Utah State University

DigitalCommons@USU

All Graduate Plan B and other Reports

Graduate Studies

12-2016

Econometric Modeling of the Public Grazing Fee's Impact on the U.S. Sheep Industry

Ryan C. Feuz
Utah State University

Follow this and additional works at: https://digitalcommons.usu.edu/gradreports

Part of the Agribusiness Commons

Recommended Citation

Feuz, Ryan C., "Econometric Modeling of the Public Grazing Fee's Impact on the U.S. Sheep Industry" (2016). *All Graduate Plan B and other Reports*. 867.
https://digitalcommons.usu.edu/gradreports/867

This Report is brought to you for free and open access by the Graduate Studies at DigitalCommons@USU. It has been accepted for inclusion in All Graduate Plan B and other Reports by an authorized administrator of DigitalCommons@USU. For more information, please contact digitalcommons@usu.edu.

ECONOMETRIC MODELING OF THE PUBLIC GRAZING FEE'S IMPACT ON THE U.S. SHEEP INDUSTRY

by

Ryan Feuz

A research paper submitted in the partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Applied Economics

Approved:

Man-Keun Kim Major Professor	Ryan Larsen Committee Member
DeeVon Bailey Committee Member	

UTAH STATE UNIVERSITY
Logan, Utah 2016

Copyright © Ryan Feuz 2016

All Rights Reserved

ABSTRACT

ECONOMETRIC MODELING OF THE PUBLIC GRAZING FEE'S IMPACT ON THE U.S. SHEEP INDUSTRY

by

Ryan Feuz, Master of Science

Utah State University, 2016

Major Professor: Dr. Man-Keun Kim
Department: Applied Economics

The U.S. sheep and wool industry is one of the oldest agricultural industries within the country. Since the mid 1940's the industry has witnessed dramatic annual declines in sheep inventories. Many factors have contributed to the decline of the sheep industry including declining consumption of lamb and mutton, the growth in manmade fiber use, scarcity of labor, and predator losses. The U.S. congress has attempted to slow this decline throughout the years with various policy including the use of wool marketing loan programs. Such programs are intended to help bring stability as well as to mitigate price risk within the industry. However, despite these efforts the industry continues to experience annual declines in inventory.

The United States has vast quantities of public land especially within the western states that is utilized for grazing of livestock every year. Public-land grazing is an important element within the sheep industry with a large portion of sheep producers utilizing the resources available through public-land grazing. For the vast majority of this public land, the fee to graze livestock is charged on a per AUM (animal unit month) basis and is established annually through the use of a set formula. Public grazing fee policy is a widely debated topic with many opposing viewpoints.

This research will attempt to evaluate the effects on the sheep and wool industry of policy change in regards to increasing or decreasing the public grazing fee.

This analysis uses capital stock inventory accounting methodology to create an econometric model of the U.S. sheep and wool industry. The model is then used to quantify the impact of different levels of public grazing fees under three scenarios which represent a baseline (current level of grazing fee), an increase in the public grazing fee, as well as a decrease in the grazing fee, respectively. Results indicate under a baseline no change scenario the sheep industry will remain relatively stable with some modest decline in numbers expected within the next five years. Abolishment of the public grazing fee would be expected to bring added stability to the sheep and wool industries with total sheep inventories expected to remain fairly constant with some modest growth projected within the next five years. This suggests that lowering the public grazing fee could be a possible policy alternative which could be implemented to help bring stability to the sheep and wool industries. Conversely, projections indicate that raising the grazing fee would have an adverse effect on these industries and contribute to a projected increase in the rate of decline of the sheep and wool industries.

CONTENTS Page

ABSTRACT iii

LIST OF TABLES vii

LIST OF FIGURES vii

1. INTRODUCTION 1

1.1. Introduction 1
1.2. Research Objectives 3
1.2.1 Topic Justification 4

2. LITERATURE REVIEW 5

2.1. Modeling Sheep and Wool Industry 5
2.2. Studies on Public Land Grazing 8

3. U.S. SHEEP AND WOOL MODEL 17

3.1. Model Development 17

3.1.1. Individual Equations 18
3.1.2. Supply and Demand 28

3.2. Data .... **Error! Bookmark not defined.**
3.3. Regression Results 29

4. DISCUSSION AND IMPLICATION 36

4.1. Public Grazing Fee Policy Implications: 36
4.2. Scenario Results: 40

4.2.1. Scenario 1: Baseline 40
4.2.2. Scenario 2: Public Grazing Fee Increased 40
4.2.3. Scenario 3: Public Grazing Fee Decreased 41

5. CONCLUSIONS AND POLICY IMPLCATIONS 43

5.1. Conclusions and Implications 43
5.2. Future Policy Expectations: 44
5.3. Scope and Limitations: 44
5.4. Future Research: 44

REFERENCES .... **Error! Bookmark not defined.**

APPENDIX 51

LIST OF TABLES

Table Page

Table 1. 2013 World Sheep Inventory- Top 10 Countries 3

Table 2. 2016 U.S. Sheep and Lamp Inventory- Top 10 States 3

Table 3. Summary of Fee and Non-Fee Grazing Costs, 1966 14

Table 4. Model Variables 19

Table 5. Regression Results 30

Table 6. Scenario 1: Baseline Projections 40

Table 7. Scenario 2: Increased Public Grazing Fee Projections 41

Table 8. Scenario 3: $0/AUM Public Grazing Fee Projections 42

Table 9. Examination of Grazing Cost Passthrough 44

Table 10. Data Summary Statistics 50

LIST OF FIGURES

Figure Page

Figure 1. Total All Sheep Inventory 1

Figure 2. Model Outline........ 17

Figure 3. Total BLM and USFS Direct Grazing Appropriations vs. Receipts 2002-2014 37

Figure 4. Calculated Public Fee and PRIA Fee Compared to Private Grazing Rates........ 38

Figure 5. All Sheep Inventory........ 42

CHAPTER 1

INTRODUCTION

1.1. Introduction

The U.S. sheep industry, in terms of sheep inventory, has experienced dramatic declines over the last 70 years. Since 1942 when the industry reached its climax within the country with over 56 million total head, it has now fallen to under 9.5 percent of that value with only 5.28 million head in 2015. Figure 1 depicts the dramatic decline within the sheep industry between 1942 and the present.

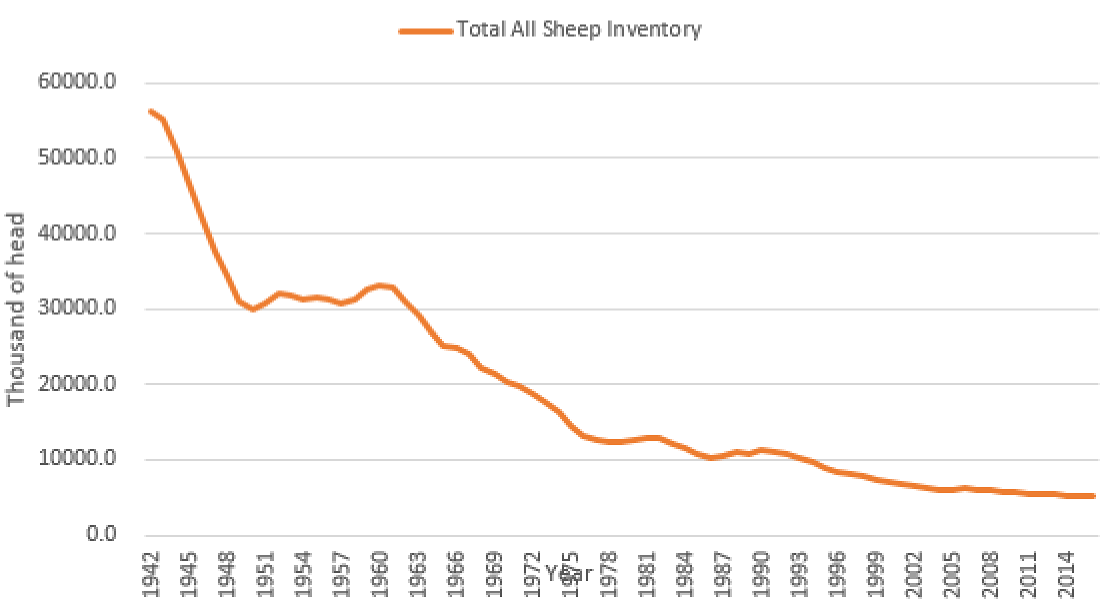

Figure 1. Total All Sheep Inventory

Many have speculated as to the cause of this large decline in numbers and have pointed to various events and changes within the industry as the main culprit. However, the reality is that there is no one single culprit but rather the decline has come as a result of a culmination of various events and consumer preference changes.

Beginning in the mid 1940’s, the industry first started to experience a decline as WWII came to an end and resulted in a large decrease in demand for wool used for the military (Jones, 2004). Throughout the 1960’s and into the 1970’s many synthetic fibers were developed and grew in prominence and a wide spread consumer preference change occurred as more and more consumers demanded synthetic fiber blends over wool as they preferred the appearance as well as the favorable price (Jones, 2004). While the industry may have weathered the storm from the decrease in wool demand, compounding those effects was the simultaneous decline in lamb and sheep meat consumption. Ever since sheep were first domesticated nearly 10,000 years ago in central Asia, the industry has revolved around the joint products of wool and meat. As the wool industry contracted in the U.S. a shift to a greater focus towards meat production would have been expected. However, just as wool and fiber preferences changed so too did the meat consumption preferences of consumers. Per capita consumption fell from over 4.5 lbs. in 1961 to just over 1 lb. in 2015. During the same time period, consumption of chicken rose from 30 lbs. to over 91lbs. per capita (Livestock Marketing Information Center meat consumption data). Additionally, the scarcity of labor to tend sheep as well as predator losses have also been suggested as contributors to the decline (Jones, 2004). All of these factors have combined to create the perfect storm of conditions to render the U.S. sheep market nearly insignificant within the world economy.

Table 1 lists the top 10 sheep inventory countries. While China has the highest total inventory, it is truly Australia that is the king of the sheep industry with the highest number of sheep per capita. The U.S. has a very small presence in the overall global sheep market. Nearly half of the lamb and mutton consumed within the U.S. is imported annually most notably from Canada, Australia, and New Zeeland (Jones, 2004). The U.S. sheep inventory accounts for less than 0.5 percent of the total global sheep inventory. Within the U.S., sheep production takes place in all 50 states, however, the vast majority of production is concentrated in Texas and the mountain west states. In table 2 the top 10 sheep inventory states can be seen making it very evident that the distribution of sheep production within the country is very uneven with the vast majority of production taking place in the western states.

Table 1. 2013 World Sheep Inventory - Top 10 countries

Country	Number of head
China	185,000,000
Australia	75,547,846
India	75,500,000
Sudan	52,500,000
Iran	50,220,000
Nigeria	39,000,000
New Zealand	30,786,761
United Kingdom	32,856,000
Pakistan	28,800,000
Turkey	27,425,233
Total	**1,172,833,190**

Source: FAOSTAT 2014

Table 2. 2016 U.S. Sheep and Lamb Inventory - Top 10 states

State	Number of head
Texas	735,000
California	575,000
Colorado	435,000
Wyoming	355,000
Utah	285,000
Idaho	255,000
South Dakota	255,000
Montana	230,000
Oregon	190,000
Iowa	175,000
Total	**5,320,000**

Source: USDA NASS Sheep and Goat Report, January 29, 2016

1.2. Research Objectives

With the current conditions of the declining U.S. sheep industry in mind, the chief aim of this research will be to evaluate the consequences on the U.S. sheep and wool industry of policy changes increasing the public grazing fee used by the Bureau of Land Management (BLM) and United States Forest Service (USFS). Additionally, the research will aim to evaluate whether a decrease in this same public grazing fee could be utilized as a potential policy change to help reverse the negative trend on inventory in these industries or at least slow the decline to some degree.

This aim will be accomplished through the completion of various objectives. First, a comprehensive literature review will be conducted to gain a better understanding about the establishment of the current and historic public grazing fee as well as to evaluate current research for possible connections between the public grazing fee and sheep inventory levels. Second, data will be collected for the U.S. sheep and wool market to build an econometric model utilizing capital stock inventory accounting methodology to model both the supply and demand within the joint sheep and wool industries. Third, the model will be utilized to create a baseline projection for the next five years. Fourth, multiple scenarios will be created with adjustments made to the public grazing fee and updated projections will be obtained from the model which will demonstrate the effects of public grazing fee adjustments on the levels of sheep and wool production within the country.

1.2.1. Topic Justification

The sheep industry is among the oldest domesticated livestock industries in the world (Beam, 2009). While it is by no means a large contributor to the U.S. economy at large, it is still an important part of the agricultural sector and is vital to the livelihood of many ranchers throughout the country (National Research Council , 2008). In order to help protect the industry the U.S. government has established various tools and aids. Public grazing fees are charged to ranchers permitting them to graze livestock on public lands. This cost is surely influential in determining the overall viability of all livestock industries. The level of the public grazing fee has been widely debated with some arguing it should be raised dramatically to coincide with private grazing fees determined by the market (Halladay, 2015), while others argue it should be lowered to help stabilize livestock industries as well as provide access to public lands for more ranchers (Rimbey & Torell, 2011).

This research evaluates the impacts of various policy changes affecting the public grazing fee on the U.S. sheep industry. If raising the level of the fee can be shown to promote further declines in the industry or inversely if a lowered fee can be shown to help slow the decline in the industry this research could be instrumental in providing evidence for the direction which policy makers should pursue in setting the public grazing fee moving forward. This research is larger than simply informing policy decisions because it may have a direct effect on the livelihood of sheep ranchers as well as other livestock producers throughout the country. The sheep industry has been experiencing long-term declines in the U.S. This research will aid in evaluating a possible tool that could be utilized to help slow this decline.

CHAPTER 2

LITERATURE REVIEW

A thorough review of current and relevant literature will be undertaken in conjunction with this research. A literature review helps pave the way for achieving the research aims of this project as well as placing them into context. Few studies have been conducted on the sheep industry in the U.S. with the majority of livestock research focusing on cattle and swine. Within this review two main topics will be focused on; literature regarding modeling sheep inventories in the U.S., and research about public grazing fees. The review is primarily based on current literature as well as older research that is considered seminal to the research question.

2.1. Modeling Sheep and Wool Industry

Research on sheep and wool supply/demand models is limited with only a few prominent studies having been completed. Witherell (1969) is one of the earliest researchers to build econometric models to describe characteristics of wool production in five leading countries including Australia and New Zealand, and the U.S. Witherell (1969) found wool production is highly price inelastic and the cross-price effect of lamb was not significant.

Whipple and Menkhaus (1989) constructed a dynamic supply model of the U.S. sheep industry. The model was estimated using least squares techniques while incorporating restrictions on fixed capital and the demographic characteristics of the breeding flock. The model is then simulated to generate a matrix of short- and intermediate-run elasticity estimates. “The estimates indicate that the sheep inventory is positively related to lamb price in the short-run and the intermediate-run (ten plus years), although it is inelastic in the short run. The supply response to wool price also is positive and quite elastic in the intermediate term. These results imply that both lamb and wool prices are important to the maintenance of the U.S. sheep industry” (Whipple & Menkhaus, 1989, page 126).

Anderson, Richardson, and Smith (2001) built upon an econometric model of the sheep industries to help evaluate policy change regarding various wool marketing loan rates. Nonrecourse marketing assistance loans are administered by USDA's Farm Service Agency (FSA) on behalf of the Commodity Credit Corporation (CCC). These are nine-month loans designed to provide eligible producers with interim financing for their wool production. The intent of the program is to help stabilize production and to facilitate orderly distribution of production throughout the year. Producers who qualify are able to store production instead of selling immediately after shearing when prices tend to be the lowest. The wool itself is pledged as collateral for these marketing loans. As prices become more favorable producers can then sell their wool and repay the loan. If in the event that producers are unable to sell their wool they are able to deliver to the CCC the quantity of wool pledged as collateral as full payment for the loan at maturity (Farm Service Agency, 2004).

Anderson, Richardson, and Smith (2001) modeled two scenarios with the marketing loan rate set at $1.00 and $1.20 per pound greasy for wool. Through the use of the model, projections for total supply, demand, and market price for a five year period (2001-2005) were made. Using simulation modeling techniques the researchers were then able to develop probabilities of outcomes. This then allowed them to develop average government costs associated with the marketing loan rate program and probabilities of costs in each year. The results indicated that under $1.20 per pound loan rate government costs would average about $19 million per year while at the $1.00 per pound loan rate these costs would decline to an average of $10 million per year. With these results the authors were then able to work with industry participants to develop a potential schedule of premiums and discounts for the marketing loan program (Anderson, Richardson, and Smith, 2001).

Meyer (2002) noted that within most models of agriculture commodities factors outside of agricultural markets are often treated as exogenous. This is only natural as few direct substitutes for the products produced in agricultural markets exist outside of agricultural markets. Meyer (2002) recognized, however, that with the development of synthetic fibers the fiber markets such as cotton and wool possess a substitute outside of the agricultural markets which should not be treated as exogenous. As the demand for fibers is a derived demand for their use in production of textile products, it is equally important to understand the market for finished textile products. Meyer (2002) developed a model of inter-fiber competition with cotton as the primary focus but also covered synthetic and cellulosic fibers as well as wool within the United States. The results indicated that “natural and man-made fibers are indeed substitutes, and that productive capacity of man-made fibers is therefore likely to have an impact on the market prices for man-made and natural fibers for an extended period of time” (Meyer, 2002, page iii)

Ribera, Anderson, and Richardson (2004) developed an econometric model of the U.S. Sheep and Wool market to evaluate policy changes regarding the wool marketing loan rate. A baseline projection was created for the 2003-2008 time span with the assumptions of no change in the loan rate at the current time ($1 per pound of wool). The baseline indicated stock ewe numbers continuing to decline throughout the time horizon reaching about 2.5 million by 2008, while lamb and mutton imports were projected to increase to about 200 million pounds by 2008. Adjustments were then made to evaluate two policy alternative scenarios. In scenario 1 the loan rate was eliminated and therefore set at $0/lb. In scenario 2 the loan rate was increased by 100 percent to $2.00/lb. The results of these scenario projections showed stock ewe numbers would continue their negative trend, however, the magnitude of the negative trend was projected to be much smaller under scenario 2 as compared to scenario 1. Under the first scenario stock ewe numbers were projected to reach just 2 million by 2008 compared to 3.7 million under the second scenario. These results indicated that while policy adjustment to the marketing loan rate would most likely not stop the negative trend in the industry, it could be utilized as a tool to slow the negative trend. Ribera also noted that the scenarios would also have a projected impact on lamb and mutton imports, wool exports, and slaughter lamb price. In the short-run the loan rate was shown to have a positive effect on imports as producers would be looking to build their herds and therefore increase the replacement numbers, however, in the long-run the loan rate was projected to have a negative effect on imports. The model indicated a positive relationship between the loan rate and wool exports because a higher loan rate would result in an increase in wool production and thus an increase in the wool available for export. Finally, slaughter lamb prices were also shown to be impacted through wool marketing loan rate policy change. A higher loan rate lead to an increase in projected lamb slaughtering and a decrease in lamb prices, while a lower loan rate was shown to have an inverse effect (Ribera, Anderson, and Richardson, 2004).

2.2. Studies on Public Land Grazing

As this research will focus on the implications of policy changes surrounding the public grazing fee, a review of relevant literature surrounding public land grazing as well as the public grazing fee is necessary.

Within the U.S. there are millions of acres of rangeland owned by the federal government. This land has played a large part in the grazing of livestock for some time. Since the early 1900s, the federal government has required ranchers to pay a fee for grazing their livestock on these vast public rangelands located primarily in the western states. Ten federal agencies have programs to allow private ranchers to graze livestock on portions of the rangelands they manage: the Department of the Interior's Bureau of Land Management (BLM), National Park Service, U.S. Fish and Wildlife Service, and Bureau of Reclamation; the U.S. Department of Agriculture's (USDA) Forest Service; the Department of Energy (DOE); and the Department of Defense's (DOD) Army, Army Corps of Engineers (Corps), Air Force, and Navy.

Tanaka and Gentner (2001) conducted a random survey of ranchers holding public land grazing permits in all western states in 1998 to determine the social and economic characteristics of permit holders, to assess their attitudes about public land policies, and to gauge their responses to three policies related to public land grazing. Respondents were asked how their operations would change due to three different levels of AUM[1] reductions, three different grazing fee increases, and to changes in allowed season of use. The respondents were then placed within eight groups based on characteristics such as management objectives, education, business organization, ranch size, labor, income, and financial aspects. Interestingly, the results of the survey showed that responses to the various policy changes varied between the eight cluster groups and demonstrated the need to consider such variation in attitudes of producers based on such characteristics when making policy decisions. The survey indicated sheep ranchers (one of the eight clusters) have the highest dependence on public forage across all seasons. Their findings also indicated when faced with an increased public grazing fee of $5-$8/AUM the sheep ranchers demonstrated the largest inclination towards reducing the scale of their ranching operations. The researchers felt since sheep margins tend to be relatively tighter, and higher costs will make that enterprise less profitable faster, ranchers may begin to make a move from fewer sheep and perhaps more profitable cattle (Tanaka & Gentner, 2001).

Godfrey (2008) completed a report for the Utah Governor's Public Lands Policy Coordination Office in which he surveyed livestock producers within Utah. The main objective of the report was to provide data on the use of public and private lands in Utah by domestic livestock with an emphasis on sheep and beef cattle. Additionally, the report outlined some of the issues that are associated with the use of public rangelands. Godfrey concluded that within Utah there has been a large reduction in the use of public lands administered by the BLM and USFS by cattle, sheep, horses, and goats overtime. This decrease has resulted in an increasing proportion of the feed needed for livestock to be produced on private lands. He also found that on average producers who hold public grazing permits have much larger operations than livestock producers without permits. He found that those without permits could generally be considered part-time producers whose primary occupation is not the production of livestock (Godfrey, 2008).

[1] By definition, the AUM is the amount of forage needed by an "animal unit" (AU) grazing for one month. The quantity of forage needed is based on the cow's metabolic weight, and the animal unit is defined as one mature 1,000 pound cow and her suckling calf.

Watts, Shimshack, and LaFrance (2006) addressed the appropriate public grazing policy using a dynamic game to determine the optimal grazing policy. Similar to fishing without a license or poaching big game, the authors noted that overgrazing by privately-owned livestock on public lands are all examples of a common resource management problem. The tragedy of the commons is a theory of a situation in a shared-resource system where individual users acting independently according to their own self-interest behave contrary to the common good of all users by depleting that resource through their collective action. The problem arises as individual users face incentives that are not socially optimal. Generally, to help protect against this tragedy of the commons occurring, access fees for public resources are established. However, a delicate balance is created as fees are charged. If fees are found to be too low then resources will continue to be over used and abused. If fees are deemed too high then often this produces a greater incentive for users to engage in unlawful activities. To find the optimal balance the researchers developed an economic model using game theory.

In the first stage of the game the government chose the administrative rules, grazing fees, penalties for failing to comply, and monitoring strategy. These are then announced publicly and the government commits to this policy regime for all time. In each subsequent stage individual ranchers choose the stocking rate and the government chooses its monitoring actions. The assumptions are that all parties are risk neutral and form rational expectations, and the focus is on a subgame perfect Nash equilibrium for the dynamic resource-use game. The optimal solution arrived at is that the optimal grazing policy should include grazing fees that are lower than competitive private rates, along with an element of random monitoring to prevent strategic learning by cheating ranchers and avoid wasteful efforts to disguise noncompliant behavior. Additionally, within the optimal policy it was determined that it was necessary to include a penalty for cheating beyond terminating of the lease. The penalty should be large enough that the rancher who would profit the most from cheating would actually experience negative expected net returns (Watts, Shimshack, and LaFrance, 2006).

In 1978 the Public Rangeland Improvement Act (PRIA) was created. This established the formula to be used in calculation of the public grazing fee. The PRIA formula (1) was created as follows:

$$\textbf{(1)}\ Fee_t = \$1.23 \times (FVI_{t-1} + \beta_2 BCPI_{t-1} - PPI_{t-1})/100,$$

Where:

FVI = Forage Value Index, or an index of private grazing lease rates in the 11 western states, with 1964-68 as the base period

BCPI = Beef Cattle Price Index, or an index of cattle prices with 1964-68 as the base period

PPI = Prices Paid Index, or an index of the prices paid by producers to purchase inputs, with 1964-68 as the base period

When the PRIA formula was first proposed it only included the FVI which tracks price movement in the private forage market. However, public land ranchers and the Interdepartmental Grazing Fee Technical Committee assigned to study grazing fee alternatives in the 1960s questioned the ability of the FVI to account for short-term demand, supply, and price equilibrium, and, for this reason, the BCPI and PPI were added to the fee formula (Torell et al, 2003).

Torell et al. (2003) wanted to evaluate whether adding the BCPI and PPI did, in fact, help explain short-term market fluctuations. Torell et al (2003) utilized the statistical model in formula (2) below, which had been developed earlier by McCarl and Brokken (1985), in order to evaluate the effectiveness of the PRIA formula.

$$\textbf{(2)}\ FVI_{t+1} = \beta_0 + \beta_1 FVI_t + \beta_2 BCPI_t + \beta_3 PPI_t + u_t$$

McCarl and Brokken (1985) noted, "The regression of current and lagged values is based on a normalization (indexing) of private land lease rate data. Predicting lease rates at year t +1 is equivalent to predicting FVIt+1 with normalization of the data. The error term (u_t) captures random differences in the FVI between years" (Torell, Rimbey, Van Tassell, Tanaka, & Bartlett, 2003, page 775). Dividing the predicted FVI_{t+1} (from equation 2) by 100 and multiplying by the 1964–1968 base lease rate used to estimate the FVI index ($3.65 AUM) gives the estimated private land lease rate at time t + 1. To estimate the public land lease rate at t+1, the predicted FVI_{t+1} is divided by 100 and then multiplied by $1.23 (Public Rangeland Improvement Act (PRIA) base). The researchers noted that the PRIA formula implies the restrictions β_0=0, β_1=1, β_2=1, and β_3=-1. Using data from 1964-2001, they first created an unrestricted PRIA equation (3) using regression as follows:

$$\textbf{(3)} \quad FV\hat{}I_t = 4.5561 + 0.906^{*}FVI_{t-1} + 0.085BCPI_{t-1} + 0.0085PPI_{t-1}$$

(10.572) (0.164) (0.0476) (0.08475)

R^2= 0.985 Adjusted R^2= 0.984 n=37

(Values in parenthesis are standard errors)

From these results the researchers noted that only the parameter for Forage Value Index (FVI) came back as statistically significant at the α=0.05 level. They then imposed the PRIA restrictions such as those previously noted above. This resulted in a highly significant F-statistic (F = 1,526, P < 0.0001) suggesting that at least one of the restrictions implied by PRIA did not hold. The second test, H_0: β_1= 1, β_2= 0, and β_3= 0, resulted in an insignificant F-statistic (F = 1.17, P < 0.34), suggesting that the PRIA restrictions that did not hold in the first test were the inclusion of the BCPI and PPI. The authors then concluded that, "Adding the Beef Cattle Price Index (BCPI) and Prices Paid Index (PPI) to the Public Rangeland Improvement Act (PRIA) formula did not improve the fee formula's ability to predict annual forage values. In fact, adding these 2 indices greatly hindered the predictive ability of the formula and PRIA-generated grazing fees have fallen further and further behind private land lease rates through time. Similar to the earlier findings of

McCarl and Brokken (1985), our results show that these 2 indices did not improve the ability of the fee formula to predict forage value and did not help explain short-term market imperfections as envisioned by the 1977 Grazing Fee Technical Committee. Including these 2 indices in the PRIA formula, especially with a weighting of 1, was mistake if predictive power and tracking of the private forage market are important" (Torell, Rimbey, Van Tassell, Tanaka, & Bartlett, 2003, page 580). Interestingly, had only the Forage Value Index (FVI) been used to adjust grazing fees as originally purposed in 1969, the federal grazing fee would have been $4.15 AUM during the 2002 grazing season as compared to $1.43 (Torell, Rimbey, Van Tassell, Tanaka, & Bartlett, 2003).

Citing studies similar to Torell, Rimbey, Van Tassell, Tanaka, & Bartlett (2003). many argue the public grazing fee should be raised to be brought more in line with private grazing rates (Halladay, 2015). However, when considering the value of grazing fees it is important to recognize the full costs of grazing livestock on public and private land. Many of the costs associated with livestock grazing (fence maintenance, water supply, etc.) are covered by the private land owner whereas on public land many of these costs must be covered by the permit holder. This has long been recognized as a problem when trying to make comparisons between public and private grazing rates. Rimbey and Torell (2011) summarized two previous studies completed in which the public grazing rate was analyzed and the cost differential between public and private rates was quantified. They then completed and updated analysis of the cost differential between the 2011 grazing fee ($1.35/AUM) and the market private rates at the time. Rimbey and Torell (2011) first referenced a study completed in 1966 by an Interdepartmental Task Force established by congress and tasked with establishing the method of setting the public grazing rate each year. Among the chief goals of the task force's study was to establish the difference between public and private grazing rates. This price differential was arrived at through a cost comparison between public and private grazing between both cattle and sheep. A summary of the findings at the time of the 1966 study can be seen in table 3 below.

The cost differential arrived at ($1.23/AUM) was then suggested to be used as the basis of the public grazing fee at that time to bring the public fee in line with private grazing fees.

Table 3. Summary of Fee and Non-Fee Grazing Costs, 1966

Item	Cattle Public	Cattle Private	Sheep Public	Sheep Private
Lost Animals	$ 0.60	$ 0.37	$ 0.70	$ 0.65
Associtaion Fees	$ 0.08	$ -	$ 0.04	$ -
Veterinarian	$ 0.11	$ 0.13	$ 0.11	$ 0.11
Moving Livestock	$ 0.24	$ 0.25	$ 0.42	$ 0.38
Herding	$ 0.46	$ 0.19	$ 1.33	$ 1.16
Salt and Feed	$ 0.56	$ 0.83	$ 0.55	$ 0.45
Travel	$ 0.32	$ 0.25	$ 0.49	$ 0.43
Water	$ 0.08	$ 0.06	$ 0.15	$ 0.16
Horse Cost	$ 0.16	$ 0.10	$ 0.16	$ 0.07
Maintenance	$ 0.43	$ 0.40	$ 0.20	$ 0.24
Development Depreciation	$ 0.11	$ 0.03	$ 0.09	$ 0.02
Other Costs	$ 0.13	$ 0.14	$ 0.29	$ 0.22
Private Lease Rate	$ -	$ 1.79	$ -	$ 1.77
Total Non-Fee Costs	$ 3.28	$ 4.54	$ 4.53	$ 5.66
Cost Difference/Forage Value		$ 1.26		$ 1.13
Weighted Cost Difference			$ 1.23	

(weighted by relative AUMs of cattle and sheep on public lands)
Source: Rimbley and Torell, 2011

They then referenced a study completed by themselves along with Bartlett and Van Tassell in 1991-92. For this study the authors had been asked by the BLM and USFS to take a look at the grazing fee and evaluate the cost differential at that time. In order to accomplish this objective the researchers attempt to update the previous 1966 study completed by the interdepartmental task force and determine the current cost differential between public and private grazing rates. Given their limited resources they chose to complete the update using a limited scope of only three states; New Mexico, Wyoming, and Idaho. Random samples of public and private grazers were drawn in each state and face-to-face interviews were held with permittees/lessees of public and private forage resources during 1991-92. Through the sampling and interview process the cost values were updated for both private and public grazing and the cost differential at that time was found to have declined to $0.13/AUM for those three states in 1992. Then in 2011 Rimbey and Torell again made an updated calculation for the cost differential. For the 2011 update the data collected in the 1992 study was utilized and updated it to 2011 values through the use of USDA-NASS indices. The total cost to graze on public land was estimated to be $33.24/AUM, while comparable private land grazing costs were estimated to be $32.04/AUM. This indicated that the differential had now changed signs. In others words in 2010, public land grazers were paying $1.20/AUM more than those leasing private land and, therefore, the fee that would have equalized total costs of grazing in 2010 would have been a payment to public land ranchers of $1.20/AUM (Rimbey & Torell, 2011).

In 2005 the U.S. Government Accountability Office (GAO), in response to a request by Congress, released a report wherein they were asked to determine four things; "(1) the extent of grazing on, and program purposes for, lands managed by the 10 federal agencies within the fiscal year of 2004; (2) amount spent in the fiscal year by the 10 agencies, and other federal agencies having grazing-related activities, to manage livestock grazing on public lands, (3) total receipts collected during the fiscal year for grazing privileges by the 10 federal agencies with grazing programs, and amounts disbursed to counties, states, or the federal government; (4) fees charged by the 10 federal agencies, western states, and private ranchers, and the reasons for any differences among the fees"(GAO, 2005, page 3). A summary of the findings outlined in the report is as follows:

- The 10 federal agencies collectively managed more than 22.6 million AUMs on about 235 million acres of federal lands for private grazing and land management in fiscal year 2004. Of this total the BLM and USFS managed 21.9 million AUMs on almost 231 million acres or more than 98 percent of the federal lands used for grazing.
- The 10 agencies spent at least $135.9 million of which BLM and the USFS spent the majority of about $132.5 million. The grazing permits and leases the 10 federal agencies manage generated a total of about $21 million from fees charged in fiscal year 2004, or less than one-sixth of the expenditures to manage grazing. From that amount, the agencies distributed almost $5.7 million

to states and counties in which grazing occurred, deposited almost $3.8 million in the treasury as miscellaneous receipts, and deposited at least $11.7 million in separate treasury accounts for the agencies' use.

- Fees charged in 2004 by the 10 federal agencies, as well as state land agencies and private ranchers, varied widely, depending on the purpose for which the fees were established and the approach used to set the fees. The fee BLM and the USFS charged for grazing was established by the PRIA formula with the intent to account for livestock industry prices and to support ranchers and the western livestock industry. It was therefore generally lower than the fees charged by the other federal agencies, states, and private ranchers. The formula was the same PRIA formula used today which incorporates factors that consider ranchers' ability to pay and therefore, the purpose of the fee is not to recover agency expenditures or capture the fair market value of forage.
- For the year 2004 the public grazing fee was established at $1.43 per AUM. The other agencies generally establish their fees based on the market value of the forage, and as a result charged fees ranging from $0.29 to more than $112 per AUM in fiscal year 2004, depending on the location, range condition, and accompanying in-kind services. In order for the BLM and the Forest Service to recover expenditures in the form of fees they would have had to charge $7.64 and $12.26 per AUM respectively.

While this report was mainly intended to be informative in nature and, therefore, did not have any concrete results, the GAO's (2005) conclusions were enlightening. "Depending on the approach taken to set and implement a grazing fee for lands managed by BLM and the Forest Service, the federal government could close the gap that exists between those programs' grazing expenditures and receipts. But any change in the current fee may necessitate that Congress reconsider the purpose of the fee and policy trade-offs of different fees. In addition, an evaluation of the difficulties of implementing the chosen fee would need to be conducted in order to understand the consequences for the agencies' programs and expenditures and to deal fairly with such issues as preference and permit value" (GAO, 2005, page 51).

CHAPTER 3

U.S. SHEEP AND WOOL MODEL

Following the comprehensive review of the literature an explanation of the model constructed for this study as well as the data used will be contained within this chapter.

3.1. Model Development

Figure 2 depicts the model structure developed for the U.S. sheep and wool industry in this research. Each box within figure 2 represents behavioral equations or identities estimated using the historical data gathered. Individual equations are estimated using ordinary least squares (OLS).

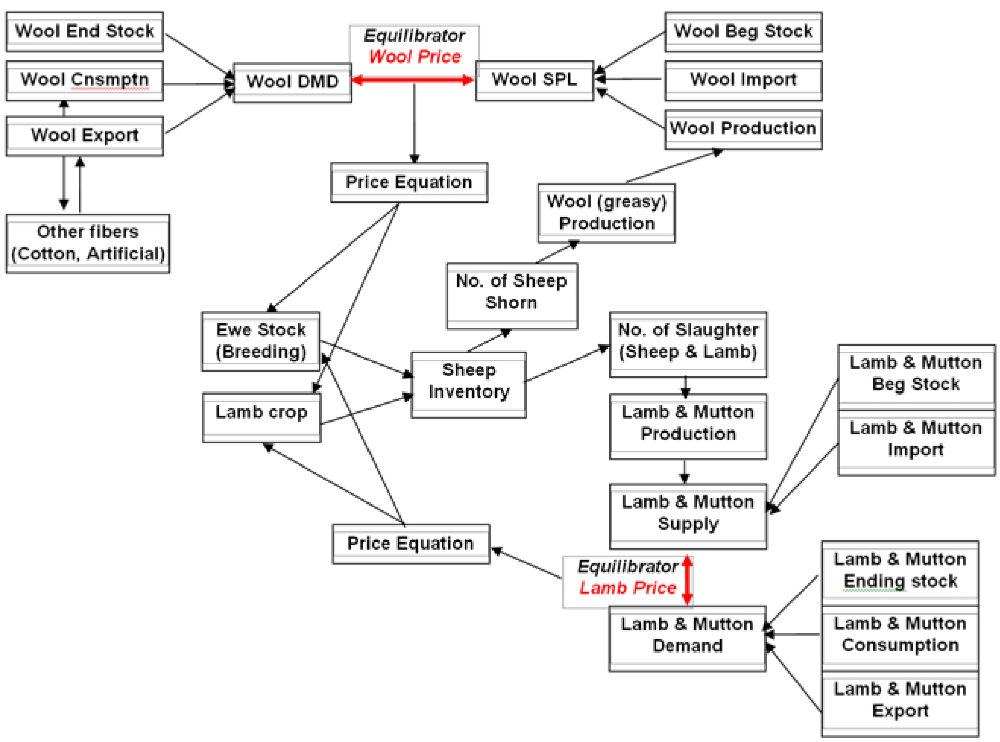

Figure 2. Model Outline

To solve for the equilibrium price within the wool and lamb system, supply and demand are set equal to each other to solve for the market clearing price within the systems.

The market clearing equation is:

(1) $$Supply_{it} - Demand_{it} = 0,$$

where $i = sheep$ and $wool$, and $t =$ year.

The estimated parameters from the various individual equations are used in the calculation of supply and demand and then, through iteration within excel, the equation can be solved resulting in an equilibrium price being established for the lamb and wool system. The lamb and wool industry parameters as well as price will then be projected as a baseline to compare policy alternatives (i.e. grazing fee increase/decrease). With a complex system of equations such as the system contained within this model it becomes difficult to account for simultaneity of equations. Thus, it is noted that this model does not address or account for simultaneity within the system of equations.

3.1.1 Individual Equations:

Table 4 presents definitions and the summary of the variables used in the model. As the individual equations are defined the variable names will be used freely throughout the remainder of this paper. For a table displaying summary statistics for each variable see table 12 in the appendix.

Table 4. Model Variables

Data	Units	Variale Name
Lamb & Mutton Production	Million pounds	LBPROD
Lamb & Mutton Ending Stocks	Million pounds	LBSTK
Dressed Weight	Pounds	DRESWGHT
Total Disappearance	Million pounds	TOTDSPP
Per Capita Disappearance	Pounds per capita	CAPDSPP
Sheep Shorn	Thousand head	SHSHORN
Weight Per Fleece	Pounds	WFLEECE
Wool Production- Greasy	Thousand pounds	WLPRODG
Wool Price Per Unit	Dollar/pound	WOOLP
Wool Loan Rate	Dollar/pound	WLLR
Wool Domestic Production- Clean	Thousand pounds	WLPRODC
Wool Import	Thousand pounds	WOOLIMPT
Wool Export	Thousand pounds	WOOLEXPT
Wool Mill Demand	Thousand pounds	WOOLDMD
Wool Ending Stock	Thousand pounds	WOOLSTK
Wool Unaccounted	Thousand pounds	WOOLUNACT
Wool Mill Price	Dollar/pound	WLMILLP
Average Synthetic Fiber Price (PPI)	1982=100	FIBERP
All Sheep and Lamb, Dec. 31	Thousand head	SHLBFRM
Stock Ewe, Dec. 31	Thousand head	EWESTK
Ewe Lamb, Dec. 31	Thousand head	EWELB
Lamb Crop	Thousand head	LBCROP
Ewe Lamb Added to Stock of Sheep	Thousand head	EWETOSTK
Lamb and Yearling Slaughter	Thousand head	LBYRSLGT
Sheep (mature) Slaughter	Thousand head	SHPSLGT
Feeder Lamp Price, Medium & Large No 1-2, San Angelo	Dollars/Cwt.	LBFEEDP
Slaughter Lamb Price, Choice, San Angelo	Dollars/Cwt.	LBSLGTP
Lamb Carcass Price, Choice-Prime, East Coast, 55-65 lb.	Dollars/Cwt.	LBWP
Sheep Import	Thousand head	SHIMPT
Sheep Export	Thousand head	SHEXPT
Lamb and Mutton Import	Million Pound (carcass)	LBIMPT
Lamb and Mutton Export	Million Pound (carcass)	LBEXPT
Prices Paid Index (all commodities)	1990-92=100	PPIW
Death Loss	Thousand head	LBDEATH
Federal Grazing Fee	Dollar/AUM	GRFEE
US Population	Million people	POPTOTW
Personal Disposable Income	Billions of dollars	ZCEW
Corn Price	Dollars/Bushel	CORNP
International (Australian) Wool Price	Dollar/pound	INTWLP
Consumer Price Index	1982-84=100	CPIUW
Average Price of other meats (beef, chicken, turkey)	Dollars/Cwt.	OMEATP

Slaughter weight equation in (5) is assumed to be a function of the real slaughter lamb price, the maximum between a one period lagged real wool price and the current real marking wool loan rate, the percentage of total head slaughtered that are sheep (vs. lambs and yearlings), and a trend:

$$(5) \qquad Slaughter\ weight_t = SLGTP_t/PPIW_t + MAX(WOOLP_{t-1}/PPIW_{t-1}, WLLR_t/PPIW_t) + Percentage\ sheep\ slaughter_t + Trend.$$

It is hypothesized as the real lamb slaughter price increases the slaughter weight will also increase as producers look to capture more revenue from heavier livestock. Additionally, as the lagged wool price increases or the current year wool marketing loan rate the slaughter weight should also increase as producers postpone slaughtering younger sheep and lambs as they aim to capitalize on high wool prices. As the percentage of sheep slaughtered increases the slaughter weight would be expected to decrease as mature sheep tend to have a lower dressed weight compared to lambs and yearlings who have been raised and fatten for the purpose of slaughter.

The total number of sheep slaughtered is represented in equation (6) as a function of the one-period lagged real sheep slaughter price, the maximum between a one period lagged real wool price and the current real marking wool loan rate, one period lagged lamb crop, one period lagged sheep slaughter, and a one period lagged ewe stock:

$$(6) \qquad Sheep\ Slaughter_t = -SLGTP_{t-1}/PPIW_{t-1} + MAX(WOOLP_{t-1}/PPIW_{t-1}, WLLR_t/PPIW_t) + LBCROP_{t-1} + SHPSLGT_{t-1} + EWESTK_{t-1}$$

All variables aside from lagged real slaughter price are hypothesized to have a positive relationship with the dependent (sheep slaughter) variable. As the slaughter price increases last period more producers would tend to send more of the herd to slaughter. This would result in less inventory available to send to slaughter within the current period and more inventory retained for herd growth during the current period. As the wool price increases last period less sheep would be expected to have been sent to slaughter as producers would tend to retain more sheep to be sheered. During the current period this would most likely result in an increase in sheep inventory and more sheep would be expected to be sent to slaughter as a result.

As the lagged lamb crop increases we would expect there would be greater numbers of sheep and lambs in the current year leading to an increase in the number slaughtered. As the lagged sheep slaughter increases the hypothesis is that the current year number of sheep slaughtered would also increase simply following a trend. As the lagged ewe stock increases we expect to see an increase in the current year sheep slaughter as there would be an abundance of ewe sheep inventory.

Lamb slaughter in equation (7) is a function of the one period lagged real sheep slaughter price, the maximum of either a one period lagged real wool price or the current real marking wool loan rate, a one period lagged lamb and yearling slaughter, a one period lagged lamb crop, current year lamb crop, and a trend.

$$(7) \quad Lamb\ Slaughter_t = -SLGTP_{t-1}/PPIW_{t-1} + MAX(WOOLP_{t-1}/PPIW_{t-1}\ ,\ WLLR_t/PPIW_t) + FEEDERP_{t-1}/PPIW_{t-1} + LBYRSLGT_{t-1} - LBCROP_{t-1} + LBCROP_t + SHPSLGT_{t-1} + Trend$$

Similar to the sheep slaughter equation, within this equation the lagged slaughter price is hypothesized to have a negative relationship with lamb slaughter. Higher slaughter prices increase the number of sheep sent to slaughter. So, a high price in earlier periods results in a smaller inventory being available in the current period to send to slaughter as well as more female lambs being retained for herd growth during the current period. The same positive relationship with lagged wool price/loan rate is hypothesized to exist within the lamb slaughter equation as is hypothesized to exist within the sheep slaughter equation following the same logic. Similar positive signs are also expected in connection with both the lagged and current year lamb crop. As the lagged lamb and yearling slaughter increases it is hypothesized the current year would also increase simply following a short-run trend. A negative overall trend is also expected in line with the long-run trend within the industry.

The slaughter lamb price equation in (8) is a function of the current lamb wholesale price, lamb and yearling lamb slaughter, sheep slaughter, and lamb imports.

$$(8)\quad Slaughter\ Lamb\ Price_t = LBWP_t - LBYRSLGT_t - SHSLGT_t - LBIMPT_t$$

All explanatory variables other than lamb wholesale price are hypothesized to have a negative relationship with slaughter lamb price. Naturally, as the wholesale lamb prices increases or decreases the slaughter lamb price would be expected to have a positive relationship. As total lamb and yearling as well as sheep slaughter increases this increases the supply of lamb and sheep meat and puts downward pressure on the lamb slaughter price. Similarly, as imports increase the supply of lamb increases in the US market and places downward pressure on lamb slaughter prices.

The lamb Crop equation in (9) is a function of the current ewe ending stock as well as a one-period lagged ending stock, one period lagged real slaughter price, the maximum between a one-period lagged real wool price and the current real marking wool loan rate, real public grazing fee, and a trend.

$$(9)\quad Lamb\ Crop_t = EWESTK_t + EWESTK_{t-1} - SLGTP_{t-1}/PPIW_{t-1} + MAX(WOOLP_{t-1}/PPIW_{t-1}\ ,$$
$$WLLR_t/PPIW_t) - GRFEE_t\ /PPIW_t - Trend$$

As both the lagged and current ewe ending stock variables increase the lamb crop is expected increase as greater number of ewe stock leads to more ewes being breed and more lambs produced as a result. As the lagged real slaughter price increases we expect to see a decrease in lambs as producers tend to send more lambs to slaughter. As the lagged real wool price/loan rate increases the expectation is an increase in lamb production as producers look to build herds to capitalize on increased wool prices. As the real public grazing fee increases the hypothesized effect is a corresponding decrease in the lamb crop. Many sheep producers utilize public grazing extensively and as the cost to graze on public land increases it is expected that sheep operations diminish in size and fewer lambs are produced. A negative overall trend is also expected in line with the long-run trend within the industry.

The ewe Stock equation (10) is assumed to be a function of a one-period lagged ewe stock, one period lagged real slaughter price, the maximum of either a one period lagged real wool price or the current real marking wool loan rate, the real public grazing fee, and the U.S. corn price.

$$(10) \quad \textit{Ewe Stock}_t = EWESTK_{t-1} - SLGTP_{t-1}/PPIW_{t-1} + MAX(WOOLP_{t-1}/PPIW_t\,,\ WLLR_t/PPIW_t) - GRFEE_t/PPIW_t - CORNP_t - \textit{Trend}$$

As the lagged ewe stock increases the hypothesis is that the current year would also increase simply following a short-run trend. A hypothesized negative relationship exists between the lagged real slaughter price and ewe stock, as the lagged real slaughter price increases producers look to take advantage of the increase by sending additional ewes to slaughter. As the lagged real wool price/real loan rate increases producers add more lambs to the herd to increase wool production and thus ewe stock increases. As the real public grazing fee increases a decrease in ewe stock is expected as operations downsize in reaction to the increased costs of production (grazing cost). Corn price is included in this equation to represent feed costs in the aggregate. Thus, as corn price increases we expect to see a decrease in ewe stock as operations adjust to the higher cost of feed.

The wool price equation (11) is estimated simply as a function of the wool mill price and a trend.

$$(11) \quad \textit{Wool Price}_t = WLMILLP_t + \textit{Trend}$$

The wool mill price is expected to possess a highly significant positive relationship with the wool price.

The sheep shorn equation (12) is a function of the maximum of either the real wool price or the real marketing wool loan rate, all sheep, and a one period lagged sheep shorn variable.

$$(12)\quad Sheep\ Shorn_t = WOOLP_t/PPIW_t + SHLBFRM_t + SHPSHORNt_{-1}$$

All explanatory variables are hypothesized to have a positive relationship with total sheep shorn. As the real wool price increases produces tend to increase wool production. As total sheep inventory increases more sheep are available for sheering and thus the expectation is an increase in wool production. Finally, as lagged sheep shorn increases we might expect for the current period to also increase following a short-run trend.

Wool production greasy in equation (13) is simply a function of sheep shorn and a trend.

$$(13)\quad Wool\ Production\ Greasy_t = SHPSHORN_t + Trend$$

As total sheep shorn increases the expectation is for wool production to increases as well. A trend is also important in this equation as the industry continues to trend downward as a whole.

Wool production clean equation (14) is a function of wool production greasy and a trend.

$$(14)\quad Wool\ Production\ Clean_t = WLPRODG_t + Trend$$

It is expected clean and greasy wool production will naturally move together in a positive relationship. Increases in wool production greasy should result in an increase in the clean production as well. Again, a negative trend is also expected as a result of the long run decline in the wool industry.

In estimating wool imports (15) the real wool mill price, average synthetic fiber producer price index, wool mill demand, and real international wool price have been included as explanatory variables.

$$(15)\quad Wool\ Import_t = WLMILLP_t/PPIW_t + FIBERPPI_t + WOOLDMD_t - INTLWLP_t/PPIW_t$$

An increasing real wool mill price is hypothesized to increase imports as those demanding wool look for more favorable prices in foreign markets. As the average synthetic fiber producer price index increases (substitute fiber prices increase), wool imports also are expected to increase as additional wool supply may be demanded by those typically demanding other fibers. As wool mill demand increases imports also increase to help fill this increase in demand. As the international wool price increases we expect to see a decrease in wool imports as prices become less favorable to import.

In estimating wool exports in equation (16) all the same explanatory variables will be included as are included in the wool import equation (15) with the exception of wool mill demand. For the wool export equation, however, the hypothesized signs for all variables are hypothesized to be the opposite of those in the import equation.

$$(16)\quad Wool\ Export_t = FIBERPPI_t - WLMILLP_t/PPIW_t - WOOLDMD_t + INTLWLP_t$$

Wool mill demand in equation (17) is estimated as a function of average synthetic fiber producer price index, real wool mill price, and a trend.

$$(17)\quad Wool\ Demand\ from\ Mill_t = FIBERPPI_t - WLMILLP_t/PPIW_t - Trend$$

As the wool mill price goes up the demand naturally is expected to decline. As the average synthetic fiber producer price index increases the wool mill demand increases as more consumers choose to opt for wool over the rising prices of other substitute fiber options.

Wool ending stock equation in (18) is a function of real wool mill price, average synthetic fiber producer price index, and a trend.

$$(18)\quad Wool\ Stock_t = -WLMILLP_t/PPIW_t + FIBERPPI_t - Trend$$

As the mill wool price increases it is hypothesized that the ending stock will decrease as the increase in price indicates higher demands leading to a decrease in ending stock. As the average synthetic fiber prices increase it is expected that the ending stock also increases as the demand for synthetic fibers is high and lower for the wool substitute. Additionally a negative trend is hypothesized within this equation.

Wool unaccounted equation in (19) is a function of wool mill demand, wool supply, and the real marketing wool loan.

$$(19) \quad Wool\ Unaccounted_t = WOOLDMD_t – WOOLSPL_t – WLLR_t /PPIW_t$$

It is hypothesized as wool demand increases so too does wool unaccounted and as the supply increases wool unaccounted decreases. Thus the sign for wool mill demand is expected to be positive while the signs for wool supply and the real marketing loan rate are expected to be negative.

The equation for ewe lambs (20) is estimated as a function of ewe ending stock, a one period lagged real slaughter price, and a one period lagged ewe lamb variable.

$$(20) \quad Ewe\ Lamb_t = EWESTK_{t-1} + SLGTP_{t-1}/PPIW_{t-1} + EWELB_{t-1}$$

All explanatory variables are hypothesized to have a positive relationship with the dependent variable. As the ewe ending stock increases lambs in the current period lamb production is expected to increase and thus ewe lambs increases. As the lagged slaughter price increases producers retain more lambs in the lagged period to increase lamb production for the current period and thus ewe lambs is expected to increase in the current period. As lagged ewe lambs increase we might expect for the current period to also increase following a short-run trend.

Rams equation in (21) is a function of ewe ending stock, a one period lagged real slaughter price, and a one period lagged ram variable.

$$(21) \quad Ram_t = EWESTK_t + SLGTP_{t-1}/PPIW_{t-1} + RAM_{t-1}$$

Similar to the ewe lamb equation above (20) all explanatory variables are hypothesized to have a positive relationship with the dependent variable following the same logic.

Lamb and Mutton Ending Stocks equation in (22) is estimated as a function of the real lamb price, lamb production, lamb imports, and real personal disposable income.

$$(22)\quad \textit{Lamb \& Mutton Ending Stocks}_t = LBWP_t/PPIW_t - LBPROD_t - LBIMPT_t + ZCEW_t/CPIUW_t$$

As the lamb price goes up so too does ending stocks as less lamb and mutton is expected to be demanded by consumers at the higher price. As lamb production as well as lamb imports increase it is expected that ending stocks decrease. As disposable income increases it is expected that ending stocks increase.

Per capita (lamb and mutton) consumption equation in (23) is a function of per capita real personal disposable income, real lamb price, and a trend.

$$(23)\quad \textit{Per Capita (Lamb \& Mutton Disappearance}_t = ZCEW_t/POPTOTW_t/CPIUW_t - LBWP_t/PPIW_t - Trend_t$$

As income increases and consumers have more disposable income to spend we expect to see an increase in the consumption of lamb and mutton assuming they are normal goods. As the lamb price increases we expect a decrease in lamb consumption as consumers' willingness to consume at the higher price would decrease. A negative trend is also expected in conjunction with an entire sheep and wool long-run trend.

Lamb and mutton exporting demand equation in (24) is hypothesized to be a function of the real lamb price, average substitute meat real prices, and a trend.

$$(24)\quad \textit{Lamb \& Mutton Exporting Demand}_t = -LBWP_t/PPIW_t + OMEATP_t/PPIW_t + Trend$$

As the lamb price increases a decrease in export demand is expected to result as the price would be less favorable for importers. As the average price for other substitute meats increases we expect an increase in the exporting demand as lamb and mutton would be priced more favorably as compared to substitute meats. A trend has also been included and hypothesized as a positive trend to reflect an overall increase in global trade throughout time.

Lamb and mutton imports equation in (25) is estimated similarly to that of exports (24) above. It is a function of the real lamb price, average substitute meat real prices, and a trend.

$$(25) \quad Lamb\ \&\ Mutton\ Import_t = LBWP_t\ /PPIW_t - OMEATP_t\ /PPIW_t + Trend$$

Opposite signs as those hypothesized for equation (24) are expected on the variables of real lamb price and average substitute meat real prices, while a positive trend is still expected.

Total all sheep (26) is an identity within this model and will be calculated by adding ewe ending stock (EWESTK), ewe lambs (EWELB), and rams (RAM).

$$(26)\ Total\ All\ Sheep_t = EWESTK_t + EWELB_t + RAM_t$$

3.1.2 Supply and Demand:

Total lamb and mutton supply and demand as well as wool supply and demand are all identities within the model and will be calculated as follows:

(27) *Lamb & Mutton Supply = Lamb Production + Lagged Lamb Ending Stock + Lamb & Mutton Imports*

(28) *Lamb & Mutton Demand= Lamb Ending Stock + Lamb & Mutton Exports + Lamb Consumption*

(29) *Wool Supply = Production + Lagged Ending Stock + Imports*

(30) *Wool Demand = Ending Stock + Wool Exports + Wool Mill Demand*

3.2. Data

Annual data from 1979 through 2015 yielding 37 observations is used for analysis. As the sheep industry has been declining for approximately the last 70 years it is thought that a time trend has a large impact within the model. Therefore, similar to Ribera's approach (2004) the data period used in this model is shortened to the last 37 years (1979-2015). This allows for the differing structures of the industries to be captured while still ensuring an adequate number of degrees of freedom. Additionally, as the sheep production cycle lasts approximately seven years this data set encompasses about five production cycles (Ribera, Anderson, & Richardson, 2004). The majority of the data has been collected through the United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) as well as the Economic Research Service (ERS) with lesser portions coming from tables and spreadsheets organized and presented by the Livestock Information Center (LMIC) and the Bureau of Labor Statistics.

3.3. Regression Results

The econometric estimation results for each equation are discussed in this section. Equations are evaluated for goodness-of-fit using primarily adjusted R^2 and p-values. Explanatory variables were retained if they were statistically significant at least at the 95 percent confidence level or based upon economic theory which would dictate they remain in the equation. Variables for prices of lamb, sheep and wool, as well as the incentive price for wool, were always retained even if they were not significant so the model could be solved for the market-clearing price. A summary of the results for each individual estimated equation can be seen in table 5 below.

Table 5. Regression Results

Equation No.			Results of Equations Estimated	Adjusted R^2
(5)	Slaughter Weight$_t$	=	$64.962^{*} - 1.333^{*}$(SHPSLGTt/(LBYRSLGTt+SHPSLGTt)x100)+ 0.409^{*}Trend	0.909
(6)			(0.0000) (0.0002) (0.0000)	
(6)	LN(Sheep Slaughter$_t$)	=	4.292^{*} -0.001433 SLGTP$_{t-1}$ /PPIW$_{t-1}$ + 0.036 MAX(WOOLP$_{t-1}$/PPIW$_{t-1}$, WLLR$_t$/PPIW$_t$)	0.949
			(0.0000) (0.4671) (0.5857)	
			+ 0.000041 LBCROP$_{t-1}$ + 0.001847*SHPSLGT$_{t-1}$ + 0.000083 EWESTK$_{t-1}$	
			(0.6674) (0.0003) (0.2964)	
(7)	LN(Lamb Slaughter$_t$)	=	7.714^{*} -0.002498^{*}SLGTP$_{t-1}$ /PPIW$_{t-1}$ -0.029 MAX(WOOLP$_{t-1}$/PPIW$_{t-1}$, WLLR$_t$/PPIW$_t$)	0.983
			(0.0000) (0.0345) (0.4683)	
			(+) 0.000173*LBYRSLGT$_{t-1}$ -0.0000000557 LBCROP$_{t-1}$ +0.000032 LBCROP$_t$ -0.011^{*}Trend	
			(0.0000) (0.9992) (0.4812) (0.0233)	
(8)	Slaughter Lamb Price$_t$	=	20.883 + 0.389^{*}LBWP$_t$ -0.000392 LBYRSLGT$_t$ - 0.011SHSLGT$_t$ -0.046 LBIMPT$_t$	0.897
			(0.4721) (0.0000) (0.9508) (0.8274) (0.5669)	
(9)	LN(Lamb Crop$_t$)	=	8.444^{*} +0.000025 EWESTK$_t$ + 0.000065 EWESTK$_{t-1}$ -0.001705 SLGTP$_{t-1}$ /PPIW$_{t-1}$	0.985
			(0.0000) (0.4951) (0.0954) (0.0569)	
			(+) 0.040 MAX(WOOLP$_{t-1}$/PPIW$_{t-1}$, WLLR$_t$/PPIW$_t$) -1.547 GRFEE$_t$ /PPIW$_t$ -0.014*Trend	
			(0.0837) (0.6244) (0.0000)	
(10)	LN(Ewe Stock$_t$)	=	7.517^{*} +0.000162^{*}EWESTK$_{t-1}$ +0.001814^{*}SLGTP$_{t-1}$ /PPIW$_{t-1}$ + 0.053^{*}MAX(WOOLP$_{t-1}$/PPIW$_{t-1}$, WLLR$_t$/PPIW$_t$)	0.992
			(0.0000) (0.0000) (0.0073) (0.0160)	
			(-)1.038 GRFEE$_t$ /PPIW$_t$ -0.011*CORNP$_t$	
			(0.6877) (0.0000)	
(11)	Wool Price$_t$	=	(-)0.017 +0.458^{*}WLMILLP$_t$ +0.002113 Trend	0.934
			(0.6930) (0.0000) (0.1501)	
(12)	Sheep Shorn$_t$	=	(-)1600^{*} +13.724 MAX(WOOLP$_t$/PPIW$_t$, WLLR$_t$/PPIW$_t$) + 0.613^{*}SHLBFRM$_t$ + 0.536^{*}SHSHORN$_{t-1}$	0.997
			(0.0000) (0.9059) (0.0000) (0.0000)	
(13)	Wool Production Greasy$_t$	=	(-)3893^{*}+8.237^{*} SHPSHORN$_t$	0.999
			(0.0000) (0.0000)	
(14)	Wool Production Clean$_t$	=	(-)185.255^{*} + 0.533^{*}WLPRODG$_t$	1.000
			(0.0505) (0.0000)	
(15)	Wool Import$_t$	=	(-)58164 -6193 WLMILLP$_t$/PPIW$_t$ + 504.973 FIBERPPI$_t$ + 0.636^{*}WOOLDMD$_t$ -2758 INTLWLP$_t$/PPIW$_t$	0.921
			(0.1027) (0.3722) (0.1563) (0.0000) (0.5120)	
(16)	Wool Export$_t$	=	2558 +105.765 FIBERPPI$_t$ -2731 WLMILLP$_t$/PPIW$_t$ + 320.592 INTLWLP$_t$ -0.052^{*}WOOLDMD$_t$	0.711
			(0.743) (0.120) (0.216) (0.827) (0.0001)	
(17)	Wool Demand from Mill$_t$	=	(-)124170 +3617^{*}FIBERPPI$_t$/PPIW$_t$ -14579^{*} WLMILLP$_t$ - 6887^{*}Trend	0.814
			(0.1480) (0.0008) (0.0225) (0.0000)	
(18)	Wool Stock$_t$	=	(-)18317 -2937 WLMILLP$_t$/PPIW$_t$ + 989.695^{*}FIBERPPI$_t$ - 1853^{*}Trend	0.519
			(0.6316) (0.4798) (0.0295) (0.0001)	
(19)	Wool Unaccounted$_t$	=	14592^{*} +0.395^{*}WOOLDMD$_t$ -0.269^{*}WOOLSPL$_t$ -6280 WLLR$_t$ /PPIW$_t$	0.486
			(0.0002) (0.0000) (0.0030) (0.0860)	
(20)	Ewe Lamb$_t$	=	(-)264.802^{*} +0.074^{*}EWESTK$_t$ +6.094^{*}SLGTP$_{t-1}$ /PPIW$_{t-1}$ +0.464^{*}EWELB$_{t-1}$	0.952
			(0.0014) (0.0040) (0.0000) (0.132)	
(21)	Ram$_t$	=	268.261 +0.044^{*}EWESTK$_t$ -1.612SLGTP$_{t-1}$ /PPIW$_{t-1}$ +0.800^{*}RAM$_{t-1}$	0.87
			(0.2100) (0.0202) (0.5054) (0.0000)	
(22)	Lamb & Mutton Ending Stocks$_t$	=	0.147^{*}LBWP$_t$ /PPIW$_t$ -0.047^{*}LBPROD$_t$ -0.043 LBIMPT$_t$ +0.255 ZCEW$_t$ /CPIUW$_t$	0.853
			(0.047) (0.0134) (0.4793) (0.4056)	
(23)	Per Capita (Lamb & Mutton) Disappearanc	=	1.506^{*} +0.042 ZCEW$_t$ /POPTOTW$_t$ /CPIUW$_t$ -0.002133^{*}LBWP$_t$ /PPIW$_t$ -0.026^{*}Trend$_t$	0.889
			(0.0014) (0.2623) (0.0093) (0.0015)	
(24)	Lamb & Mutton Exporting Demand$_t$	=	9.636^{*} -0.073^{*}LBWPt /PPIWt +0.359^{*}Trend	0.552
			(0.0238) (0.0308) (0.0000)	
(25)	Lamb & Mutton Import	=	(-)4.823 +0.000382 LBWP$_t$ /PPIW$_t$ + 5.712^{*}Trend	0.869
			(0.8750) (0.9987) (0.0000)	

Values in parenthesis are p-values

Variables defined previously in Table 4

Sheep slaughter weight (5) has been estimated as a function of the percentage of total sheep slaughtered that were mature sheep (versus lamb and yearlings) and a trend. Other originally hypothesized variables of slaughter price and wool price have been omitted as they were not shown to be significant at the 95 percent level. The adjusted R^2 for the equation is a strong .909 with both explanatory variables highly significant at over the 99 percent level. The negative sign on the percentage sheep slaughtered variable as well as the positive trend is in agreement with original hypotheses.

Sheep slaughter (6) has been estimated as a log linear model. Goodness of fit as measured by adjusted R^2 is strong at .947. Only the constant and the lagged sheep slaughter variable are shown to be significant at the 95 percent level. Other hypothesized variables all possess the correct signs according to hypotheses and while they are not shown to be significant they have still been included as they align with theory.

Lamb slaughter (7) has been estimated similar to sheep slaughter (6) using a log-linear model. The resulting estimated equation has similar results as well compared to sheep slaughter (6). The adjusted R^2 is very high at 0.983 and indicates a strong goodness of fit for the estimated equation. The constant, the maximum between a one period lagged real wool price and the current real marking wool loan rate, lagged lamb and yearling slaughter, and real public grazing fee are all significant at the 95 percent level. All variables have the correct signs.

The estimated equation for slaughter lamb price (8) has a relatively strong goodness of fit with an adjusted R^2 of 0.897. Signs for all explanatory variables are as hypothesized. Only the wholesale lamb price variable is shown to be significant at the 95 percent level indicating much of the variation in lamb slaughter price can be explained by the change in wholesale lamb price.

The equation for lamb crop (9) has been estimated as a log-linear model. Goodness of fit for this equation is very strong as indicated by a high adjusted R^2 of 0.985. All explanatory variables possess the correct signs according to what has been hypothesized. However, only the constant and trend are shown as significant at the 95 percent level. Multiple other variables are significant at the 90 percent level and all variables are being kept within the estimated equation as theory would dictate. It is noted that the real public grazing fee variable which will become of greater interest in evaluating the objectives of the research is not shown to be significant. Concerns over the lack of significance of this variable are addressed more in depth within the scope and limitations section of this paper.

Ewe ending stock has been estimated similarly to lamb crop (10). A log-linear functional form has been used in its estimation. All variables aside from the lagged real sheep slaughter price possess the correct hypothesized sign, however this variable is not significant at the 95 percent level. Variables which are significant at the 95 percent level include lagged ewe ending stock, the maximum between a one period lagged real wool price and the current real marking wool loan rate, corn price, trend, and the constant. Overall, the estimated equation possesses a strong goodness of fit as indicated by the very high adjusted R^2 of 0.992. Similar to the lamp crop equation (9) the real public grazing fee is not shown as significant within these results. This lack of significance is addressed more fully in the scope and limitations section of the paper.

Wool price (11) has been estimated simply as a function of a constant, wool mill price, and a trend. Both the wool mill price variable and the trend possess the correct positive hypothesized signs. The wool mill price variable is significant at the 95 percent level. While the trend is not shown to be significant at the 95 percent level it has not been admitted as the goodness of fit for the estimated equation is shown to improve with the inclusion of the trend as measured by the adjusted R^2. The goodness of fit for this equation is strong with an adjusted R^2 of 0.934.

Sheep shorn (12) is estimated as a function of the maximum of the current year wool price and wool marketing loan rate, all sheep, and a one period lagged sheep shorn variable. Goodness of fit for the estimated equation is very high with an adjusted R^2 of 0.997. All variables besides the maximum of the current year wool price and wool marketing loan rate are shown to be significant at over the 99 percent level. The wool price/loan rate variable is significant at the 90 percent level and possess the correct sign. Though it is not significant at the 95 percent level it has been retained within the estimated equation to coincide with economic theory.

Wool production greasy (13) and wool production clean (14) have been estimated as functions of each other as well as a constant. Resulting adjusted R^2 for each are very high 0.999 and 1.000 respectfully. This indicates that the variation in greasy production can be explained almost entirely by variation in clean production and vice versa as would be naturally expected as clean production is simple a result of greasy wool being cleaned. Both the variables and constants are shown to be significant at the 95 percent level.

Wool import (15) has been estimated as a function of the real wool mill price, producer price index for synthetic fibers, wool mill demand, and the real international wool price. Goodness of fit for this equation is strong with an adjusted R^2 of 0.921. Only the wool mill demand variable is showing significance at the 95 percent level. All variables aside from the real wool mill price variable possess the correctly hypothesized sign.

The equation for wool exports (16) is hypothesized to be the same as wool imports (15) with the only change being that inverse signs are expected for all explanatory variables besides for the producer price index for synthetic fibers variable. The estimated equation only resulted in a moderate goodness of fit as measured by the adjusted R^2, 0.711. All variables have the correct sign, however, only the wool mill demand variable is shown to be significant at the 95 percent level.

Wool demand from mill (17) is assumed to be a function of the producer price index for synthetic fibers, the real wool mill price, and a trend. The resulting estimated equation's goodness of fit is reasonable with an adjusted R^2 of 0.814. Signs for all of the variables complied with prior expectation and all are shown to be significant at the 95 percent level.

Wool ending stock (18) is estimated as a function of the real wool mill price, the producer price index for synthetic fibers, and a trend. The estimated equation has weak goodness of fit as indicated by an adjusted R^2 of only 0.486. Signs for all variables do align with prior expectations and the synthetic fiber PPI as well as the trend are significant at the 95 percent level.

Wool unaccounted (19) is assumed to be a function of wool mill demand, wool supply, and the real wool marketing loan rate. Similar to the wool ending stock equation (18), wool unaccounted also only possess a weak goodness of fit as indicated by a low adjusted R^2 of 0.486. All variables possess the correct sign as originally hypothesized and both the wool mill demand as well as the wool supply variable are shown to be significant at the 95 percent level.

Ewe lamb (20) is estimated as a function of ewe ending stock, a one period lagged real slaughter price, and a one period lagged ewe lamb variable. All variables as well as the constant are shown to be significant at the 95 percent level and all possess the correct sign as originally hypothesized. Goodness of fit for the estimated equation is very good with a strong adjusted R^2 of 0.952.

Rams (21) is estimated in similar fashion to ewe lambs (20) with only one change being made. The one period lagged ewe lamb variable has been replace by a one period lagged ram variable. The resulting estimated equation has a reasonable goodness of fit as indicated by the adjusted R^2 of 0.87. The constant along with the ewe ending stock and lagged ram variable are shown to be significant at the 95 percent level and possess the correct signs. The lagged real slaughter price variable does not possess the correct sign but is also not shown to be significant at the 95 percent level. It has been retained within the estimated equation to coincide with economic theory.

Lamb and mutton ending stocks (22) is estimated assuming it to be a function of the real lamb wholesale price, lamb production, lamb imports, and real personal disposable income. A moderate goodness of fit is indicated by an adjusted R^2 of 0.853. While all explanatory variables possess the correct signs as originally hypothesized only ewe ending stock and the constant are shown to be significant at the 95 percent level.

Per Capita (lamb and mutton) disappearance (23) is estimated as a function of per capita real personal disposable income, the real lamb wholesale price and a trend. All parameter estimates have the correct sign to align with theory and only the per capita real personal disposable income variable is not shown to be significant at the 95 percent level.

Lamb and mutton exporting demand (24) and lamb and mutton import (25) are both estimated as a function of the real lamb wholesale price, and a trend. The adjusted R^2 for the export equation is low at 0.552 and indicates that the goodness of fit for this equation is weak. For the import equation goodness of fit is much better and is reasonable with an adjusted R^2 of 0.869. Signs for all variables in both equations are correct as originally hypothesized. All variables and the constant are shown to be significant at the 95 percent level in the export equation while only the trend is shown to be significant within the import equation. The average other meat (substitute) price variable has not been included in either the import or export equation as originally hypothesized as it was not shown to be significant and current theory does not indicate that other meats share a strong substitute relationship with lamb.

CHAPTER 4

DISCUSSION AND IMPLICATION

Having completed the model it is now used to evaluate the effects on sheep inventory of changing the public grazing fee. This chapter also highlights the importance of the public grazing fee as well as outline the method used in order to evaluate grazing fee policy alternatives. This will be accomplished through the comparison of three modeled scenarios discussed in the sections to follow.

4.1. Public Grazing Fee Policy Implications:

The PRIA grazing fee is an ongoing source of debate as opposing sides take a stance on public grazing fee policy. There are some policy makers who believe the current PRIA grazing fee formula does not do an adequate job of establishing a fee with some in support of raising the fee more in line with private grazing rates. In fact, for fiscal year 2016 the Obama administration originally purposed a budget, that would later be revised, which would have added a $2.50/AUM additional administrative fee to the current public grazing rate (Halladay, 2015). The main argument cited in support of this view is that current expenses for the BLM and USFS for both agencies far exceed receipts from grazing permits. For the fiscal year 2014 the total inflation-adjusted appropriations for BLM and USFS were $143.6 million while grazing receipts amounted to only $18.5 million, or 13 percent of the appropriations (Glaser, Romaniello, and Moskowitz, 2015). A similar relationship can be seen throughout all receipt years. Figure 3 below summarizes total inflation adjusted appropriations for both BLM and USFS as compared to total inflation adjusted receipts. These appropriations and receipts are only those connected with grazing activity and do not represent total appropriations and receipts for other activities within the BLM and USFS.

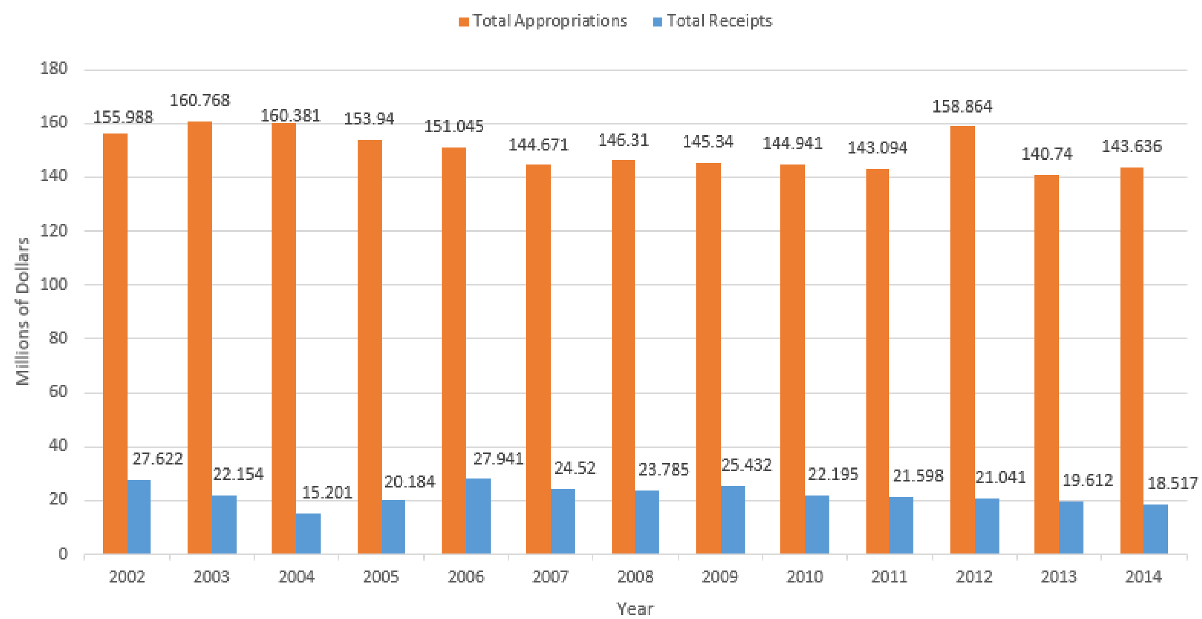

Figure 3. Total BLM and USFS Direct Grazing Appropriations Vs. Receipts 2002-2014 in Dollars

Source: (Glaser, et al., 2015)

There are, however, others in support of rate cuts as they believe when the true costs of grazing on public land are compared with the costs of grazing on private land then the public rate would actually be higher than the average private rate as indicated by past research (Rimbey & Torell, 2011). This study does not attempt to provide support for any one stance within the range of views concerning the current PRIA grazing rate system, but rather to demonstrate the effects on the sheep and wool industry of changing the public grazing fee either up or down. The results will aid policy makers to be able to weigh all arguments within the context of the PRIA grazing fee and make appropriate policy decisions in the future. In looking at figure 4 on the next page a summary of the calculated public grazing fee as well as the established PRIA grazing fee can be seen as compared to average private grazing rates for years 1980-2013.

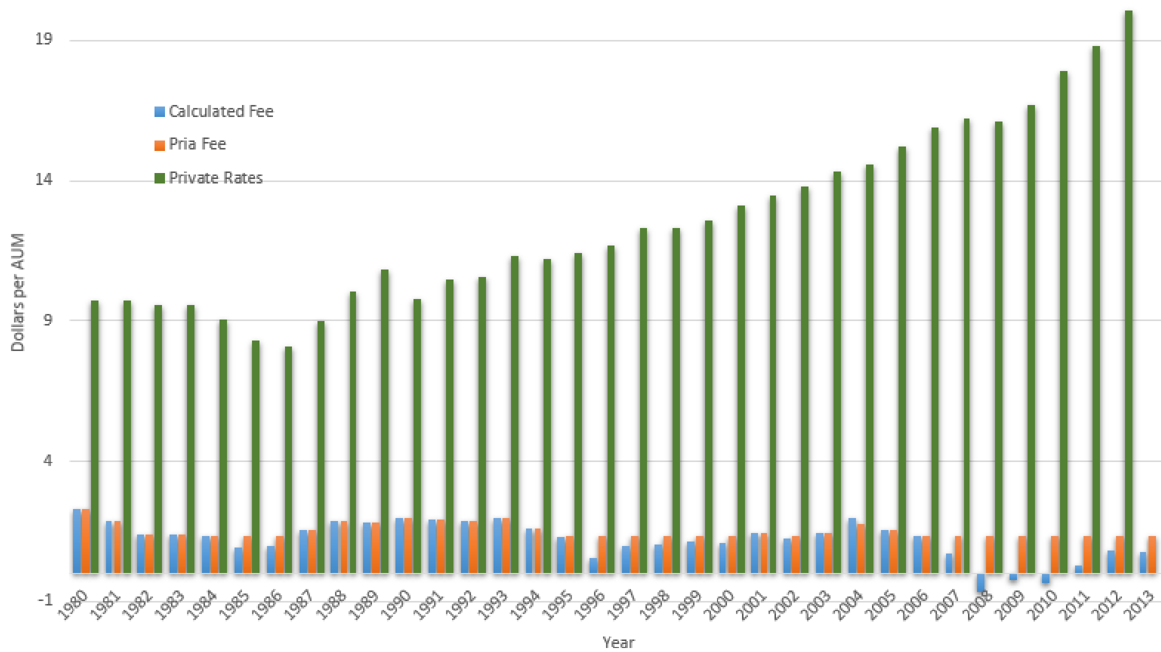

Figure 4. Calculated Public Fee and PRIA Fee Compared to Private Grazing Rates

Source: (Glaser, et al., 2015)

It is clear by looking at the public rate as a percentage of the average private rate that there has definitely been a downward trend. This may indicate that perhaps it is time for policy makers to consider establishing new policy to replace the current PRIA grazing fee formula in order to increase the public rate to be more in line with average private rates. This study will not attempt to formulate the details of such a new policy but will instead demonstrate the effects of raising the public grazing fee to the overall sheep and wool industry over a five year time period. Although, the sheep and wool industry is by no means a large or vital part of the U.S. economy, it has a unique and important history within the U.S. and is vital to those within the industry. Great care and consideration must be taken as policy makers attempt to address the public grazing fee concerns. While grazing fee policy is sure to affect many livestock industries throughout the country, due to the current drastically weakened state of the sheep and wool industry perhaps greater consideration is needed in evaluating possible effects of new public grazing fee policy on this industry.

To demonstrate the possible effects of various policy changes within the public grazing fee three scenarios are evaluated within the context of the sheep and wool model. Scenario 1 represents the baseline or no change to current grazing fee policy. Projections are then be made for total supply and demand within the sheep and wool markets along with the market clearing prices established through setting supply and demand equal to each other and allowing the model to solve for the market clearing price. These projections are comprised of the next five years (2016-2020) and can be compared with the other two scenarios to evaluate effects on the industry of the policy change. Scenario 2 represents a policy change which increases the current public grazing fee ($1.69/AUM in 2015) to $10/AUM. This fee is still less than half of the private grazing fee average (trending upward and $20.10/AUM in 2012 (Glaser, Romaniello, & Moskowitz, 2015)) but represents a substantial increase in the current fee and helps bridge the gap between the current public and private grazing fees. Similar to scenario 1, projections for the industry are then made for the next five years and compared with other scenario projections. Scenario 3 represents an abolishment of a public grazing fee. Policy of this nature has been suggested by various research and by those within the industry. Torrell and Rimbey (2011) found that if the true costs of grazing public land were compared with private grazing costs the public grazing costs would be larger than the private costs and thus suggest that a reduction or abolishment of the public grazing fee may be appropriate. In place of the fee other researchers have suggested that current permit holders be allowed to retain their permits and be given the rights to sell their permits as they please in an open market format. Therefore, for this scenario the public grazing fee is set at $0/AUM for each of the following five years and the model is used to make projections for industry supply and demand as well as establish the market clearing price.

4.2. Scenario Results:

4.2.1. Scenario 1: Baseline

Baseline projections have been made for years 2016-2020. The projections are based on the assumption of no change within current policy affecting the sheep and wool industry. As the public grazing fee is already set for 2016 at $2.11/AUM this value is used for 2016 and is held constant for the years 2017-2020 to approximate the public grazing fee under a no policy change environment. The results for the baseline projection can be seen in table 6 below.

Table 6. Scenario 1: Baseline Projections

	2016	**2017**	**2018**	**2019**	**2020**
Lamb Wholesale Price (Dollars/cwt)	$ 350.32	$ 349.92	$ 323.88	$ 298.30	$ 283.13
Lamb and Mutton Supply/Demand (million lbs)	375.74	376.54	383.79	389.47	393.66
Wool Mill Price (dollars/lb.)	$ 2.98	$ 2.67	$ 2.64	$ 2.55	$ 2.32
Wool Supply/Demand (thousand lbs.)	44563.7	42241.6	40727.1	39673.8	38138.1
Baseline: All Sheep Inventory (thousands)	**5,347**	**5,352**	**5,373**	**5,346**	**5,298**

From these results it is clearly shown that under a no change environment the sheep and wool industries are projected to remain fairly constant throughout the next five years with continued decline expected in years 2019 and 2020. Total sheep inventory is shown to decrease 49,000 head by the year 2020. The results demonstrate that the current state of the industry is not stable and with no changes made will be expected to continue to experience declines annually.

4.2.2. Scenario 2: Public Grazing Fee Increased

Under scenario 2 the public grazing fee is being increased to $10/AUM for years 2017-2020. As this represents an increase in costs for producers it is hypothesized that this increase in the grazing fee will cause a decrease in both sheep and wool production and increase the rate of decline in the total sheep industry over the years projected as compared to the baseline. The results of scenario 2 are summarized in table 7 below.

Table 7. Scenario 2: Increased Public Grazing Fee Projections

	2016	**2017**	**2018**	**2019**	**2020**
Lamb Wholesale Price (Dollars/cwt)	$ 350.32	$ 352.96	$ 328.02	$ 303.29	$ 288.60
Lamb and Mutton Supply/Demand (million lbs)	375.74	375.69	382.64	388.07	392.12
Wool Mill Price (dollars/lb.)	$ 2.98	$ 2.80	$ 2.87	$ 2.83	$ 2.62
Wool Supply/Demand (thousand lbs.)	44563.7	41903.6	40138.3	38943.5	37340
Scenario 2: All Sheep Inventory (thousands)	**5,347**	**5,211**	**5,163**	**5,102**	**5,042**
Percent of Baseline Inventory	100%	97.38%	96.09%	95.45%	95.16%

From these results it is evident that the hypothesized negative relationship between the public grazing fee and sheep and wool production holds according to the model projections. When the public grazing fee is increased to $10/, total inventory over this five year period is projected to decline by 306,000 head. This represents and average decline in sheep inventory of 1.46% annually over this time period.

4.2.3. Scenario 3: Public Grazing Fee Decreased

The final scenario evaluated in this study is a decrease or complete elimination of the public grazing fee ($0/AUM). Similar to the previous two scenarios the grazing fee is left at $2.11/AUM for 2016 as it has already been established. For the years 2017-2020 the fee will be set at $0/AUM. As this would represent a decrease in the cost of production for sheep and wool it is hypothesized that production and inventory will increase over this five year time period as compared with the baseline projections. The projections for scenario 3 can be seen summarized below in table 8.

Table 8. **Scenario 3: $0/AUM Public Grazing Fee Projections**

	2016	2017	2018	2019	2020
Lamb Wholesale Price (Dollars/cwt)	$ 350.32	$ 349.07	$ 322.71	$ 296.87	$ 281.56
Lamb and Mutton Supply/Demand (million lbs)	375.74	376.78	384.12	389.87	394.11
Wool Mill Price (dollars/lb.	$ 2.98	$ 2.63	$ 2.58	$ 2.47	$ 2.23
Wool Supply/Demand (thousand lbs.)	44563.7	42334.2	40891	39879.7	38365.7
Scenario 3: All Sheep Inventory (thousands)	**5,347**	**5,390**	**5,432**	**5,414**	**5,372**
Percent of Baseline Inventory	100%	100.72%	101.09%	101.29%	101.38%

The results of scenario 3 are in line with the hypothesis. Over the time period, total sheep inventory remains fairly constant with some improvement being seen in comparison to scenario 1. Total inventory is projected to increase 24,000 head by year 2020 which would represent an increase of 73,000 head when compared to the baseline 2020 projection. Thus, under a $0/AUM grazing fee environment the sheep and wool industry is projected to remain in a steady to slightly increasing state and is projected to benefit from this change as compared to the baseline no change. Figure 5 below helps illustrate this point through a graphical comparison of the three scenarios' projected sheep inventories through this five year time period

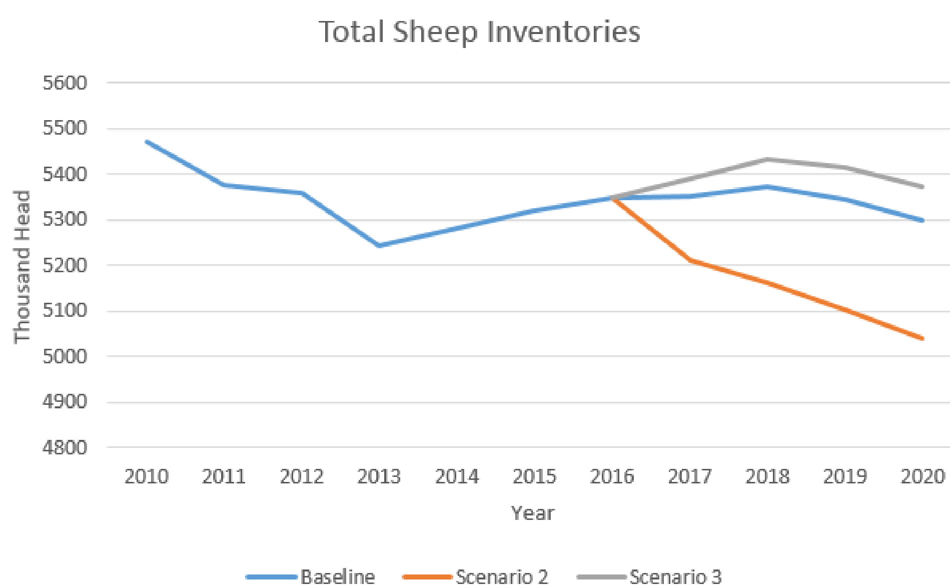

Figure 5. All Sheep Inventory

CHAPTER 5

CONCLUSIONS AND POLICY IMPLCATIONS

Within this chapter implications will now be drawn from the results presented in chapter 4. Additional conclusions will also be presented and discussed in further detail.

5.1. Conclusions and Implications

This study has evaluated the effects on the US sheep and wool industry of various policy changes regarding public grazing fees. Under the baseline no-change-to-the-fee scenario, the sheep industry is projected to remain relatively stable with some modest decline expected within the next five years. Abolishment of the public grazing fee would be expected to bring added stability to the sheep and wool industries with total sheep inventories expected to remain fairly constant with some modest growth projected within the next five years. This suggests that perhaps reducing the public grazing fee could be a viable policy alternative which could be implemented to help bring stability to the sheep and wool industries. Conversely projections indicate that raising the grazing fee would have an adverse effect on these industries. Scenario three which represents an increase in the public grazing fee to $10/AUM would increase the rate of decline within the industry. As the U.S. government has considered the possibility of raising the public grazing fee in the past (Halladay, 2015) it is, therefore, imperative for policy makers to consider this negative projected effect on the sheep and wool industry as further grazing fee policy change is considered. The industry is already in a fragile state having experienced dramatic declines since the mid 1940’s. Increases to the public grazing fee would ultimately increase the rate of decline of the sheep and wool industry and, therefore, policy makers are urged to take great care in consideration of such policy change.

It is also important to consider who would ultimately bare the weight of the added cost associated with an increase in the public grazing fee. Table 9 below helps illustrate the amount of the increase in grazing fee cost that is ultimately passed onto consumers through an increase in price. The results indicate that in the first year of implementation of an increase in grazing costs under scenario 2 approximately 62 percent of the increased cost would be felt by producers while 38 percent of the increase would be felt further down the supply chain with a good portion of this amount expected to be passed onto the end consumers. The following three years are then expected to see a decrease in the amount of the fee cost carried by producers and an increase carried by consumers. By the year 2020 it is projected that producers will only carry approximately 31 percent of the increased cost burden with the remaining 69 percent being passed on to consumers further down the supply chain, indicating that as time passes an increasing amount of the grazing fee cost increase will be expected to be carried by consumers.

Table 9. Examination of Grazing Cost Passthrough

Year	2017	2018	2019	2020
Scenario 2 Grazing Fee	$ 10.00	$ 10.00	$ 10.00	$ 10.00
Baseline Grazing Fee	$ 2.10	$ 2.10	$ 2.10	$ 2.10
Change in Fee	$ 7.90	$ 7.90	$ 7.90	$ 7.90
Scenario 2 Lamb Price	$ 352.96	$ 328.02	$ 303.29	$ 288.60
Baseline Lamb Price	$ 349.92	$ 323.88	$ 298.30	$ 283.13
Change in Price	$ 3.04	$ 4.13	$ 5.00	$ 5.47
Price Change/Fee Change	38%	52%	63%	69%

5.2. Future Policy Expectations:

Throughout history there have been many attempts by policy makers to raise the price of the public grazing fee (Halladay, 2015) (Westerners Block Hike in Grazing Fees, 1991). Looking to the future as an indication as to what might be the most likely grazing fee policy moving forward, it stands to reason that there will continue to be pressure by many policy makers to raise grazing fees. Undoubtedly there will continue to be opposition to rate increases by those connected with the livestock industries utilizing the public lands as a grazing resource. However, eventually as private rates continue to increase with public rates remaining fairly constant more policy will likely be purposed to increase the public rate. As the PRIA grazing fee is well established it will be difficult to abandon its use entirely. Most likely a policy similar in nature to that of the one the Obama administration purposed in 2014 would be the outcome. That policy purposed that the PRIA formula continue to be utilized in establishing the public fee annually within an additional $2.50/AUM flat tax added to the calculate PRIA fee. A policy of this kind may be successfully implemented as it may appease those advocating for rate increases in order for the public grazing fee to move closer to private rates, while at the same time it may be a small enough increase to eventually be able to pass into law despite some opposition. If such a policy were successfully implemented it would certainly have a negative effect on the sheep and wool industries, however the magnitude of the effect may not be very significant. For example, when the policy scenario suggested above adding a $2.50/AUM increase to the public grazing fee is run in the model the results indicate that by year 2020 the projected sheep inventory would only decline by 84,000 head as compared with the baseline. While of course, this would not be beneficial for an already struggling sheep industry it may be seen as an acceptable consequence for policy makers as it would lead to an increase in public grazing revenue for the BLM and USFS.

5.3. Scope and Limitations:

Within this research study there are some limitations and a limited scope which should be addressed. The research focuses solely on the U.S. sheep industry with regards to possible policy change in connection with the U.S. public grazing fee. The research is, therefore, limited geographically to the U.S. national sheep market and does not address the effects of such grazing fee policy change to other international markets. Additionally, the data set utilized within the model comprises years 1979-2015 yielding 37 annual observations. This provides a strong set of data for analysis and modeling purposes but does still limit the research to that specific time frame. The U.S. sheep market reached its climax in 1942.

Ideally the data set could include the years 1942-1978, however, much of the data for those years was not reported and thus constrains the data set to a smaller range.

From the results of the individual regression equations it can be seen that the real public grazing fee variable is not shown to be significant in either the ewe stock (10) or the lamb crop (9) equations that it has been included in. As this research centers on evaluating the effects of policy changes surrounding the public grazing fee rate it is important to understand why this variable is not significant and to address the limitations this presents to the research. While the grazing fee variable does possess the correct hypothesized sign in both equations it is not significant at even the 10 percent level. As the majority of the public lands (BLM and USFS) are located in the western states as well as a good portion of sheep production it was hypothesized that fluctuations with the grazing fee may be more impactful to that region. Thus in an attempt to highlight the significance of the public grazing fee variable as part of this research the model was split into two separate models one to model sheep inventory within the three state region of Wyoming, Utah, and Idaho, with the other model including the rest of the country. The end resulting forecasted values would then be combine to represent national results. However, when this hypothesis was explored it was found that the public grazing fee was found to be significant at the 10 percent level, however, the parameter possessed the incorrect sign (positive).

After examining the data, perhaps the most important explanation of the lack of significance within the national model and the incorrect sign within the Mountain West regional model of this variable comes as a result of its lack of variability relative to the dependent variables being measured. Throughout history the PRIA fee has remained fairly stable. This comes in large part as a result of the rules and regulations surrounding the establishment of the annual fee. As discussed previously, the PRIA fee attempts to incorporate grazing value and profitability thus we would expect in years when the agriculture industries are doing very well the fee would adjust significantly upward. However, current policy only allows a maximum of 25 percent upward or downward movement annually regardless of what the PRIA formula dictates as well as establishes a floor for the fee at $1.35. As a consequence, the public grazing fee is often limited from truly moving subject to market forces to the full extent possible. This limits the variability within this variable. Additionally, within this model the public grazing fee is adjusted to a real basis using the PPI index. As the nominal fee values are fairly constant, after being deflated this yields a variable that is downward trending through time. It then becomes apparent that when regressed on sheep inventory (also downward trending) the relationship is found to be positive or opposite of what theory would suggest.

Due to the lack of significance of the grazing fee variable, the amount of public grazing land available to producers was also considered as part of this research. While the grazing fee is thought to be highly influential to livestock producers' viability, the amount of land available to graze may be shown to be just as much if not more influential if there exists a greater variability within the amount of public land available to producers. In order to test whether this may indeed be the case the real public grazing fee was replaced within the ewe stock and lamb crop regression equations with an annual wildfire total acreage burned variable. The acreage burned variable represents a good proxy for the inverse of public land available for grazing as when acreage burns increases, land available to graze should decrease proportionately. Thus a negative relationship between acreage burned and sheep inventories is hypothesized. The results of the estimated ewe stock and lamb crop equations with the acreage burned variable included were very similar to the results previously estimated using the public grazing fee variable. The acreage burned variable was not shown to be significant within either equation and total goodness of fit as indicated by the adjusted R squared was unaltered.

Finally, it is important to emphasis this study only addressed one specific policy alternative in conjunction with three levels of public grazing fee. Other policy alternatives must still be considered such as public land acreages available for grazing as well as possible restrictions placed on lamb and wool imports.

5.4. Future Research

After the preceding discussion of the limitations of this research it is apparent that it would be difficult to utilize econometric analysis to adequately analyze research questions surrounding the public grazing fee in connection with the sheep inventory as the public grazing fee is not shown to be significant and possess the correct sign. However, this does not indicate that the public grazing fee is without significance to the industry, but rather that this significance is difficult to demonstrate through statistical analysis. Therefore, moving forward with similar research questions perhaps a smaller scale approach may be necessary in order to demonstrate the importance of the public grazing fee as well as evaluate the effects on the industry of changing the public grazing fee. This may be accomplished through enterprise budget analysis for a specific region within the sheep industry. Elements of risk could be implemented within the budget by replacing certain static elements of the budget (most notably prices) with fitted stochastic distributions. Then utilizing simulation techniques the budget could be analyzed to reveal profitability with risk being measured. The public grazing fee rate could then be adjusted upwards and downwards within the budgets to get a sense of what effects this could have on profitability within the sheep industry of that region.

References

Anderson, D. P., Richardson, J. W., & G., S. E. (2001). Evaluating a Marketing Loan Program For Wool and Mohair. *Agricultural & Food Policy Center Breifing Series*(01-1).

Beam, C. (2009, Marcg 6). Man's First Friend; What was the original domesticated animal? *Slate*.

Farm Service Agency. (2004). *Fact Sheet: Wool and Mohair Marketing Assistance Loan and Loan Deficiency Payment Program.* United States Department of Agriculture.

Food and Agriculture Organization of the United Nations. (2013). *FAO Statistical Yearbook 2013 World Food and Agriculture.* Rome.

Glaser, C., Romaniello, C., & Moskowitz, K. (2015). *Costs and Consequences, The Real Price of Livestock Grazing on America's Public Lands.* Tucson: Center for Biological Diversity.

Halladay, K. (2015). House Subcommittee Blasts Obama Budget. *Western Livestock Journal*.

Jones, K. G. (2004, January). Trends in the U.S. Sheep Industry. *Agriculture Information Bulletin(787)*. United State Department of Agriculture.

Meyer, S. D. (2002, August). A Model of Textile Fiber Supply and Inter-Fiber Competition with Emphasis on the United States of America.

National Research Council . (2008). *Changes in the Sheep Industry in the United States.* The National Academy of Sciences.

Office, U. S. (2005). Livestock Grazing, Federal Expenditures and Receipts Vary, Depending on the Agency and the Purpose of the Fee Charged. *Report to Congressional Requesters*(GAO-05-869).

Ribera, L. A., Anderson, D. P., & Richardson, J. W. (2004). Econometric Model of the U.S. Sheep Industry for Policy Analysis . *American Agricultural Economics Association Meeting*.

Rimbey, N., & Torell, A. L. (2011). Grazing Costs: What's the Current Situation? *Agricultural Economics Extension Series*(02).

Tanaka, J. A., & Gentner, B. J. (2001). Response of Public Land Ranchers to Policy Changes. *Society for Range Management Annual Meeting*.

Torell, L. A., Rimbey, N. R., Van Tassell, L. W., Tanaka, J. A., & Bartlett, E. T. (2003). An Evaluation of the Federal Grazing Fee Formula. *Journal of Range Management, 56*, 577-584.

United States Department of Agriculture National Agricultural Statistics Service. (2016). *Sheep and Goats.*

Watts, M. J., Shimshack, J. P., & LaFrance, J. T. (2006). Grazing Fees versus Stewardship on Fedeal Lands. *eScholarship Repository, University of California, 1022*.

Westerners Block Hike in Grazing Fees. (1991). *CQ Almanac*(47), 214-17. Retrieved from http://library.cqpress.com/cqalmanac/cqal91-1110385

Whipple, G. D., & Menkhaus, D. J. (1989). Supply Response in the U.S. Sheep Industry. *American Journal of Agricultural Economics, 71(1)*, 126-135.

Witherell, W. (1969). A Comparison of the Determinants of Wool Production in the Six Leading Producing Countries: 1949-1965. *American Journal of Agricultural Economics, 51(1)*, 139-158.

Appendix

Table 10 shows summary statistics for each variable as well as displays variable names and units.

Table 10. Summary Statistics

Data	Lamb & Mutton Production	Lamb & Mutton Ending Stocks	Dressed Weight	Total Disappearance	Per Capita Disappearance	Sheep Shorn	Weight Per Fleece	Wool Production-Greasy
Units	Million pounds	Million pounds	Pounds	Million pounds	Pounds per capita	Thousand head	Pounds	Thousand pounds
Variable	**LBPROD**	**LBSTK**	**DRESWGHT**	**TOTDSPP**	**CAPDSPP**	**SHSHORN**	**WFLEECE**	**WLPRODG**
Min	153.00	3.50	55.08	294.89	0.94	3680.00	7.30	26680.00
Median	260.00	10.70	66.00	359.58	1.30	6959.90	7.70	53578.00
Mean	263.89	12.53	64.70	360.09	1.34	7947.45	7.65	61571.92
Standard Dev	77.60	7.69	5.18	26.92	0.22	3477.38	0.25	28655.90
Max	379.00	41.45	73.67	400.70	1.69	13492.70	8.14	109787.00

					Ewe Lamb	Lamb and		Feeder Lamp Price, Medium
Data	Slaughter Lamb Price, Choice, San Angelo	Lamb Carcass Price, Choice-Prime, East Coast, 55-65 lb.	Price of other meats (beef, chicken, turkey)	Wool Loan Rate	Wool Domestic Production-Clean	Wool Import	Wool Export	Wool Mill Demand
Units	Dollars/Cwt.	Dollars/Cwt.	Dollars/Cwt.	Dollar/pound	Thousand pounds	Thousand pounds	Thousand pounds	Thousand pounds
Variable	**LBSLGTP**	**LBWP**	**OMEATP**	**WLLR**	**WLPRODC**	**WOOLIMPT**	**WOOLEXPT**	**WOOLDMD**
Min	53.21	117.33	88.8	0.00	14200.00	7000.00	300.00	15000.00
Median	75.86	156.75	104.325	1.15	28289.00	56500.00	4732.00	115700.00
Mean	83.33	183.43	112.1959459	1.19	32641.35	52689.86	5719.71	90210.81
Standard Dev	26.61	67.87	22.31652116	0.64	15279.39	35290.22	4769.87	53598.53
Max	160.75	346.70	165.9	2.12	58800.00	106940.00	17998.00	156800.00

Data	Wool Ending Stock	Wool Unaccounted	Wool Mill Price	Average Synthetic Fiber Price (PPI)	All Sheep and Lamb, Dec. 31	Sheep Import	Sheep Export	Lamb and Mutton Import
Units	Thousand pounds	Thousand pounds	Dollar/pound	1982=100	Thousand head	Thousand head	Thousand head	Million Pound (carcass)
Variable	**WOOLSTK**	**WOOLUNACT**	**WLMILLP**	**FIBERP**	**SHLBFRM**	**SHIMPT**	**SHEXPT**	**LBIMPT**
Min	22700.00	-9302.00	0.72	75.96	5245.00	0.00	42.06	18.10
Median	45300.00	8900.00	1.72	102.50	7825.10	22.83	220.56	83.04
Mean	44181.08	9607.57	1.84	102.86	8385.44	29.49	316.91	103.75
Standard Dev	15306.71	11718.34	0.70	9.66	2627.96	34.39	299.23	66.05
Max	89200.00	44920.00	4.02	120.31	12996.80	142.00	1407.14	213.37

Data	Lamb and Mutton Export	Prices Paid Index (all commodities)	Death Loss	Federal Grazing Fee	US Population	Personal Disposable Income	Corn Price
Units	Million Pound (carcass)	1990-92=100	Thousand head	Dollar/AUM	Million people	Billions of dollars	Dollars/Bushel
Variable	**LBEXPT**	**PPIW**	**LBDEATH**	**GRFEE**	**POPTOTW**	**ZCEW**	**CORNP**
Min	1.01	78.74	585.00	1.35	225.40	1809.30	1.50
Median	5.95	125.49	848.20	1.37	273.37	6148.90	2.48
Mean	6.79	136.30	1011.74	1.57	273.36	6845.05	3.04
Standard Dev	4.78	36.41	438.14	0.30	30.70	3586.68	1.27
Max	18.82	205.30	1930.00	2.39	322.76	13403.20	5.45