:	Hours per day:	Total Hours:	Acres per hour:	Width Needed:	Number of Rows:
Plow:	Sugar beet	300	5	12	60	5	10.7843137	
Disk:	Sugar beet, corn, alfalfa	700	5	12	60	11.6666667	20.0520833	
Striptill:	Corn	100	1	6	6	16.6666667		
Bed:	Corn	100	1	7	7	14.2857143	29.4642857	11.6
Bed:	Sugar beet	100	1	10	10	10	20.625	11.25
Striptill:	Sugar beet	100	1	6	6	16.6666667		
Harrow:	Sugar beet, corn, alfalfa	700	5	12	60	11.6666667	16.1764706	
Plant:	Alfalfa	200	2	12	24	8.33333333	19.6428571	40
Plant:	Beets	400	4	12	48	8.33333333	19.2307692	10.48951
Plant:	Corn	300	3	12	36	8.33333333	19.2307692	7.692308
Corrogate:	Alfalfa	50	1	10	10	5	10.3125	
Swathing:	Alfalfa	300	5	12	60	5	10.3125	
Rake:	Alfalfa	300	5	4	20	15		
Bale:	Alfalfa	300	5	4	20	15		
Spray:	Sugarbeet, corn, alfalfa	2100	15	6	90	23.3333333	45.5621302	
Topper:	Beets	400	10	12	120	3.33333333	6.875	3.75
Harvester:	Beets	400	10	12	120	3.33333333	9.16666667	5
Combine:	Corn	300	6	10	60	5	19.6428571	7.857143

Appendix II

Adapted From *Introduction to Agricultural Engineering Technology* Appendix IV

Machine	Field Efficiency		Field Speed	
	Range(%)	Typical (%)	Range (mi/hr)	Typical (mi/hr)
Tillage and Planting				
Moldboard Plow	70-90	85%	3.0-6.0	4.5
Tandem Disk Harrow Offset	70-90	80%	4.0-7.0	6
Spring Tooth Harrow	70-90	85%	5.0-8.0	7
Row Crop Cultivator	70-90	80%	3.0-7.0	5
Row Crop Planter	50-75	65%	4.0-7.0	5.5
Grain Drill	55-80	70%	4.0-7.0	5
Harvesting				
Combine	65-80	70%	2.0-5.0	3
Swather (windrower)	70-85	80%	3.0-8.0	5
Side Delivery Rake	70-90	80%	4.0-8.0	6
Large Rectangular Baler	70-90	80%	4.0-8.0	5
Sugar Beet Harvester	50-70	60%	4.0-6.0	5
Miscellaneous				
Boom-type Sprayer	50-80	65%	3.0-7.0	6.5
Sugar Beet Topper	70-90	80%	4.0-7.0	5

Appendix III

Draft Force Calculation $(D_i = F_i \times [C_1 + (C_2 \times V) + (C_3 \times V^2)] \times W \times T_d)$

Operation:	Crop:	Draft Force (lb):	Drawbar HP:	PTO HP:	Engine HP:	Tractor Used
Plow	Sugarbeet	20845.92055	250.151047	290.87331	338.224779	340 HP
Disk	Sugarbeet, corn, alfalfa	15700.608	251.209728	292.1043349	339.656203	340 HP
Striptill	Corn, Sugarbeet	25 HP/Row			300	250 HP
Bed	Corn	14178	189.04	219.8139535	255.59762	250 HP
Bed	Sugar Beet	14178	189.04	219.8139535	255.59762	250 HP
Harrow	Sugarbeet, corn, alfalfa	7593.75	141.75	164.8255814	191.657653	250 HP
Plant	Alfalfa	4000	53.3333333	62.01550388	72.111051	150 HP
Plant	Sugar Beets	2400	35.2	40.93023256	47.5932937	150 HP
Plant	Corn	2400	35.2	40.93023256	47.5932937	150 HP
Swath	Alfalfa			24	27.9069767	
Bale	Alfalfa					250 & 340 HP
Spray	Sugarbeet, corn, alfalfa			18	20.9302326	250 HP
Combine	Corn			120	139.534884	
Topper	Beets			84	97.6744186 *	250 HP
Harvester	Beets	10800	144	167.4418605	194.699838 *	340 HP

*- According to Amity website 12 row beet defoliator requires 150 hp, and Parma website 250 hp is required.

*- According to Amity website 12 row beet harvester requires 250 hp, and Parma website 320 hp is required.

Appendix IV

Adapted From *Introduction to Agricultural Engineering Technology* Appendix V

Implement	Width (units)	Machine Parameters C_1	Machine Parameters C_2	Machine Parameters C_3	Soil Parameters F_1	Soil Parameters F_2	Soil Parameters F_3
Major Tillage Tools							
Moldboard Plow	Feet	113	0	2.3	1	0.7	0.45
Disk Harrow, Offset							
Primary Tillage	Feet	62	5.4	0	1	0.88	0.78
Secondary Tillage	Feet	44	3.8	0	1	0.88	0.78
Row Crop Cultivator							
C-shank	Rows	248	19.9	0	1	0.85	0.65
Minor Tillage Tools							
Spring Tooth Harrow	Feet	135	0	0	1	1	1
Seeding Implements							
Row Crop Planter							
Mounted	Rows	200	0	0	1	1	1
Grain Drill w/press wheels							
<8 feet	Rows	90	0	0	1	1	1
8 feet to 12 feet	Rows	67	0	0	1	1	1
>12 feet	Rows	25	0	1	1	1	1

Appendix V
Adapted from *Farm Power and Machinery Management* Figure 2.5

Machine			Draft, Force per Unit Width (Pound / Unit)	Unit
Tillage Implements				
	Plow, Moldboard or Disk			
		(7 inch depth)		
		Light Soils	220-430	Foot
		Medium Soils	350-650	Foot
		Heavy Soils	580-1140	Foot
	Disk Harrow			
		Light Tandem	100-180	Foot
		Heavy Tandem	80-150% of implement weight	
	Spring Tooth Harrow		70-300	Foot
Seeders				
	Row Planter		100-180	Row
	Grain Drill		30-100	Foot
Chemical Applicators			**(HP/ Foot)**	
	Sprayer		.3 HP	Foot
Cultivation				
	Row Cultivator			
		Shallow	40-80	Foot
		Deep (3 inch)	60-120	Foot
Special Crop Harvesters				
	Beet Lifter (22 Inch Row)		450-900	Row

			PTO Power (HP/ Unit)	
Grain Harvesting				
	Combine			
		Corn (30 in Row)	10-15.0	Row
Forage Harvesting				
	Conditioner, cutterbar		1.5-2	Foot
	Side Delivery Rake		.2-.3	Foot
	Baler, Rectangular			
		Hay	1.2-2.7	HP·hr/ac
Special Crop Harvesters				
	Beet Topper (22 Inch Row)		5-7.0	Row
	Beet Lifter (22 Inch Row)		2-4.0	Row

Appendix VI

Calendar of Field Operations

Month:	Week:	Operation:	Crop:	Tractor:	Implement:	Acres:	Total Hours:
November							
	Week 1	Plow	Sugarbeets	340 HP	10-16 Plow	300	60
	Week 2	Disk	Corn	340 HP	21 Foot Disk	700	60
		Striptill	Corn	250 HP	12 Row Striptill 30"	100	6
		Bedding	Sugarbeets	250 HP	12 Row 22" Bedding bar	100	10
		Bedding	Corn	250 HP	12 Row 30" Bedding bar	100	7
Late March or Early April (depending upon weather)							
		Striptill	Sugarbeets	340 HP	12 Row Striptill 22"	100	6
		Harrow	Alfalfa, Corn, Sugarbeets	250 HP	18 Foot Springtooth Harrow	700	60
		Plant	Alfalfa	150 HP	20 Foot Drill	200	24
		Plant	Sugarbeets	150 HP	12 Row Planter 22"	400	48
		Plant	Corn	150 HP	12 Row Planter 30"	300	36
May, July, August, October (depending upon weather)							
		Swath	Alfalfa		12 foot swathers	300	60
		Rake	Alfalfa	100 & 150 HP	Double Basket Rakes	300	20
		Bale	Alfalfa	250 & 340 HP	3x4 Baler	300	20
Throughout Summer							
		Apply Pesticide	Sugarbeets, Corn, Alfalfa	250 HP	Tractor and Spray Rig	1400	60
October							
	Week 1 and 2						
		Top Beets	Sugarbeets	250 HP	12 Row Beet Topper	400	120
		Harvest Beets	Sugarbeets	340 HP	12 Row Beet Harvester	400	120
November							
	Week 1						
		Combine Corn	Corn		6 Row Corn Header	300	60

Appendix VII

Operation	Farm energy audit[a] Range (gal/ac) Average	High	Low	Average from other states[b]
Primary tillage				
Moldboard plow	1.81	3.50	0.90	1.87
Chisel disk	1.36	3.50	0.80	1.09
Offset disk	1.11	1.20	0.90	0.97
Subsoiler	1.54	2.30	1.10	1.56
Secondary tillage				
Disk	0.93	3.30	0.30	0.65
Field cultivator	0.78	1.80	0.30	0.68
Spring tooth harrow (drag)	0.73	1.80	0.20	0.48
Fertilizer and chemical application				
Pesticide spraying	0.33	2.90	0.10	0.13
Chemical incorporation	0.80	1.10	0.50	–
Spreading fertilizer	0.30	0.50	0.10	0.19
Knife in fertilizer	0.58	1.30	0.20	1.05
Planting				
Row crop planter	0.51	1.00	0.20	0.54
Grain drill	0.56	2.31	0.10	0.33
Potato planter	0.95	1.90	0.90	0.95
Broadcast seeder	0.28	1.12	0.10	0.15
No-till planter	0.68	–	–	0.43
Cultivation				
Cultivator	0.39	1.90	0.10	0.42
Rotary hoe	0.23	0.70	0.10	0.21
Forage harvesting				
Mower/conditioner	0.72	1.80	0.30	0.66
Rake	0.46	1.26	0.20	0.24
Baler	0.65	2.90	0.10	0.69
Large round baler	0.80	–	–	–
Forage harvester or green chop	1.57	2.00	0.20	1.87
Corn silage harvester	3.14	6.70	1.70	2.69
Grain and row crop harvest				
Small grain or bean combine	1.23	1.80	0.70	1.01
Corn combine	1.51	2.20	0.70	1.37
Corn picker	1.84	3.00	1.20	1.10
Pull and window	0.52	1.10	0.30	0.34
Beet harvester	1.37	1.90	0.90	1.91
Topping beets	0.83	1.20	0.40	1.47
Potato harvester	2.69	–	–	1.73
PTO operated (gal/hr)				
Forage blower	2.19	6.20	0.90	–
Irrigation	3.41	4.40	1.10	–
Grinding	3.84	6.90	2.20	–

[a]Helsel, Z., and T. Oguntunde. 1985. Fuel requirements for field operations with energy saving tips. In *Farm Energy Use: Standards, Worksheets, Conservation*, ed. C. Myers. East Lansing: Michigan State University.
[b]Iowa, Pennsylvania, Nebraska, Missouri, New York, Oklahoma, North Dakota, and Ontario, Canada

Appendix VIII

Repair and Maintenance Costs, Percentage of List Price

Adapted from *Farm Power and Machinery Management* Figure 4.5

Machine	Wear-out life, hr	R&M, Lifetime	R&M/ 100 hr
Tractors			
2-wheel drive	12,000	100	0.83
4-wheel drive	16,000	80	0.50
Tillage			
Moldboard plow	2,000	100	5.00
Heavy-duty disk	2,000	60	3.00
Tandem disk harrow	2,000	60	3.00
Chisel plow	2,000	75	3.75
Field cultivator	2,000	70	3.50
Spring-tooth harrow	2,000	70	3.50
Roller harrow	2,000	40	2.00
Rotary hoe	2,000	60	3.00
Row crop cultivator	2,000	80	4.00
Rotary tiller	1,500	80	5.33
Seeders			
Row crop planter	1,500	75	5.00
Grain drill	1,500	75	5.00
Harvesters			
Combine	2,000	60	3.00
Combine, self propelled	3,000	40	1.33
Forage harvester	2,500	65	2.60
Forage harvester, SP	4,000	40	1.25
Sugar beet harvester	1,500	70	6.67
Hay Machines			
Mower, cutterbar	2,000	150	7.50
Mower, rotary	2,000	175	8.75
Mower-conditioner	2,500	80	3.20
Mower-conditioner, rotary	2,500	100	4.00
Windrower, self-propelled	3,000	55	1.83
Side-delivery rake	2,500	60	2.40
Rectangular baler	2,000	80	4.00
Large, rectangular baler	3,000	75	2.50
Large, round baler	1,500	90	6.00
Miscellaneous			
Fertilizer spreader	1,200	80	6.67
Boom sprayer	1,500	70	4.67
Beet topper/ stalk chopper	1,200	35	2.92
Grain wagon	3,000	80	2.67

Appendix IX

Selected Equipment and Function

Function	Implement Type	Initial Cost	Approximate Hours of Use	Total Annual Cost*	Hourly Costs
General	340 HP Tractor	$ 285,000	300	$ 51,368	$ 171.23
	250 HP Tractor	$ 215,000	300	$ 38,062	$ 126.87
	150 HP Tractor	$ 131,000	200	$ 21,126	$ 105.63
	100 HP Tractor	$ 75,000	100	$ 10,460	$ 104.60
Tillage					
	10 Bottom 16 Inch Plow	$ 45,000	75	$ 6,013	$ 80.17
	21 Foot Disk	$ 31,000	75	$ 3,924	$ 52.31
	12 Row Striptill Machine	$ 75,296	15	$ 335	$ 22.31
	12 Row Bedding Bar	$ 58,000	50	$ 7,342	$ 146.84
	18 Foot Harrow	$ 51,000	75	$ 6,379	$ 85.05
Planters					
	12 Row 22"	$ 44,000	50	$ 6,436	$ 128.72
	12 Row 30"	$ 44,000	50	$ 6,436	$ 128.72
	20 Foot Drill	$ 3,700	50	$ 5,412	$ 108.24
Alfalfa Harvest					
	12 Foot Swather	$ 102,000	120	$ 17,246	$ 143.72
	Double Basket Rake	$ 21,000	50	$ 3,060	$ 61.20
	3x4 Large Baler	$ 95,000	50	$ 14,531	$ 290.62
Beet Harvest					
	12 Row Beet Topper	$ 59,000	150	$ 11,865	$ 79.10
	12 Row Beet Harvester	$ 127,000	150	$ 29,464	$ 196.43
Corn Harvest					
	6 Row Corn Header	$ 220,000	75	$ 28,541	$ 380.54

Appendix X

Enterprise Budget

Revenue	Unit	Quantity/ Acre	Price/ Unit	Acres	Amount	Amount/Acre
Alfalfa Hay	Tons	4.5	$ 185.00	300	$ 249,750.00	$ 832.50
Total Revenue					**$ 249,750.00**	**$ 832.50**
Operating Expenses						
Seed						
Round-up Ready	Pounds	12	$ 7.25	100	$ 8,700.00	$ 29.00
Fertilizer					**$ 29,895.00**	**$ 99.65**
Dry Nitrogen	Pounds	15	$ 0.66	300	$ 2,970.00	$ 9.90
Dry P2O5	Pounds	75	$ 0.53	300	$ 11,925.00	$ 39.75
K2O	Pounds	80	$ 0.50	300	$ 12,000.00	$ 40.00
Sulfur	Pounds	40	$ 0.25	300	$ 3,000.00	$ 10.00
Pesticide					**$ 15,120.00**	**$ 50.40**
Velpar Alfamax DG	Pounds	2	$ 15.15	300	$ 9,090.00	$ 30.30
Furadan 4F	Quart	1	$ 20.10	300	$ 6,030.00	$ 20.10
Irrigation					**$ 15,870.00**	**$ 52.90**
Water Assessment	Acre	1	$ 50.60	300	$ 15,180.00	$ 50.60
Repairs	Acre	1	$ 2.30	300	$ 690.00	$ 2.30
Harvest					**$ 16,204.50**	**$ 54.02**
Swathing	Acre	3	$ 4.03	300	$ 3,627.00	$ 12.09
Raking	Acre	3	$ 1.39	300	$ 1,251.00	$ 4.17
Baling	Tons	4.5	$ 4.76	300	$ 6,426.00	$ 21.42
Stacking	Tons	4.5	$ 3.63	300	$ 4,900.50	$ 16.34
Labor					**$ 25,405.50**	**$ 84.69**
Equipment Operator	Hours	1.2	$ 18.10	300	$ 6,516.00	$ 21.72
Irrigation Labor	Hours	4.9	$ 12.85	300	$ 18,889.50	$ 62.97
Machinery					**$ 4,934.25**	**$ 16.45**
Gasoline	Gallon	1.27	$ 3.60	300	$ 1,371.60	$ 4.57
Diesel	Gallon	0.63	$ 4.05	300	$ 765.45	$ 2.55
Off-road Diesel	Gallon	1.48	$ 3.55	300	$ 1,576.20	$ 5.25
Lube						$ 1.89
Repair						$ 2.18
Operating Costs					**$ 116,129.25**	**$ 387.10**

Appendix X (cont.)

Overhead Costs						$	**95,160.00**	$	**317.20**
General Overhead								$	16.00
Land Rent								$	250.00
Property Insurance								$	1.20
Management Fee								$	50.00
Ownership Costs						$	**25,653.00**	$	**85.51**
Machinery	Acre	1	$	77.26	300	$	23,178.00	$	77.26
Irrigation	Acre	1	$	8.25	300	$	2,475.00	$	8.25
Total Costs						$	**236,942.25**	$	**789.81**
		Net Returns				$	12,807.75	$	42.69

Appendix XI

Enterprise Budget

Revenue	Unit	Quantity/ Acre	Price/ Unit	Acres	Amount	Amount/Acre
Sugar Beets	Tons	33	$ 44.00	400	$ 580,800.00	$ 1,452.00
Total Revenue					$ 580,800.00	$ 1,452.00
Operating Expenses						
Seed						
Round-up Ready	Units	0.5	$ 345.00	400	$ 69,000.00	$ 172.50
Fertilizer					$ 55,840.00	$ 139.60
Dry Nitrogen	Pounds	115	$ 0.66	400	$ 30,360.00	$ 75.90
Dry P2O5	Pounds	40	$ 0.53	400	$ 8,480.00	$ 21.20
K2O	Pounds	60	$ 0.50	400	$ 12,000.00	$ 30.00
Sulfur	Pounds	50	$ 0.25	400	$ 5,000.00	$ 12.50
Liquid Nitrogen	Pounds	10	$ 0.82	400	$ 3,280.00	$ 8.20
Liquid P2O5	Pounds	35	$ 0.76	400	$ 10,640.00	$ 26.60
Micronutrients	Acre	1	$ 14.00	400	$ 5,600.00	$ 14.00
Pesticide					$ 10,160.00	$ 25.40
Roundup Power Max 4.5	Fluid Ounce	54	$ 0.20	400	$ 4,320.00	$ 10.80
Ammonium Sulfate	Pounds	2.4	$ -	400	$ -	$ -
Tilt	Fluid Ounce	4	$ 3.65	400	$ 5,840.00	$ 14.60
Irrigation					$ 21,160.00	$ 52.90
Water Assessment	Acre	1	$ 50.60	400	$ 20,240.00	$ 50.60
Repairs	Acre	1	$ 2.30	400	$ 920.00	$ 2.30
Harvest					$ 64,608.00	$ 161.52
Top Beets	Acre	1	$ 33.17	400	$ 13,268.00	$ 33.17
Lift Beets	Acre	1	$ 36.73	400	$ 14,692.00	$ 36.73
Crop Hauling	Acre	1	$ 52.02	400	$ 20,808.00	$ 52.02
Hauling Assessment	Acre	1	$ 39.60	400	$ 15,840.00	$ 39.60
Other					$ 40,240.00	$ 100.60
Crop Insurance	Acre	1	$ 45.00	400	$ 18,000.00	$ 45.00
Sugarbeet Hauling Charge	Ton	33	$ 1.20	400	$ 15,840.00	$ 39.60
Consultant-Soil Test	Acre	1	$ 16.00	400	$ 6,400.00	$ 16.00
Labor					$ 58,709.60	$ 146.77
Equipment Operator	Hours	3.42	$ 18.10	400	$ 24,760.80	$ 61.90
Truck Driver	Hours	2.64	$ 14.05	400	$ 14,836.80	$ 37.09
Irrigation Labor	Hours	1.64	$ 18.10	400	$ 11,873.60	$ 29.68
General Farm Labor	Hours	1.74	$ 10.40	400	$ 7,238.40	$ 18.10

Appendix XI (cont.)

Machinery						$	25,135.00	$	62.84
Gasoline	Gallon	1.27	$	3.60	400	$	1,828.80	$	4.57
Diesel	Gallon	0.63	$	4.05	400	$	1,020.60	$	2.55
Off-road Diesel	Gallon	1.48	$	3.55	400	$	2,101.60	$	5.25
Lube								$	13.89
Repair								$	36.57
Operating Costs						$	344,852.60	$	862.13
Overhead Costs						$	193,260.00	$	483.15
Co-op Stock								$	30.00
General Overhead								$	24.00
Land Rent								$	350.00
Property Insurance								$	4.15
Management Fee								$	75.00
Ownership Costs						$	34,204.00	$	85.51
Machinery	Acre	1	$	77.26	400	$	30,904.00	$	77.26
Irrigation	Acre	1	$	8.25	400	$	3,300.00	$	8.25
Total Costs						$	572,316.60	$	1,430.79
		Net Returns				$	8,483.40	$	21.21

Appendix XII
Enterprise Budget

Revenue	Unit	Quantity/ Acre	Price/Unit	Acres	Amount	Amount/Acre
Corn Grain	Bushels	205	$ 5.50	300	$ 338,250.00	$ 1,127.50
Total Revenue					**$ 338,250.00**	**$ 1,127.50**
Operating Expenses						
Seed						
Round-up Ready	Bag	0.45	$ 225.00	300	$ 30,375.00	$ 101.25
Fertilizer					**$ 71,550.00**	**$ 238.50**
Dry Nitrogen	Pounds	210	$ 0.66	300	$ 41,580.00	$ 138.60
Dry P2O5	Pounds	80	$ 0.53	300	$ 12,720.00	$ 42.40
K2O	Pounds	100	$ 0.50	300	$ 15,000.00	$ 50.00
Sulfur	Pounds	30	$ 0.25	300	$ 2,250.00	$ 7.50
Pesticide					**$ 4,614.00**	**$ 15.38**
Micro-tech	Quart	2	$ 7.30	300	$ 4,380.00	$ 14.60
Counter 15G L-N-L	Pounds	8	$ 300.00	300	$ 720,000.00	$ 2,400.00
Roundup Power Max 4.5	Fluid Ounce	40	$ 0.20	300	$ 2,400.00	$ 8.00
AMS	Pounds	2	$ 0.39	300	$ 234.00	$ 0.78
Irrigation					**$ 15,870.00**	**$ 52.90**
Water Assessment	Acre	1	$ 50.60	300	$ 15,180.00	$ 50.60
Repairs	Acre	1	$ 2.30	300	$ 690.00	$ 2.30
Harvest					**$ 27,030.00**	**$ 90.10**
Combine	Acre	1	$ 55.00	300	$ 16,500.00	$ 55.00
Crop Hauling	Acre	1	$ 35.10	300	$ 10,530.00	$ 35.10
Other					**$ 9,000.00**	**$ 30.00**
Crop Insurance	Acre	1	$ 30.00	300	$ 9,000.00	$ 30.00
Labor					**$ 47,077.20**	**$ 117.69**
Equipment Operator	Hours	2.48	$ 18.10	400	$ 17,955.20	$ 44.89
Irrigation Labor	Hours	3.85	$ 18.10	400	$ 27,874.00	$ 69.69
General Farm Labor	Hours	0.3	$ 10.40	400	$ 1,248.00	$ 3.12
Machinery					**$ 17,103.45**	**$ 57.01**
Gasoline	Gallon	1.27	$ 3.60	300	$ 1,371.60	$ 4.57
Diesel	Gallon	0.08	$ 4.05	300	$ 97.20	$ 0.32
Off-road Diesel	Gallon	9.41	$ 3.55	300	$ 10,021.65	$ 33.41
Lube						$ 5.83
Repair						$ 12.88

Appendix XII (cont.)

Operating Costs						$ 210,850.35	$	702.83
Overhead Costs						$ 100,347.00	$	334.49
General Overhead							$	37.00
Land Rent							$	250.00
Property Insurance							$	1.49
Management Fee							$	46.00
Ownership Costs						$ 25,653.00	$	85.51
Machinery	Acre	1	$	77.26	400	$ 30,904.00	$	77.26
Irrigation	Acre	1	$	8.25	400	$ 3,300.00	$	8.25
Total Costs						$ 336,850.35	$	1,122.83
		Net Returns				$ 1,399.65	$	4.67

Appendix XIII

Alfalfa Ranging Analysis

Price ($/ton) Alfalfa Hay	Return above Operating Costs									$ 387.10
	Yield (ton/acre)										
	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8
$ 145.00	$ 47.90	$ 120.40	$ 192.90	$ 265.40	$ 337.90	$ 410.40	$ 482.90	$ 555.40	$ 627.90	$ 700.40	$ 772.90
$ 155.00	$ 77.90	$ 155.40	$ 232.90	$ 310.40	$ 387.90	$ 465.40	$ 542.90	$ 620.40	$ 697.90	$ 775.40	$ 852.90
$ 165.00	$ 107.90	$ 190.40	$ 272.90	$ 355.40	$ 437.90	$ 575.40	$ 602.90	$ 685.40	$ 767.90	$ 850.40	$ 932.90
$ 175.00	$ 137.90	$ 225.40	$ 312.90	$ 400.40	$ 487.90	$ 575.40	$ 662.90	$ 750.40	$ 837.90	$ 925.40	$ 1,012.90
$ 185.00	$ 167.90	$ 260.40	$ 352.90	$ 445.40	$ 537.90	$ 630.40	$ 722.90	$ 815.40	$ 907.90	$ 1,000.40	$ 1,092.90
$ 195.00	$ 197.90	$ 295.40	$ 392.90	$ 490.40	$ 587.90	$ 685.40	$ 782.90	$ 880.40	$ 977.90	$ 1,075.40	$ 1,172.90
$ 205.00	$ 227.90	$ 330.40	$ 432.90	$ 535.40	$ 637.90	$ 740.40	$ 842.90	$ 945.40	$ 1,047.90	$ 1,150.40	$ 1,252.90
$ 215.00	$ 257.90	$ 365.40	$ 472.90	$ 580.40	$ 687.90	$ 795.40	$ 902.90	$ 1,010.40	$ 1,117.90	$ 1,225.40	$ 1,332.90
$ 225.00	$ 287.90	$ 400.40	$ 512.90	$ 625.40	$ 737.90	$ 850.40	$ 962.90	$ 1,075.40	$ 1,187.90	$ 1,300.40	$ 1,412.90
$ 235.00	$ 317.90	$ 435.40	$ 552.90	$ 670.40	$ 787.90	$ 905.40	$ 1,022.90	$ 1,140.40	$ 1,257.90	$ 1,375.40	$ 1,492.90

Price ($/ton) Alfalfa Hay	Return above Total Costs									$ 789.81
	Yield (ton/acre)										
	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8
$ 145.00	$ (354.81)	$ (282.31)	$ (209.81)	$ (137.31)	$ (64.81)	$ 7.69	$ 80.19	$ 152.69	$ 225.19	$ 297.69	$ 370.19
$ 155.00	$ (324.81)	$ (247.31)	$ (169.81)	$ (92.31)	$ (14.81)	$ 62.69	$ 140.19	$ 217.69	$ 295.19	$ 372.69	$ 450.19
$ 165.00	$ (294.81)	$ (212.31)	$ (129.81)	$ (47.31)	$ 35.19	$ 172.69	$ 200.19	$ 282.69	$ 365.19	$ 447.69	$ 530.19
$ 175.00	$ (264.81)	$ (177.31)	$ (89.81)	$ (2.31)	$ 85.19	$ 172.69	$ 260.19	$ 347.69	$ 435.19	$ 522.69	$ 610.19
$ 185.00	$ (234.81)	$ (142.31)	$ (49.81)	$ 42.69	$ 135.19	$ 227.69	$ 320.19	$ 412.69	$ 505.19	$ 597.69	$ 690.19
$ 195.00	$ (204.81)	$ (107.31)	$ (9.81)	$ 87.69	$ 185.19	$ 282.69	$ 380.19	$ 477.69	$ 575.19	$ 672.69	$ 770.19
$ 205.00	$ (174.81)	$ (72.31)	$ 30.19	$ 132.69	$ 235.19	$ 337.69	$ 440.19	$ 542.69	$ 645.19	$ 747.69	$ 850.19
$ 215.00	$ (144.81)	$ (37.31)	$ 70.19	$ 177.69	$ 285.19	$ 392.69	$ 500.19	$ 607.69	$ 715.19	$ 822.69	$ 930.19
$ 225.00	$ (114.81)	$ (2.31)	$ 110.19	$ 222.69	$ 335.19	$ 447.69	$ 560.19	$ 672.69	$ 785.19	$ 897.69	$ 1,010.19
$ 235.00	$ (84.81)	$ 32.69	$ 150.19	$ 267.69	$ 385.19	$ 502.69	$ 620.19	$ 737.69	$ 855.19	$ 972.69	$ 1,090.19

Appendix XIV

Sugarbeet Ranging Analysis

Return above Operating Costs — $ 862.13

Price ($/ton) Sugar beets	Yield (ton/acre) 28	30	32	34	36	38	40	42	44	46	48
$ 40.00	$ 257.87	$ 337.87	$ 417.87	$ 497.87	$ 577.87	$ 657.87	$ 737.87	$ 817.87	$ 897.87	$ 977.87	$ 1,057.87
$ 42.00	$ 313.87	$ 397.87	$ 481.87	$ 565.87	$ 649.87	$ 733.87	$ 817.87	$ 901.87	$ 985.87	$ 1,069.87	$ 1,153.87
$ 44.00	$ 369.87	$ 457.87	$ 545.87	$ 633.87	$ 721.87	$ 885.87	$ 897.87	$ 985.87	$ 1,073.87	$ 1,161.87	$ 1,249.87
$ 46.00	$ 425.87	$ 517.87	$ 609.87	$ 701.87	$ 793.87	$ 885.87	$ 977.87	$ 1,069.87	$ 1,161.87	$ 1,253.87	$ 1,345.87
$ 48.00	$ 481.87	$ 577.87	$ 673.87	$ 769.87	$ 865.87	$ 961.87	$ 1,057.87	$ 1,153.87	$ 1,249.87	$ 1,345.87	$ 1,441.87
$ 50.00	$ 537.87	$ 637.87	$ 737.87	$ 837.87	$ 937.87	$ 1,037.87	$ 1,137.87	$ 1,237.87	$ 1,337.87	$ 1,437.87	$ 1,537.87
$ 52.00	$ 593.87	$ 697.87	$ 801.87	$ 905.87	$ 1,009.87	$ 1,113.87	$ 1,217.87	$ 1,321.87	$ 1,425.87	$ 1,529.87	$ 1,633.87
$ 54.00	$ 649.87	$ 757.87	$ 865.87	$ 973.87	$ 1,081.87	$ 1,189.87	$ 1,297.87	$ 1,405.87	$ 1,513.87	$ 1,621.87	$ 1,729.87
$ 56.00	$ 705.87	$ 817.87	$ 929.87	$ 1,041.87	$ 1,153.87	$ 1,265.87	$ 1,377.87	$ 1,489.87	$ 1,601.87	$ 1,713.87	$ 1,825.87
$ 58.00	$ 761.87	$ 877.87	$ 993.87	$ 1,109.87	$ 1,225.87	$ 1,341.87	$ 1,457.87	$ 1,573.87	$ 1,689.87	$ 1,805.87	$ 1,921.87
$ 60.00	$ 817.87	$ 937.87	$ 1,057.87	$ 1,177.87	$ 1,297.87	$ 1,417.87	$ 1,537.87	$ 1,657.87	$ 1,777.87	$ 1,897.87	$ 2,017.87

Return above Total Costs — $ 1,430.79

Price ($/ton) Sugar beets	Yield (ton/acre) 28	30	32	34	36	38	40	42	44	46	48
$ 40.00	$ (310.79)	$ (230.79)	$ (150.79)	$ (70.79)	$ 9.21	$ 89.21	$ 169.21	$ 249.21	$ 329.21	$ 409.21	$ 489.21
$ 42.00	$ (254.79)	$ (170.79)	$ (86.79)	$ (2.79)	$ 81.21	$ 165.21	$ 249.21	$ 333.21	$ 417.21	$ 501.21	$ 585.21
$ 44.00	$ (198.79)	$ (110.79)	$ (22.79)	$ 65.21	$ 153.21	$ 241.21	$ 329.21	$ 417.21	$ 505.21	$ 593.21	$ 681.21
$ 46.00	$ (142.79)	$ (50.79)	$ 41.21	$ 133.21	$ 225.21	$ 317.21	$ 409.21	$ 501.21	$ 593.21	$ 685.21	$ 777.21
$ 48.00	$ (86.79)	$ 9.21	$ 105.21	$ 201.21	$ 297.21	$ 393.21	$ 489.21	$ 585.21	$ 681.21	$ 777.21	$ 873.21
$ 50.00	$ (30.79)	$ 69.21	$ 169.21	$ 269.21	$ 369.21	$ 469.21	$ 569.21	$ 669.21	$ 769.21	$ 869.21	$ 969.21
$ 52.00	$ 25.21	$ 129.21	$ 233.21	$ 337.21	$ 441.21	$ 545.21	$ 649.21	$ 753.21	$ 857.21	$ 961.21	$ 1,065.21
$ 54.00	$ 81.21	$ 189.21	$ 297.21	$ 405.21	$ 513.21	$ 621.21	$ 729.21	$ 837.21	$ 945.21	$ 1,053.21	$ 1,161.21
$ 56.00	$ 137.21	$ 249.21	$ 361.21	$ 473.21	$ 585.21	$ 697.21	$ 809.21	$ 921.21	$ 1,033.21	$ 1,145.21	$ 1,257.21
$ 58.00	$ 193.21	$ 309.21	$ 425.21	$ 541.21	$ 657.21	$ 773.21	$ 889.21	$ 1,005.21	$ 1,121.21	$ 1,237.21	$ 1,353.21
$ 60.00	$ 249.21	$ 369.21	$ 489.21	$ 609.21	$ 729.21	$ 849.21	$ 969.21	$ 1,089.21	$ 1,209.21	$ 1,329.21	$ 1,449.21

Appendix XV

Grain Corn Ranging Analysis

Return above Operating Costs $ 702.83

Price ($/Bushel) Grain Corn	Yield (bushel/acre) 135	145	155	165	175	185	195	205	215	225	235
$ 3.75	$ (196.58)	$ (159.08)	$ (121.58)	$ (84.08)	$ (46.58)	$ (9.08)	$ 28.42	$ 65.92	$ 103.42	$ 140.92	$ 178.42
$ 4.00	$ (162.83)	$ (122.83)	$ (82.83)	$ (42.83)	$ (2.83)	$ 37.17	$ 77.17	$ 117.17	$ 157.17	$ 197.17	$ 237.17
$ 4.25	$ (129.08)	$ (86.58)	$ (44.08)	$ (1.58)	$ 40.92	$ 129.67	$ 125.92	$ 168.42	$ 210.92	$ 253.42	$ 295.92
$ 4.50	$ (95.33)	$ (50.33)	$ (5.33)	$ 39.67	$ 84.67	$ 129.67	$ 174.67	$ 219.67	$ 264.67	$ 309.67	$ 354.67
$ 4.75	$ (61.58)	$ (14.08)	$ 33.42	$ 80.92	$ 128.42	$ 175.92	$ 223.42	$ 270.92	$ 318.42	$ 365.92	$ 413.42
$ 5.00	$ (27.83)	$ 22.17	$ 72.17	$ 122.17	$ 172.17	$ 222.17	$ 272.17	$ 322.17	$ 372.17	$ 422.17	$ 472.17
$ 5.25	$ 5.92	$ 58.42	$ 110.92	$ 163.42	$ 215.92	$ 268.42	$ 320.92	$ 373.42	$ 425.92	$ 478.42	$ 530.92
$ 5.50	$ 39.67	$ 94.67	$ 149.67	$ 204.67	$ 259.67	$ 314.67	$ 369.67	$ 424.67	$ 479.67	$ 534.67	$ 589.67
$ 5.75	$ 73.42	$ 130.92	$ 188.42	$ 245.92	$ 303.42	$ 360.92	$ 418.42	$ 475.92	$ 533.42	$ 590.92	$ 648.42
$ 6.00	$ 107.17	$ 167.17	$ 227.17	$ 287.17	$ 347.17	$ 407.17	$ 467.17	$ 527.17	$ 587.17	$ 647.17	$ 707.17
$ 6.25	$ 140.92	$ 203.42	$ 265.92	$ 328.42	$ 390.92	$ 453.42	$ 515.92	$ 578.42	$ 640.92	$ 703.42	$ 765.92

Return above Total Costs $ 1,122.83

Price ($/Bushel) Grain Corn	Yield (bushel/acre) 135	145	155	165	175	185	195	205	215	225	235
$ 3.75	$ (616.58)	$ (579.08)	$ (541.58)	$ (504.08)	$ (466.58)	$ (429.08)	$ (391.58)	$ (354.08)	$ (316.58)	$ (279.08)	$ (241.58)
$ 4.00	$ (582.83)	$ (542.83)	$ (502.83)	$ (462.83)	$ (422.83)	$ (382.83)	$ (342.83)	$ (302.83)	$ (262.83)	$ (222.83)	$ (182.83)
$ 4.25	$ (549.08)	$ (506.58)	$ (464.08)	$ (421.58)	$ (379.08)	$ (290.33)	$ (294.08)	$ (251.58)	$ (209.08)	$ (166.58)	$ (124.08)
$ 4.50	$ (515.33)	$ (470.33)	$ (425.33)	$ (380.33)	$ (335.33)	$ (290.33)	$ (245.33)	$ (200.33)	$ (155.33)	$ (110.33)	$ (65.33)
$ 4.75	$ (481.58)	$ (434.08)	$ (386.58)	$ (339.08)	$ (291.58)	$ (244.08)	$ (196.58)	$ (149.08)	$ (101.58)	$ (54.08)	$ (6.58)
$ 5.00	$ (447.83)	$ (397.83)	$ (347.83)	$ (297.83)	$ (247.83)	$ (197.83)	$ (147.83)	$ (97.83)	$ (47.83)	$ 2.17	$ 52.17
$ 5.25	$ (414.08)	$ (361.58)	$ (309.08)	$ (256.58)	$ (204.08)	$ (151.58)	$ (99.08)	$ (46.58)	$ 5.92	$ 58.42	$ 110.92
$ 5.50	$ (380.33)	$ (325.33)	$ (270.33)	$ (215.33)	$ (160.33)	$ (105.33)	$ (50.33)	$ 4.67	$ 59.67	$ 114.67	$ 169.67
$ 5.75	$ (346.58)	$ (289.08)	$ (231.58)	$ (174.08)	$ (116.58)	$ (59.08)	$ (1.58)	$ 55.92	$ 113.42	$ 170.92	$ 228.42
$ 6.00	$ (312.83)	$ (252.83)	$ (192.83)	$ (132.83)	$ (72.83)	$ (12.83)	$ 47.17	$ 107.17	$ 167.17	$ 227.17	$ 287.17
$ 6.25	$ (279.08)	$ (216.58)	$ (154.08)	$ (91.58)	$ (29.08)	$ 33.42	$ 95.92	$ 158.42	$ 220.92	$ 283.42	$ 345.92

Appendix XVI

Soil Texture:	Water Holding Capacity (in/ft)	Amount of Soil Water Available for Plant (in/ft)
Sand	0.43	0.215
Sandy Loam	1.67	0.835
Loam	2.1	1.05
Silt	2.12	1.06
Clay Loam	2.08	1.04
Clay	1.94	0.97

Plant Evapotranspiration			*Conversion=	0.03937008	
		Amount per day		Days per month	ET per Month
Crop	Month:	mm/day	* in/day		in/month
Alfalfa					
	March	1.422	0.05598425	31	1.735512
	April	4.27	0.16811024	30	5.043307
	May	5.47	0.21535434	31	6.675984
	June	5.896	0.23212599	30	6.96378
	July	6.152	0.24220473	31	7.508347
	August	5.306	0.20889764	31	6.475827
	September	3.934	0.15488189	30	4.646457
	October	2.472	0.09732284	31	3.017008
Corn					
	April	0.732	0.0288189	30	0.864567
	May	1.368	0.05385827	31	1.669606
	June	3.97	0.15629922	30	4.688977
	July	7.498	0.29519686	31	9.151103
	August	6.452	0.25401576	31	7.874488
	September	3.708	0.14598426	30	4.379528
	October	1.394	0.05488189	31	1.701339
	November	0.544	0.02141732	30	0.64252
Sugar Beet					
	April	0.946	0.0372441	30	1.117323
	May	2.4	0.09448819	31	2.929134
	June	6.278	0.24716536	30	7.414961
	July	8.348	0.32866143	31	10.1885
	August	6.79	0.26732284	31	8.287008
	September	4.404	0.17338583	30	5.201575
	October	1.828	0.07196851	31	2.231024

Appendix XVII

Days Between Irrigations Depending on Month and Soil Type

Alfalfa

	March	April	May	June	July	August	September	October
Sand	3.840	1.279	0.998	0.926	0.888	1.029	1.388	2.209
Sandy Loam	14.915	4.967	3.877	3.597	3.447	3.997	5.391	8.580
Loam	18.755	6.246	4.876	4.523	4.335	5.026	6.779	10.789
Silt	18.934	6.305	4.922	4.566	4.376	5.074	6.844	10.892
Clay Loam	18.577	6.186	4.829	4.480	4.294	4.979	6.715	10.686
Clay	17.326	5.770	4.504	4.179	4.005	4.643	6.263	9.967

Corn

	April	May	June	July	August	September	October	November
Sand	7.460	3.992	1.376	0.728	0.846	1.473	3.918	10.039
Sandy Loam	28.974	15.504	5.342	2.829	3.287	5.720	15.214	38.987
Loam	36.434	19.496	6.718	3.557	4.134	7.193	19.132	49.026
Silt	36.781	19.681	6.782	3.591	4.173	7.261	19.314	49.493
Clay Loam	36.087	19.310	6.654	3.523	4.094	7.124	18.950	48.559
Clay	33.658	18.010	6.206	3.286	3.819	6.645	17.674	45.290

Sugar Beet

	April	May	June	July	August	September	October
Sand	5.773	2.275	0.870	0.654	0.804	1.240	2.987
Sandy Loam	22.420	8.837	3.378	2.541	3.124	4.816	430.744
Loam	28.192	11.112	4.248	3.195	3.928	6.056	14.590
Silt	28.461	11.218	4.289	3.225	3.965	6.114	14.729
Clay Loam	27.924	11.007	4.208	3.164	3.890	5.998	14.451
Clay	26.044	10.266	3.924	2.951	3.629	5.594	13.478

Author Bio

Jacob T. Briscoe is from a small town in southern Oregon where he grew up learning about agriculture on his twenty-acre farm, his friend's beef cattle ranch, and a job stacking hay throughout high school. When the time came for college, there were a lot of choices, but the school needed to have a good agriculture program. The agriculture program at Utah State University caught Jacob's attention, coupled with a good scholarship, Utah State became Jacob's first choice. He started into school with a major in Agricultural Systems Technology, and along the way he found a number of subjects interesting so he added three minors to his education, Animal and Dairy Science, Agribusiness Management, and Agronomy. Through his time at Utah State he became the Ag Tech Club President, appeared on the Dean's List numerous times, was awarded the Seely-Hinckly Scholarship for academic excellence twice, and earned the University A-Pin award for maintaining a 4.0 GPA for two consecutive semesters with 15 or more academic credits. Jacob will start a Master's Degree in Plant Science at Utah State University in the fall of 2016 and then he plans to work in agricultural production as an agronomist or farm manager.