An Economic Analysis of a Longitudinal Survey of Wheat Growers in the Inland Pacific Northwest

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Abstract

Current information on farm production practices are lacking for dryland cropping systems of the Pacific Northwest. The objectives of this project were to collect baseline wheat production data and assess economic differences among three agroecological classes (AECs). Wheat production data were collected annually for three years (2011-2013) using a longitudinal survey of dryland wheat growers. Collected data were used to develop AEC representative farm enterprise budgets. Economic differences among AECs were evaluated using pairwise statistical tests. Annual returns for winter wheat production were statistically different across all AECs, at $170 per acre in the annual AEC, $73 per acre in the transition AEC, and $39 per acre in the grain-fallow AEC. Winter wheat production in the annual AEC was the most profitable, the transition AEC followed, while the grain-fallow AEC was the least profitable. In conclusion, the longitudinal survey was successful for developing current, baseline production data and for determining significant economic differences among AECs.

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I want to thank Kate for giving me an opportunity to work with wheat growers in the region and always being supportive. I will never forget enterprise budgeting. Dennis also deserves acknowledgment as he drove me to many of the grower interviews and answered numerous questions about wheat production. Also, I want to thank Larry for giving me critical feedback to better present my thesis. To the mastermind behind the AECs, Dave, I thank him for the AECs otherwise my research would have been less focused. Lastly, I want to give a huge thank you to the REACCH project not only for the financial support of this research but for making me a better researcher.

Dedication

JESUS,
YOU HAVE
REDEEMED ME
GIVEN LIGHT
TO LIFE
FILLED WITH
DARKNESS
CHANGED WHO I AM
BROUGHT PEACE AND FREEDOM BY TURNING GLASS TO CARBON
FILLED ME WITH STRENGTH TO DO WHAT I AM UNABLE
BLESSED ME WITH A LOVING HUSBAND
WITHOUT YOU
I WOULD
HAVE NOTHING
YOU HAVE
SHOWN ME
GRACE
BESTOWED
FORGIVNESS
UPON ME
AND
GIVEN ME
LIFE
HELP ME
LIVE IT
ABUNDANTLY
FOR YOU

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Chapter 1: Introduction to REACCH and the Longitudinal Survey

In 2011, the Regional Approaches to Climate Change (REACCH) was funded by the National Institute for Food and Agriculture (NIFA) as a five year interdisciplinary project focused on cereal grains in the Pacific Northwest. This project, "aims to ensure the long-term viability of cereal-based farming in the inland Pacific Northwest … and to identify farming practices that can help reduce agricultural greenhouse gas emissions" (REACCH, 2012). REACCH includes eight different objective teams which work independently as well as across objectives to conduct research. These objective teams work on the following topics: (1) modeling framework, (2) monitoring, (3) cropping systems, (4) economic and social, (5) biotic factors, (6) education, (7) extension, and (8) cyber-infrastructure.

The REACCH project's study area is within Eastern Washington, Northern Idaho, and North Central Oregon (see Figure 1.1). Cereal production is a major contributor to agricultural revenues for each of the three states, with wheat being the prominent cereal produced. In 2013, the annual value of wheat produced was 19% of the value of non-horticulture agricultural production in Idaho, 27% in Oregon, and almost 32% in Washington (USDA-NASS). Wheat is the dominant crop in the dryland portion of the study area. The importance of wheat production in this region combined with its potential vulnerability due to climate change is why the REACCH project and its research can play an important role in the future of wheat production.

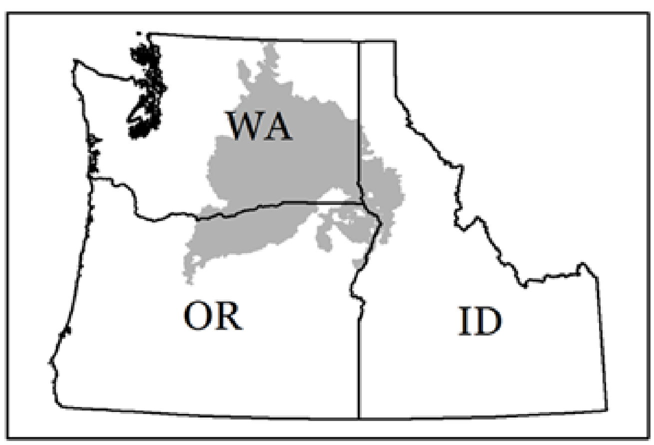

Figure 1.1: REACCH study area in gray.

The longitudinal survey focused on wheat producers in the REACCH study area with the purpose of collecting detailed production practice data as part of the economic and social objective. A longitudinal survey, by definition, is a study where "individuals are measured repeatedly through time" (Diggle, Heagerty, Liang, & Zeger, 2002). In this study the individuals are farm operators surveyed about their annual production practices for the years 2011, 2012, and 2013.

Agricultural practices vary from year to year due to changes in weather, relative prices, resource constraints, and agricultural policy incentives. The longitudinal survey gathered data from multiple years to reduce the risk of collecting data in an abnormal year. These data will serve as a robust baseline of wheat production practices due to multiple years of extensive data collection from a large cross-section of growers. A baseline is an important benchmark against which changes can be measured, such as how farming practices evolve as climate changes (Samji & Sur, 2006). The value of this baseline will continue to increase with time and impacts of developing this baseline will extend well beyond the life of the REACCH project.

The purpose of the longitudinal survey within REACCH as an integrative survey for informing other objectives has been successful. The collected data have been shared with other objective teams for many different purposes. Beyond the economic information collected, questions were asked relating to weeds, insects, soil management, crop rotation, precision agriculture use, technology adoption, farm program enrollment, opinions on climate change, observed weather changes, demographic information, and more. Because of the extensive nature of the survey, the information has been used for a number of purposes. For example, the Extension Team received firsthand data on current technology usage by these producers and their preferred methods for receiving Extension information.

Within the wheat growing region there is a great deal of variation in wheat production practices. Wheat is grown either under dryland or irrigated conditions. Because of the Cascade Mountains, the precipitation gradient increases from six inches of annual precipitation in the western part of the study area to over 21 inches annually in the eastern part of the study area. The western part of the study area is primarily irrigated because of low precipitation; moving eastward, precipitation increases to allow for dryland wheat farming. These different wheat growing areas are categorized into agroecological classes (AECs).

Cropland in the REACCH study area is classified into the different AECs by geospatially delineating agricultural systems from the National Agricultural Statistical Service (NASS) Cropland Data Layer

(Huggins, Rupp, Kaur, & Eigenbrode, 2014). The percent of fallow ground per year is used as the classification criterion. Fallow land lacks any growing crop in order to store precipitation for the following winter wheat crop. Four distinct AECs have been defined for the study area.

The grain-fallow AEC has greater than 40% of land in fallow and is the largest dryland AEC in terms of acreage (Huggins, Rupp, Kaur, & Eigenbrode, 2014). Generally, growers in this AEC alternate winter wheat and fallow in a two-year rotation. The annual AEC is defined as less than 10% fallow; a typical three-year rotation for growers would be winter wheat, followed by a spring grain, followed by a legume. Located between the grain-fallow and annual AECs is the annual crop-fallow transition AEC, which will be referred to as the transition AEC. It has 10% to 40% of its cropland in fallow, and a typical three-year rotation for growers would be winter wheat followed by a spring grain and then by a fallow year. Lastly, the irrigated AEC is less than 10% fallow and receives less than 13 inches of precipitation per year (Huggins, Rupp, Kaur, & Eigenbrode, 2014). Table 1.1 summarizes the differences among the AECs from data collected from longitudinal survey participants.

Table 1.1: Summary of agronomic characteristics of the AECs from longitudinal survey data

Agroecological Class (AEC)	Average Precipitation (in/year)	Rotation	3-Year Winter Wheat Yield Average (bu/ac)
Annual	21	winter wheat, spring grain, legume	92
Transition	16	winter wheat, spring grain, fallow	82
Grain-Fallow	12	winter wheat, fallow	56
Irrigated	6	varies	142

In the longitudinal survey only two observations came from the irrigated AEC. The irrigated AEC created a data problem due to its higher yields and changing statistical variance of its economic variables compared to other AECs. Winter wheat plays a much smaller role in the irrigated region, particularly with respect to farm income. Potatoes, corn, tree fruit, and other high value crops are more important in the irrigated AEC. In addition, costs of production in the irrigated AEC differ due to the cost of water, electricity, and irrigation labor, which are costs that do not exist in the dryland AECs. Lastly, irrigated wheat comprises just a small fraction of the total wheat crop for the three states in this study. In Washington, the state with the highest amount of irrigated wheat, only 7.8% of the harvested wheat acreage is irrigated in the counties that make up the study area (USDA-NASS, 2012). Due to the minor role wheat plays in the irrigated AEC, the small sample size, and the large differences between irrigated and dryland production practices and costs, the irrigated AEC was excluded from the economic analysis. The remainder of the discussion focuses on dryland wheat production.

This economic analysis of data collected from the longitudinal survey has three objectives:

1) Create representative enterprise budgets for dryland AECs.

2) Analyze economic differences among the dryland AECs for growing winter wheat.

3) Analyze the usefulness of AECs to explain economic variables.

The AECs play an important role in this research since longitudinal survey participants are categorized by AECs. A representative farm is developed for each AEC, which will be described in Chapter Two. These representative farms are used by REACCH researchers to inform the modeling objective, with the purpose of predicting future farming scenarios based on climate models and current practices. The representative farms also provide the basis for detailed cost and return estimates, also known as enterprise budgets. Chapter Two will present the process of creating enterprise budgets and report on the costs of production differences among the AECs.

Additionally, the AECs provide parameters for comparing economic variables from each dryland AEC, which will be presented in Chapter Three. Because REACCH uses the AECs as a way to explain not only agronomic differences but also social and economic changes, this researcher tested whether the AECs are in fact a good method for delineating economic differences. A statistical analysis of the economic variables, total cost per acre, cost per bushel, and returns to risk, is conducted across AECs to determine if their differences are statistically significant. If these economic variables do not perform as hypothesized, then perhaps AECs should not be used to explain economic variation. In the fourth and final chapter of this thesis, the results and implications of Chapters Two and Three will be summarized.

Chapter 2: Enterprise Budgets for Dryland Wheat by Agroecological Class in the Inland Pacific Northwest

Introduction

An enterprise budget is an estimate of costs and returns for production of a product (Chase, 2006). Enterprise budgets can be used for many purposes, including research, insurance underwriting, banking, litigation, and as a grower decision-making tool. Growers can customize the Excel-based budgets for their operation in order to estimate future profits based on their expected revenues and expenses, or to simply compare their operation to a representative budget for their area.

Detailed data on wheat operations in the inland Pacific Northwest were collected using a longitudinal survey of growers. Three years of data from this intensive survey were used to develop representative farms and enterprise budgets for each agroecological class (AEC). Budgets for soft white winter wheat, soft white spring wheat, and Dark Northern Spring wheat (DNS) budgets were developed for the dryland AECs. Since spring wheat is not produced in the grain-fallow AEC, this region only has a soft white winter wheat budget.

The enterprise budgets presented in this chapter differ from typical enterprise budgets, which are usually defined by state or county boundaries rather than a land use classification system like the AECs. Also, budgets are more commonly used to compare costs and returns of different crops in the same region rather than comparing the same crop across regions as this study does for winter wheat production. However, some studies use budgets to compare different production regions within a state. For example, in Michigan production costs for cherries were examined using three difference production regions made up of county groups (Black, Nugent, Rothwell, Thornsbury, & Olynk, 2010).

The budgets created for this research focus on direct seed or reduced tillage systems, as opposed to conventional or intensive tillage systems. All of the longitudinal survey growers implement direct seed practices for winter wheat. One objective of the REACCH project is to help producers adopt practices that mitigate climate change, direct seeding being one of these, and these direct seed enterprise budgets will be used as an educational tool. This chapter will explain how the enterprise budgets were created and provide a comparison among the AECs for wheat production.

Methods

Using a longitudinal survey to gather information entailed collecting multiple years and therefore many observations to help develop the representative farm. Most longitudinal surveys are used to explore patterns of change; however, in this study the primary purpose was to develop a representative set of current practices (Menard, 1991). A panel study was used as the survey design where the same growers answered the same production questions for three continuous years (Toon, 2000). Because of the length and detail of the survey questions, the surveys were conducted in person (Nuthall, 2011). Personal interviews were conducted with 45 dryland wheat growers each year for the 2011, 2012, and 2013 crop years[1]. Such an effort is rarely used for collecting grower data for several reasons. In-person interviews are expensive and time-consuming. And growers must be willing to spend several hours in a one-on-one interview, explaining their crop production practices in great detail. Few research projects devote this much time and money for collecting accurate economic information. The survey participants were chosen for their past collaboration with university research and their willingness to be involved in a multiyear survey. The survey included 45 growers: the grain-fallow AEC had 14 observations, the transition AEC had 11 observations, while the annual AEC had 20 observations.

Collected production practice information includes detailed information on each operation. For each field operation the date, type of operation, equipment used, and the inputs applied were recorded. This information is organized in a calendar format for each producer for each year, as can be seen in Table 2.1, using forms found in Appendix A. In addition to the calendar of operations, a form describing each participant's machinery complement was completed. This form provided the necessary data for calculating machinery variable and fixed costs (see Appendix A). The following information was obtained for each piece of machinery: current value, years of life, salvage value, repair cost, annual hours of use or annual miles, and acres per hour for self-propelled machines or tractors with implements.

Table 2.1: Example of survey data organized into a calendar

Month	Operation	Tooling	Inputs/Materials
October	Spray Weeds	100' Self Propelled Sprayer	24 oz Roundup, 6.4 oz Surfactant, 1.5 lb Ammonium Sulfate
May	Drill	300HP WT, 40' NT Drill	65 lb seed, 40lbs N, 8 lb S
May	Spray Weeds	100' Self Propelled Sprayer	4 oz Tilt, 3.2 oz Surfactant, 16.4 oz Axial, .5 oz Harmony
August	Harvest	Combine, 30' Header	

[1] A crop year is different from a calendar year, as it represents all the operations for a crop harvested in the given year. For winter wheat, the crop year starts when the wheat is planted in the fall, nearly a year prior to harvesting.

Survey data were used to create a representative farm for each AEC. Creating a representative farm based on typical practices is the preferred approach, rather than creating a representative farm based on averages, which may not be realistic (Nuthall, 2011). However, the size of each representative farm was determined based on AEC average acreage. Representative farm size for both the annual and transitional AECs is 2500 acres, while the representative farm for the grain-fallow AEC is 5000 acres. Representative machinery complements for each AEC were determined based on the most commonly used equipment; for example, in the grain-fallow AEC a typical tractor had a 300 horsepower engine and was 10 years old. For implements like a drill or sprayer, the most commonly used width and type were used for the representative farm. The machinery complement for each AEC can be found in Appendix D.

After defining the representative farm size and machinery complement, typical field operations were determined. The number of operations and input choices greatly affect profitability. Since these budgets use direct seeding practices, only light tillage or no tillage is used. Operations by crop within each AEC were determined based on the most common practices according to the survey data (see Appendix B for operation lists). The types of inputs used in the field operations for the representative enterprise budgets are based on survey data from producers in the AEC. In the case of fertilizers, survey data on fertilizer usage by AEC were used to determine typical amounts for average yield.

Enterprise budgets were created using the representative farm and representative operations. The enterprise budgets developed for this project were based on Excel budget templates developed at the University of Idaho (Painter, 2013). For field crops, enterprise budgets are developed on a per acre basis. Economic rather than cash-based enterprise budgets were used for this research. Economic budgets account for all factors of production, including opportunity costs for inputs not typically factored into the costs of production, such as land, labor, and capital provided by the owner (Hinman, 1997). Some of these costs are not directly incurred by the growers. For example, a landowner would not have a land cost. But all production costs need to be included in an economic analysis in order to determine whether the enterprise is both profitable and sustainable. Positive returns to all factors of production are necessary in order for an enterprise to continue to operate in the long term.

Sections of the representative enterprise budget for the transition AEC are presented below to illustrate how an enterprise budget is created (see Appendix C for complete version). The transition

AEC budget is featured since it demonstrates how fallow costs are included as a fixed cost for the soft white winter wheat budget. The methods discussed below are used for all the enterprise budgets developed for each AEC. The first section of the budget below presents expected revenue from selling wheat based on yield and price assumptions in this study, with yield based on the AEC average. Wheat prices for the budgets are based on USDA-AMS five-year average prices from Portland adjusted by the cost of transportation to Portland from the REACCH study area. Wheat prices vary by classes of wheat, such as soft white or Dark Northern Spring (DNS). Prices for hard red wheat classes, like DNS, are typically higher than prices for soft white wheat. In this study, soft white wheat has a price of $6.50 per bushel, while the price for DNS is $7.75 per bushel.

Table 2.2: Revenue for the transition AEC soft white winter wheat enterprise budget

Item	Quantity Per Acre	Unit	Price or Cost/Unit	Value or Cost/Acre
Revenue				
Wheat	80	bu	$6.50	$520.00

The next section of the budget describes variable costs, including seed, fertilizer, pesticides, fuel, machinery, labor, and more. Variable costs are directly related to production, and typically increase with an increase in production (Kay, Edwards, & Duffy, 2012). Input prices are based on an annual survey of regional agricultural input suppliers as documented in the Idaho Crop Input Price Summary (Patterson & Painter, 2013).

Table 2.3 shows all the variable costs for the transition AEC enterprise budget. Costs per acre for seed, fertilizer, and pesticides are determined by multiplying the amount used per acre by the input price. Variable machinery costs are calculated with the University of Idaho Machinery Cost Program using longitudinal survey data on machinery usage. This software program can be found at http://web.cals.uidaho.edu/idahoagbiz/management-tools/. Machinery costs include all field operations plus costs of general farm equipment, such as pickups, trucks, ATVs, and small tractors, which are allocated evenly across all acreage. Machinery labor costs might represent actual cash costs, if someone is hired to do the work, or it might represent an opportunity cost if the grower operates the machinery without payment. In these budgets, all economic costs are quantified, including potential non-cash opportunity costs such as unpaid operator labor.

Table 2.3: Variable costs for the transition AEC winter wheat enterprise budget

Item	Quantity Per Acre	Unit	Price or Cost/Unit	Cost/Acre
Variable Costs				
Seed:				
Wheat Seed	75	lb	$0.28	$21.00
Fertilizer:				
Nitrogen	100	lb	$0.77	$77.00
Pesticides:				
Powerflex	3.50	oz	$4.68	$16.38
Machinery:				
Fuel	4.81	gal	$3.40	$16.36
Lubricants	1	acre	$1.73	$1.73
Machinery Repairs	1	acre	$8.27	$8.27
Machinery Labor	0.78	hour	$17.80	$13.87
Other:				
Crop insurance	1	acre	$20.00	$20.00
Fire & Hail Insurance	0.7	$/100	100%	$3.64
Operating Interest				$8.57
Total Variable Costs				**$210.68**
Net Returns Above Variable Costs				**$309.32**

In the "Other" category, two types of crop insurance are listed. The first type of crop insurance is a revenue protection plan at the 85% level; this is the most common type and level of insurance for the region (Williams, 2014). The revenue protection crop insurance premium was estimated using USDA-Risk Management Agency's Cost Estimator (accessed at https://ewebapp.rma.usda.gov/apps/costestimator/Estimates/QuickEstimate.aspx0). Fire and hail insurance is calculated using the insurance rate per $100 of crop value. For this example, the insurance premium costs $0.70 per $100 of coverage, which for 100% coverage of the estimated $520 revenue per acre would be $0.70 multiplied by 5.2, or $3.64 per acre (Kile, 2014).

The last variable cost in the budget is operating interest, which may be a cash cost or an opportunity cost. Individual farm operations differ in terms of whether they finance all or none of their operating capital. There is an opportunity cost to using capital to finance a farming operation because if capital is not used for this purpose, it could be invested elsewhere. Operating interest on variable costs is based on a nine-month borrowing period for winter wheat and a six-month borrowing period for spring wheat at the interest rate of 5.75%, based on the input price summary (Patterson & Painter, 2013). The length of time is based on the approximate time span between planting and harvesting each crop. The last budget line, in the table above, calculates net returns above variable costs per acre by subtracting total variable costs from crop revenue, which is $309.32 per acre for winter wheat in the transition AEC.

The enterprise budget also includes fixed costs as presented in Table 2.4, shown below. Fixed or ownership costs are incurred regardless of production levels and cannot be changed in the short run (Kay, Edwards, & Duffy, 2012). Depreciation, interest, taxes, housing, insurance, and licenses all pertain to ownership costs of machinery and equipment, which were calculated using the University of Idaho Machinery Cost Program. This program calculates variable and fixed costs for each machine operation based upon industry standards (see Appendix D for complete machinery costs). These standards are established and updated on a regular basis by the American Society of Agricultural and Biological Engineers (ASABE). Budget values for machinery costs, shown in Table 2.3 and Tables 2.4, represent the total cost per acre for that category for the entire machinery complement.

Table 2.4: Fixed and total costs for the transition AEC winter wheat enterprise budget

Ownership (Fixed) Costs:	
Machinery:	
Depreciation	$15.46
Interest	$10.87
Taxes, Housing, Insurance, Licenses	$5.12
Other:	
Land Cost	$127.00
Summer Fallow Cost	$36.99
Overhead	$10.00
Management fee	$26.00
Total Fixed Costs	**$231.44**
Total Cost per Acre	**$442.12**
Net Returns over Total Cost, or Returns to Risk	**$77.88**

The next fixed cost category is land cost, which is calculated for the purposes of these budgets as a cost-share equivalent. In a cost-share arrangement, the farm manager and the landlord (assuming they are different individuals) share the risks associated with dryland production. The landlord receives one-third of the crop and pays one-third of the fertilizer, pesticide, and insurance premium. This is a common crop share lease agreement for the region (Hinman, 2006). The land cost is calculated as one-third of the per acre crop revenue minus one-third of the per acre costs for fertilizer, pesticide, and insurance. The cost-share equivalent serves as an appropriate proxy for land rent in this region. While the owner-operator will not actually experience a land rental cost, this cost represents the minimum return owner-operators must receive to justify growing the crop themselves.

Summer fallow cost is relevant for winter wheat production in the transition and grain-fallow AECs. Winter wheat in these two drier AECs relies on a preceding fallow year to preserve moisture. The summer fallow cost represents operations and inputs for maintaining summer fallow. Summer fallow operations include tilling and spraying for weed control. In addition to the costs of maintaining summer fallow, one year of interest on the summer fallow expenses is included in the fallow cost for the winter wheat budgets in these two drier AECs, as shown in Table 2.4. For further details on summer fallow and its costs please see Appendix F.

The final fixed costs cover the management and overhead expenses. In these budgets, a management fee is calculated as five percent of revenue. This is a standard procedure for allocating a cost for the important task of managing crop production (Painter, 2013). Finally, an overhead charge is assessed at two and half percent of operating expenses to cover items like legal, accounting, and utilities. It is commonly calculated as a percent of total operating expenses in enterprise budgets (Kay, Edwards, & Duffy, 2012).

The last line item in the enterprise budget is per acre net returns over total cost, or returns to risk. Returns to risk are calculated as revenue minus all of the costs; in other words this is the amount of expected profit from one acre of wheat production.

Analysis

For the three AECs, seven enterprise budgets were developed. In the annual and transition AECs, soft white winter wheat, soft white spring wheat, and DNS wheat budgets were created. In the grain-fallow AEC only a soft white winter wheat budget was developed because spring wheat is rarely produced. In Table 2.5, per acre yield and price per bushel are multiplied to determine revenue in dollars per acre by AEC and type of wheat. The annual AEC has the highest per acre revenue for winter wheat while the lowest are experienced in the grain-fallow AEC. Note that per acre winter wheat revenue for the transition and grain-fallow AECs represents a two-year period of winter wheat preceded by a year of summer fallow.

Table 2.5: Yield, crop price, and per acre revenue by AEC and type of wheat

By Crop:	Unit	Yield per acre	Price per unit	Revenue per acre
Annual				
Winter Wheat	bu	90	$6.50	$585
Soft White Spring Wheat	bu	60	$6.50	$390
Dark Northern Spring Wheat	bu	60	$7.75	$465
Transition				
Winter Wheat on Fallow*	bu	80	$6.50	$520
Soft White Spring Wheat	bu	55	$6.50	$358
Dark Northern Spring Wheat	bu	50	$7.75	$388
Grain-Fallow				
Winter Wheat on Fallow*	bu	55	$6.50	$358

*Crop represents a two-year production cycle.

A summary of costs and returns by AEC and wheat type are presented in Table 2.6. Returns to risk represent the net returns over total cost for these budgets, as all of the economic costs except for risk are included in the budgets. Returns over variable cost show profit per acre after all variable expenses are paid; this measures the short-term profitability. The most profitable crop is consistent regardless of returns category; thus rankings of returns over variable cost or returns over total cost do not change from one wheat type to another. If returns over variable cost are highest for soft white winter wheat in one AEC, returns over total cost are also highest in that AEC in this study.

Table 2.6: Costs and returns per acre by AEC and type of wheat

By Crop:	Total Cost (TC) of Production	Returns to Risk	Total Variable Cost (VC)	Returns over VC	Land Cost
Annual					
Winter Wheat	$481	$104	$257	$328	$140
Soft White Spring Wheat	$385	$5	$223	$167	$85
Dark Northern Spring Wheat	$445	$20	$264	$201	$99
Transition					
Winter Wheat on Fallow*	$442	$39	$211	$155	$127
Soft White Spring Wheat	$337	$21	$209	$149	$73
Dark Northern Spring Wheat	$383	$5	$255	$133	$70
Grain-Fallow					
Winter Wheat on Fallow*	$322	$18	$141	$108	$91

*Crop represents a two-year production cycle.

Winter wheat is the most profitable crop in all of the AECs (see Table 2.6, returns to risk). There is considerable difference in profit among the AECs for winter wheat production. The annual AEC has the highest per acre returns for winter wheat, whereas the grain-fallow has the lowest returns. It is important to remember the transition and grain-fallow AECs have one year of fallow prior to winter wheat, therefore returns to risk represent two production years. For the grain-fallow AEC, returns to risk are $18 per acre per production year, and the transition AEC's returns to risk are $39 per acre per production year. The annual AEC returns to risk are $104 per acre, only one production year is required, so its relative profitability is greater.

The land cost category is represented by the land rent value for each AEC. The annual AEC has the highest land cost because it is the most productive land. The grain-fallow AEC is the least productive and profitable AEC, and its land cost reflects this fact as it is almost $50 per acre less than in the annual AEC for winter wheat.

Some differences between the revenues and costs of the AECs are easily explained. Revenue for each wheat crop is based on its price and yield. Yield differences are caused by environmental differences across AECs, particularly annual precipitation levels. Differences in costs by AEC reflect different input requirements. For example, growers in the annual AEC apply fertilizer based on a higher yield expectation than in the grain-fallow AEC. The budget expense for fertilizer in the annual cropping AEC is $95.10 per acre for winter wheat compared to $51.80 per acre in the grain-fallow AEC. Growers in the annual AEC typically have newer machinery, with higher ownership costs, than growers in the grain-fallow AEC. For winter wheat, the fixed machinery cost is $42.41 per acre for the annual AEC, compared to the $17.06 per acre in the grain-fallow AEC. For more information, please refer to the complete enterprise budgets in Appendix C.

Conclusion

From the summary of costs and returns, the profitability of each AEC can be observed. The annual AEC has the highest profitability for soft white winter wheat. Even though it has the highest costs for winter wheat, its higher revenue offsets the high costs. Because the transition and grain-fallow AEC use two production years to grow the same crop of winter wheat as the annual AEC, they are disadvantaged compared to the annual AEC. The transition AEC has the second highest profitability for winter wheat. Lastly, the grain-fallow AEC has the lowest costs paired with the lowest revenue for soft white winter wheat. This AEC is obviously vulnerable in terms of having only one viable crop option, and only marginally profitable compared to the other two AECs.

Enterprise budgets represent an important management tool for growers as well as an important resource for researchers and policymakers who are interested in predicting grower behavior. The enterprise budgets created in this study are used to inform researchers about production cost and return differences among the AECs. When costs are broken down into individual components comprising variable and fixed costs, impacts of adopting new technologies or practices can be examined. This is important as REACCH's purpose of long-term viability of cereal production includes promoting practices and technologies for mitigation and adaption to climate changes. Understanding the economic impacts of new technologies or different farming practices is critical to growers. The budgets can demonstrate increasing revenues or decreasing costs for a new technology or practice.

Representative enterprise budgets can assist in understanding how climate change will affect profitability for growers in each AEC. For example, possible climate change predictions with potential increased precipitation and thus increased yield will have the greatest benefit for growers in the grain-fallow AEC. On the other hand, climate predictions of lower precipitation could jeopardize the grain-fallow AEC's ability to profitably grow wheat and remain a viable production region. While it is difficult to predict how climate change will affect yield, revenue, and costs, having a well-documented baseline analysis by AEC is a great resource for current and future growers, educators, and researchers. Further implications of this research will be discussed in Chapter 4.

Chapter 3: A Statistical Analysis of Economic Variables by Agroecological Class in the Inland Pacific Northwest

Introduction

In Chapter 2, representative farm enterprise budgets showed differences in revenue, costs, and returns for the dryland AECs. One representative enterprise budget was created for each AEC based on typical practices gathered in three years of surveys across the region. In this chapter, data from individual enterprise budgets created for each of the 45 longitudinal survey participant are analyzed. Using these enterprise budgets, three economic variables of interest were calculated. Data for total cost per acre, cost per bushel, and returns to risk were compiled into a larger data set that allowed for statistical analysis of cost and profitability. In this study, soft white winter wheat is used for these comparisons, as it is the dominant cash crop in all of the dryland AECs. Soft white winter wheat is more common than hard red winter wheat in all three states; the percentage of soft white winter wheat ranged from 78% to 94% of the winter wheat grown (USDA-NASS, 2014).

The AECs are used for many purposes, from analyzing agronomics to social and economic comparisons. Statistically testing the economic variables from each AEC will help evaluate their usefulness as a classification for economic variables. The purpose of testing for economic differences among the AECs is to help determine if the AECs are a valid classification for economic variables.

Methods

Data for this analysis were collected from the longitudinal survey participants and used to formulate enterprise budgets for each survey participant for the 2011, 2012, and 2013 crop years. Crop prices reflect those used in the representative enterprise budgets discussed in Chapter 2, but yield figures are based on each grower's actual winter wheat yield. Variable costs were calculated based on each grower's individual response regarding amounts of inputs, machinery costs, and other variable inputs like custom application rates. Fixed machinery costs also reflect the actual machinery complement used on each farm. In addition to observed costs, opportunity costs for land, capital, and labor are calculated for these budgets. These are all calculated in the same manner described in Chapter Two. Land cost was calculated as a cost-share agreement, capital cost used interest on operating expenses, and labor cost was made up of machinery labor and a management fee. Thus, these are comprehensive economic budgets focused on differences in production costs, both fixed and variable. Few studies include comprehensive analyses of both fixed and variable costs, and no other studies have been done in this region with a large number of survey participants over three consecutive years.

For the 2011 crop year, 46 winter wheat enterprise budgets were developed, with another 44 completed in 2012, and 45 additional budgets in 2013. Even though there are 45 dryland producers in the longitudinal survey, in some years no winter wheat was planted on the particular area chosen for the study. And there was one case of attrition. From each enterprise budget, the data necessary for the statistical analysis were extracted from the Excel enterprise budgets and compiled into one dataset.

The statistical analysis is conducted to test for significant differences in economic variables across AECs. A pairwise comparison statistical test of means was used to look for significant differences among AECs. The procedure for the pairwise comparison test will be explained and then the statistical results will be presented.

The first step in the statistical analysis is to test the null hypothesis for the variable of interest, which assumes all AEC means, μ, are equal; that is H_0: $\mu_1 = \mu_2 = \mu_3$. The alternative hypothesis assumes that at least one mean is statistically different across AECs. This first test is needed to ensure at least one mean is statistically different, otherwise moving on to the pairwise test is unnecessary. A simple one-way analysis of variance (ANOVA) using the variable of interest as the dependent variable and AECs for the explanatory variable is used for this first step. The assumptions of the ANOVA procedure must be met in order for the results to be valid. Those assumptions are 1) a linear relationship between dependent and independent variables, 2) the errors all have equal variances, 3) the errors are independent of each other, and 4) the errors are normally distributed (Ott & Longnecker, 2010). The errors are the unpredictable part of the relationship estimated by the ANOVA; in other words, errors represent the unexplained factors affecting the relationship between the independent and dependent variable. These assumptions were checked using diagnostic plots found in Appendix E. For all statistical tests the assumptions were satisfactory.

When the assumptions of the ANOVA are met, the test will result in an f-statistic, which will be used to determine if the null hypothesis can be rejected. If the null hypothesis is rejected, suggesting at least one AEC mean is statistically different from another, then the second step will be to move on to a pairwise test.

Typically Fisher's Least Significant Difference pairwise comparison test is used, but because of the unequal number of participants in the sampled AECs another test was needed. The procedure best tailored to this situation was the Tukey-Kramer. Of the few tests available to perform with unequal group sizes, this one is best for controlling α, the Type 1 error rate for each comparison (Toothaker, 1993). For just one comparison α does not need to be controlled; however, as more comparisons are added the error rate for each comparison increases. The Tukey-Kramer procedure was used in SAS to test which AEC means were different. This procedure allowed comparison of one AEC with another, hence three pairs were tested for each procedure. A p-value associated with each pair determined the statistical significance of each pair tested. If the p-value is less than the desired confidence level of 10% for this study, then the pair of economic means can be assumed to be different.

Analysis

The purpose of the analysis is to test if the economic variables act as hypothesized among the AECs. The economic variables of interest in this study are total cost per acre, cost per bushel, and returns to risk per acre. The total cost per acre sums all of the economic costs per acre including both variable and fixed costs. Costs are assumed to vary across the AECs, therefore it is hypothesized total cost per acre will be statistically different among AECs. Cost per bushel is the total cost per acre divided by the output. In this case the output is yield, specifically, bushels of winter wheat produced per acre. The cost per bushel eliminates the yield factor, which varies greatly across the study area. Since it is hypothesized that production costs vary, it is also hypothesized cost per bushel should differ across AECs.

The last economic variable tests profitability of each AEC. Profit, or net returns, is also called returns to risk, calculated as total revenue per acre minus total cost per acre. It is the residual after all economic costs are deducted from revenue. Returns to risk are hypothesized to be different across the AECs because it is assumed economic profitability of these AECs varies. Unlike the other variables, returns to risk are adjusted to account for two years of production necessary for growing winter wheat in the grain-fallow and transition AECs. Returns to risk are divided by two to get returns to risk per acre per year for the transition and grain-fallow AECs. Another approach would be to compare returns per rotational acre, but information was not collected on non-wheat crops typically produced in the annual AEC rotation. Returns to risk per rotational acre would calculate the gain or loss from each year in the rotation and divide it by the rotational length in years (Nail, Young, Hinman, & Schillinger, 2005).

In addition to economic variables, mean yield by AEC was tested for statistical difference. Yield encompasses many different factors such as climate, soil, pest issues and so forth. Overall yield provides an indication of whether the AECs represent a useful classification at the basic agronomic level. If yields by AECs are similar yields, then using AEC divisions might not be appropriate for delineating wheat production regions. Yield also serves as a proxy for revenue, with higher yields representing higher revenue. The null hypothesis of equal means was rejected based on the ANOVA results. This allowed the Tukey-Kramer test to be performed. The results showed each AEC has a statistically different mean yield. Thus, based on these results, the AECs serve as an effective land classification system for winter wheat. And because yield determines revenue, the highest revenue potential is in the annual AEC while the lowest is in the grain-fallow AEC (see Table 3.1 below). All statistical output and results for this test and those displayed below are in Appendix E.

Table 3.1: Average winter wheat yield by AEC in bushels per acre

Agroecological Class (AEC)	2011 Yield Average	2012 Yield Average	2013 Yield Average
Annual	93.8 (15.10)	89.31 (11.01)	92.03 (11.94)
Transition	82.92 (17.20)	83.36 (16.44)	79.08 (19.10)
Grain-Fallow	64.83 (19.21)	54.75 (20.37)	49.70 (20.75)

Standard deviations are in parentheses.

For the economic variables, all of the 2011-2013 data were combined for each economic variable. In addition, variability among crop years was tested using the cost per bushel variable.

Total cost per acre was analyzed to determine if costs differed by AEC. As seen in Figure 3.1, total cost per acre for the annual and transition AECs hover around $400 per acre. For the grain-fallow AEC, total cost per acre is much lower than for the other AECs, at around $300 per acre or less. Costs for the transition and the grain-fallow AECs contain summer fallow expenses, including a year of interest on those costs.

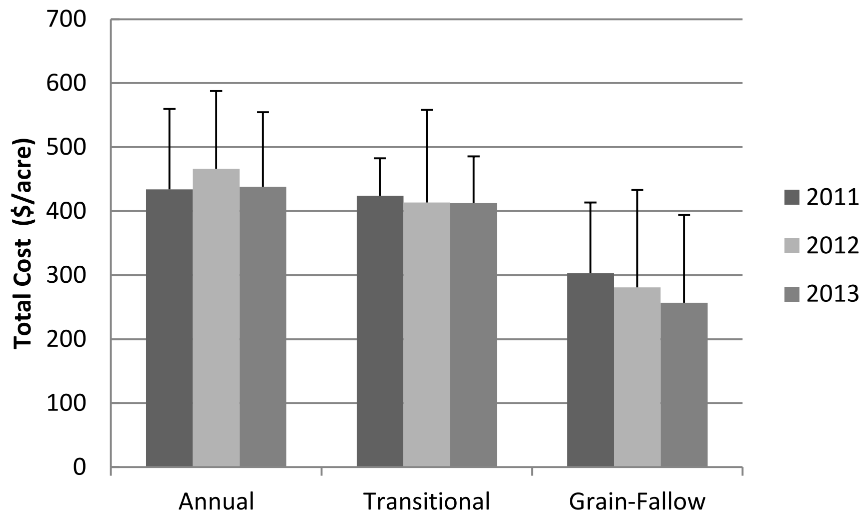

Figure 3.1: Total cost per acre for winter wheat by AEC
(Bars indicate standard deviation.)

Using the ANOVA test, the null hypothesis that total cost per acre were similar was rejected, thus the Tukey-Kramer procedure was performed. The Tukey-Kramer pairwise comparison showed total cost per acre for the annual, transition, and grain-fallow AECs to be statistically different from each other at the 10% confidence level. This test confirms the hypothesis that each of the three dryland AECs have different total cost per acre for producing winter wheat.

Table 3.2: Tukey-Kramer test p-values for AEC pairwise comparisons of total cost per acre

Comparison	**2011-2013 P-value**
Annual - Transition	0.0568* (15.6172)
Transition - Grain-Fallow	<.0001* (14.9131)
Annual - Grain-Fallow	<.0001* (17.2230)

*Statistically different at a 10% confidence level. Standard errors are in parentheses.

The second economic variable to be tested was cost per bushel. This variable compares per unit cost for producing one bushel of wheat across AECs. For 2011-2013 crop years, average cost per bushel is highest for the grain-fallow AEC at $5.91 per bushel (see Table 3.3). In contrast, the annual AEC has the lowest average cost at $5.13 per bushel.

Cost per acre is tested in two ways, first with all crop year data combined and then for each crop year individually. Using the combined data for all years, 2011-2013, the null hypothesis was rejected using the ANOVA test. The Tukey-Kramer procedure showed cost per bushel in the grain-fallow AEC as statistically different from cost per bushel in the annual and transition AECs. However, the annual and transition AECs did not have statistically different cost per bushel (see Table 3.4).

Table 3.3: Average cost per bushel by AEC

Agroecological Class (AEC)	2011 Cost per Bushel Average	2012 Cost per Bushel Average	2013 Cost per Bushel Average	2011-2013 Cost per Bushel Average
Annual	$4.89 (0.61)	$5.51 (0.57)	$5.02 (0.41)	$5.13 (0.59)
Transition	$5.32 (0.63)	$5.55 (0.66)	$5.47 (1.19)	$5.44 (0.85)
Grain-Fallow	$5.16 (0.86)	$6.19 (0.88)	$6.43 (1.20)	$5.91 (1.11)

Standard deviations are in parentheses.

Each crop year was then individually tested. For 2011, the null hypothesis was not rejected using ANOVA, implying cost per bushel by AEC was not statistically different. Therefore the Tukey-Kramer test was not performed. In 2011, higher than average precipitation caused higher yields, especially in the drier AECs (Table 3.1). These higher yield values resulted in a lower cost per bushel in 2011. Typically growers in the grain-fallow AEC spread their costs over fewer bushels, especially fixed costs. The three-year average yield for the grain-fallow AEC was 58.89 bushels per acre, but in 2011 the average was almost 65 bushels per acre (see Table 3.1). Since the Tukey-Kramer test was not performed for 2011, no test results are available in Table 3.4.

In 2012, the null hypothesis was rejected; hence at least one AEC cost per bushel mean was significantly different. Therefore, the Tukey-Kramer procedure was performed. As can be seen in Table 3.3 above, in 2012 the average cost per bushel for the annual and transition AECs are almost identical, averaging $5.51 per bushel for the annual AEC and $5.55 per bushel for the transition AEC. These values were not statistically different (see Table 3.4). However, 2012 cost per bushel was statistically different for the annual and grain-fallow AECs as well as for the transition and grain-fallow AECs. For the 2013 crop year, ANOVA results rejected the null hypothesis that cost per bushel differed by AEC. Tukey-Kramer test results were the same as in 2012, with the grain-fallow AEC statistically different from the other two AECs.

Table 3.4: Tukey-Kramer test p-values for pairwise comparison of cost per bushel

Comparison	2011 P-value	2012 P-value	2013 P-value	2011-2013 P-value
Annual & Transition	-	0.9924 (.2672)	0.3879 (.3411)	0.2248 (.1826)
Transition & Grain-Fallow	-	0.0851* (.2954)	0.0408* (.3798)	0.0582* (.2014)
Annual & Grain-Fallow	-	0.0272* (.2519)	0.0004* (.3318)	<.0001* (.1744)

*Statistically different at a 10% confidence level. Standard errors are in parentheses.

Finally, returns to risk, or economic profit, was tested for differences by AEC. If these three dryland growing regions have dissimilar cost structures, paired with different yields that translate into revenue, it would be assumed profitability would change from one AEC to the next. Returns to risk for grain-fallow and transition AECs are divided by two to adjust for the two year period necessary to produce a winter wheat crop in these categories. The highest average returns to risk for dryland winter wheat occur in the annual AEC at $170.48 per acre per year, followed by returns for the transition AEC at $72.93 per acre (see Table 3.5). The least profitable AEC for dryland winter wheat production is the grain-fallow AEC with returns to risk of $36.61 per acre. Also shown in the table below is the coefficient of variation which normalizes the variability of returns to risk. The grain-fallow AEC has a very large coefficient of variation; therefore this AEC has more variability than the other AECs. The higher variability of grain-fallow winter wheat production may place this AEC at higher risk as climate changes.

Table 3.5: Returns to risk average, maximum, and minimum per acre by AEC for 2011-2013.

Agroecological Class (AEC)	2011-13 Returns to Risk Average	2011-13 Coefficient of Variation	2011-13 Returns to Risk Max	2011-13 Returns to Risk Min
Annual	$170.48 (48.80)	0.29	$283.04	$36.69
Transition	$72.93 (38.26)	0.52	$141.92	-$20.58
Grain - Fallow	$36.51 (33.32)	0.91	$99.32	-$14.50

Standard deviations are in parentheses.

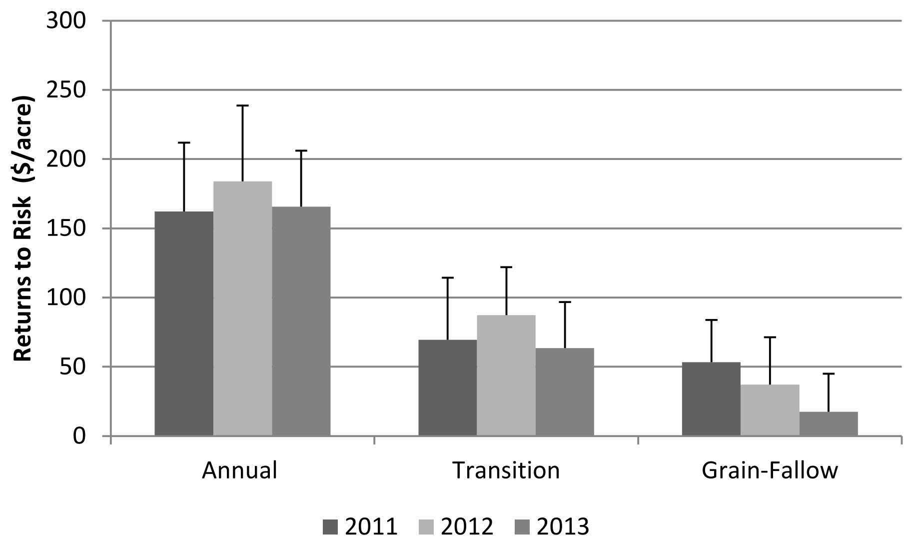

Figure 3.2: Returns to risk for winter wheat by AEC
(Standard deviation bars included.)

Again the same methods for a pairwise comparison test are used for returns to risk. Using all crop year data combined, the ANOVA results rejected the null hypothesis, therefore at least one AEC mean is different for returns to risk. The Tukey-Kramer test was then performed, showing that returns to risk were statistically different among all AECs (see Table 3.6). These results are similar to those for yield and total cost per acre.

Table 3.6: Tukey-Kramer test p-values for pairwise comparison of returns to risk

Comparison	2011-2013 P-value
Annual - Transition	<.0001* (7.0060)
Transition - Grain-Fallow	<.0001* (7.7264)
Annual - Grain-Fallow	0.0132* (6.6902)

*Statistically different at a 10% confidence level. Standard errors are in parentheses.

Conclusion

Agroecological classes, or AECs, define distinct growing practices for winter wheat. In the annual AEC, a crop is produced every year; in the transition AEC, two crops are produced every three years; a crop is produced every other year in the grain-fallow AEC. This study focused on comparing economic and agronomic variables for these three dryland AECs with the intention to understand if the AECs provide a relevant distinction. Four variables were tested using a Tukey-Kramer pairwise comparison procedure: yield, total cost per acre, cost per bushel, and returns to risk. Yield by AEC was shown to be statistically different, as were total cost per acre (see Table 3.7). Per acre costs were highest for the annual AEC, but these costs were offset by its higher yield and revenue, resulting in highest per acre returns to risk for this AEC. The lowest per acre returns to risk occurred in the grain-fallow AEC (see Table 3.5).

Table 3.7: Statistically significant differences by variable and AEC at a 10% confident level

Comparison	Yield	Total Cost per Acre	Returns to Risk	Cost per Bushel
Annual -Transition	Yes	Yes	Yes	No
Transition - Grain-Fallow	Yes	Yes	Yes	Yes
Annual - Grain-Fallow	Yes	Yes	Yes	Yes

The only variable that was not statistically different was cost per bushel when compared for the annual and the transition AECs (see Table 3.7). This variable shows profit margins by AEC. All of the producers in this survey sell their wheat into the same competitive market in which no farmer has any price setting ability. In other words, they all essentially receive the same price. Since their cost per bushel is not the same, their profit margins will differ as well. For example, the annual and transition AECs have an average cost per bushel under $5.50 while cost for the grain-fallow AEC averages around $5.90 per bushel. While a spread of $0.40 per bushel appears small, it quickly multiplies when a producer has thousands of bushels to sell. Cost per bushel was tested separately for each year as well as averaged across years. By testing years individually it was found that some year to year variation existed due to uncontrollable factors like weather. The statistical testing of these four variables revealed that the AECs are good delineators for economic variables.

As researchers predict how climate change will affect the weather in the REACCH study area, the economic implication of these changes and how they differ by AEC will be easier to predict with the existence of these robust estimates of returns by AEC. Since the grain-fallow AEC has a smaller profit margin, if climate change results in lower precipitation, this AEC will struggle to remain profitable. In Chapter 4, more implications of this research will be discussed.

Chapter 4: Conclusion and Implications

A three-year in-depth survey of wheat growers in the inland Pacific Northwest provided detailed production cost data across a diverse region with annual precipitation that ranges from less than 12 inches to over 21 inches. Personal interviews were used to collect information on wheat production practices, farm machinery, demographics, pest observations, opinions on university research and Extension programming, climate change, and technology. In this study, the economic data are used to test whether differences exist among growing regions classified by cropping intensity. These regions are termed agroecological classes, or AECs, and refer to annual cropping systems, grain-fallow systems, and an intermediary system with a fallow year preceding winter wheat, followed by a spring crop.

The first objective of this study was to develop representative enterprise budgets to inform research and create a grower management tool. A representative dryland enterprise budget was developed for each of the three AECs. The second objective of this study was to determine whether differences existed in terms of costs of production and profitability across the AECs. Creating enterprise budgets was the first step in identifying cost and profitability differences for the representative farms, and they showed cost of production and profitability changed from one AEC to another. The annual AEC enterprise budget had the highest returns to risk for winter wheat at $104 per acre while the grain-fallow AEC had the lowest at $18 per acre.

Three economic variables and one agronomic variable were tested using the Tukey-Kramer pairwise comparison procedure described in Chapter Three. Yield, total cost per acre, cost per bushel, and returns to risk were tested for statistical significance across AECs. The results of these comparisons showed that the grain-fallow AEC has statistically different costs and profitability from the other AECs. Compared to the annual and transition AECs, the grain-fallow AEC has lower total cost per acre but a higher cost per bushel, resulting in the smallest returns to risk.

The final objective of this study was to determine if AECs provide a useful analytical tool for characterizing economic differences for this region. Since significant differences for the economic variables of cost per bushel, total cost per acre, and returns to risk were found, AECs were shown to be a useful distinction for economic variables during this time period of 2011 through 2013.

The objectives of this research have been met, but the implications have yet to be discussed. An important outcome of this research is creating a current baseline of wheat production practices in the study area. As climate change continues to impact farming practices this baseline can be used to research how practices are evolving in both time and space. At this point it is difficult to estimate the value of this extensive research project through time. Current purposes of informing research scientists, the agricultural community, and policymakers, have already shown the value of this research. Again the products created by these in-depth surveys over three years are unprecedented, both in their level of detail and the length of time involved.

A second implication of this research is the knowledge of how each AEC differs in terms of cost and returns, as discussed above. Using climate models, economic predictions can be made based on this fundamental understanding of the costs, profitability, and current production practices of each AEC. The annual AEC stands apart from the other two dryland AECs as the winter wheat production only takes one year. The grain-fallow and transition AECs, with lower returns, will be more vulnerable with climate changes that decrease their profitability.

These comprehensive, up-to-date enterprise budgets by AEC are useful for Extension practitioners, including the REACCH Extension team, as they are promoting practices to reduce greenhouse gas emissions and increase resource use efficiency. Growers in the more profitable annual and transition AECs are better able to adopt more costly practices than growers in the grain-fallow AEC. However, because moisture is the biggest limiting factor in the grain-fallow AEC, these growers would look very favorably upon technologies that can save moisture and thus increase their yields.

The results of this research project can be used to highlight the inherent underlying variability in farming for agricultural policy makers. Within this one small yet highly productive farming region, both wheat production practices and profitability differ considerably. This result highlights the importance of tailoring conservation programs and agricultural policy to regions, particularly when yield and cropping systems vary as dramatically as they do in the REACCH study area.

This project has documented actual production practices for 45 dryland growers over a wide swath of the wheat-producing region of the inland Pacific Northwest over a three-year period. Detailed production practices have created an invaluable resource for the agricultural sector. In addition to the farm production data, growers answered questions on numerous topics, including technology adoption and opinions on and attitudes toward climate change. With this baseline economic and sociological information, better predictions of climate change impacts in the region can be made. These predictions will be useful to growers, researchers, and policymakers in this region as they search for solutions to the challenges confronting agriculture, both today and in the future, whatever that may bring.

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Appendix A: Longitudinal Survey Approval and Forms

REACCH Institutional Review Board Exemption

University of Idaho

Office of Research Assurances
Institutional Review Board
PO Box 443010
Moscow ID 83844-3010

Phone: 208-885-6162
Fax: 208-885-5752
irb@uidaho.edu

To: J.D. Wulfhorst and Sanford Eigenbrode

From: Traci Craig, PhD
Chair, University of Idaho Institutional Review Board
University Research Office
Moscow, ID 83844-3010

IRB No.: IRB00000843

FWA: FWA00005639

Date: Approved as Exempt January 26, 2011

Project: Approaches to Climate Change for Inland Pacific Northwest Agriculture (10-139) has been approved as Exempt under Category 2.

On behalf of the Institutional Review Board at the University of Idaho, I am pleased to inform you that the above-named project is approved as exempt from review by the Committee. Please note, however, that you should make every effort to ensure that your project is conducted in a manner consistent with the three fundamental principles identified in the Belmont Report: respect for persons; beneficence; and justice.

Should there be significant changes in the protocol for this project, it will be necessary for you to resubmit the protocol for review by the Committee.

Traci Craig

Machinery Complement

Type of Machine (include model & year)	Current Value	Years of Life	Salvage Value	Annual Hours of Use	Annual Repairs (Materials)	Annual Repairs (Labor Hours)

Schedule of Operations, Part 1

Date	Operation	Times Over	Equipment (Tractor & Implement Number from Machinery List)							
			Tooling	Owned	Rented	Custom Hire	Cost per acre if rented		Cost per acre if custom hire	
							$	Unit	$	Unit

Schedule of Operations, Part 2

Acre/Hour		Fuel Consumption Per Machine Hour	Materials used with operation (type, amount/acre) Other comments
Machine	Labor		

Appendix B: Calendars for Schedule of Operations

Annual AEC Calendars

Schedule of Operations for Soft White Winter Wheat

Month	Operation	Tooling	Materials/Service
September	Spray Weed	250HP WT, 90' Pull Sprayer	32 oz Roundup, 3.2 oz Surfactant
Late September	Ripper Shooter	450HP Tractor, 45' Ripper Shooter	Rental Ripper Shooter, 100 lb N, 20 lbs P, 20 lbs S
October	Drill	450HP Tractor, 30' NT Drill	90 lb Seed, 10lbs N
April	Spray Weeds	250HP WT, 90' Pull Sprayer	15 oz Huskie, 17 oz Orion, 4.75 oz Osprey, 3.2 oz Surfactant, 4 oz Tilt
August	Harvest	Combine, 30' header	
August	Harvest	450HP Tractor, Bankout Wagon	

Schedule of Operations for Soft White Spring Wheat

Month	Operation	Tooling	Materials/Service
March	Spray Weeds	250HP WT, 90' Pull Sprayer	24 oz Roundup, 6.4 oz Surfactant, 1.7 lb Ammonium Sulfate
April	Harrow	450HP Tractor, Heavy Harrow	
April	Ripper Shooter	450HP Tractor, 36' Ripper Shooter	Rental Ripper Shooter, 80lbs N, 15lbs S
April	Drill	450HP Tractor, 30' NT Drill	80 lbs seed, 10lbs N, 10lbs P
May-June	Spray Weeds	250HP WT, 90' Pull Sprayer	16.4 oz Axial, 10 oz Huskie, 5 oz InPlace, 4 oz Tilt
August	Harvest	Combine, 30' header	

Schedule of Operations for Dark Northern Spring Wheat

Month	Operation	Tooling	Materials/Service
March	Spray Weeds	250HP WT, 90' Pull Sprayer	24 oz Roundup, 6.4 oz, Surfactant, 1.7 lb Ammonium Sulfate
April	Harrow	450HP Tractor, Heavy Harrow	
April	Ripper Shooter	450HP Tractor, 36' Ripper Shooter	Rental Ripper Shooter, 130lbs N, 15lbs S
April	Drill	450HP Tractor, 30' NT Drill	100 lbs seed, 10lbs N, 10lbs P
May-June	Spray Weeds	250HP WT, 90' Pull Sprayer	16.4 oz Axial, 10 oz Huskie, 12 oz BroxM, 5 oz InPlace, 4 oz Tilt
August	Harvest	Combine, 30' header	
August	Harvest	450HP Tractor, Bankout Wagon	

Transition AEC Calendars

Schedule of Operations for Soft White Winter Wheat

Month	Operation	Tooling	Materials/Service
September	Seed and Fertilize	400HP Tractor, 36' NT Drill	75 lb seed, 100lbs N, 10lbs P, 15 lbs S
April	Spray Weeds	200HP Tractor, 90' Sprayer	4 oz Tilt, 3.2 oz Surfactant, 3.5 oz Powerflex, 12 oz 2,4-D
August	Harvest	Combine, 30' Header	
Fall	Mow	400HP Tractor, 36' Mower	75% of the winter wheat ground

Schedule of Operations for Soft White Spring Wheat

Month	Operation	Tooling	Materials/Service
April	Spray Weeds	200HP Tractor, 90' Sprayer	24 oz Roundup, 6.4 oz, Surfactant, 1.7 lb Ammonium Sulfate
May	Drill	400HP Tractor, 36' NT Drill	80 lb seed, 80lbs N, 10lbs P, 12 lbs S
May	Spray Weeds	200HP Tractor, 90' Sprayer	3.2 oz Surfactant, 16.4 oz Axial, 1.3 pt Widematch, 4 oz Tilt
August	Harvest	Combine, 30' Header	

Schedule of Operations for Dark Northern Spring Wheat

Month	Operation	Tooling	Materials/Service
April	Spray Weeds	200HP Tractor, 90' Sprayer	24 oz Roundup, 6.4 oz, Surfactant, 1.7 lb Ammonium Sulfate
May	Drill	400HP Tractor, 36' NT Drill	95 lb seed, 120lbs N, 15lbs P, 15 lbs S
May	Spray Weeds	200HP Tractor, 90' Sprayer	5 oz InPlace, 16.4 oz Axial, 1.3 pt Widematch, 4 oz Tilt
August	Harvest	Combine, 30' Header	

Schedule of Operations for Summer Fallow

Month	Operation	Tooling	Materials/Service
April	Spray Weeds	200HP Tractor, 90' Sprayer	24 oz Roundup, 3 oz Banvel, 3.2 oz Surfactant
June	Spray Weeds	200HP Tractor, 90' Sprayer	30 oz Roundup, 3 oz Banvel, 3.2 oz Surfactant
August	Spray Weeds	200HP Tractor, 90' Sprayer	32 oz Roundup, 3 oz Banvel, 3.2 oz Surfactant

Grain-Fallow AEC Calendars

Schedule of Operations for Soft White Winter Wheat

Month	Operation	Tooling	Materials/Service
August to September	Drill	300HP WT, 40' NT Drill	40 lbs seed, 60 lbs N, 10lbs S
April	Spray Weeds	100' Self Propelled Sprayer	4 oz Tilt, 3.2 oz Surfactant, 0.3 oz AllyEx, 16 oz 2,4-D
August	Harvest	Combine, 30' Header	

Schedule of Operations for Summer Fallow

Month	Operation	Tooling	Materials/Service
Fall	Spray Weeds	100' Self Propelled Sprayer	16 oz Roundup, 1 lb AMS, 3.2 oz Surfactant
April	Spray Weeds	100' Self Propelled Sprayer	20 oz Roundup, 1 lb AMS, 3.2 oz Surfactant
June	Spray Weeds	100' Self Propelled Sprayer	32 oz Roundup, 1 lb AMS, 3.2 oz Surfactant
August	Spray Weeds	100' Self Propelled Sprayer	40 oz Roundup, 1 lb AMS, 3.2 oz Surfactant

Appendix C: Enterprise Budgets

Annual AEC Soft White Winter Wheat Enterprise Budget

Item	Quantity Per Acre	Unit	Price or Cost/Unit		Value or Cost/Acre
Gross Returns					
Wheat	90	bu	$6.50		$585.00
Variable Costs					
Seed:				$25.20	
Wheat Seed	90	lb	$0.28		$25.20
Fertilizer:				$95.10	
Base your rate on your soil test results.					
A typical recommendation might include the following:					
Nitrogen	100	lb	$0.63		$63.00
Phosphorous	20	lb	$0.66		$13.20
Sulfur	20	lb	$0.56		$11.20
Nitrogen	10	lb	$0.77		$7.70
Pesticides:				$47.41	
Rates & chemicals will depend on the pests in your crop.					
Consult a certified pesticide applicator or the PNW Pest Control Management Guides.					
The following cost estimates are typical:					
Roundup	32.00	oz	$0.19		$6.15
Surfactant	3.20	oz	$0.25		$0.80
Huskie	15.00	oz	$0.90		$13.50
Orion	17.00	oz	$0.51		$8.59
Osprey	4.75	oz	$3.70		$17.58
Surfactant	3.20	oz	$0.25		$0.80
Fungicides:				$3.40	
Tilt	4.00	oz	$0.85		$3.40
Machinery:				$49.64	
Fuel	5.99	gal	$3.40		$20.36
Lubricants	1	acre	$2.04		$2.04
Machinery Repairs	1	acre	$12.76		$12.76
Machinery Labor	0.81	hour	$17.80		$14.48
Custom & Consultants:				$2.50	
Custom Aerial	0	acre	$8.95		$0.00
Rental Sprayer	0	acre	$2.00		$0.00
Rental Ripper Shooter	1	acre	$2.50		$2.50
Other:				$23.68	
Crop insurance	1	acre	$19.00		$19.00

Fire & Hail Insurance	**0.8**	$/100	**100%**	$4.68
Storage Facility & Equip. Repairs				$0.00
Other Labor				
Operating Interest[1]				$10.50
Total Variable Costs				**$257.43**
Variable Costs per Unit				$2.86
Net Returns Above Variable Costs				**$327.57**
Ownership Costs:				
Depreciation		acre	**$21.65**	$21.65
Interest		acre	**$13.94**	$13.94
Taxes, Housing, Insurance, Licenses		acre	**$6.82**	$6.82
Land Cost*		acre	$140.00	$140.00
*Based on Share Rent Percentage:				
Landlord	**33.00%**			
Tenant	**67.00%**			
Overhead[2]				$12.00
Management fee[3]				$29.00
Total Fixed Costs				**$223.41**
Fixed Costs per Unit				$2.48
Total Costs per Acre				**$480.84**
Total Cost per Unit				$5.34
Net Returns over Total Costs, or Returns to Risk				**$104.16**

Annual AEC Soft White Spring Wheat Enterprise Budget

Item	Quantity Per Acre	Unit	Price or Cost/Unit		Value or Cost/Acre
Gross Returns					
Soft White Wheat	60	bu	$6.50		$390.00
Variable Costs					
Seed:				$24.00	
Soft White Wheat Seed	80	lb	$0.30		$24.00
Fertilizer:				$73.10	
Base your rate on your soil test results.					
A typical recommendation might include the following:					
Nitrogen	80	lb	$0.63		$50.40
Phosphorous	10	lb	$0.66		$6.60
Sulfur	15	lb	$0.56		$8.40
Nitrogen	10	lb	$0.77		$7.70
Pesticides:				$36.16	
Rates & chemicals will depend on the pests in your crop.					
Consult a certified pesticide applicator or the PNW Pest Control Management Guides.					
The following cost estimates are typical:					
Roundup	24.0	oz	$0.19		$4.61
Surfactant	6.4	oz	$0.25		$1.60
Ammonium Sulfate	2.0	lb	$0.42		$0.84
Axial	16.4	oz	$1.14		$18.71
Huskie	10.0	oz	$0.90		$9.00
InPlace	5.0	oz	$0.28		$1.40
Fungicides:				$3.40	
Tilt	4.0	oz	$0.85		$3.40
Machinery:				$54.10	
Fuel	6.78	gal	$3.40		$23.07
Lubricants	1	acre	$2.31		$2.31
Machinery Repairs	1	acre	$13.52		$13.52
Machinery Labor	0.85	hour	$17.80		$15.20
Custom & Consultants:				$2.50	
Rental Sprayer	0.0	acre	$2.00		$0.00
Custom Aerial	0.0	acre	$8.95		$0.00
Rental Ripper Shooter	1.0	acre	$2.50		$2.50
Other:				$23.12	
Crop insurance (85% Revenue)	1	acre	$20.00		$20.00
Fire & Hail Insurance	0.8	$/100	100%		$3.12

Storage Facility & Equip. Repairs				$0.00
Other Labor				
Operating Interest				$6.22
Total Variable Costs				**$222.60**
Variable Costs per Unit				$3.71
Net Returns Above Variable Costs				**$167.40**
<u>Ownership Costs:</u>				
Depreciation		acre	**$23.88**	$23.88
Interest		acre	**$15.38**	$15.38
Taxes, Housing, Insurance, Licenses		acre	**$7.04**	$7.04
Land Cost*		acre	$85.00	$85.00
*Based on Share Rent Percentage:				
Landlord	**33.00%**			
Tenant	**67.00%**			
Overhead				$11.00
Management fee				$20.00
Total Fixed Costs				**$162.29**
Fixed Costs per Unit				$2.70
Total Costs per Acre				**$384.88**
Total Cost per Unit				$6.41
Returns to Risk				**$5.12**

Annual AEC Dark Northern Spring Wheat Enterprise Budget

Item	Quantity Per Acre	Unit	Price or Cost/Unit		Value or Cost/Acre
Gross Returns					
Dark Northern Wheat	60	bu	$7.75		$465.00
Variable Costs					
Seed:				$33.00	
Dark Northern Wheat Seed	100	lb	$0.33		$33.00
Fertilizer:				$104.60	
Base your rate on your soil test results.					
A typical recommendation might include the following:					
Nitrogen	130	lb	$0.63		$81.90
Phosphorous	15	lb	$0.66		$9.90
Potassium	20	lb	$0.36		$7.20
Sulfur	10	lb	$0.56		$5.60
Pesticides:				$37.00	
Rates & chemicals will depend on the pests in your crop.					
Consult a certified pesticide applicator or the PNW Pest Control Management Guides.					
The following cost estimates are typical:					
Roundup	24	oz	$0.19		$4.61
Surfactant	7.4	oz	$0.25		$1.85
Ammonium Sulfate	3.4	lb	$0.42		$1.43
Axial	16.4	oz	$1.14		$18.71
Huskie	10.0	oz	$0.90		$9.00
InPlace	5.0	oz	$0.28		$1.40
Fungicides:				$3.40	
Tilt	4.0	oz	$0.85		$3.40
Machinery:				$54.10	
Fuel	6.78	gal	$3.40		$23.07
Lubricants	1	acre	$2.31		$2.31
Machinery Repairs	1	acre	$13.52		$13.52
Machinery Labor	0.85	hour	$17.80		$15.20
Custom & Consultants:				$2.50	
Rental Sprayer	0	acre	$2.00		$0.00
Custom Aerial	0.0	acre	$8.95		$0.00
Rental Ripper Shooter	1	acre	$2.50		$2.50
Other:				$23.72	
Crop insurance	1	acre	$20.00		$20.00

Fire & Hail Insurance	0.8	$/100	100%	$3.72
Storage Facility & Equip. Repairs				$0.00
Other Labor				
Operating Interest				$7.43
Total Variable Costs				**$265.74**
Variable Costs per Unit				$4.43
Net Returns Above Variable Costs				**$199.26**
<u>Ownership Costs:</u>				
Depreciation		acre	**$23.88**	$23.88
Interest		acre	**$15.38**	$15.38
Taxes, Housing, Insurance, Licenses		acre	**$7.04**	$7.04
Land Cost*		acre	$99.00	$99.00
*Based on Share Rent Percentage:				
Landlord	33.00%			
Tenant	67.00%			
Overhead				$13.00
Management fee				$23.00
Total Fixed Costs				**$181.29**
Fixed Costs per Unit				$3.02
Total Costs per Acre				**$447.03**
Total Cost per Unit				$7.45
Returns to Risk				**$17.97**

Transition AEC Soft White Winter Wheat Enterprise Budget

Item	Quantity Per Acre	Unit	Price or Cost/Unit		Value or Cost/Acre
Gross Returns					
Wheat	80	bu	$6.50		$520.00
Variable Costs					
Seed:				$21.00	
Wheat Seed	75	lb	$0.28		$21.00
Fertilizer:				$92.50	
Base your rate on your soil test results.					
A typical recommendation might include the following:					
Nitrogen	100	lb	$0.77		$77.00
Phosphorous	15	lb	$0.66		$9.90
Sulfur	10	lb	$0.56		$5.60
Pesticides:				$21.34	
Rates & chemicals will depend on the pests in your crop.					
Consult a certified pesticide applicator or the PNW Pest Control Management Guides.					
The following cost estimates are typical:					
Powerflex	3.50	oz	$4.68		$16.38
2,4-D	12.00	oz	$0.35		$4.16
Surfactant	3.20	oz	$0.25		$0.80
Fungicides:				$3.40	
Tilt	4.00	oz	$0.85		$3.40
Machinery:				$40.23	
Fuel	4.81	gal	$3.40		$16.36
Lubricants	1	acre	$1.73		$1.73
Machinery Repairs	1	acre	$8.27		$8.27
Machinery Labor	0.78	hour	$17.80		$13.87
Custom & Consultants:				$0.00	
Custom Aerial	0	acre	$8.95		$0.00
Rental Sprayer	0	acre	$2.00		$0.00
Rental Ripper Shooter	0	acre	$2.50		$0.00
Other:				$23.64	
Crop insurance	1	acre	$20.00		$20.00
Fire & Hail Insurance	0.7	$/100	100%		$3.64
Storage Facility & Equip. Repairs					$0.00
Other Labor					

Operating Interest				$8.57
Total Variable Costs				**$210.68**
Variable Costs per Unit				$2.63
Net Returns Above Variable Costs				**$309.32**
Ownership Costs:				
Depreciation		acre	$15.46	$15.46
Interest		acre	$10.87	$10.87
Taxes, Housing, Insurance, Licenses		acre	$5.12	$5.12
Land Cost*		acre	$127.00	$127.00
*Based on Share Rent Percentage:				
Landlord	33.00%			
Tenant	67.00%			
Summer Fallow				$36.99
Overhead				$10.00
Management fee				$26.00
Total Fixed Costs				**$231.44**
Fixed Costs per Unit				$2.89
Total Costs per Acre				**$442.12**
Total Cost per Unit				$5.53
Net Returns over Total Costs, or Returns to Risk				**$77.88**

Transition AEC Soft White Spring Wheat Enterprise Budget

Item	Quantity Per Acre	Unit	Price or Cost/Unit		Value or Cost/Acre
Gross Returns					
Soft White Wheat	55	bu	$6.50		$357.50
Variable Costs					
Seed:				$24.00	
Soft White Wheat Seed	80	lb	$0.30		$24.00
Fertilizer:				$74.92	
Base your rate on your soil test results.					
A typical recommendation might include the following:					
Nitrogen	80	lb	$0.77		$61.60
Phosphorous	10	lb	$0.66		$6.60
Sulfur	12	lb	$0.56		$6.72
					$0.00
Pesticides:				$39.12	
Rates & chemicals will depend on the pests in your crop.					
Consult a certified pesticide applicator or the PNW Pest Control Management Guides.					
The following cost estimates are typical:					
Roundup	24.0	oz	$0.19		$4.61
Surfactant	6.4	oz	$0.25		$1.60
Ammonium Sulfate	1.7	lb	$0.42		$0.71
Axial	16.4	oz	$1.14		$18.71
Widematch	1.3	pt	$9.76		$12.69
Surfactant	3.2	oz	$0.25		$0.80
Fungicides:				$3.40	
Tilt	4	oz	$0.85		$3.40
Machinery:				$39.83	
Fuel	4.65	gal	$3.40		$15.83
Lubricants	1	acre	$1.58		$1.58
Machinery Repairs	1	acre	$8.23		$8.23
Machinery Labor	0.80	hour	$17.80		$14.19
Custom & Consultants:				$0.00	
Rental Sprayer	0.0	acre	$2.00		$0.00
Custom Aerial	0.0	acre	$8.95		$0.00
Rental Ripper Shooter	0.0	acre	$2.50		$0.00
Other:				$21.50	
Crop insurance	1	acre	$19.00		$19.00

Fire & Hail Insurance	0.7	$/100	100%	$2.50
Storage Facility & Equip. Repairs				$0.00
Other Labor				
Operating Interest				$5.83
Total Variable Costs				**$208.61**
Variable Costs per Unit				$3.79
Net Returns Above Variable Costs				**$148.89**
Ownership Costs:				
Depreciation		acre	$12.99	$12.99
Interest		acre	$9.28	$9.28
Taxes, Housing, Insurance, Licenses		acre	$4.78	$4.78
Land Cost*		acre	$73.00	$73.00
*Based on Share Rent Percentage:				
Landlord	33.00%			
Tenant	67.00%			
Overhead				$10.00
Management fee				$18.00
Total Fixed Costs				**$128.05**
Fixed Costs per Unit				$2.33
Total Costs per Acre				**$336.65**
Total Cost per Unit				$6.12
Returns to Risk				**$20.85**

Transition AEC Dark Northern Spring Wheat Enterprise Budget

Item	Quantity Per Acre	Unit	Price or Cost/Unit	Value or Cost/Acre
Gross Returns				
Dark Northern Wheat	50	bu	$7.75	$387.50
Variable Costs				
Seed:				**$31.35**
Dark Northern Spring Wheat Seed	95	lb	$0.33	$31.35
Fertilizer:				**$114.00**
Base your rate on your soil test results.				
A typical recommendation might include the following:				
Nitrogen	120	lb	$0.77	$92.40
Phosphorous	20	lb	$0.66	$13.20
Sulfur	15	lb	$0.56	$8.40
Pesticides:				**$39.12**
Rates & chemicals will depend on the pests in your crop.				
Consult a certified pesticide applicator or the PNW Pest Control Management Guides.				
The following cost estimates are typical:				
Roundup	24.0	oz	$0.19	$4.61
Surfactant	6.4	oz	$0.25	$1.60
Ammonium Sulfate	1.7	lb	$0.42	$0.71
Axial	16.4	oz	$1.14	$18.71
Widematch	1.3	pt	$9.76	$12.69
Surfactant	3.2	oz	$0.25	$0.80
Fungicides:				**$3.40**
Tilt	4	oz	$0.85	$3.40
Machinery:				**$39.83**
Fuel	4.65	gal	$3.40	$15.83
Lubricants	1	acre	$1.58	$1.58
Machinery Repairs	1	acre	$8.23	$8.23
Machinery Labor	0.80	hour	$17.80	$14.19
Custom & Consultants:				**$0.00**
Rental Sprayer	0.0	acre	$2.00	$0.00
Custom Aerial	0.0	acre	$8.95	$0.00
Rental Ripper Shooter	0.0	acre	$2.50	$0.00
Other:				**$21.71**
Crop insurance	1	acre	$19.00	$19.00
Fire & Hail Insurance	0.7	$/100	100%	$2.71
Storage Facility & Equip. Repairs				$0.00
Other Labor				

Operating Interest				$5.29
Total Variable Costs				**$254.71**
Variable Costs per Unit				$5.09
Net Returns Above Variable Costs				**$132.79**
Ownership Costs:				
Depreciation		acre	$12.99	$12.99
Interest		acre	$9.28	$9.28
Taxes, Housing, Insurance, Licenses		acre	$4.78	$4.78
Land Cost*		acre	$70.00	$70.00
*Based on Share Rent Percentage:				
Landlord	33.00%			
Tenant	67.00%			
Overhead				$12.00
Management fee				$19.00
Total Fixed Costs				**$128.05**
Fixed Costs per Unit				$2.56
Total Costs per Acre				**$382.75**
Total Cost per Unit				$7.66
Returns to Risk				**$4.75**

Transition AEC Summer Fallow Enterprise Budget

Item	Quantity Per Acre	Unit	Price or Cost/Unit	Value or Cost/Acre
Variable Costs				
Fertilizer:				**$0.00**
Base your rate on your soil test results.				
				$0.00
				$0.00
				$0.00
Pesticides:				**$18.93**
Rates & chemicals will depend on the pests in your crop.				
Consult a certified pesticide applicator or the PNW Pest Control Management Guides.				
The following cost estimates are typical:				
Roundup	86	oz	$0.19	$16.53
Surfactant	10	oz	$0.25	$2.40
Machinery:				**$3.36**
Fuel	0.53	gal	$3.40	$1.80
Lubricants	1	acre	$0.18	$0.18
Machinery Repairs	1	acre	$0.30	$0.30
Machinery Labor	0.06	hour	$17.80	$1.08
Custom & Consultants:				**$0.00**
Rental Sprayer	0	acre	$2.00	$0.00
Operating Interest				$0.64
Total Variable Costs				**$22.93**
Ownership Costs:				
Depreciation		acre	$1.17	$11.05
Interest		acre	$0.62	
Taxes, Housing, Insurance, Licenses		acre	$0.11	
Overhead				$1.00
Total Fixed Costs				**$12.05**
Total Costs per Acre				**$34.98**

Grain-Fallow AEC Soft White Winter Wheat Enterprise Budget

Item	Quantity Per Acre	Unit	Price or Cost/Unit		Value or Cost/Acre
Gross Returns					
Wheat	55	bu	$6.50		$357.50
Variable Costs					
Seed:				$11.20	
Wheat Seed	40	lb	$0.28		$11.20
Fertilizer:				$51.80	
Base your rate on your soil test results.					
A typical recommendation might include the following:					
Nitrogen	60	lb	$0.77		$46.20
Sulfur	10	lb	$0.56		$5.60
Pesticides:				$11.15	
Rates & chemicals will depend on the pests in your crop.					
Consult a certified pesticide applicator or the PNW Pest Control Management Guides.					
The following cost estimates are typical:					
AllyExtra	0.30	oz	$16.00		$4.80
2,4-D	16.00	oz	$0.35		$5.55
Surfactant	3.20	oz	$0.25		$0.80
Fungicides:				$3.40	
Tilt	4.00	oz	$0.85		$3.40
Machinery:				$36.84	
Fuel	4.09	gal	$3.40		$13.91
Lubricants	1	acre	$2.10		$2.10
Machinery Repairs	1	acre	$7.55		$7.55
Machinery Labor	0.75	hour	$17.80		$13.29
Custom & Consultants:				$0.00	
Custom Aerial	0	acre	$8.95		$0.00
Rental Sprayer	0	acre	$2.00		$0.00
Rental Ripper Shooter	0	acre	$2.50		$0.00
Other:				$21.36	
Revenue Protection, 85%	1	acre	$19.00		$19.00
Fire & Hail Insurance	0.66	$/100	100%		$2.36
Storage Facility & Equip. Repairs					$0.00
Other Labor					

Operating Interest				$5.71
Total Variable Costs				**$141.46**
Variable Costs per Unit				$2.57
Net Returns Above Variable Costs				**$216.04**
Ownership Costs:				
Depreciation		acre	$7.66	$7.66
Interest		acre	$5.84	$5.84
Taxes, Housing, Insurance, Licenses		acre	$3.57	$3.57
Land Cost*		acre	$91.00	$91.00
*Based on Share Rent Percentage:				
Landlord	33.00%			
Tenant	67.00%			
Summer fallow				$47.67
Overhead				$7.00
Management fee				$18.00
Total Fixed Costs				**$180.74**
Fixed Costs per Unit				$3.29
Total Costs per Acre				**$322.20**
Total Cost per Unit				$5.86
Net Returns over Total Costs, or Returns to Risk				**$35.30**

Grain-Fallow AEC Summer Fallow Enterprise Budget

Item	Quantity Per Acre	Unit	Price or Cost/Unit	Value or Cost/Acre
Variable Costs				
Fertilizer:				**$0.00**
Base your rate on your soil test results.				
		lb		$0.00
		lb		$0.00
		lb		$0.00
Pesticides:				**$25.64**
Rates & chemicals will depend on the pests in your crop.				
Consult a certified pesticide applicator or the PNW Pest Control Management Guides.				
The following cost estimates are typical:				
Roundup	108	oz	$0.19	$20.76
Surfactant	13	oz	$0.25	$3.20
Ammonium Sulfate	4	lb	$0.42	$1.68
Machinery:				**$10.55**
Fuel	0.91	gal	$3.40	$3.09
Lubricants	1	acre	$0.48	$0.48
Machinery Repairs	1	acre	$1.72	$1.72
Machinery Labor	0.30	hour	$17.80	$5.26
Custom & Consultants:				**$0.00**
Rental Sprayer	0	acre	$2.00	$0.00
Operating Interest				$1.04
Total Variable Costs				**$37.23**
Ownership Costs:				
Depreciation		acre	$4.10	$4.10
Interest		acre	$2.62	$2.62
Taxes, Housing, Insurance, Licenses		acre	$1.67	$1.67
Overhead				$2.00
Total Fixed Costs				**$10.39**
Total Costs per Acre				**$47.62**

Appendix D: Machinery Complements and Costs

Annual AEC Machinery Complement

Type of Machine	Replacement Value $	Age When Purchased	Years of Life	Annual Hours of Use	Salvage Value $	Annual Repair (Materials & Labor) $	Gallons of Fuel/ Hour	Taxes, Housing, Insur., Licenses %	Labor Multiplier	Acres per Hour
Tractors, ATVs:										
4WD-ATV	7,000	0	10	150	2,000	100	1.2	1.2	1.1	
250HP FWA Tractor	85,000	2	10	200	40,000	2,000	10	1.2	1.1	
450HP Track Tractor	220,000	10	10	400	80,000	2,500	19	1.2	1.1	
Equipment:										
Bankout Wagon	15,000	5	15	100	3,000	500	19	0.6	1.1	-
35' NT Drill	110,000	5	10	200	45,000	2,000	19	0.6	1.2	13
40' Heavy Harrow	10,000	10	10	40	2,000	500	19	0.6	1.1	25
90' Sprayer	20,000	5	10	125	3,000	200	10	0.6	1.1	45
40' Ripper Shooter (Rental)	-	-	-	-	-	-	19	-	1.2	20
Combine, 30' header	250,000	5	10	270	50,000	10,000	10	2.6	1.25	9
Trucks:				Miles/year:			MPG:			
2-Ton Truck	20,000	15	15	1,000	2,000	1,250	6	10.1	1.2	
40'Grain Trailer+Tractor	50,000	7	10	8,000	18,000	2,000	6	10.1	1.2	
Trap Wagon	15,000	10	10	500	3,000	400	12	3.8	1.2	
3/4-Ton Pickup	23,000	5	7	12,000	7,500	1,500	12	6.8	1.2	

Transition AEC Machinery Complement

Type of Machine	Replacement Value $	Age When Purchased	Years of Life	Annual Hours of Use	Salvage Value $	Annual Repair (Materials & Labor) $	Gallons of Fuel/ Hour	Taxes, Housing, Insur., Licenses %	Labor Multiplier	Acres per Hour
Tractors, ATVs:										
4WD-ATV	7,000	0	10	150	2,000	100	1	1.2	1.1	
50HP-WT w/Bucket	16,000	5	20	150	3,500	300	3	1.2	1.1	
200HP FWA Tractor	60,000	10	10	300	20,000	1,000	9	1.2	1.1	
400HP-WT	200,000	10	10	300	70,000	3,000	18	1.2	1.1	
Equipment:										
Bankout Wagon	15,000	5	10	100	5,000	500	17.5	0.6	1.1	-
90' Sprayer	18,000	8	5	300	900	500	8	0.6	1.2	50
26' Mower	30,000	5	10	52	10,000	300	17.5	0.6	1.1	18
36' NT Drill	50,000	10	5	110	20,000	2,500	17.5	3.0	1.2	17
Combine, 30' header	100,000	10	5	190	75,000	5,000	12	2.6	1.2	9
Trucks:				Miles/year:			MPG:			
2-Ton Truck	10,000	15	10	2,000	1,500	1,250	6	10.1	1.2	
40'Grain Trailer+Tractor	30,000	10	10	5,000	9,000	3,000	6	10.1	1.2	
Trap Wagon	15,000	10	10	500	3,000	400	10	3.8	1.2	
3/4-Ton Pickup	23,000	5	7	12,000	7,500	800	12	6.8	1.2	

Grain-Fallow AEC Machinery Complement

Type of Machine	Replacement Value $	Age When Purchased	Years of Life	Annual Hours of Use	Salvage Value $	Annual Repair (Materials & Labor) $	Gallons of Fuel/ Hour	Taxes, Housing, Insur., Licenses %	Labor Multiplier	Acres per Hour
Tractors, ATVs:										
4WD-ATV	7,000	0	10	150	2,000	100	1.2	1.2	1.1	
200HP FWA Tractor	85,000	2	10	300	40,000	1,000	9	1.2	1.1	
300HP-WT	110,000	10	10	400	60,000	2,000	11	1.2	1.1	
Equipment:										
Bankout Wagon	15,000	0	15	100	3,000	500	10	0.6	1.1	-
100' Self Propelled Sprayer	180,000	5	10	200	70,000	3,500	3.5	0.6	1.2	68
40' NT Airseeder with cart	40,000	10	5	185	15,000	2,800	15	3.0	1.2	14
Combine, 30' header	80,000	15	5	250	60,000	7,500	12	2.6	1.25	9
Trucks:				Miles/year:			MPG:			
2-Ton Truck	20,000	15	10	1,000	5,000	1,000	6	10.1	1.2	
40'Grain Trailer+Tractor	35,000	10	10	5,000	18,000	2,000	6	10.1	1.2	
Trap Wagon	15,000	10	10	500	3,000	400	12	3.8	1.2	
3/4-Ton Pickup	23,000	5	7	20,000	7,500	1,500	12	6.8	1.2	

Annual AEC Machinery Costs from the University of Idaho Machinery Cost Calculator

Name	Ownership Costs ($/acre):				Operating Costs ($/acre):				Labor		Fuel Use	Total Cost ($/acre)
	Depre-ciation	Interest	Taxes, Housing, Insur., License	Total	Repairs	Fuel	Lubri-cants	Total	($/acre)	(hour/acre)	(gal/acre)	
3/4-Ton Pickup	$0.62	$0.41	$0.62	$1.65	$0.60	$1.36	$0.14	$2.10	$2.95	0.24	0.40	$6.70
Trap Wagon	$0.48	$0.24	$0.36	$1.09	$0.16	$0.06	$0.01	$0.22	$0.12	0.01	0.02	$1.43
Tractor w/ 40' Grain Trailer	$1.28	$0.92	$1.37	$3.57	$0.80	$1.81	$0.18	$2.79	$3.42	0.16	0.53	$9.78
2-Ton Truck	$0.48	$0.30	$0.44	$1.22	$0.50	$0.23	$0.02	$0.75	$0.43	0.02	0.07	$2.40
450HP Track Tractor w/ 30' NT Drill	$5.30	$4.04	$1.27	$10.61	$1.28	$5.27	$0.53	$7.07	$1.54	0.08	1.55	$19.22
450HP Track Tractor w/ Bankout Wagon	$1.72	$1.26	$0.20	$3.18	$0.45	$2.68	$0.27	$3.40	$0.78	0.04	0.79	$7.36
450HP Track Tractor w/ 40' Heavy Harrow	$2.22	$1.43	$0.22	$3.88	$0.76	$2.71	$0.27	$3.74	$0.79	0.04	0.80	$8.41
250HP Tractor w/ 90' Pull Sprayer	$0.78	$0.61	$0.10	$1.48	$2.24	$0.82	$0.08	$3.14	$0.43	0.02	0.24	$5.05
450HP Track Tractor w/ 40' Ripper Shooter	$1.70	$1.23	$0.22	$3.15	$0.30	$3.25	$0.33	$3.88	$0.95	0.05	0.96	$7.98
Combine, 30' Header	$8.31	$4.21	$2.12	$14.64	$4.16	$3.82	$0.38	$8.36	$2.40	0.11	1.12	$25.40
4WD-ATV	$0.20	$0.12	$0.02	$0.34	$0.04	$0.26	$0.03	$0.32	$0.77	0.06	0.07	$1.44
Total	**$23.10**	**$14.77**	**$6.94**	**$44.81**	**$11.28**	**$22.26**	**$2.23**	**$35.77**	**$14.58**	**0.83**	**6.54**	**$95.16**

Transition AEC Machinery Costs from the University of Idaho Machinery Cost Calculator

Name	Ownership Costs ($/acre):				Operating Costs ($/acre):				Labor		Fuel Use	Total Cost ($/acre)
	Depre-ciation	Interest	Taxes, Housing, Insur., License	Total	Repairs	Fuel	Lubri-cants	Total	($/ acre)	(hour/ acre)	(gal/acre)	
200HP-Tractor w/ 90' Sprayer	$0.39	$0.21	$0.04	$0.63	$0.10	$0.60	$0.06	$0.76	$0.39	0.02	0.18	$1.79
400HP Tractor w/ 36' NT Drill	$3.02	$2.56	$0.97	$6.54	$1.80	$3.55	$0.35	$5.70	$0.77	0.06	1.04	$13.01
400HP Tractor w/ Bankout Wagon	$3.19	$1.89	$0.35	$5.42	$0.94	$4.47	$0.45	$5.85	$0.97	0.08	1.31	$12.24
Combine, 30' header	$2.95	$2.97	$1.34	$7.27	$2.95	$2.67	$0.27	$5.89	$2.40	0.11	0.79	$15.56
ATV	$0.20	$0.10	$0.02	$0.33	$0.04	$0.25	$0.03	$0.32	$1.17	0.06	0.07	$1.82
50HP-Tractor w/Bucket	$0.25	$0.22	$0.05	$0.52	$0.12	$0.63	$0.06	$0.81	$1.17	0.06	0.19	$2.51
2-Ton Truck	$0.40	$0.12	$0.20	$0.72	$0.50	$0.45	$0.05	$1.00	$0.85	0.04	0.13	$2.57
Tractor w/ 40' Grain trailer	$0.84	$0.45	$0.79	$2.08	$1.20	$1.13	$0.11	$2.45	$2.14	0.10	0.33	$6.66
400HP Tractor w/ 26' Mower	$4.34	$2.55	$0.78	$7.67	$0.85	$3.38	$0.34	$4.56	$1.11	0.06	0.62	$13.35
3/4 Ton Pickup	$0.89	$0.35	$0.62	$1.85	$0.32	$1.36	$0.14	$1.82	$5.13	0.24	0.40	$8.79
Trap Wagon	$0.48	$0.21	$0.36	$1.05	$0.16	$0.11	$0.01	$0.28	$0.21	0.01	0.03	$1.55
Total	**$16.95**	**$11.62**	**$5.52**	**$34.09**	**$8.98**	**$18.60**	**$1.86**	**$29.44**	**$16.31**	**0.83**	**5.10**	**$79.84**

Grain-Fallow AEC Machinery Costs from the University of Idaho Machinery Cost Calculator

Name	Ownership Costs ($/acre):				Operating Costs ($/acre):				Labor		Fuel Use	Total Cost ($/acre)
	Depre-ciation	Interest	Taxes, Housing, Insur., License	Total	Repairs	Fuel	Lubri-cants	Total	($/ acre)	(hour/ acre)	(gal/acre)	
0.75-Ton 4WD Pickup	$0.31	$0.20	$0.24	$0.75	$0.30	$1.17	$0.18	$1.65	$1.92	0.10	0.34	$4.32
2-Ton Truck	$0.30	$0.14	$0.25	$0.69	$0.20	$0.11	$0.02	$0.33	$0.24	0.01	0.03	$1.26
300 HP Tractor w/Bankout Wagon	$0.82	$0.70	$0.12	$1.64	$0.50	$1.36	$0.20	$2.06	$0.88	0.04	0.40	$4.58
Trap Wagon	$0.24	$0.10	$0.07	$0.41	$0.08	$0.03	$0.00	$0.11	$0.08	0.00	0.01	$0.60
4WD-ATV	$0.31	$0.20	$0.24	$0.75	$0.30	$1.17	$0.18	$1.65	$1.92	0.10	0.34	$4.32
50HP Tractor w/ Bucket	$0.17	$0.18	$0.03	$0.37	$0.08	$0.42	$0.06	$0.56	$0.88	0.04	0.12	$1.82
300HP Tractor w/ 40' NT Drill	$2.45	$1.38	$0.44	$4.27	$1.66	$3.76	$0.56	$5.98	$1.62	0.10	1.11	$11.87
Combine, 30' header	$1.80	$1.81	$0.82	$4.43	$3.37	$4.58	$0.69	$8.64	$2.81	0.28	1.35	$15.88
100' Self Propelled Sprayer	$0.81	$0.53	$0.28	$1.62	$0.26	$0.18	$0.03	$0.47	$0.35	0.02	0.05	$2.44
Tractor w/ 40' Grain Trailer	$0.45	$0.61	$1.07	$2.13	$0.80	$1.13	$0.17	$2.10	$2.40	0.05	0.33	$6.63
Total:	**$7.66**	**$5.84**	**$3.57**	**$17.06**	**$7.55**	**$13.91**	**$2.10**	**$23.56**	**$13.10**	**0.75**	**4.09**	**$53.72**

Appendix E: Statistical Output from SAS

Please note for the results below the agroecological classes (AECs) are numbered as follows:

1) Annual 2) Transitional 3) Grain-Fallow 4) Irrigated

One-Way ANOVA of Yield for 2011-2013

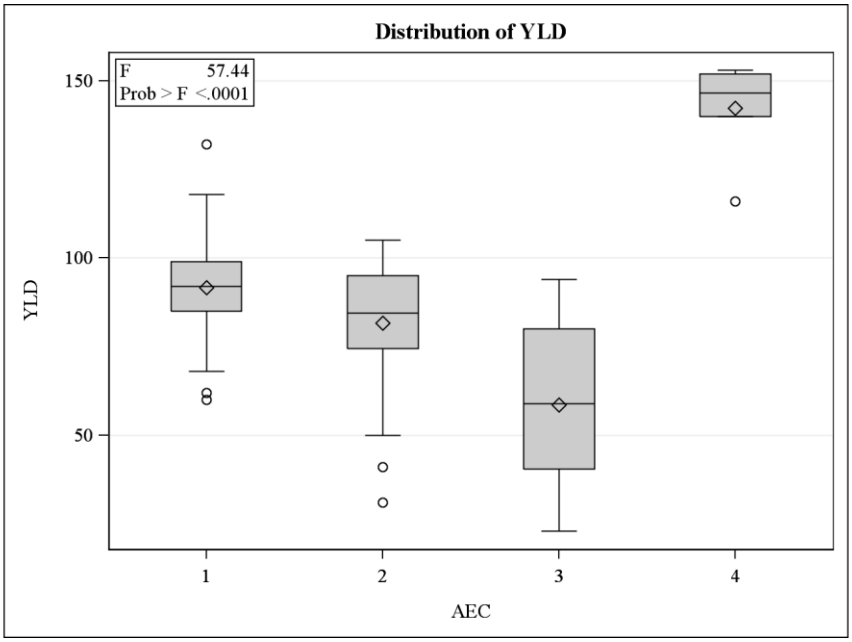
Number of Observations Read	140
Number of Observations Used	135
Number of Observations with Missing Values	5

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1	4311.25169	4311.25169	7.19	0.0083
Error	133	79745	599.58818		
Corrected Total	134	84056			

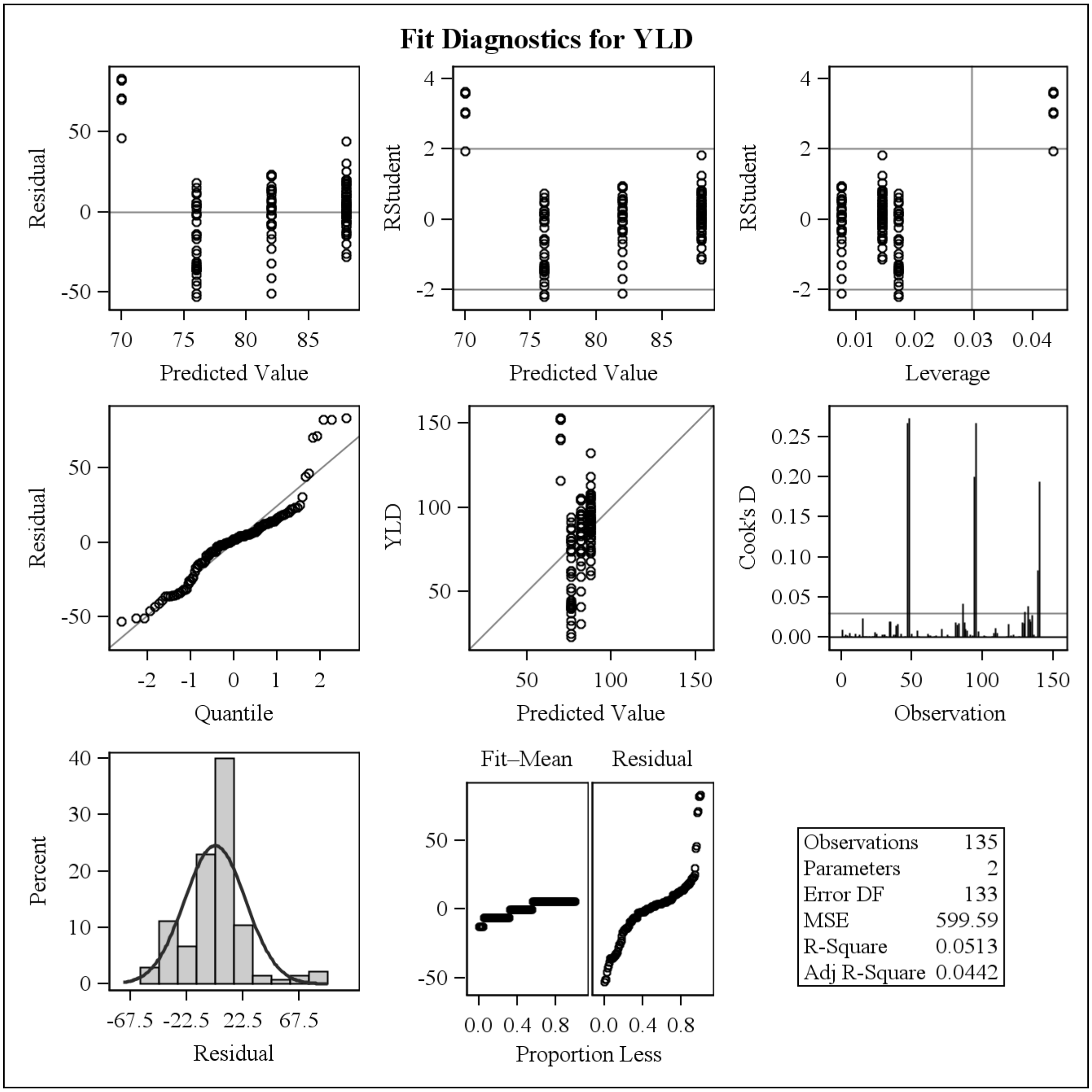
Root MSE	24.48649	**R-Square**	0.0513
Dependent Mean	82.48533	**Adj R-Sq**	0.0442
Coeff Var	29.68587		

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	93.97982	4.77666	19.67	<.0001
AEC	1	-5.99133	2.23434	-2.68	0.0083

Durbin-Watson D	1.129
Number of Observations	135
1st Order Autocorrelation	0.400



Level of AEC	N	YLD Mean	YLD Std Dev
1	60	91.712000	12.7211034
2	32	81.593750	17.8594140
3	37	58.589189	20.9945070
4	6	142.333333	14.1515606


Fit Diagnostics for YLD
Residual
Predicted Value
RStudent
Predicted Value
RStudent
Leverage
Residual
Quantile
YLD
Predicted Value
Cook's D
Observation
Percent
Residual
Fit–Mean
Residual
Proportion Less
Observations 135
Parameters 2
Error DF 133
MSE 599.59
R-Square 0.0513
Adj R-Square 0.0442

Pairwise Comparison of Yield for 2011-2013

Least Squares Means						
Effect	AEC	Estimate	Standard Error	DF	t Value	Pr > |t|
AEC	1	91.7120	2.1492	131	42.67	<.0001
AEC	2	81.5938	2.9429	131	27.73	<.0001
AEC	3	58.5892	2.7368	131	21.41	<.0001
AEC	4	142.33	6.7962	131	20.94	<.0001

Differences of Least Squares Means									
Effect	AEC	_AEC	Estimate	Standard Error	DF	t Value	Pr > |t|	Adjustment	Adj P
AEC	1	2	10.1182	3.6441	131	2.78	0.0063	Tukey-Kramer	0.0316
AEC	1	3	33.1228	3.4798	131	9.52	<.0001	Tukey-Kramer	<.0001
AEC	1	4	-50.6213	7.1280	131	-7.10	<.0001	Tukey-Kramer	<.0001
AEC	2	3	23.0046	4.0188	131	5.72	<.0001	Tukey-Kramer	<.0001
AEC	2	4	-60.7396	7.4060	131	-8.20	<.0001	Tukey-Kramer	<.0001
AEC	3	4	-83.7441	7.3266	131	-11.43	<.0001	Tukey-Kramer	<.0001

One-Way ANOVA of Total Cost per Acre for 2011-2013

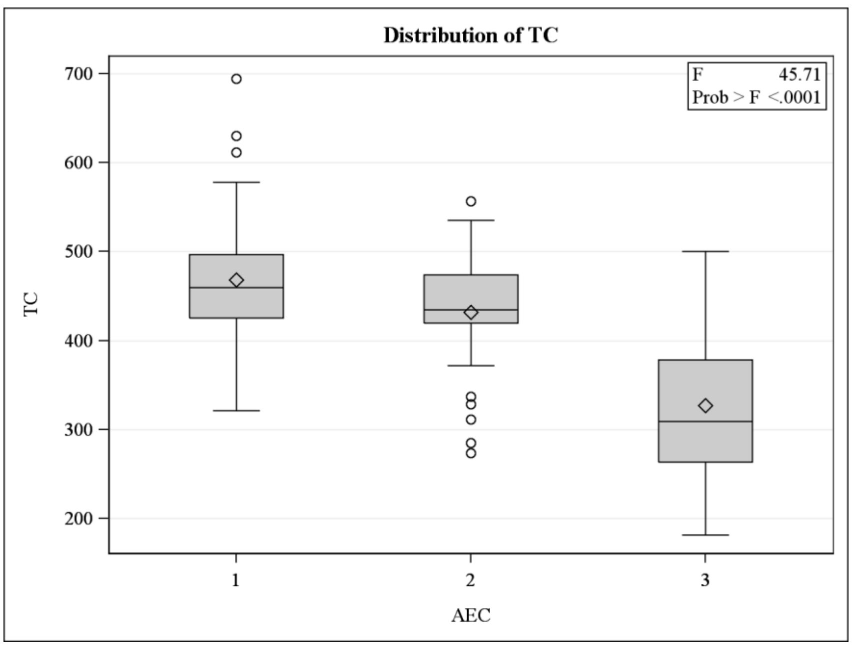
Number of Observations Read	135
Number of Observations Used	129
Number of Observations with Missing Values	6

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	437147	437147	82.92	<.0001
Error	127	669567	5272.18139		
Corrected Total	128	1106714			

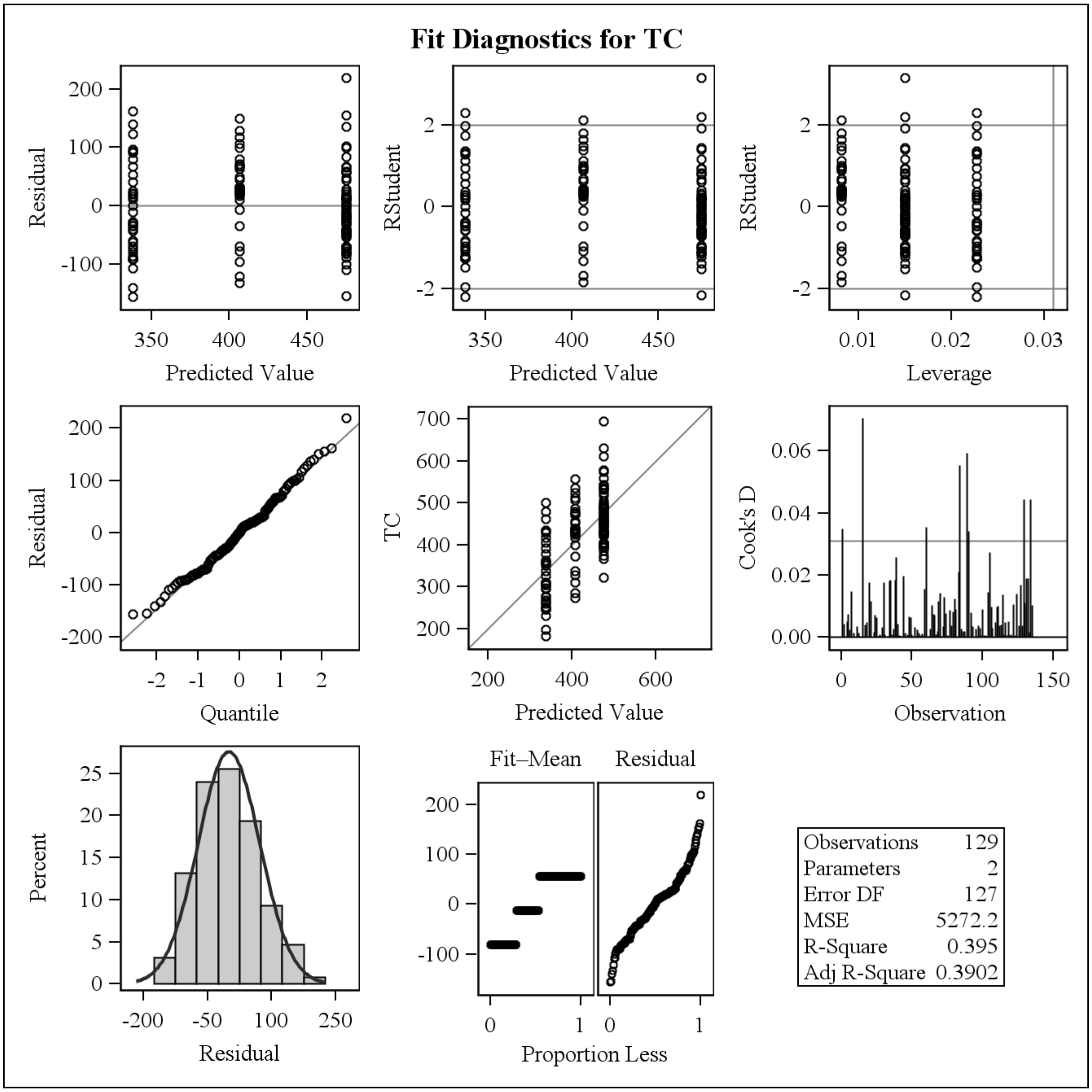
Root MSE	72.60979	**R-Square**	0.3950
Dependent Mean	418.79550	**Adj R-Sq**	0.3902
Coeff Var	17.33777		

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	543.75972	15.13956	35.92	<.0001
AEC	1	-68.59738	7.53337	-9.11	<.0001

Durbin-Watson D	1.635
Number of Observations	129
1st Order Autocorrelation	0.161



Level of AEC	N	TC	
		Mean	**Std Dev**
1	60	468.344833	67.4909900
2	32	432.130625	68.1182335
3	37	326.912162	79.7131855



Pairwise Comparison of Yield for 2011-2013

Least Squares Means						
Effect	AEC	Estimate	Standard Error	DF	t Value	Pr > |t|
AEC	1	468.34	9.2105	126	50.85	<.0001
AEC	2	432.13	12.6120	126	34.26	<.0001
AEC	3	326.91	11.7289	126	27.87	<.0001

Differences of Least Squares Means									
Effect	AEC	_AEC	Estimate	Standard Error	DF	t Value	Pr > |t|	Adjustment	Adj P
AEC	1	2	36.2142	15.6172	126	2.32	0.0220	Tukey-Kramer	0.0568
AEC	1	3	141.43	14.9131	126	9.48	<.0001	Tukey-Kramer	<.0001
AEC	2	3	105.22	17.2230	126	6.11	<.0001	Tukey-Kramer	<.0001

One-Way ANOVA of Total Cost per Bushel for 2011

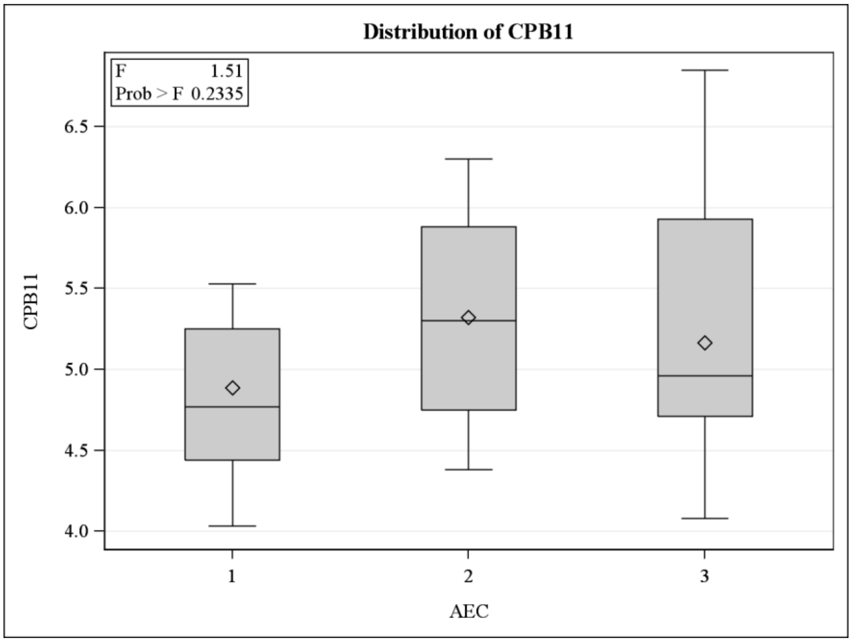
Number of Observations Read	45
Number of Observations Used	44
Number of Observations with Missing Values	1

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	0.76252	0.76252	1.54	0.2211
Error	42	20.76096	0.49431		
Corrected Total	43	21.52347			

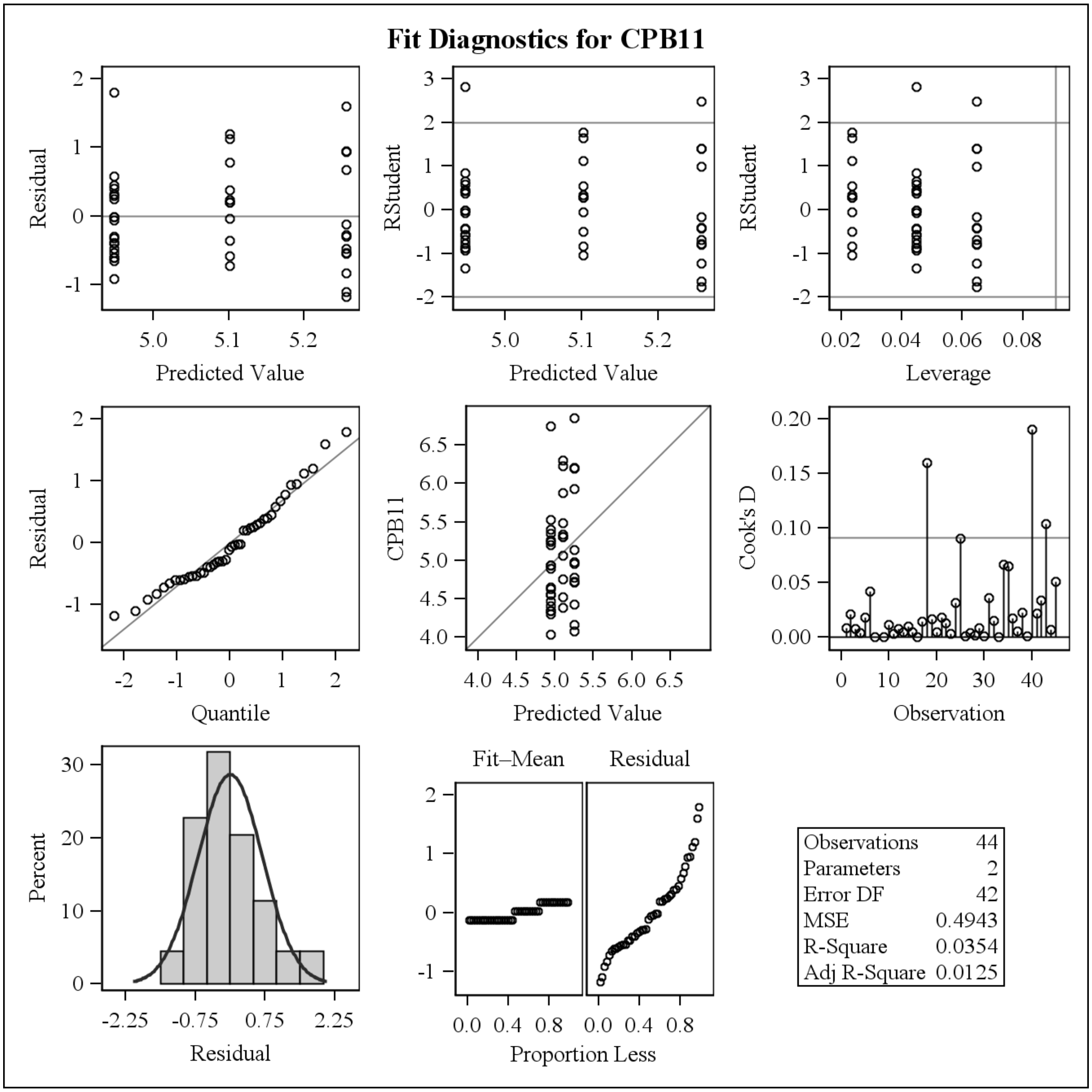
Root MSE	0.70307	R-Square	0.0354
Dependent Mean	5.07727	Adj R-Sq	0.0125
Coeff Var	13.84741		

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	4.79259	0.25253	18.98	<.0001
AEC	1	0.15464	0.12451	1.24	0.2211

Durbin-Watson D	2.023
Number of Observations	44
1st Order Autocorrelation	-0.032



Level of AEC	N	CPB11	
		Mean	Std Dev
1	20	4.88700000	0.61208101
2	11	5.32090909	0.63457788
3	13	5.16384615	0.86138975


Fit Diagnostics for CPB11
Residual
Predicted Value
RStudent
Predicted Value
RStudent
Leverage
Residual
Quantile
CPB11
Predicted Value
Cook's D
Observation
Percent
Residual
Fit–Mean
Residual
Proportion Less
Observations 44
Parameters 2
Error DF 42
MSE 0.4943
R-Square 0.0354
Adj R-Square 0.0125

One-Way ANOVA of Total Cost per Bushel for 2012

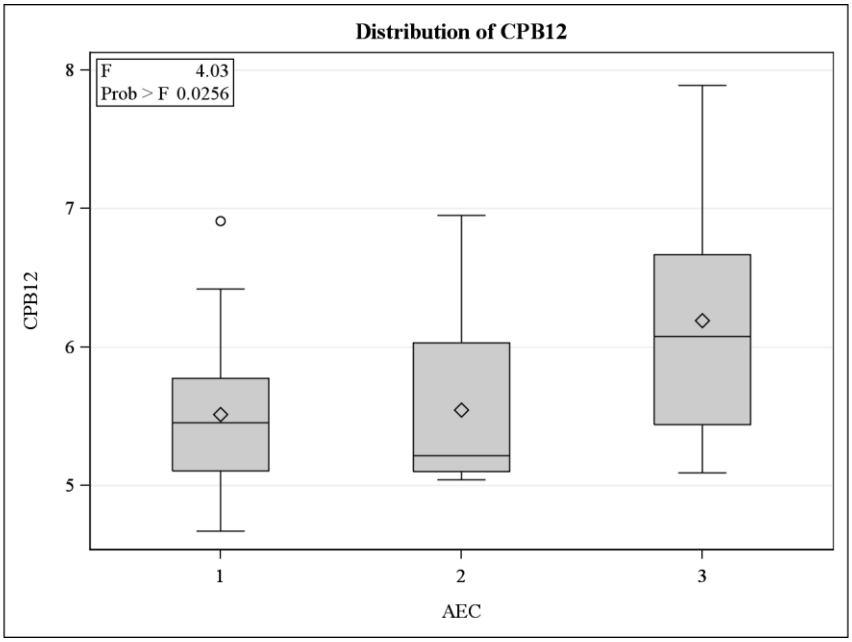
Number of Observations Read	45
Number of Observations Used	42
Number of Observations with Missing Values	3

Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	1	3.12564	3.12564	6.49	0.0148
Error	40	19.26961	0.48174		
Corrected Total	41	22.39525			

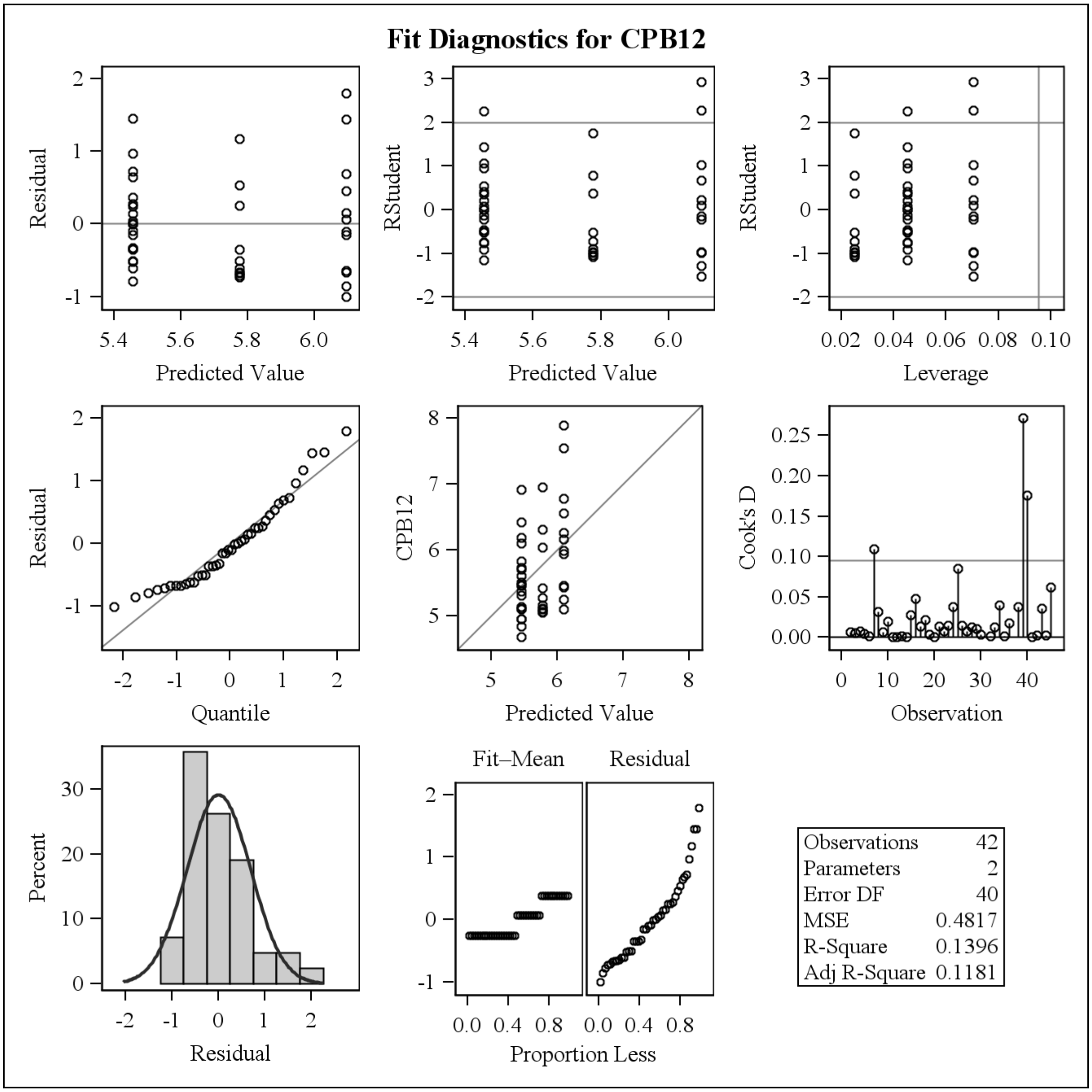
Root MSE	0.69408	**R-Square**	0.1396
Dependent Mean	5.71500	**Adj R-Sq**	0.1181
Coeff Var	12.14480		

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	5.13550	0.25145	20.42	<.0001
AEC	1	0.32025	0.12573	2.55	0.0148

Durbin-Watson D	2.046
Number of Observations	42
1st Order Autocorrelation	-0.045



Level of AEC	N	CPB12	
		Mean	Std Dev
1	20	5.51350000	0.56716539
2	10	5.54500000	0.65924620
3	12	6.19250000	0.88084799


Fit Diagnostics for CPB12
Residual
Predicted Value
RStudent
Predicted Value
RStudent
Leverage
Residual
Quantile
CPB12
Predicted Value
Cook's D
Observation
Percent
Residual
Fit–Mean
Residual
Proportion Less
Observations 42
Parameters 2
Error DF 40
MSE 0.4817
R-Square 0.1396
Adj R-Square 0.1181

Pairwise Comparison of Total Cost per Bushel for 2012

Least Squares Means						
Effect	AEC	Estimate	Standard Error	DF	t Value	Pr > |t|
AEC	1	5.5135	0.1542	39	35.74	<.0001
AEC	2	5.5450	0.2181	39	25.42	<.0001
AEC	3	6.1925	0.1991	39	31.10	<.0001

Differences of Least Squares Means									
Effect	AEC	_AEC	Estimate	Standard Error	DF	t Value	Pr > |t|	Adjustment	Adj P
AEC	1	2	-0.03150	0.2672	39	-0.12	0.9067	Tukey-Kramer	0.9924
AEC	1	3	-0.6790	0.2519	39	-2.70	0.0103	Tukey-Kramer	0.0272
AEC	2	3	-0.6475	0.2954	39	-2.19	0.0344	Tukey-Kramer	0.0851

One-Way ANOVA of Total Cost per Bushel for 2013

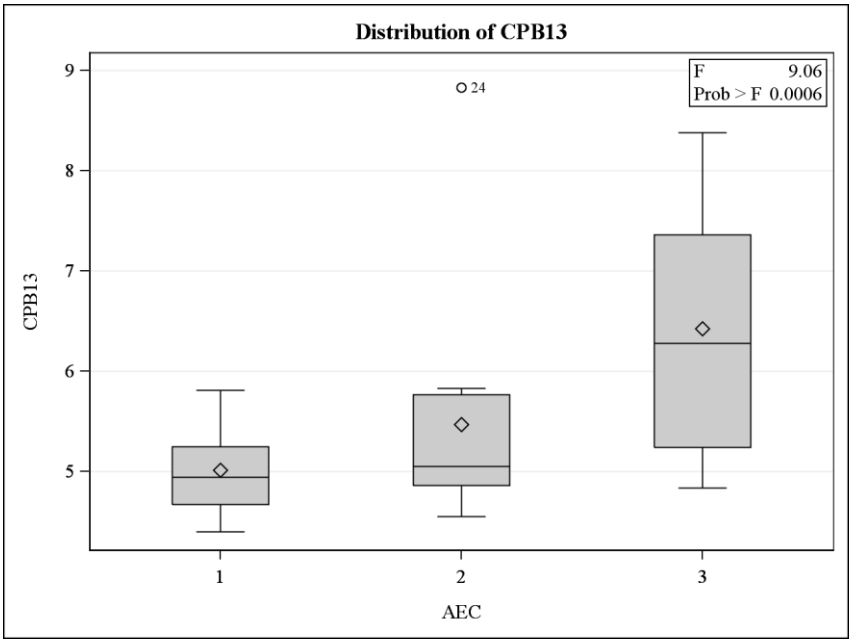
Number of Observations Read	45
Number of Observations Used	43
Number of Observations with Missing Values	2

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	14.44710	14.44710	17.66	0.0001
Error	41	33.53216	0.81786		
Corrected Total	42	47.97926			

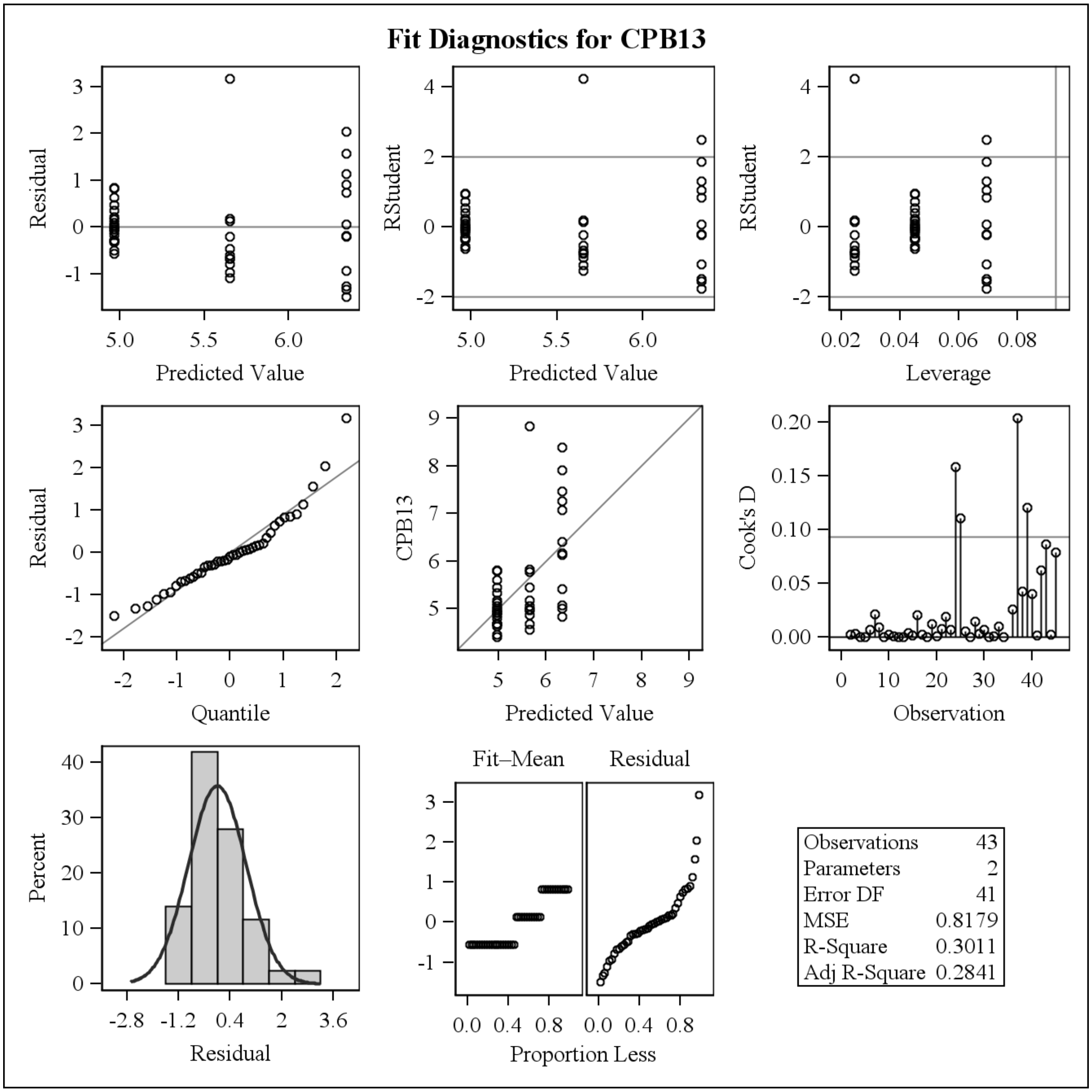
Root MSE	0.90435	R-Square	0.3011
Dependent Mean	5.52442	Adj R-Sq	0.2841
Coeff Var	16.37013		

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	4.27622	0.32744	13.06	<.0001
AEC	1	0.68811	0.16372	4.20	0.0001

Durbin-Watson D	2.300
Number of Observations	43
1st Order Autocorrelation	-0.175



Level of AEC	N	CPB13	
		Mean	**Std Dev**
1	20	5.01500000	0.40810860
2	11	5.46818182	1.18755057
3	12	6.42500000	1.19675698


Fit Diagnostics for CPB13
Residual
Predicted Value
RStudent
Leverage
Quantile
CPB13
Cook's D
Observation
Percent
Fit–Mean
Proportion Less
Observations 43
Parameters 2
Error DF 41
MSE 0.8179
R-Square 0.3011
Adj R-Square 0.2841

Pairwise Comparison of Total Cost per Bushel for 2013

Least Squares Means						
Effect	AEC	Estimate	Standard Error	DF	t Value	Pr > |t|
AEC	1	5.0150	0.2032	40	24.68	<.0001
AEC	2	5.4682	0.2740	40	19.96	<.0001
AEC	3	6.4250	0.2623	40	24.50	<.0001

Differences of Least Squares Means									
Effect	AEC	_AEC	Estimate	Standard Error	DF	t Value	Pr > |t|	Adjustment	Adj P
AEC	1	2	-0.4532	0.3411	40	-1.33	0.1915	Tukey-Kramer	0.3879
AEC	1	3	-1.4100	0.3318	40	-4.25	0.0001	Tukey-Kramer	0.0004
AEC	2	3	-0.9568	0.3793	40	-2.52	0.0157	Tukey-Kramer	0.0408

One-Way ANOVA of Total Cost per Bushel for 2011-2013

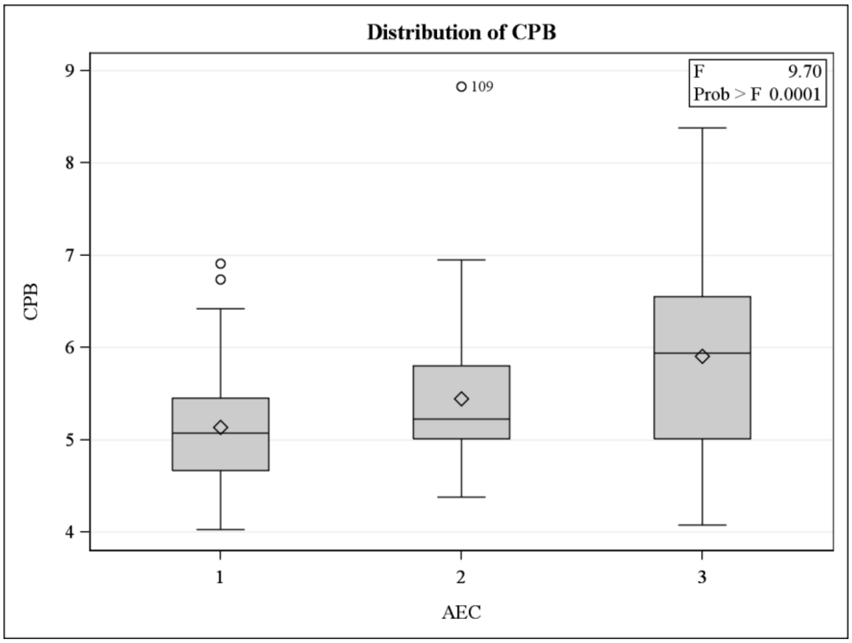
Number of Observations Read	129
Number of Observations Used	129

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	13.34575	13.34575	19.30	<.0001
Error	127	87.81934	0.69149		
Corrected Total	128	101.16508			

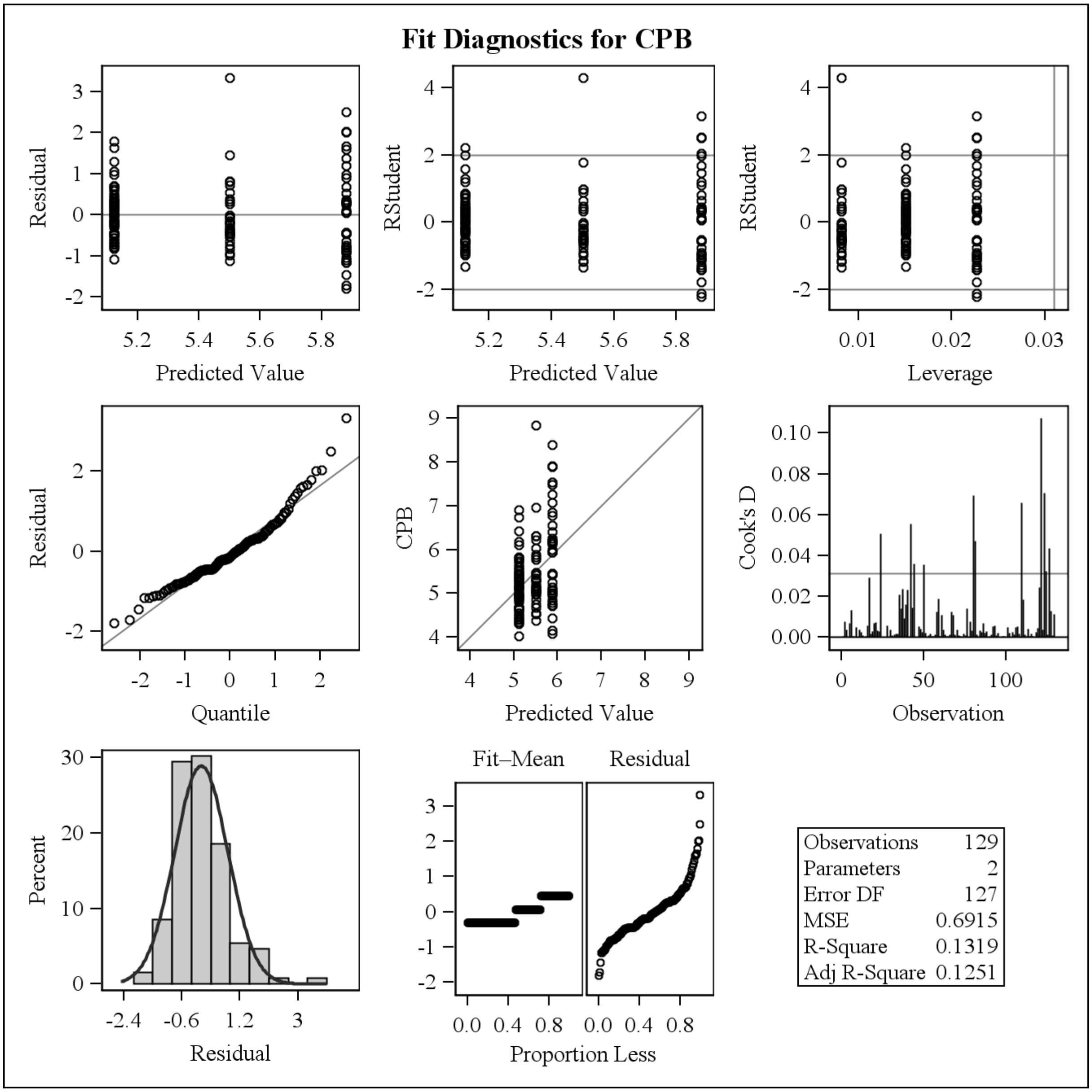
Root MSE	0.83156	R-Square	0.1319
Dependent Mean	5.43395	Adj R-Sq	0.1251
Coeff Var	15.30303		

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	1	4.74349	0.17338	27.36	<.0001
AEC	1	0.37902	0.08628	4.39	<.0001

Durbin-Watson D	1.814
Number of Observations	129
1st Order Autocorrelation	0.089



Level of AEC	N	CPB	
		Mean	**Std Dev**
1	60	5.13850000	0.59342678
2	32	5.44156250	0.84845252
3	37	5.90648649	1.11268997


Fit Diagnostics for CPB
Residual
Predicted Value
RStudent
Predicted Value
RStudent
Leverage
Residual
Quantile
CPB
Predicted Value
Cook's D
Observation
Percent
Residual
Fit–Mean
Residual
Proportion Less
Observations 129
Parameters 2
Error DF 127
MSE 0.6915
R-Square 0.1319
Adj R-Square 0.1251

Pairwise Comparison of Total Cost per Bushel for 2011-2013

Least Squares Means						
Effect	AEC	Estimate	Standard Error	DF	t Value	Pr > |t|
AEC	1	5.1385	0.1077	126	47.72	<.0001
AEC	2	5.4416	0.1475	126	36.90	<.0001
AEC	3	5.9065	0.1371	126	43.07	<.0001

Differences of Least Squares Means									
Effect	AEC	_AEC	Estimate	Standard Error	DF	t Value	Pr > |t|	Adjustment	Adj P
AEC	1	2	-0.3031	0.1826	126	-1.66	0.0994	Tukey-Kramer	0.2248
AEC	1	3	-0.7680	0.1744	126	-4.40	<.0001	Tukey-Kramer	<.0001
AEC	2	3	-0.4649	0.2014	126	-2.31	0.0226	Tukey-Kramer	0.0582

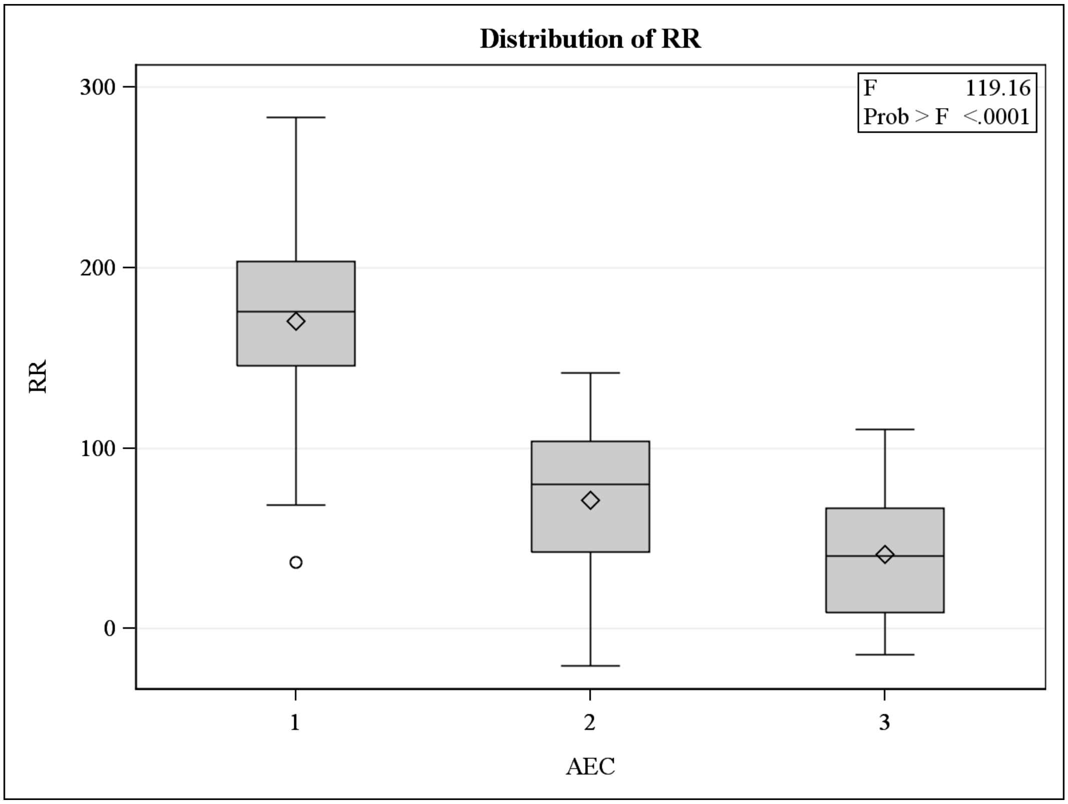
One-Way ANOVA of Returns to Risk for 2011-2013

Number of Observations Read	134
Number of Observations Used	128
Number of Observations with Missing Values	6

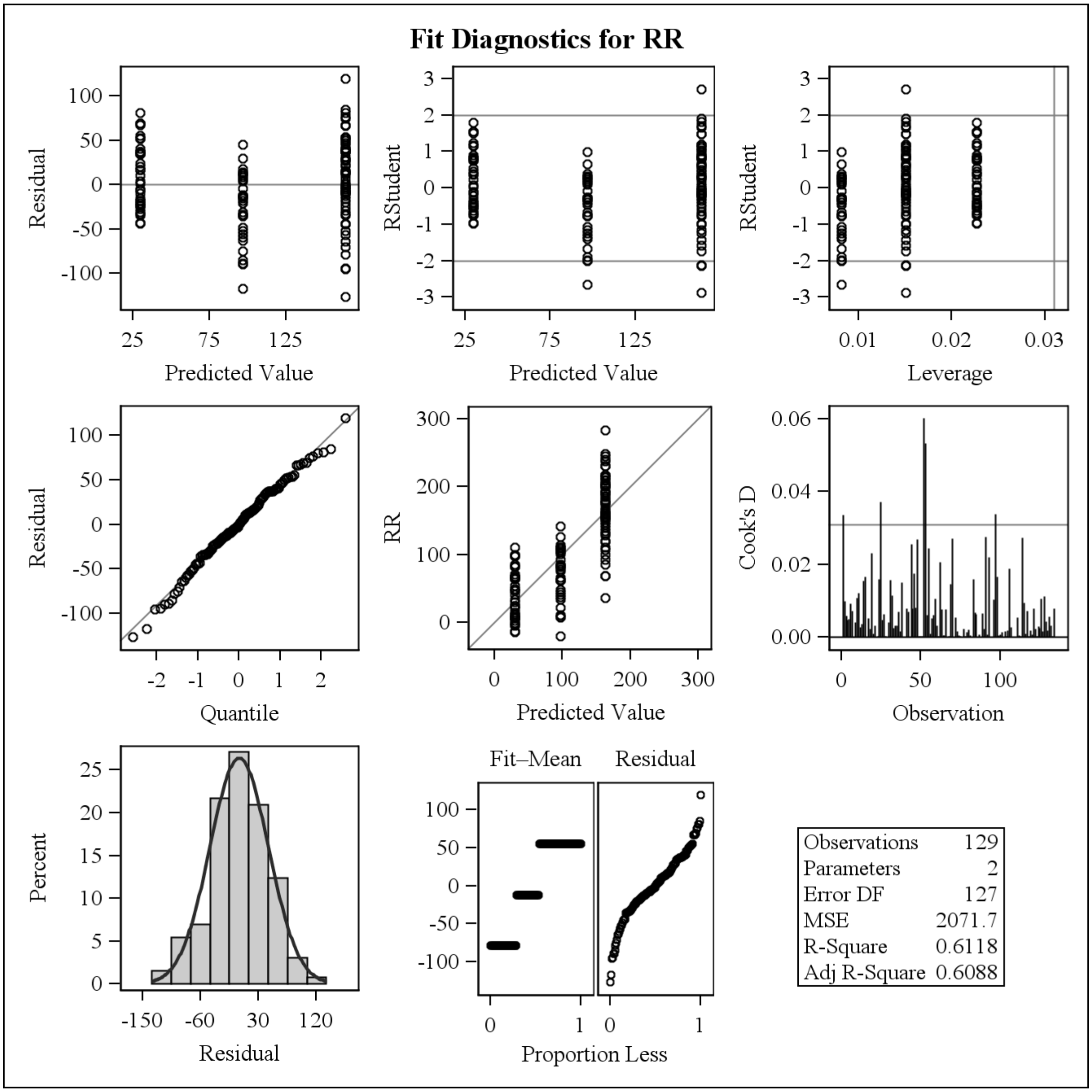
Root MSE	45.51642	R-Square	0.6118
Dependent Mean	108.70488	Adj R-Sq	0.6088
Coeff Var	41.87155		

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	230.42490	9.49043	24.28	<.0001
AEC	1	-66.81652	4.72239	-14.15	<.0001

Durbin-Watson D	2.084
Number of Observations	128
1st Order Autocorrelation	-0.062



Level of AEC	**N**	**RR**	
		Mean	**Std Dev**
1	60	170.480167	48.7962717
2	32	71.022656	39.1808170
3	37	41.118784	35.8861312


Fit Diagnostics for RR
Residual
Predicted Value
RStudent
Predicted Value
RStudent
Leverage
Residual
Quantile
RR
Predicted Value
Cook's D
Observation
Percent
Residual
Fit–Mean
Residual
Proportion Less
Observations 129
Parameters 2
Error DF 127
MSE 2071.7
R-Square 0.6118
Adj R-Square 0.6088

Pairwise Comparison of Returns to Risk for 2011-2013

Least Squares Means						
Effect	**AEC**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
AEC	1	170.48	5.5686	126	30.61	<.0001
AEC	2	71.0227	7.6252	126	9.31	<.0001
AEC	3	41.1188	7.0913	126	5.80	<.0001

Differences of Least Squares Means									
Effect	**AEC**	**_AEC**	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**	**Adjustment**	**Adj P**
AEC	1	2	99.4575	9.4421	126	10.53	<.0001	Tukey-Kramer	<.0001
AEC	1	3	129.36	9.0164	126	14.35	<.0001	Tukey-Kramer	<.0001
AEC	2	3	29.9039	10.4129	126	2.87	0.0048	Tukey-Kramer	0.0132

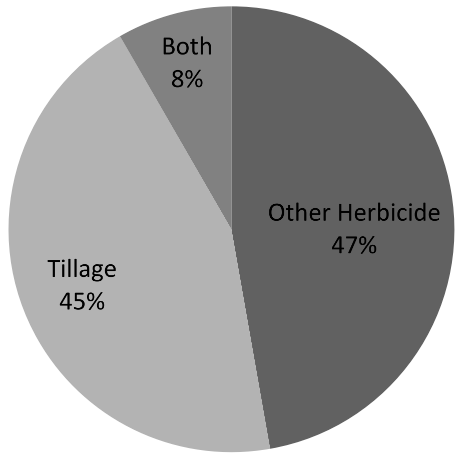
Appendix F: Summer Fallow

While it may seem little management or money would be involved in maintaining fallow ground, its management is actually critical to the following winter wheat crop. In order to preserve stored moisture, weeds must be managed to prevent their uptake of water. Traditional summer fallow involves many tillage operations to eliminate weeds. Current trends to use less tillage have popularized chemical fallow, which is typically referred to as "chem fallow." This type of fallow relies heavily on herbicides to suppress weeds, although some lighter tillage operations may still occur. Herbicide timing is critical, and highly dependent on the weather. The longitudinal survey provided an opportunity to collect data on fallow practices. Since many of the survey participants use chem fallow, the following economic data are more typical of chem fallow than traditional summer fallow.

Costs of Fallow maintenance and glyphosate application by year.

Year	Average Cost of Fallow	Average Ounces of Glyphosate Applied
2010	$34.82	62.5
2011	$29.91	63.7
2012	$36.06	66.1
2010-12	$33.60	64.1

Chemical fallow uses glyphosate applications, as it provides a cheap and efficient way to kill weeds. Growers in the longitudinal survey with chemical fallow use three to four applications over a 12-month period, typically applying over 60 ounces of glyphosate. These applications include different strengths and formulations of glyphosate, so the specific amount applied should not be emphasized, but these data reveal how important glyphosate is to chemical fallow practices. Also it is important to note over 60% of growers in this survey are using techniques in addition to glyphosate during fallow to control weeds, either another herbicide with a different mode of action or some form of tillage.



Percent of Growers Using Other Weed Control Methods in "Chem Fallow"

The cost of summer fallow includes inputs, machinery, and labor. While the average cost per acre is not large, on average less than $40, these expenses will not be reimbursed for over a year. Winter wheat is planted in the fall following fallow, which will be harvested almost a year later. On a 5,000-acre farm with half the acres fallowed, this represents $85,000 in outlays. The fallow costs plus a year's interest are paid for by the winter wheat enterprise. Additional spray applications or tillage passes add to the fallow cost, therefore timing is important to limit the passes in summer fallow. The management of fallow ground is rarely given the attention it merits.

Appendix G: Participant Demographics

The growers involved in this survey were chosen because of past collaboration with the university research and their willingness to be involved in a longitudinal study. Demographic information about the producers interviewed is summarized in this section to give a description of the producers.

Age of longitudinal survey participants

Age	Percentage
Less than 45	21.6%
45-59	37.3%
60+	41.2%
Average Age	55.51

The average age of the participants is similar to the average grower age nationally, which was 56.3 years for all operators in 2012 (USDA-NASS). Survey participants represent a high level of education, as almost 90% have at least some college, and over 40% have at least a 4-year degree.

Level of education of longitudinal survey participants

Level of Education	Percent
High School	5.9%
Vocational training	3.9%
Associate's degree	17.6%
Some college	25.5%
Bachelor's degree	37.3%
Graduate/professional degree	9.8%

The bulk of the REACCH study area is located in WA, which explains why the majority of the participants are from Washington. Out of the 47 growers, 34 are from Washington, five from Oregon, and nine from Idaho.