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AN ANALYSIS OF FACTORS IMPACTING HAY AUCTION PRICES AND THE POTENTIAL FOR NAP TO REDUCE ALFALFA REVENUE RISK

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THESIS

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Agricultural Economics in the College of Agriculture at the University of Kentucky

By

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Lexington, Kentucky

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ABSTRACT OF THESIS

AN ANALYSIS OF FACTORS IMPACTING HAY AUCTION PRICES AND THE POTENTIAL FOR NAP TO REDUCE ALFALFA REVENUE RISK

Hay auctions have generally been understudied due to their unique market structure. Therefore, the factors that influence the price of hay at auction markets are not well-known. The price of hay at auction markets reflects the various characteristics that differentiate each lot of hay sold. This study is aimed at analyzing the determinants of Central Kentucky hay prices. A hedonic price model is estimated using data collected from a Central Kentucky hay auction. Known hay attributes include forage species, form, bale weight, and nutritive value. An important aspect of this analysis is to determine whether the quality measures of the hay are significant factors in determining hay prices in this auction setting. While price discovery of hay is important, it is also important to know about the insurance that is available to producers. Insurance for hay production is very limited with only two insurance programs available to Kentucky producers. An evaluation of the Noninsured Crop Disaster Assistance Program is conducted by simulating yields from an alfalfa producer and alfalfa trials from University of Kentucky Agriculture Research Centers in Princeton and Lexington, Kentucky. This analysis reveals the effectiveness of the coverage levels offered through the program for alfalfa producers in Kentucky.

Keywords: hay price, hay auction, hedonic pricing model, crop insurance, alfalfa, simulation

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April 26, 2017

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Chapter 1: Introduction

Hay is an important commodity for Kentucky's agricultural sector as it is a very versatile forage for several reasons. When stored properly, hay can be kept for long amounts of time without losing nutrients. There are numerous crops that are used for hay production such as alfalfa, timothy, orchard grass, clover and much more. Hay can be produced and fed in either square or round bales varying in size. Being rich in nutrients, hay can often be the primary feed source for different classes of livestock. However, hay production be severely impacted by disease, drought or other disastrous weather impacts which can be financially devastating to the hay producer.

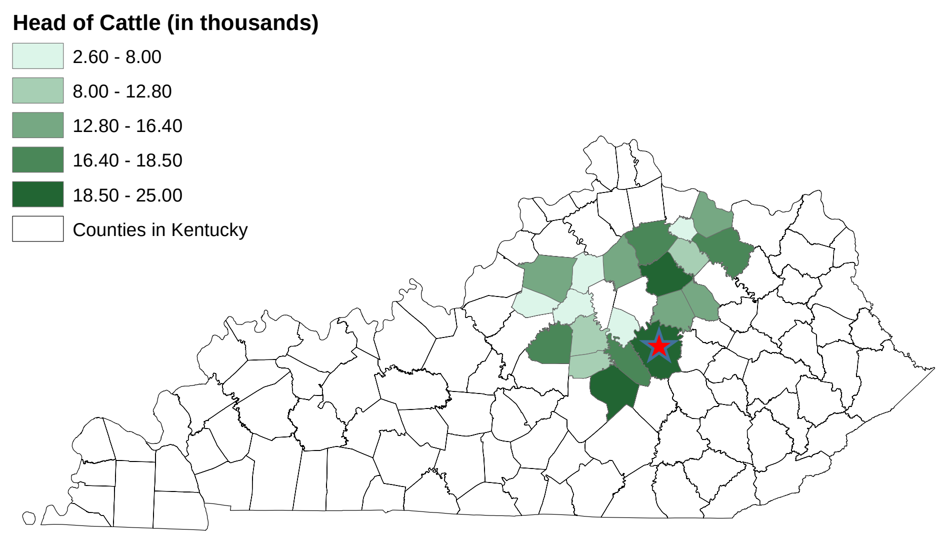
USDA primarily reports hay in two categories, Alfalfa and Alfalfa mixes and Other hay. According to the National Agricultural Statistics Service, Kentucky ranks 2nd nationally for other hay production and 7th for all hay production. Over the last ten years, the average yield of hay in Kentucky has been approximately 2.24 tons/acre. The lowest average yield was seen in 2007 with the highest average yield occurring in 2006 (Table 1). This hay sold with an average price of $137 per ton according to the USDA's Crop Production 2016 Summary. There are approximately 2.25 million acres of hay that is produced annually in Kentucky with the primary market consisting of beef producers, equine owners and dairy producers (USDA/NASS, 2017).

Table 1: All Hay Area Harvested, Yield and Production- Kentucky: 2005-2016

	Area Harvested (1,000 acres)	Yield per acre (tons)	Production (1,000 tons)
2005	2410	2.4	5777
2006	2480	2.55	6316
2007	2680	1.53	4104
2008	2640	1.95	5160
2009	2520	2.5	6290
2010	2530	2.25	5704
2011	2310	2.31	5334
2012	2380	2.07	4922
2013	2600	2.28	5940
2014	2265	2.1	4761
2015	2370	2.4	5689
2016	2250	2.48	5580
Source: Crop Production 2016 Summary (January 2017) USDA, National Agricultural Statistics Service			

There are several hay auctions that are held each year in Kentucky. Some of those auctions include the annual hay auction in Madison County and Fairview, Kentucky. Hay auction data used in this analysis was made available from the annual hay auction held in Madison County, Kentucky. The primary buyers of the auction are beef cattle producers. Figure 1 represents the inventory of beef cattle for the Bluegrass Region, with the star indicating Madison County. Three of the counties within the region have an inventory between 18,500 to 25,000 head of beef cattle (USDA/NASS 2017).

Figure 1: Head of Cattle in Bluegrass Region of Kentucky.



Source: USDA/NASS Quick Stats (2017).

Hay auctions have become increasingly popular as a method of sale, however there has been little research on prices received at these auctions. The first goal of this research is to examine the price received at the auction and determine how the characteristics of each lot sold influences the price.

With hay being an important commodity to the agricultural economy of Kentucky, it is also important to understand the risk management and insurance programs that are available to hay producers in Kentucky. The Noninsured Crop Disaster Assistance Program (NAP) is one available insurance program that protects against yield loss for producers. A second goal of this research will be to estimate the potential of the NAP program to provide downside revenue risk reduction, resulting from yield losses for Kentucky alfalfa producers.

The structure of the thesis is as follows: Chapter 1 provides an overview of the Kentucky hay market structure. Chapter 2 discusses the Madison County hay auction and the details of factors that influence the price of hay at that auction using a hedonic analysis. Chapter 3 provides an evaluation of the NAP program and the effectiveness of that program when using it to insure alfalfa hay in Kentucky and Chapter 4 summarizes the conclusions and implications of the research presented in this thesis.

Chapter 2: Analysis of Hay Prices from a Central Kentucky Hay Auction

2.1 Background of the Kentucky Hay Market

Auction markets have been widely used as a method of buying and selling agricultural commodities, with hay auction markets growing in popularity in Kentucky. The normal sale method of hay has been through private treaty which has limited research of price discovery for hay. The market structure of hay in Kentucky has also limited price data collection. However, with this growing popularity of hay auctions, there has been more opportunity for price data to be collected.

When buying and selling hay, it is important to understand what factors are influencing the price of hay in that market. However, information on hay markets is not readily available and there has not been much literature written on the topic for several reasons. McCullock et al. (2014) attributes limited information on the hay market to the variable characteristics of hay auctions or sales. The value of the hay is impacted by the type of hay, size of the bale, nutritive value, transportation costs, value of feed substitutes, and the number and type of buyers and sellers in a given marketplace. The majority of hay produced is fed to livestock and what may be leftover, is sold. However, this represents a small amount that is actually being sold in a market that allows price data to be collected. The hay could also be sold through private treaties which can be contractual with little reporting of the financial aspects (McCullock et al. 2014).

Another reason as to why there is little information on the hay market is that it is not certain if producers put an emphasis on the nutritive value of hay and could view it as a homogenous commodity. If this were the case, hay nutritive value information might not be a major factor when farmers make purchasing decisions. Hay markets are typically localized, creating extreme differences across regions of a given state. Rudstrom (2004) reported that local hay markets occur due to buyers not traveling far to purchase hay and because the bulkiness of the bales makes hay hard to be transported long distances. The localization of hay markets can also be attributed to local supply and demand conditions.

There are very few hay auctions in the United States that are reported by the USDA-AMS due limited fiscal funding also limiting availability of data (McCullock et al. 2014). The National Agricultural Statistics Service (NASS) divides state level hay price data into two categories: alfalfa/alfalfa mixes and all other hay types. This division of hay price data causes little information to be known about the species of hay that falls under ‘all other hay’ which also makes the nutritive value of the ‘all other hay’ category hard to determine. With limited data and the inability to distinguish hay types in some reporting, it is difficult to make sense of what is truly influencing the price of hay.

Hedonic models are commonly used in finding the value of certain attributes of a particular commodity. Often times, hedonic models are used in feeder cattle analysis, Yeboah and Lawrence (2000) modeled feeder cattle price by a combination of cattle and lot characteristics and market forces. The authors found that source verified cattle and pooling the cattle into lots were associated with price premiums because buyers were looking for background information when making purchasing decisions. Zimmerman et al. (2012) used a hedonic model to examine the price of individual lots of cattle on auction date being dependent on the individual lot characteristics and auction day market forces. The authors found that premiums were associated with cattle that were part of animal health programs.

Grisley et al. (1985) examined the interactions between selected characteristics of the hay sold at a Pennsylvania hay auction market, the bidders and hay based on the prices that were paid. Their data was comprised of 107 buyers from September 1982-April 1983 and used a linear multiple regression model. The variables included in the regression were average load size, loads sold per auction, miles to market, tons purchased annually, percent purchased at auction, percent used for cattle feeding, forage type, and percent above-average quality. Hay use was categorized as “alfalfa hay intended for horse feeding” and “alfalfa intended for cattle feeding.” The types of hay analyzed were alfalfa, legume-grass and straw. These authors found that the intended use of hay, perceived quality, and type were significant variables in determining the prices that were paid for hay. Intended use for horse feeding resulted in higher prices over intended use for cattle feeding. Alfalfa that was perceived to be of higher quality brought higher prices than average quality hay. Alfalfa hay was also associated with higher premiums over that of straw and legume-grass.

Rudstrom (2004) used a hedonic model to analyze the significance of nutritive value, bale size and type of hay in influencing the market price of hay in Minnesota auctions from 2000-2002. A hedonic model was also used to determine if premiums or discounts are related to the different sizes and types of hay bales. Rudstrom found that large round, large square and medium round bales were significant and discounted by a marginal value of roughly $11-$14 per ton in comparison to small square bales. Medium square bales were found to be insignificant.

McCullock et al. (2014) used data from the Centennial Hay Auction, in Fort Collins, CO, that consisted of alfalfa, grass and alfalfa/grass mixes. These authors used a hedonic price model for each hay type, with the weighted average prices as the dependent variable and year, month, grade, bale type (size), tonnes per size/grade, and total tonnes offered (whole auction) as the independent variables. In this study, large price increases were related to specific grade size combinations where grade size refers to the nutritive value and form of the hay, while price reductions were connected with larger sized bales and lower quality grades.

The motivation of this research is to provide more information about factors that influence the price of hay and to evaluate the accuracy of anecdotal evidence. It also adds to existing literature in that it examines more than one forage type. Other studies have examined hay auction data that primarily consists of beef and dairy production, while the area of this data set includes buyers from both the beef and equine industries. This work is different from previous literature as it further explores the impacts of Total Digestible Nutrients by categorizing lots of hay as high, medium or low, whereas McCullock et al. (2014) primarily focused on the impact that crude protein had on the price of hay. This research examined data from central Kentucky auctions and estimated how attributes impacted the value of hay sold.

It is expected that the species composition of hay and the nutritive value parameters would have the most influence on the price of hay that is sold at the auction which is consistent with previous work (McCullock et al., 2014; Grisley, Stefanou and Dickerson, 1985; Rudstrom 2004). Square bales should bring higher prices because they can be transported and sold in larger lot sizes and reduce the costs to the seller. In addition, square bales offer ease of handling which is more suitable to the equine market. McCullock et al. (2014) states that larger size bales sold at discounts to smaller ones and found that size had an impact on price differentials. Lot size (i.e. the number of bales per lot) is unlikely to have a major impact on the price of hay. While bale weight is not expected to be a major pricing factor for large bales, hay producers often indicate that smaller square bales are preferred by many buyers. Therefore, it is expected that smaller square bales would sell at a premium to larger square bales.

The species of the hay should also have some influence on price due to nutritive value differences across species of hay. Legumes such as alfalfa generally have higher nutritive values than grasses. However, each group of grasses nutritive values can vary greatly and depends on stage of maturity at the time of harvest (Ball, Hoveland and Lacefield, 2015).

2.2 Sale Process of Madison County Hay Auction and Data Collection

Data was collected from an annual January hay auction that is held in Richmond, KY. Hay arrived at the sale during the week prior to the auction and was tested for nutritive value by the Forage Testing Program of the Kentucky Department of Agriculture (KDA). Nutritive value results and average weight per bale were posted with each lot of hay. Total Digestible Nutrients (TDN), Crude Protein (CP) and Relative Feed Value (RFV) were highlighted for each lot and buyers were provided with a publication on interpretation of the analysis in regard to the nutrient requirements for cattle and horses. According to the Kentucky Department of Agriculture's forage brochure, crude protein is defined as a mixture of true protein and non-protein nitrogen. The National Forage Testing Association (NFTA) states that crude protein is 6.25 times the nitrogen content for forage. Total digestible nutrients (TDN) is the digestible components of fiber, protein, fat and nitrogen-free extract in the diet. TDN equations are broken into two different calculations for legume hay and grass/mixed hay. The equation used to calculate TDN for legume hay is as follows:

$$TDN = 4.898 + (89.796 * NEL)$$

The grass and mixed hay TDN equation is

$$TDN = 8 + (86 * NEL)$$

In both equations, NEL refers to net energy for lactation. Relative feed value is defined as combining the digestibility and potential intake of a forage into one number that increases as forage quality increases (Forage Testing Program/KDA, NFTA).

McCullock et al. (2014) sorted hay according to crude protein value as premium, good, fair and utility. Similarly, the quality of hay in this study was ranked as high, medium or low quality according to the total digestible nutrient value of each lot sold at auction. If the TDN of the observation of hay was 50 or higher, the hay was considered high quality. If the TDN value ranged from 40-49.99, the hay was considered medium quality and if the hay is 39.99 or below, the hay was sorted as low quality.

The Central Kentucky area is largely a cow-calf area with limited equine and dairy operations. This sale provided an opportunity to evaluate multiple factors that influence the value of hay, such as nutritive value, bale weight, lot size, round versus square and forage species.

Sales information from 2012-2017 was used in the analysis from this auction. In 2014, the weight of each bale was not recorded and therefore excluded from the analysis. Several observations are excluded from the analysis due to missing information such as bale weight, nutrient values and lot sizes. There were also a few observations not used due to no nutrient data being included. In total, 215 observations that included approximately 30-60 lots of hay sold for each year were used.

In addition, total precipitation and average temperature during the months of April to August for Madison County in Kentucky were collected. Total precipitation and temperature should have some influence on the price of hay, as both variables are important in the production of hay and specifically can impact yield and nutritive value. Total precipitation and average temperature were determined using Kentucky Mesonet's reported temperatures and rainfall. Live cattle futures for the month of the auction were included in the analysis. Live cattle futures were included to capture demand for hay from cattle producers and were collected from the Livestock Marketing Information Center's monthly live cattle futures report. The futures price utilized in the data set is the February futures price for the month of January for each sale date. Live cattle futures should also have a positive effect on hay price as cattle producers are the primary buyers at the hay auction.

The forage species were sorted into three different categories based on each observations description: alfalfa mix, mixed grass, timothy/orchard/clover and bad hay Timothy/orchard/clover was sorted based on the description only including timothy or orchard or clover. The bad hay refers to any observation that included a description such as “bad,” “sticks” or “stemmy.”

The data from the central Kentucky hay auction was used to develop a hedonic model to explain hay price using the following dependent variables: type of hay, number of bales sold in a single lot, square versus round, weight of hay per bale, nutritive values of hay (CP, RFV, and TDN), total precipitation, average temperature and live cattle futures. Ordinary Least Squares (OLS) estimation provided the results of the model. A Variance of Inflation (VIF) test was performed to test for multicollinearity, while a Breusch-Pagan test accounted for any heteroskedasticity within the model

2.3 Regression Models of Madison County Hay Auction Prices

The following equation was used as the theoretical framework of the analysis:

$$P_i = f(\gamma_i, \theta_i, \delta_i)$$

where P_i is the price per ton of hay, $\gamma_i$are hay characteristics such as forage type, bale weight, lot size, form and quality. θ_i is weather variables such as average temperature and total precipitation and $\delta_i$is live cattle futures. Subscript i represents time. From the theoretical framework, six hedonic models were developed to explain hay price per ton. Figure 2 lists equations of the linear models used for the analysis:

Figure 2: List of Model Equations

Equation 1:

$$\begin{aligned}Adjusted\ Hay\ price &= \beta_0 + \beta_1 Alfalfa\ Mix \\ &+ \beta_2 Timothy, Orchard, Clover + \beta_3 Bad\ Hay + \beta_4 Live\ Cattle\ Futures \\ &+ \beta_5 Temperature + \beta_6 Temperature^2 + \beta_7 Total\ Precipitation \\ &+ \beta_8 Round\ Crude + \beta_9 Square\ Crude + \beta_{10} Square\ Bale\ Weight \\ &+ \beta_{11} Round\ Bale\ Weight + \beta_{12} Round\ Lot\ Size + \beta_{13} Square\ Lot\ Size \\ &+ \beta_{14} Square\ High + \beta_{15} Square\ Medium + \beta_{16} Square\ Low \\ &+ \beta_{17} Round\ High + \beta_{18} Round\ Medium + \varepsilon\end{aligned}$$

Equation 2:

$$\begin{aligned}Adjusted\ Hay\ price &= \beta_0 + \beta_1 Alfalfa\ Mix \\ &+ \beta_2 Timothy, Orchard, Clover + \beta_3 Bad\ Hay + \beta_4 Live\ Cattle\ Futures \\ &+ \beta_5 Temperature + \beta_6 Temperature^2 + \beta_7 Total\ Precipitation \\ &+ \beta_8 Crude\ Protein + \beta_9 Bale\ Weight + \beta_{10} Lot\ Size + \beta_{11} High\ TDN \\ &+ \beta_{12} Medium\ TDN + \varepsilon\end{aligned}$$

Equation 3:

$$\begin{aligned}Hay\ price = {} & \beta_0 + \beta_1 2012 + \beta_2 2013 + \beta_3 2015 + \beta_4 2016 + \beta_5 Alfalfa\ Mix \\ &+ \beta_6 Timothy\ Orchard\ Clover + \beta_7 Bad\ Hay + \beta_8 Round\ Crude \\ &+ \beta_9 Square\ Crude + \beta_{10} Square\ Bale\ Weight + \beta_{11} Round\ Bale\ Weight \\ &+ \beta_{12} Round\ Lot\ Size + \beta_{13} Square\ Lot\ Size + \beta_{14} Square\ High \\ &+ \beta_{15} Square\ Medium + \beta_{16} Square\ Low + \beta_{17} Round\ High \\ &+ \beta_{18} Round\ Medium + \varepsilon\end{aligned}$$

Equation 4:

$$\begin{aligned}Adjusted\ Hay\ price &= \beta_0 + \beta_1 Alfalfa\ Mix \\ &+ \beta_2 Timothy, Orchard, Clover + \beta_3 Bad\ Hay + \beta_4 Live\ Cattle\ Futures \\ &+ \beta_5 Temperature + \beta_6 Temperature^2 + \beta_7 Total\ Precipitation \\ &+ \beta_8 Round\ TDN + \beta_9 Square\ TDN + \beta_{10} Square\ Bale\ Weight \\ &+ \beta_{11} Round\ Bale\ Weight + \beta_{12} Round\ Lot\ Size + \beta_{13} Square\ Lot\ Size \\ &+ \varepsilon\end{aligned}$$

Equation 5:

$$\begin{aligned}Adjusted\ Hay\ price &= \beta_0 + \beta_1 Alfalfa\ Mix \\ &+ \beta_2 Timothy, Orchard, Clover + \beta_3 Bad\ Hay + \beta_4 Live\ Cattle\ Futures \\ &+ \beta_5 Temperature + \beta_6 Temperature^2 + \beta_7 Total\ Precipitation \\ &+ \beta_8 Round\ RFV + \beta_9 Square\ RFV + \beta_{10} Square\ Bale\ Weight \\ &+ \beta_{11} Round\ Bale\ Weight + \beta_{12} Round\ Lot\ Size + \beta_{13} Square\ Lot\ Size \\ &+ \varepsilon\end{aligned}$$

Table 2 on the following page provides an explanation of the variables used in the models. All equations do not include mixed grasses in order to interpret and compare alfalfa mix, timothy, orchard and clover, and bad hay to mixed grass. Low quality, round bale-hay was not included in the equations in order to interpret the results as price differences compared to this grouping. A round bale linear model and a square bale linear model were also estimated using equation 2 to show the individual impact each bale type has on the price of hay and test robustness of results. Equation 3 included yearly dummies with 2017 as the base year and utilized non-adjusted hay sale prices. Also, Equation 3 does not use the monthly feed index to adjust for prices. In equation 4, CP concentrations were excluded and TDN was made a continuous variable, rather than using the high, medium and low groupings, with equation 5 being similar but representing RFV.

Table 2: Explanation of Variables with Descriptive Statistics

Variable	Description	Average	Standard Deviation	Minimum	Maximum
Hay Price	price per ton received for each lot of hay	$130.40	$87.44	$14.99	$380.00
Adjusted Hay Price	Deflated price per ton received for each lot of hay	$154.88	$110.01	$21.19	$445.63
Mixed Grass	Binomial variable, 1 if mixed grass, 0 if otherwise	0.2	0.4	0	1
Alfalfa Mix	Binomial variable, 1 if alfalfa mix, 0 if otherwise	0.47	0.5	0	1
Timothy/Orchard/ Clover	Binomial variable, 1 if timothy, orchard, clover, 0 if otherwise	0.22	0.41	0	1
Bad Hay	Binomial variable, 1 if bad hay, 0 if otherwise	0.1	0.3	0	1
Temperature	Average temperature for Madison County (April-August)	68.48	0.55	67.32	69.02
Total Precipitation	Total precipitation for Madison County (April-August)	24.65	5.59	14.77	30.7
Live Cattle Futures	The February Future price for the month of January	$129.79	$12.80	$118.07	$157.29
Round	Binomial variable, 1 if round, 0 if otherwise	0.59	0.49	0	1
Square	Binomial variable, 1 if square, 0 if otherwise	0.41	0.49	0	1
Round*Crude	Interaction term between round bale and crude protein	5.48	5.36	0	18.72
Square*Crude	Interaction term between square bale and crude protein	4.83	6.59	0	21.01
Round*TDN	Interaction term between round bale and TDN	25.42	22.05	0	60.62
Square*TDN	Interaction term between square bale and TDN	20.48	25.08	0	63.97
Round*RFV	Interaction term between round bale and RFV	46.43	40.14	0	115.86
Square*RFV	Interaction term between square bale and RFV	38.04	47.21	0	135.4
Round*Bale Weight	Interaction term between round bale and bale weight	525.79	490.20	0	1688
Square*Bale Weight	Interaction term between square bale and bale weight	17.58	21.45	0	61
Round*Lot Size	Interaction term between round bale and lot size	10.38	17.03	0	109
Square*Lot Size	Interaction term between square bale and lot size	58.21	88.36	0	420
Round*High	Interaction term between round bale and high TDN hay	0.10	0.30	0	1
Round*Medium	Interaction term between round bale and medium TDN hay	0.33	0.47	0	1
Round*Low	Interaction term between round bale and low TDN hay	0.16	0.37	0	1
Square*High	Interaction term between square bale and high TDN hay	0.20	0.40	0	1
Square*Medium	Interaction term between square bale and medium TDN hay	0.18	0.39	0	1
Square*Low	Interaction term between square bale and low TDN hay	0.02	0.15	0	1

VIF test results concluded that multicollinearity was found for the following variables: Temperature, Live Cattle Futures, Total Precipitation, Square Crude Protein, Square Bale Weight, Square High and Square Medium. However, the problem was ignored because the independent variables were deemed key factors when attempting to determine the impacts on hay price. Some consequences of leaving ignoring the multicollinearity problem would be that some variables would be captured in others and not have a significant influence on the price of hay. Like McCullock et al. (2014), the initial model, using hay price per ton, suffered from heteroscedasticity. The problem was resolved by using a deflated price per ton, which is the method used in McCullock et al. (2014). The price per ton was adjusted by using the USDA-NASS's (2006-2016) monthly feed index published in the monthly Agricultural Prices report, with the base year being 2017. Due to 2017 agricultural prices not yet being reported, a trend was used to determine the forage price. This index serves to normalize values but also controls for market factors that would impact hay prices across years.

2.4 Results

A basic summary of the data analyzed from the five sale years is provided in Table 3 and 4. Out of the 215 observations, 59% of the lots were sold as round bales and 41% of the lots were sold as small square bales. No large square bales were sold at this auction. The total number of round bales sold in the auction was 2,231 while the total number of square bales sold was 12,516. The average price per ton of round bales was \$69.64 and \$218.08 for square bales. The average bale weight of round and square bales was 890 and 43 pounds, respectively.

Table 3: Descriptive Statistics - Round Bales

Variable	*Mean*	*St. Deviation*	*Low*	*High*
Price per ton	$69.64	$31.19	$14.99	$173.33
Bale weight (lbs)	890.11	285.06	354	1688
Lot Size (# of bales)	17.57	19.12	1	109
TDN	43.04	7.87	9.6	60.62
Crude Protein	9.28	3.65	2.75	18.72
RFV	78.61	13.67	41.96	115.86

Table 4: Descriptive Statistics - Square Bales

Variable	*Mean*	*St. Deviation*	*Low*	*High*
Price per ton	$218.08	$65.07	$90.91	$380.00
Bale weight (lbs)	42.95	5.46	31.00	61.00
Lot Size (# of bales)	142.23	84.37	3.00	420.00
TDN	50.04	7.18	34.92	63.97
Crude Protein	11.80	4.85	2.29	21.01
RFV	92.93	17.97	54.81	135.40

As mentioned earlier, nutritive value groups were sorted based on TDN value. The higher TDN groupings sold at higher prices and this was especially true for square bales (Table 5). High TDN square bales sold for $151 more than high TDN round bales. The difference between medium and high TDN square bales was $55, while for round bales, the difference was $29.

Table 5: Hay Form and TDN Descriptive Statistics

	# of Lots Sold	Average Price per Ton
Round bales	127	
High Quality	21	$98.30
Medium Quality	72	$69.25
Low Quality	34	$52.77
Square bales	88	
High Quality	44	$249.32
Medium Quality	39	$193.90
Low Quality	5	$131.73

The results of the regression are displayed in Table 6 for equation 1. The model explained 88% of variation in the hay auction prices. With the baseline for the regression equation being mixed grass hay, alfalfa mix and bad hay are significant at the 95% confidence level. Alfalfa mix hay offered premiums relative to mixed grass hay, while bad hay was discounted. Alfalfa mix hay sold for $34.68 per ton more than mixed grass hay, while hay noted as "bad" was associated with $26.54 lower price per ton, holding everything else constant. Much of alfalfa mixed hay was sorted as high TDN hay according to the given TDN value, which is in line with the hypothesis that higher nutritive value hay would offer premiums over lower quality hay such as mixed grass, and is also consistent with previous literature (McCullock Et al. 2014; Grisley, Stefanou and Dickerson, 1985; Rudstrom 2004). As expected, bad hay was discounted due to lower nutritive value measures. While timothy, orchard grass and clover hay was insignificant, those hay types should bring higher prices than mixed grass hay because they generally are associated with higher TDN values (refer to Table 3 & 4). Also, the nutritive value variables captured much of the impacts that timothy, orchard and clover hay would have on price.

Table 6: Regression Results for Equation 1

N	215	
R-Square	0.8785	
F-Value	78.71	
Variable	**Parameter Estimate**	**Standard Error**
Intercept	-119489.00	142535.00
Alfalfa Mix	34.68***	11.15
Timothy Orchard Clover	9.02	7.97
Bad Hay	-26.54***	9.95
Temperature	3342.06	4197.13
Temperature^2	-23.53	30.88
Live Cattle Futures	7.28***	0.92
Total Precipitation	2.71	2.27
Round Crude Protein	4.01***	1.33
Square Crude Protein	1.52	1.48
Square Bale Weight	-3.35***	0.89
Round Bale Weight	-0.01	0.01
Round Lot Size	0.46**	0.20
Square Lot Size	-0.11**	0.05
Square High	391.75***	44.69
Square Medium	342.15***	40.33
Square Low	278.17***	44.35
Round High	14.49	14.55
Round Medium	25.84***	9.72
***Indicates significance at the 99% confidence level **Indicates significance at the 95% confidence level		

With low TDN round bales used as the base, interaction terms of TDN level and bale type were significant in the regression apart from high TDN round bales. These results were similar to that of McCullock et al. (2014), where all grades (Good, Premium, Supreme and Utility) and their interactions were significant and the higher the grade, the higher the premium. Different from McCullock et al. (2014), this analysis found that prices for high TDN round bales were not significantly different from low TDN round bales. As expected, the interaction terms between square bales and nutritive value resulted in high premiums compared to round bales. High TDN square bales had a premium of $391.75 per ton than that of low TDN round bales, with decreasing premiums with lower TDN hay. This indicates that buyers in these sales are more concerned with the nutritive value of the hay being sold and were willing to pay more for higher TDN values, especially for square bales. While high TDN round bales were insignificant, it is interesting that the parameter estimate is lower than that of medium TDN round bales. This is an unexpected result and is likely due to the small sample size as only 16% of round bale observations were sorted as high TDN, while 57% were medium TDN.

It was relatively surprising that CP did not assist in explaining square bale price, but was positively related to hay prices for round bales (Table 6). While this may be partially due to the small sample size, it is most likely that TDN is capturing much of the nutritive value information because CP is part of the TDN equation. For round bales, a 1% increase in crude protein was associated with an increase in the price of $4.01 per ton. Premiums for higher nutritive value hay are related to buyers who are concerned with the nutritional value of the hay that is being fed to their livestock. Also, CP is not a critical nutrient for livestock because excess quantities (i.e. more than approximately 12%) would be excreted by the animal.

When examining the marginal effect of bale weight on square bale price, it was determined that the marginal value of square bales decreased with additional pounds. The bale weight for square bales is significant in influencing the price of hay, in that a one-pound increase in square bales resulted in a discount of $3.35 per ton. For example, the actual average weight of a square bale from the data set is 45 lbs with an average price of

$218 per ton ($4.91 per bale). If the weight of the bale is increased to 55 lbs, the price per ton is $184.50 per ton ($5.07 per bale). Assuming yield is 5 tons per acre, at 45 lb bales, the revenue would be $1090 per acre. Using 55 lb bales and $184.50 price/ton, revenue would be $922.50. With a ten-pound increase in bale weight, revenue per acre would decrease by $167.50. These results suggest that square bales can become too heavy and discourage buyers, which can have implications for revenues. Another reason for the discount in heavier bales is that a producer may not have the equipment necessary to handle larger bales (McCullock et al. 2014).

Lot size for square and round bales was significant, with discounts as lot size increased for square bales and premiums for increases in round bale lots (Table 6). This suggests that buyers are willing to pay more for larger lots of round bales, while not as willing to bid on increasing square bale lots. Live cattle futures had some impact on price per ton and as live cattle futures increased by $1 per cwt, the price of hay increased by $7.28 per ton. This would suggest that cattle producers value hay more when the market for cattle is high.

Although not significant in the regression, temperature and precipitation were included to account for effects on yield and nutritive value of hay. Temperature may affect nutritive value as higher temperatures tend to dry out hay faster and preserve more of the dietary fractions that constitute TDN and CP. However, quicker drying can have negative impact on the nutritive value because if the hay becomes too dry, the nutritive values could decrease due to loss of leaf material. Total precipitation may also effect hay yield and nutritive value by delaying harvest which may result in lower nutritive value due to prolonged maturity. Precipitation may also impact yields and hay supply in the region, which could impact price as well. A drought could result in higher prices due to less availability of hay.

The results were similar for equations 2-5. Equation 2 for round bales explained 62% of variation in hay prices at the auction (Table 7). Different from equation 1, alfalfa mix hay was not significant and timothy, orchard and clover became significant. This result is because most alfalfa is produced as square bales versus round. Timothy, orchard grass, clover round bales are associated with a $12.64 premium over mix grass round bales. Bale weight is associated with negative impacts on the price per ton of hay. Also, different from equation 1, lot size was insignificant, suggesting that the results are not robust and the impact on price per ton is small. High TDN and medium TDN round bales offer a $22.68 and $14.86 per ton premium, respectively, over low TDN round bales. A 1% increase in crude protein increases the price per ton by $3.35. While not significant in other equations, temperature was significant in round bales revealing that as temperature increases, the price of hay will decrease in round bales. This could partly be attributed to the high temperature drying the hay too quickly and decreasing the nutritive value of the hay.

The square bale model using equation 2 from Table 7 explained 80% of variation. In this model, alfalfa mix hay is the only significant forage type and offers a $48.37 per ton premium over mixed grass hay. As in the round bale model, bale weight had a negative impact on hay price per ton. The premiums offered by square bales where high TDN and medium TDN square bales offer a $79.12 and $57.58 per ton premium respectively, over low TDN square bales. A 1% increase in crude protein increased the price per ton for $3.64 for square bales.

These findings suggest that alfalfa mix hay is the dominant forage type in the form of square bales, while most mixed grass, timothy, orchard, and clover, and bad hay is in the form of round bales. In addition, as the weight of the bale increases, it makes it harder to handle which resulted in lower prices. What is interesting is that in the results of equation 1, round bale weight had a positive impact on the price of hay. As in equation 1, round bale weight was not significant but was significant for square bale weight, which was associated with a discount. It can be assumed that as bale weight increases in both round and square bales, the hay price will decrease because buyers do not want bales that are too heavy to where they, or their machinery, cannot handle the transportation of the bale. This was especially true to square bales as this was consistent across all models.

Table 7: Regression Results of Equation 2 – Round and Square Bales

	Round Bales		Square Bales	
N	127		88	
R-Square	0.6194		0.8041	
F-Value	15.46		25.66	
Variable	**Parameter Estimate**	**Standard Error**	**Parameter Estimate**	**Standard Error**
Intercept	-202821.00	111894.00	-23466.00	185581.00
Alfalfa Mix	11.06	9.91	48.37***	14.28
Timothy Orchard Clover	12.64*	6.56	14.50	12.03
Bad Hay	-28.15***	7.13	-17.11	18.08
Temperature	5872.54*	3293.77	427.76	5461.91
Temperature^2	-42.61*	24.23	-1.53	40.16
Live Cattle Futures	4.01***	0.73	11.58***	1.34
Total Precipitation	1.07	1.74	4.79	2.97
Crude Protein	3.35***	0.87	3.64***	1.29
Bale Weight	-0.02**	0.01	-3.16**	1.16
Lot Size	0.08	0.13	-0.06	0.07
High TDN	22.68**	9.31	79.12***	22.36
Medium TDN	14.86**	6.10	57.58***	21.87
***Indicates significance at the 99% confidence level **Indicates significance at the 95% confidence level				

The results of equation 3 explained 89% of variation in hay prices (Table 8). In this model, temperature, total precipitation and live cattle futures are excluded. Also, the dependent variable was not adjusted using the monthly feed index. The yearly dummy model reveals that the largest premium occurred in 2015, with in increase by $62.33 per ton over that of what was sold in 2017. By using binomial variables for each of the years, this also worked to control for market changes across years. In this model, alfalfa mix is significant and offers a premium of $33 over that of mixed grass hay. Consistent with the results of the other equations, bad hay is significant and is discounted to mixed grass hay. Similar to the results of the previous equations, square bale weight continues to be associated with negative impacts on hay price. Square lot size is significant and is discounted in this model, indicating that lots of square bales can become too large. High, medium and low TDN square bales continue to offer premiums over low TDN round bales.

Table 8: Regression Results of Equation 3

N	215	
R-square	0.8879	
F-Value	86.23	
Variable	**Parameter Estimate**	**Standard Error**
Intercept	11.93	15.02
2012	14.25*	7.80
2013	22.12***	6.48
2015	62.33***	7.81
2016	56.46***	6.87
Alfalfa Mix	33.12***	8.51
Timothy Orchard Clover	8.04	6.09
Bad Hay	-24.77***	7.60
Round Crude	3.02***	1.02
Square Crude	1.00	1.13
Square Bale Weight	-2.79***	0.68
Round Bale Weight	-0.01	0.01
Round Lot Size	0.18	0.16
Square Lot Size	-0.08*	0.04
Square High	308.86***	34.12
Square Medium	270.07***	30.79
Square Low	217.32***	33.86
Round High	6.51	11.11
Round Medium	17.89**	7.42
***Indicates significance at the 99% confidence level **Indicates significance at the 95% confidence level *Indicates significance at the 90% confidence level		

Table 9 shows the results from equation 4 which explained 87% of variation within the model. When crude protein is excluded and TDN is incorporated as a continuous variable (equation 4 and Table 9), TDN was found to have much more of an impact on square bales and will have a higher premium as TDN increases than in round bales.

Equation 5's results explained 86% of variation in hay prices (Table 10). RFV was found to be highly significant with positive impacts on hay price for both round and square bales. The parameter estimates for RFV and TDN for both square and round bales suggest that nutritive value is more important in the price per ton for square bales than in round bales, which could be attributed to the demand for square bales being stronger among horse owners who are more concerned with nutritional value. These results further prove the importance that nutritive value has on the price of hay. Hay with higher nutritive value will increase the price per ton for both round and square bales.

Table 9: Regression Results for Equation 4

N	215	
R-square	0.8736	
F-Value	106.82	
Variable	**Parameter Estimate**	**Standard Error**
Intercept	-17578.00	137492.00
Alfalfa Mix	22.15**	9.31
Timothy Orchard Clover	5.10	8.03
Bad Hay	-25.19**	9.94
Square Bale Weight	-2.35***	0.77
Round Bale Weight	-0.02	0.01
Round Lot Size	0.26	0.20
Square Lot Size	-0.04	0.05
Square TDN	7.08***	0.67
Round TDN	2.13***	0.51
Temperature	389.99	4048.77
Temperature^2	-2.12	29.79
Total Precipitation	2.25	2.20
Live Cattle Futures	5.85***	0.87

***Indicates significance at the 99% confidence level
**Indicates significance at the 95% confidence level

Table 10: Regression Results of Equation 5

N	215	
R-square	0.8594	
F-Value	94.5	
Variable	**Parameter Estimate**	**Standard Error**
Intercept	87587.00	146755.00
Alfalfa Mix	15.41	10.29
Timothy Orchard Clover	10.61	8.36
Bad Hay	-21.22**	10.49
Square Bale Weight	-0.14	0.72
Round Bale Weight	-0.03**	0.01
Round Lot Size	0.22	0.21
Square Lot Size	0.01	0.06
Square RFV	2.77***	0.31
Round RFV	1.37***	0.32
Temperature	-2703.64	4320.95
Temperature^2	20.62	31.79
Total Precipitation	2.74	2.31
Live Cattle Futures	5.97***	0.91
***Indicates significance at the 99% confidence level **Indicates significance at the 95% confidence level		

Total precipitation was not significant in any models, but as stated previously, precipitation will have effects on harvest time, yield quality measures. Live cattle futures were significant and had a positive influence on price in equation 2 for square and round and equation 4 (Table 7 & 9). The buyers in this auction are primarily cattle producers so it makes sense that live cattle futures would have a positive influence on the price of hay. Live cattle futures capture the overall cattle market and may have an impact on demand for hay in the area that the auction is held.

2.5 Conclusion & Implications of Results

As with any study such as this, results should be interpreted within the framework of the sale location. For this reason, it should not be assumed that these results are representative of hay markets across Kentucky. There will likely be differences in areas where there is a stronger presence of dairy production and dairy producers are active bidders in the hay auctions. There might also be differences in stronger equine areas, such as thoroughbred farms where owners are greatly concerned with the nutritional value of hay. However, this research does provide some solid and quantifiable results that have implications for hay producers.

The results prove that the hypothesis was correct in that nutritive value was a key factor in determining hay price. Nutritive value was found to have more impact on the price of square bales than round bales with striking differences, suggesting that buyers will pay more for hay with higher nutritive values especially when buying small square bales. When comparing the average prices for round and square bales at each TDN level, there is significant premiums for square bales over round bales in this auction. This may be because the market for small square bales in this instance is primarily horse owners, who purchase square bales due to ease of handling, and may be more concerned with what they are feeding their horse versus beef producers. At all three TDN levels, square bales offer premiums ranging from more than $275 to approximately $391 per ton over that of low TDN round bales. In other words, square baling is probably the single easiest way to add value to hay and this added value tends to increase as quality increases. However, this analysis does not consider costs associated with production where square bale production will be associated with higher labor costs. While there are significant additional costs in machinery and labor to produce, and handle square bales, there is also potential for significant price premiums.

Hay producers have continually described a strong preference for smaller square bales, primarily for their equine clients. Therefore, the impact of bale weight on sale price was examined. There is evidence to suggest that there is a negative relationship between the bale weight for both square and round bales and the price per ton, with impact being more robust for square bales. It may be possible that square bales can simply become too heavy and producers are likely better off to market a larger number of smaller square bales. Being cognizant of bale weights for small squares is likely a worthwhile practice for hay producers.

Alfalfa mix hay and hay that is either Timothy, Orchard or Clover received premiums over that of mixed grass hay, which was most likely due to having higher nutritive values than mixed grass. The lot size of round bales was not found to have a significant effect on hay price received, but larger lot sizes of small squares were found to be associated with lower price levels. Precipitation and temperature did not influence the price of hay in this regression model, though they are still important in the production of hay.

Since little research in hay production and marketing has been conducted, this work adds to the existing literature and can be used as a basis for further research. The results of this work suggest the importance of hay form, nutritive value and weight as significant factors in determining hay price. The value differences between round bales and square bales were larger than expected. It was also interesting to find that even in a sale location where the hay market is primarily driven by cattle producers and pleasure horse owners, Total Digestible Nutrients and Crude Protein were significant factors in determining the price of hay. Evidence was also found to quantitatively support the idea that producing smaller square bales can significantly impact revenue per acre.

Based on the findings of this research, producers may change purchasing habits as they attempt to get the best nutritive value for their livestock. Hay producers could make changes in the type of hay they provide and how they chose to produce and market hay to increase their profits. However, this will be dependent upon the farming operation. These changes could be switching from a species of hay of lower value, to one that has greater value. Due to square bales having such drastic impacts on the price of hay, producers may choose to switch from round bales to square bales to increase returns. Ultimately, the producer will make their production and marketing decisions based on what fits best with their operation. The results of this analysis will give producers more information about how characteristics can impact the value of hay when sold in an auction setting. This work adds to the existing literature and can serve as a basis for future research on hay price analysis.

Chapter 3: The Effectiveness of the NAP Program when insuring Alfalfa in Kentucky

3.1 Alfalfa Production in Kentucky

According to the USDA's Crop Production 2016 Summary, of all the hay produced in the state, approximately 6% (150,000 acres) was alfalfa or alfalfa mixes with an average yield of 3.6 tons/acre and average price of $222 per ton. The lowest average yield was in 2007 with the highest average yield occurring in 2006 and 2015 (Table 11). A one-year difference between 2006 and 2007 saw a decrease of more than 3 tons per acre in average hay yields. As with all crops, there is a risk associated with loss during production. Hay production may decline for various reasons including disease, drought or other disastrous weather changes occur, which may have a devastating financial impact for hay producers if the crop is not insured. The fact that the average high and lows in hay yields came in subsequent years is a clear example of risk associated with hay production. Using insurance is one way to protect against the risk of yield loss. The decision to insure hay depends on the risk aversion of the hay producer.

Table 11: Alfalfa and Alfalfa Mixtures for Hay Area Harvested, Yield and Production- Kentucky: 2005-2016

	Area Harvested (1,000 acres)	Yield per acre (tons)	Production (1,000 tons)
2005	260	3.2	832
2006	280	3.7	1036
2007	280	0.8	504
2008	240	2.5	600
2009	220	3.5	770
2010	230	2.8	644
2011	210	3.4	714
2012	180	2.9	522
2013	200	3.3	660
2014	165	3.4	561
2015	170	3.7	629
2016	150	3.6	540

Source: Crop Production 2016 Summary (January 2017)
USDA, National Agricultural Statistics Service

Many producers may look for programs that would allow them to insure their hay. However, insurance programs available for hay production have been very limited. Currently, the only two insurance programs available to Kentucky hay producers are the Noninsured Crop Disaster Assistance Program (NAP) offered through the Farm Service Agency (FSA) and Pasture, Rangeland and Forage Insurance offered through the Risk Management Agency (RMA).

3.2 Related Studies of Evaluation Insurance Programs

Several studies, such as Davis, Anderson and Smith (2014), Mark and Burdine (2015), Mane and Watkins (2016) and Williams et al. (2014), evaluate the effectiveness of insurance programs use historical yield and price data to simulate distributions in order to evaluate the way different insurance programs would have worked from a historical perspective. Methods such as this are useful in the evaluation of insurance programs, assuming that the future will closely follow that of the past.

Davis, Anderson and Smith (2014) used a stochastic simulation model of net revenue from crop production to evaluate the impact of crop insurance programs proposed by the 2014 Farm Bill. The simulation showed the return over risk management costs for three different farm enterprises: an Arkansas rice farm, a Texas cotton farm and a Georgia peanut farm. Adverse Market Payment (AMP), Agricultural Risk Coverage (ARC), Price Loss Coverage (PLC), Revenue Loss Coverage (RLC), Supplemental Coverage Option (SCO), Stacked Income Protection Plan (STAX) and Revenue Protection Crop Insurance were the programs evaluated. The authors' model simulated farm yield, county yield, projected price and harvest price for RP insurance, and marketing-year average price for each crop. The authors concluded that farm managers could shift some of the risk management costs of insurance by electing highest coverage levels of the AMP, PLC or SCO programs. This would allow premium savings and the use of other programs to provide coverage for losses that would not trigger an indemnity using the RP insurance.

Mark and Burdine (2015) used historical gross margins to evaluate the effectiveness of Margin Protection Program for Dairy as a risk management tool had it been available from 2002-2013. The authors found that the MPP-Dairy program would have been successful in reducing risk had it been available during the 12 year period from January 2002 to December 2013. Reduction in margin risk would have depended on the region and choice of coverage and percent of coverage that was selected by the individual producer.

A paper focusing on insuring rice production evaluated the Margin Protection (MP) Crop Insurance that is available to rice producers in Arkansas (Mane and Watkins, 2016). The MP program offered through the USDA Risk Management Agency provides coverage against an unexpected decrease in operating margin resulting from increased input costs. They first calculated the rice margin protection indemnity where premiums are the producer's MP subsidized premium for the coverage level that was purchased. Next county yields and prices were simulated based on ten years of data for the period 2006-2015 using SIMETAR (Simulation & Econometrics to Analyze Risk). A stochastic analysis was also used to provide a range of values that are associated with risks and uncertainties in rice production. It was found that the program was more effective in managing risk at higher coverage levels when input prices were higher and yield and harvest prices were lower.

Similar to Mane and Watkins (2016), Williams et al. (2014) presented a risk analysis of the Adjusted Gross Revenue-Lite on beef farms. Panel data from 1993-2010 for 49 southeast Kansas beef farms were used to assess the effect of AGR-Lite on net farm income variability. Premiums were calculated by dividing total indemnities by total liabilities for all farms receiving at least one indemnity over the 12-year period. The coverage levels used were based on the three coverage levels offered by AGR-Lite. The study found that AGR-Lite can be effective for some beef farms but due to the complexity of the program, it may not be suitable for other beef farms and is therefore, not widely used.

3.3 What is the Noninsured Crop Disaster Assistance Program?

The Noninsured Crop Disaster Assistance Program (NAP) of the 2014 Farm Bill provides eligible producers coverage of crops that are commercially produced agricultural commodities. Crops eligible for NAP assistance must be a non-insurable crop and an agricultural commodity for which the catastrophic risk protection level of crop insurance is not available. Some examples of crops eligible for NAP coverage are crops grown for food, crops planted and grown for livestock consumption, and specialty crops to name a few. The available coverage levels are 50%, 55%, 60% and 65% at 100% USDA price for hay producers. The eligible causes of loss are natural disasters and include the following: damaging weather, adverse natural occurrences and conditions related to either damaging weather or adverse natural occurences.

Noninsured Crop Disaster Assistance Program (NAP) is one of the few insurance programs available to hay producers to insure their crop and is offered through the Farm Service Agency (FSA). While NAP covers other crops, NAP is largely used in Kentucky by hay producers. According to the FSA, "The USDA's Farm Service Agency's (FSA) provides financial assistance to producers of noninsurable crops when a low yield, loss of inventory, or prevented planting occurs due to natural disasters." However, NAP's highest coverage level of 65% may not be sufficient to provide adequate risk protection for hay producers. At the 65% coverage level, a producer would need to incur a crop loss of more than 35%, which is rare in Kentucky, only happening once in the last ten years at the state level, as can be seen in Table 11.

Producers have the option of purchasing coverage based on “revenue” per crop per acre. The price is fixed by crop for each state at the county level. Individual yields can be used if there are at least five years available. When individual yields are not available, the FSA uses 65% of the state (county level) yields. Premiums are fixed at 5.25% of the guarantee for all crops and coverage levels. A service fee is also included that is the lesser of $250 per crop or $750 per producer per administrative county and should not exceed a total of $1,875 for a producer with farming interests in multiple counties (USDA/FSA, 2016).

According to the NAP Fact Sheet (USDA/FSA, 2016), the FSA uses crop acreage, approved yield, net production, and the coverage level elected by the producer to calculate NAP payments. An average market price for the commodity established by the FSA state committee and a payment factor reflecting the decreased cost incurred in the production cycle for a crop that is not harvested or prevented from being planted is used as well. Figure 3 shows an example of how the yield guarantee, premiums, indemnities and net revenues are calculated based on a coverage level of 65%, an FSA price of $191 and average production history of 5 tons/acre.

Figure 3: Example of NAP Payment

APH: 5 tons
NAP Coverage Level: 65%
FSA Average Market Price: $191

$$5 * .65 = 3.25$$

3.25 is the guaranteed yield that is insured.

Premium: $(Yield\ Guarantee * FSA\ Price) * 5.25\%$

$$(3.25 * \$191) * 0.0525 = \$32.59$$

If actual yield falls below 3.25, the producer receives an indemnity.

Indemnity: $(Yield\ Guarantee - Actual\ Yield) * FSA\ Price$

Actual yield: 3.00 tons

$(3.25 - 3.00) * \$191 = \$47.75$

Net Revenue: $(Actual\ Yield * FSA\ Price) - Premium + Indemnity$

$$(3 * \$191) - \$32.59 + \$47.75 = \$588.16$$

3.4 Motivation for Evaluation of NAP

There have been changes made by the government for the available disaster assistance policies with the 2014 Farm Act. These changes have made the disaster assistance programs harder to ratify and thus crop insurance has become the primary form of yield protection, which has increased interest in crop insurance for hay (USDA: Government Programs & Risk, 2016). Producers who take part in commodity income and price support programs are required to purchase the minimum catastrophic level of crop insurance coverage on every crop of economic significance on his/her farm. Yield protection through NAP is then provided when there is no other insurance available. Due to the uncertainty of whether or not producers can benefit from having the highest level of coverage, the effectiveness of NAP will be assessed through simulation.

While historical state-level yields provide some indication of yield risk over time, yield variation at the farm level is likely to be greater. This work employed simulation utilizing actual historical Alfalfa yields from a producer in Hart County, Kentucky as well as Alfalfa trial yield data from the University of Kentucky Ag Experiment Stations at Princeton, KY and Lexington, KY. The simulation of the yields allowed for indemnities, premiums, and net revenue to be calculated for each coverage level offered by NAP.

3.5 Data & Methodology

A simulation approach using historical yields and USDA prices to estimate revenues at various coverage levels was performed to determine the effectiveness of NAP as a risk management tool for Kentucky hay producers. The price used in the data set was provided by the FSA and is the guarantee price for 2017 NAP coverage. While state yield data was available, it was not used due to aggregation that occurs at the state level. The aggregation of the state yield data does not fully capture the yield variation that an individual producer would likely encounter. The historical yield data used in this analysis are from an individual farmer in Hart County and trial alfalfa yields from the University of Kentucky. The trial data comes from two different research locations within the University of Kentucky Ag Experiment Station: Princeton and Lexington. Princeton is located in the western part of the state, while Lexington is located in central Kentucky. The on-farm yield data from Hart County was collected from 2012-2016 and likely represents a more typical production setting. However, this yield data was collected by an experienced hay producer. The trial yield data from Princeton and Lexington are from 2006-2015. First year seeded biennial and perennial forage is not eligible under NAP, therefore first year stands were not included in the average yields for each year. The yields used for the analysis were total average yields for the season. The average alfalfa yields for each location are shown in Table 12.

Table 12: Average Yield Data for Hart County, Lexington and Princeton

	Hart County	Lexington Trial	Princeton Trial
2006	n/a	3.54	5.96
2007	n/a	2.64	2.79
2008	n/a	3.38	3.85
2009	n/a	5.38	4.3
2010	n/a	5.23	3.28
2011	n/a	4.34	3.99
2012	2.85	2.83	3.65
2013	4.85	5.15	6.24
2014	5.2	5.73	4.92
2015	4.85	5.78	5.63
2016	5.6	n/a	n/a

A GRKS distribution (developed by Gray-Richardson-Klose and Schumann) of alfalfa yield was created for Hart County using Simetar (Simulation & Econometrics to Analyze Risk: Richardson, Schumann & Feldman, 2008). The GRKS distribution is a continuous probability distribution that can be employed when limited empirical data is available (Richardson, 2006). This distribution method takes the minimum, maximum and average values of the data and creates a distribution with expected values that fall outside of the minimum and maximum values permitting possible outliers (Richardson, 2006). This distribution simulates values less than the minimum roughly two percent of the time and values greater than the maximum about two percent of the time (Richardson, 2006; Palma et al., 2011; Richardson and Bizimana 2017). The GRKS distribution used for the Hart County data due to the availability of fewer years. When there is less historical data than ten years, a GRKS distribution is more useful (Higgins, Richardson and Outlaw, 2008).

An empirical distribution was simulated using the data from Princeton and Lexington since more historical yield data were available (Ray et al. 1998). The empirical distribution uses a continuous distribution so it interpolates between the years of yield data using the cumulative distribution probabilities (Richardson, Schumann and Feldman 2008).

A total of 10,000 yield iterations were drawn for the GRKS distribution of the Hart County simulation as it gives a better approximation of the true distribution. A total of 1,000 iterations were drawn for the empirical distribution for both the Princeton and Lexington Trial simulations. Yield guarantees, indemnities, premiums and net revenues were calculated without insurance and with NAP coverage at the 50%, 55%, 60% and 65% levels. The NAP service fee was not included in the analysis. Since this service fee is a fixed amount, it will represent a relatively small amount when considered on a per acre basis for most producers. The yield guarantee is calculated by taking the average yield from the on-farm and trial data and multiplying it by the percent of coverage. This yield guarantee is multiplied by the alfalfa price to determine the revenue guarantee for each coverage level. Indemnities were calculated by taking the difference between the yield guarantee and the simulated yield when simulated yield fell below the guarantee, then multiplying the difference by the average price per ton for alfalfa. NAP premiums are calculated by multiplying the yield guarantee by the average price per ton of alfalfa, then multiplying that number by 5.25% (NAP Fact Sheet, 2016).

Higher coverage levels were also considered to make an estimation of the level of premium required to offer higher coverage levels for hay revenue protection using an approach similar to NAP. Since NAP premium rates would likely be too low for coverage levels beyond 65%, actuarially fair premiums (AFP) were estimated for these higher coverage levels. This premium estimation was performed for the proposed coverage levels of 70%, 80% and 90% and follows the work of Ramirez and Carpio (2012) where the AFP is the average indemnity that is paid. While this AFP does not include administrative costs, it does provide some measure of premiums that would be needed and allows for the estimation of risk reduction potential of higher coverage levels. Net revenue under each coverage level is calculated by subtracting the premium from the net revenue with no insurance and then adding the indemnity.

The root mean squared downside deviation from the median net revenue was utilized to define the associated risk. Root mean squared downside deviation has been used as a risk evaluation measure to evaluate the risk reduction of the Dairy Margin Protection Program and Livestock Gross Margin-Dairy program (Mark and Burdine, 2015; Burdine et al., 2014). The following equation is measures the risk:

$$risk = (\frac{1}{2N}\sum_{1\le c\le N}[R_c < \mu](\mu - R_c)^2)^{1/2}$$

Where R_c is the net revenue corresponding to the coverage level c and μ is the median value of the net revenue corresponding to the coverage level. Put simply, this risk measure shows the downside risk associated with net revenue that falls below the median net revenue.

As coverage levels increase for both NAP and the proposed coverage levels, risk should be reduced. However, higher risk reduction levels are also associated with higher premiums. It is expected that the NAP coverage levels will not effectively reduce risk since the highest level of coverage available was 65%.

3.6 Simulation Results using NAP Coverage

The results of the simulation can be found in Tables 15-17. The Hart County NAP simulation showed the most reduction of risk as coverage levels increased which is most likely due to the GRKS distribution allowing for more tail risk. At the highest coverage level offered by NAP of 65%, risk is reduced only by 6.47% with the degree of risk reduction decreasing with coverage levels. The maximum of coverage level of 65% indicates that a producer would be required to have a loss of 35% in yield in order to receive an indemnity, which is not likely. Over the past ten years of alfalfa yields in Kentucky, only once was there a yield loss of more than 35% (Table 11). At the 65% coverage level, the probability of receiving an indemnity is only 3.63% over 10,000 iterations. The average net revenue decreases as coverage levels increase meaning that producers receive less income in order to reduce the risk of yield loss.

As can be seen in Table 13, results suggest that purchasing NAP at the 50% coverage level was associated with a decrease in net revenue of approximately $23 from no insurance. From there, each 5% increase in coverage level is associated with a further decrease in net revenue of $1-$2. More risk averse producers will choose higher coverage levels and generate lower net revenue due to higher premiums than that of less risk averse to risk neutral producers.

The NAP simulations for Princeton and Lexington reveal that there is little to no risk reduction when using NAP to cover alfalfa production. This is also because the empirical distribution does not allow for as many extremes in yield as does the GRKS, eliminating some of the tail risk. An indemnity is only triggered at the 65% coverage level for Princeton and the probability is of that indemnity being triggered is 1% (Table 14). The Lexington trial would reduce risk under the 65% levels of coverage, however, this reduction is still very low as was the probability of receiving and indemnity. There was less yield variation among the Princeton and Lexington trial data as there was in the Hart County yield data which caused the risk reduction and probability of indemnities to be lower. With such low levels of risk reduction at the NAP coverage levels, the results suggest that NAP is not an effective insurance program for hay producers in Kentucky because it is unlikely to provide much reduction in downside revenue risk. Note that in Tables 13-15, risk reduction was less than 10% in all cases and was greater than 5% in only one. While there was a greater probability of indemnities for Lexington, it is also important to note that at the 65% NAP coverage level Hart County simulation actually saw a greater percentage or risk reduction. This was due to Hart County indemnities being much larger than that of Lexington in those few cases were indemnities were received, eliminating more risk for Hart County.

Table 13: Hart County NAP Simulation Results

	Average Net Revenue	Change in Revenue	Standard Deviation of Net Revenue	Coefficient of Variation	Percent of Risk Reduction	Probability of Indemnity
Without Insurance	$858.05		133.86	0.16		
NAP Coverage Levels						
50%	$834.93	$(23.12)	132.82	0.16	-0.99%	0.51%
55%	$832.93	$(25.12)	131.83	0.16	-1.94%	1.04%
60%	$831.25	$(26.80)	130.1	0.16	-3.63%	2.00%
65%	$830.13	$(27.92)	127.23	0.15	-6.47%	3.63%

Table 14: Princeton Trial NAP Simulation Results

	Average Net Revenue	Change In Revenue	Standard Deviation of Net Revenue	Coefficient of Variation	Percent of Risk Reduction	Probability of Indemnity
Without Insurance	$851.86		182.39	0.21		
NAP Coverage Levels						
50%	$829.49	$(22.37)	182.39	0.22	0.00%	0.00%
55%	$827.25	$(24.61)	182.39	0.22	0.00%	0.00%
60%	$825.02	$(26.84)	182.39	0.22	0.00%	0.00%
65%	$822.93	$(28.93)	182.14	0.22	-0.60%	1.40%

Table 15: Lexington Trial NAP Simulation Results

	Average Net Revenue	Change In Revenue	Standard Deviation of Net Revenue	Coefficient of Variation	Percent of Risk Reduction	Probability of Indemnity
Without Insurance	$851.03		195.15	0.23		
NAP Coverage Levels						
50%	$828.97	$(22.06)	195.15	0.24	0.00%	0.00%
55%	$826.76	$(24.27)	195.15	0.24	0.00%	0.00%
60%	$824.56	$(26.47)	195.15	0.24	0.00%	0.00%
65%	$823.86	$(27.17)	192.66	0.23	-1.75%	7.00%

A cumulative distribution function for each NAP simulation are shown in Figures 4-6. The CDF's show the probability of net revenue with no insurance and at each coverage level offered by NAP. The net revenue without insurance is higher than producers who elect to have NAP insurance at the majority of probability levels. For example, in the Hart County CDF (Fig. 4), with no insurance, 89% of the time net revenue is less than $1,000. With 65% NAP coverage, net revenue is less than $1,000 approximately 94% of the time.

The CDF's also assist in explaining the variation in risk levels across the three locations. In Hart County (Fig. 4), 2% of the time is 65% NAP coverage superior to no coverage, where net revenue of 65% NAP coverage was greater than the net revenue with no insurance. This is also present with in the Lexington trial data (Fig. 6), where a very small portion of the time is 65% NAP coverage has greater net revenue than not having insurance. This occurs on the rare occasion where the indemnities received exceeds the premium paid. However, also note that there is considerable more tail risk exists with the on-farm yield data. On very rare occasions, there is considerable difference between the NAP coverage revenues and the no coverage revenues. This is a function of both the on-farm yields and the GRSK distribution employed. With the NAP insurance, there are times when indemnities received are less than the premiums that are paid. In these cases, an indemnity is received, but revenue is actually lower under the NAP coverage.

Figure 4: CDF of Hart County Net Revenue with NAP Coverage

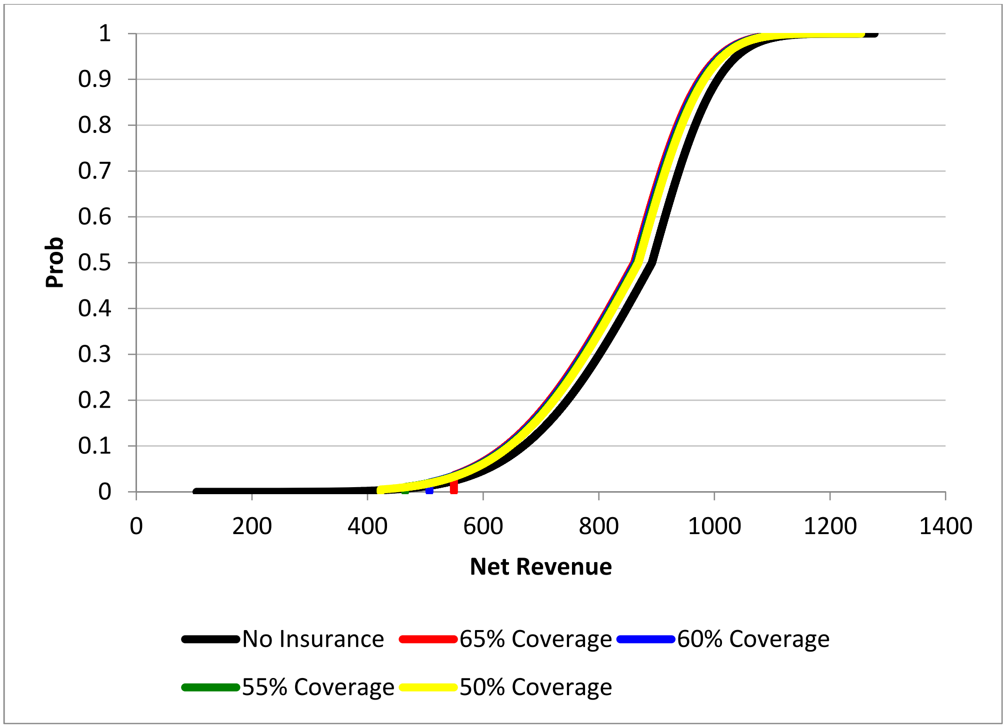


Figure 5: CDF of Princeton Net Revenue with NAP Coverage

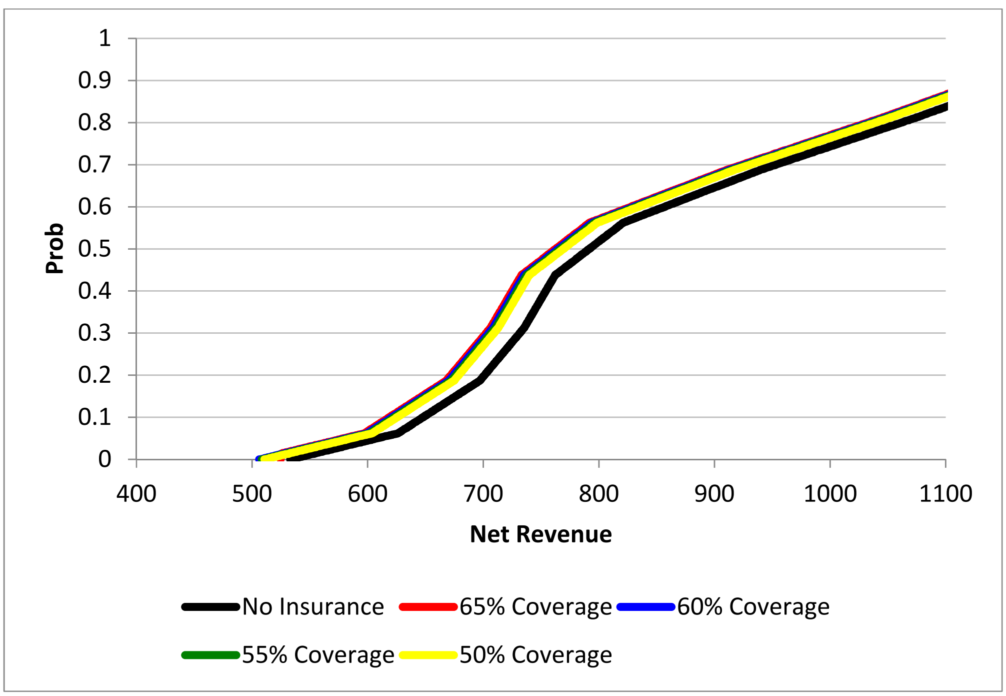
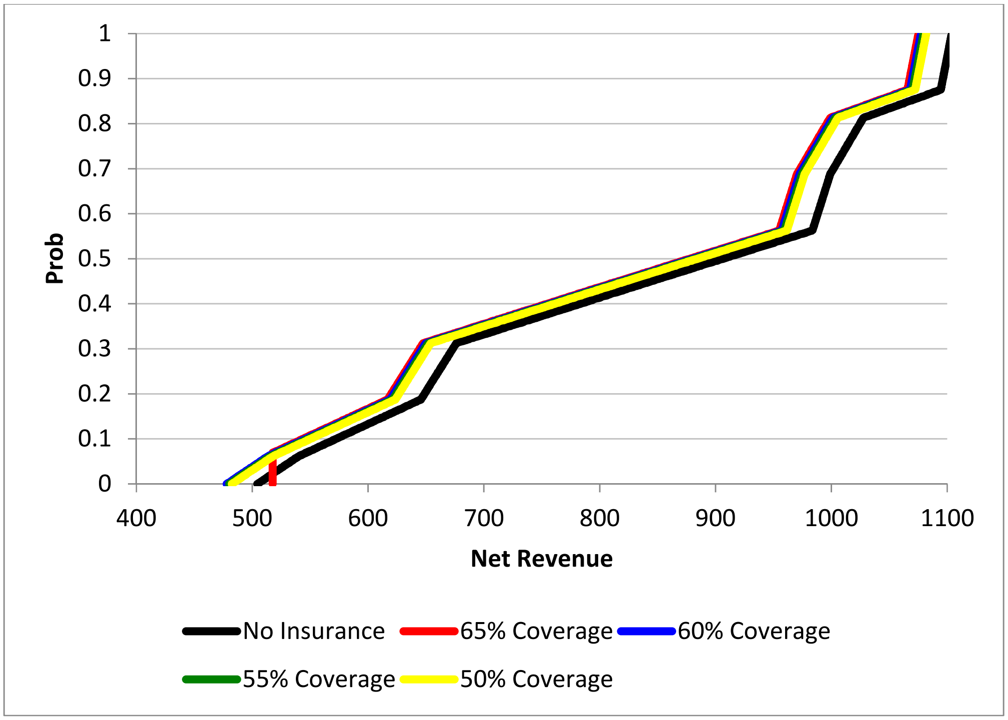


Figure 6: CDF of Lexington Net Revenue with NAP Coverage



3.7 Proposed Coverage Levels Results

Three proposed coverage levels of 70%, 80% and 90% were evaluated to see if higher coverage levels would be more effective for Kentucky hay producers as well as what premiums would need to be offered should these higher coverage levels be made available. These results can be found in Table 16-18. As discussed previously, the actuarially fair premium for the proposed coverage levels is the average of all indemnities that would be paid at the specific coverage level.

At the proposed 70% coverage, the AFP for Hart County, Princeton and Lexington is $5.00, $1.35 and $5.47 respectively. For comparison, the premium of NAP coverage level of 65% for these locations was $30, $29, and $29, respectively. This suggests that NAP premiums are higher than what has been calculated as actuarially fair, even without the service fee. The NAP premiums are the same for all commodities that can be covered by NAP, therefore the premium paid for coverage of a higher-risk commodity, such as tomatoes, is the same premium that would be paid for insuring alfalfa. This could be the reason for this difference.

Similar to the results from the NAP simulations, as coverage levels are increased, the percent of risk reduction increases as well (Tables 16-18). Risk reduction does not exceed 35% until a coverage level of 90% is utilized. For Hart County producers risk is reduced by 56% at the 90% coverage level. However, even at these higher coverage levels, the probability of receiving and indemnity is less than half of the time.

It is interesting to note that Princeton and Lexington have larger risk reductions and higher probabilities of receiving an indemnity with the proposed levels of coverage than that of Hart County, but it is reversed in the results for NAP. When using NAP, Princeton and Lexington have smaller levels of risk reduction than that of Hart County. At the 90% coverage level, the Princeton trial would see a reduction of risk of 78%. The Lexington trial saw a 46% reduction in risk at the 90% coverage level. This is most likely because the alfalfa data is an average of 10-20 varieties, whereas fewer varieties were likely used by the Hart County producer. As expected, as the coverage levels are increased, the probability of indemnities increase as well.

Table 16: Hart County Proposed Coverage Level Simulation Results

Coverage Level	Actuarially Fair Premium	Percent of Risk Reduction	Probability of Indemnity
70%	$5.00	-10.95%	6.18%
80%	$13.78	-27.06%	15.23%
90%	$33.69	-56.06%	30.39%

Table 17: Princeton Trial Proposed Coverage Level Simulation Results

Coverage Level	Actuarially Fair Premium	Percent of Risk Reduction	Probability of Indemnity
70%	$1.35	-5.00%	4.20%
80%	$9.07	-26.83%	16.00%
90%	$33.48	-78.03%	44.80%

Table 18: Lexington Trial Proposed Coverage Level Simulation Results

Coverage Level	Actuarially Fair Premium	Percent of Risk Reduction	Probability of Indemnity
70%	$5.47	-6.03%	12.00%
80%	$20.74	-20.65%	29.70%
90%	$49.61	-46.06%	37.80%

3.8 Conclusion

This work used simulation to evaluate the four NAP coverage levels currently offered for alfalfa hay producers, as well as three proposed coverage levels with higher revenue guarantees. For each actual and hypothetical coverage level, the probability of indemnities, percent of risk reduction and the average net revenue associated with each level of coverage were calculated. For the four NAP coverage levels, actual premiums were incorporated into the analysis. For the three hypothetical coverage levels, actuarially fair premiums were estimated and used in the analysis. The implications of this work are relevant for both hay producers as they consider their risk management strategies and policy makers as they consider policy options in the future.

The results show that as NAP coverage levels are increased, the probability of an indemnity increases, while risk is reduced. As higher coverage levels are elected, average net revenue decreases due to paying higher premiums. Similar to Mane & Watkins (2016) findings, as high levels of coverage are elected, NAP is more effective in reducing risk. However, risk reduction is very small for Hart County, Princeton and Lexington under NAP coverage. For example, a Hart County alfalfa producer would be giving up $30 per acre for less than 10% reduction of risk. In rare situations would the current coverage levels offered through NAP be an effective insurance program for Kentucky alfalfa producers. In the case for the Hart County producer, only 2% of the time was 65% NAP coverage better than no coverage. While there is some value in the risk reduction offered through NAP, it is unlikely that producers will find the program very attractive given the revenue decrease and risk reduction tradeoff found in this work.

This finding is further supported by comparing actuarially fair premiums estimated for higher coverage levels to actual NAP premiums. This work indicates that NAP premiums are considerably higher for this on-farm and trial data used in the analysis, suggesting a need for NAP premiums to be reevaluated which can be examined in future studies. For example, when calculating the actuarially fair premium for 65% coverage of the Hart County simulation, the AFP would be $3 instead of the actual $30 actual NAP premium. Further, the maximum NAP coverage of 65% severely limits the risk reduction that can be achieved. Allowing higher coverage levels or lowering the premiums would reduce the risk of yield loss for Kentucky alfalfa producers and likely make a program like this more attractive. Examination of both coverage levels and premiums would likely be worthwhile when considering policy options for hay revenue risk reduction products in the future.

Further work could be done in the evaluation of the effectiveness of NAP by examining other hay and forage types. It is expected that the results should be similar to the results of this work. Using additional on-farm yield data could also be examined in future work, as well as the incorporation of the enrollment fee.

Chapter 4: Summary

Within this study, an analysis of hay prices from the Madison County Hay Auction has been presented along with an evaluation of the effectiveness of the Noninsured Crop Disaster Assistance Program (NAP) for alfalfa hay producers. Both studies have implications for producers as they make decisions, but also have potential implications for policy makers. Both studies also lay the groundwork for further research in these areas.

Chapter two discusses the hay price analysis. At this particular auction, price premiums are associated with square bales, alfalfa and high nutritive value such as TDN. Significant price premiums were seen for small square bales over round bales. Results further suggested that nutritive value is a key factor in impacting the price of hay, even in a market where quality is not typically a focus. While quality was a key determinant of price for all hay sold, this was especially true to small square bales where hug differences were seen across quality levels. Evidence was also found to suggest that small square bales can become too large and be associated with lower price levels per ton.

These findings have implications for hay producers as they consider their production practices and market strategies and hay buyers as they consider the type of hay they choose to purchase. Further research could build upon this work by examining hay value determinants in markets where considerable dairy production occurs, where large square bales are produced and sold, and by examining similar factors sold by private treaty or other methods.

Chapter 3 evaluates the effectiveness of the NAP program as a risk management tool for alfalfa producers in Kentucky. This research reveals that producers using the

NAP program to insure their hay will see decreased net revenue due to paying higher premiums, with very little reduction in risk. The premiums charged by the NAP program were found to be higher than what was calculated as actuarially fair and therefore, is suggested that lower premiums might increase interest in the program. These results have implications for producers that may consider purchasing NAP coverage for hay they produce, but also has policy implications as one considers hay insurance programs in the future.

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Dant, Madeline, Kenneth H. Burdine, and Brandon Sears. "The Impact of Quality, Type, and Form at Hay Auctions. 2016 Meeting of the Southern Extension Committee. June 2016. Clear Point, AL.

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