Factors Affecting the Valuation of Hay: Producer & Consumer Preferences, Price Determinants, and Attribute Importance

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ABSTRACT

It is estimated that approximately 47 million acres of US total cropland area is used for hay production (USDA – NASS, 2022b), which means hay plays a major role in the United States' agricultural economy. Hay is an important input and a large cost category for livestock production. Similarly, hay can be a significant source of income for hay producers. Despite the importance to livestock production, hay markets are relatively understudied compared to other commodity markets. It has been demonstrated that certain characteristics or attributes, like quality, influence hay value. However, previous studies have only been conducted in auction settings where purchasing information is aggregated. Therefore, an experiment eliciting willingness-to-pay (WTP) for hay outside of an auction (spot market and private-treaty transactions) was created. The experiment was conducted at four University of Tennessee field days, where four bales (eight total across two years) were analyzed by participants who were randomly placed in a control or treatment group. Both groups were given forage species and provided access to the bales (i.e., viewing, feeling, smelling) and asked to state their WTP for each bale. The treatment group received forage analysis information and bale weight; the control group had neither. The forage analysis included the following metrics: dry matter (DM), crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), relative feed quality (RFQ), and total digestible nutrients (TDN). The purpose was to assess if bale weight and forage analysis information influence WTP. Alongside the experiment, a national survey was administered online with an embedded choice experiment to hay

market participants. The experiment and survey help develop a better understanding of the hay market outside of auction settings.

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INTRODUCTION

Hay is an important input in most livestock production. Any operation that raises livestock will likely use hay as a feedstuff, to some degree. Hay can have multiple uses including feed, bedding for animals, and landscaping and mulching, but for the purpose of this study the focus is hay as a feedstuff for livestock production. Outside of hay being a direct input to livestock production, the commodity itself serves as a significant stream of revenue for producers, and it remains a large driver of the United States' agricultural economy (Peake et. al. 2019).

While each respective agricultural operation is unique, some of the most common practices of hay use include: producing hay for personally owned livestock, buying hay to feed livestock, or producing hay to sell to others. Several combinations of these practices exist. For example, one participant may have both a livestock enterprise and a hay enterprise. This type of producer can produce hay to feed their livestock but also sell any surplus or produce more for the sole purpose of selling. Like any market, there are producers and consumers, but participants can also be referred to as buyers or sellers of hay. One participant may be referred to as an incorporation of one or more of these terms. Using the example of the producer with a livestock and hay enterprise, it can be said that this participant is a producer and consumer of hay products but may also be a seller.

Hay is baled or packaged in several forms using varying methods of production. Since production practices vary by operation due to geographic location, intended use, personal preference, and other factors, it becomes difficult to study the product with a single set of characteristics. Hay is typically packaged as either round or square bales.

This is one of the characteristics of interest in this study and it is classified as form (i.e., square versus round bales). Both forms vary in dimensions and weight. Hay is also separated by species of plant that comprises the bale, and this is often referred to as variety. The United States' Department of Agriculture (USDA) publishes the Direct Hay Report as a set of guidelines that delineates varieties of hay based on quality, form, and dimensions (USDA – AMS, n.d.). Bale weight is not included in the report because two bales of the same form and dimensions do not necessarily have a standard weight. There are many factors of production and bale characteristics for hay products, and it is assumed farmers prefer the bales most suited to their respective operation.

Despite the significance of hay to the agricultural economy and its role in livestock production, the market has been relatively understudied as compared to other commodity crops (Peake et. al. 2019). Due to the heterogeneity of hay, it is difficult to create a standard pricing model or even evaluate as a product. Hay does not have a standard market price or unit by which the product is sold. Several spot market prices and a futures market price are reported regularly for commodities such as corn and soybeans; however, the hay market does not have a futures market contract nor a regularly reported spot market price in many regions of the United States. In reported auctions, hay is typically sold by bale or ton.

Due to the multifaceted set of characteristics inherent in hay, price determination can be difficult (McCullock, Davidson, and Robb, 2014). Other factors affecting price determination include volatile supply and demand, high transportation costs, limited reporting, and hay sold on the spot market (Edwin, 2005). The USDA Agricultural

Marketing Service (AMS) publishes a weekly Direct Hay Report for 18 states (USDA-AMS, n.d.). “Even for one reported market, reporting format, items included, descriptions, etc., change (McCullock, Davidson, and Robb. 2014).” The USDA reports 19 auctions nationwide, but reports have different release intervals including monthly, semi-monthly, bi-weekly, and weekly, which can make price comparisons more difficult than if all reports were released on a consistent interval. Much of the hay produced is difficult to track due to private-treaty transactions in the spot market or the consumption of hay on the same farm in which it was produced, where no reported transaction exists.

This project uses an experiment to better understand hay markets. Specifically, the study is conducted to determine the attributes influencing the value of hay and how much each of those attributes contributes to value determination. The majority of reported data comes from auction settings and lacks consumer or producer insight. To better understand the product outside of auctions, it is important to scale down to the participant level and disaggregate data. Results could further the understanding of hay markets and could contribute to a price determination model.

CHAPTER I

EVALUATING HAY PREFERENCES USING FIELD EXPERIMENTS

Research Objectives

In 2024, over 51.5 million acres of hay were harvested in the United States (USDA-NASS, 2024) making it an important component of the national agricultural economy (Peake et. al. 2019). The primary use of hay is as a feedstuff in livestock production, but it is also used for animal bedding, landscaping, and mulching. Focusing on hay production and use for livestock, most operations can be categorized under one or more of the following designations: producing hay for personally owned livestock, buying hay to feed livestock, producing hay to sell to others, or purchasing hay for resale. Thus, market participants producing hay for personally owned livestock and those purchasing hay would be considered hay buyers while those producing hay for sell would be considered hay sellers. Similarly, market participants purchasing hay for resale would be both a buyer and a seller.

Despite the significance of hay to the agricultural economy and its role in livestock production, the market has been relatively understudied compared to other commodity crops (Peake et. al. 2019). Hay is an input to a livestock operation, and it is an output for a hay operation. Thus, it can be both a cash outlay and a revenue stream. This means understanding the attributes of hay that provide value to buyers and sellers of hay is important.

Hay is a heterogenous product and can vary by forage specie, nutrient density, bale shape, bale weight, and a host of other factors. This heterogeneity is largely due to

production practices varying by operation due to geographic location, intended use, personal preference, and other factors. Thus, it is difficult to study the product with a single set of similar characteristics.

Due to the multifaceted set of characteristics inherent in hay, price determination can be difficult among buyers and sellers (McCullock, Davidson, and Robb. 2014). Hay is typically packaged as either round or square bales and can vary in dimensions and weight. Hay is also categorized by plant species that comprises the bale, and this is often referred to as variety. The United States' Department of Agriculture (USDA) publishes the Direct Hay Report (USDA-AMS, n.d.) as a set of guidelines that delineates varieties of hay based on quality, form, and dimensions. Bale weight is not included in the report, because two bales of the same form and dimensions do not have a standard weight.

Not only is hay heterogenous in variety, quality, form, and dimensions, it also does not have a standard unit by which the product is sold. Standardized spot market prices and a futures market price are reported regularly for commodities such as corn and soybeans; however, the hay market does not have a futures market contract nor a regularly reported spot market price in many regions of the United States. Furthermore, hay prices in reported auctions may be by the bale or by the ton (i.e., weight).

The USDA Agricultural Marketing Service (AMS) publishes a weekly Direct Hay Report for 18 states (USDA-AMS, n.d.). The USDA reports 19 auctions nationwide. While this means data is readily available, reports are not structured in a format that researchers can easily develop datasets from. (McCullock, Davidson, and Robb. 2014). Part of the challenge is due to reports having different release intervals (i.e., weekly, bi-

weekly, monthly), which can make price comparisons more difficult than a consistent report interval. McCullock, Davidson, and Robb (2014) stated, “Even for one reported market, reporting format, items included, descriptions, etc., change.” Furthermore, much of the hay produced is traded via private-treaty or the hay is consumed on the same farm in which it was produced, which leads to no publicly available transaction information (Peake et. al. 2019).

The majority of reported data comes from auction settings and lacks consumer or producer insight. To better understand the product outside of auctions, it is important to scale down to the participant level and disaggregate data. Results could further the understanding of hay markets and could contribute to a price determination model.

Hay price research has primarily focused on quality, grade, and size. The majority of this work has used auction data and hedonic pricing models (Rudstrom, M. 2004; McCullock, Davidson, and Robb. 2014; Peake et. al. 2019). Publicly available auction data has allowed researchers to measure relationships, except on an aggregated level. Thus, to overcome some of the shortcomings associated with publicly available data, an experiment eliciting willingness-to-pay (WTP) was conducted.

Since hay products are not homogenous and buyers have differing preferences, this study looks to determine the attributes influencing the value of hay and the magnitude of that influence. The purpose of this study is to examine preferences for hay characteristics at a buyer and seller level. The initial goal of auction experiments is to examine the price received and determine what factors of the lots sold influenced the price (Dant 2017). The first objective is to determine hay market participant WTP for

hay. The second objective is to determine what hay characteristics and hay market participant characteristics influence their WTP for hay, which can be achieved by evaluating the relationship between hay attributes and farm and producer demographics. A particular interest is to determine if access to nutritional content and forage analysis actually influences WTP.

These results will contribute to a better understanding of private treaty transactions for hay and the overall market. Additionally, it should provide information that will assist with price discovery and market transparency and ultimately market efficiency

Literature Review

There is an abundance of literature on livestock markets examining hay as a value-added input. However, research focusing on hay independently is small. Due to limited funding, only a small number of auctions are reported, and formatting is rarely the same. Other scenarios that inhibit data collection are that a majority of hay is produced and fed on the same farm, and hay is often sold in a cash market (Peake et. al. 2019). Private treaty transactions, where one farmer buys directly from another, result in no recorded transaction.

Determining Implicit Prices for Hay Quality and Bale Characteristics

Margaretha Rudstrom uses a hedonic pricing model from an auction where most buyers are dairy farmers. Dairy producers have long been interested in high quality hay as protein has proven to increase milk production (Rudstrom, M. 2004). It is widely accepted that nutrient measures such as crude protein (CP), relative feed value (RFV),

and total digestible nutrients (TDN) are important to dairy producers. Rudstrom found that the structural changes to the dairy industry in the late 1990s led to the emergence of a growing market for quality hay. Farms began to outsource their feedstuff, which caused some to enter the market strictly as hay producers. Rudstrom's objective was to determine if premiums or discounts are associated with various sizes and types of hay. Modeling incorporates proxies that represent which cutting of the year they hay is from as well as visualization of the bale to be observed. At the time, no hedonic hay price models had used direct measures of quality, but she expected this measure as well as the proxies to have a positive effect on prices. The model estimated price based on moisture, protein (CP), RFV, a seasonality effect (proxies), size, and calculated supply and demand. Results supported her hypothesis. "Implicit value of RFV indicates that even relatively small improvement in RFV can significantly impact hay price (Rudstrom, M. 2004)." She concludes that dairy farmers prefer high quality hay packaged to fit their feeding systems. Smaller diaries that exit the market may be in an advanced position to produce hay for other dairies. (Rudstrom, M. 2004).

Price Characteristics at a Hay Auction

McCullock, Davidson, and Robb focus on relative value of different hay characteristics in a specific market, utilizing a time series dataset derived from the AMS report on the Colorado Centennial Hay Auction. Reports from 2006 to 2011 had to undergo significant reconstruction to be suitable for analysis (McCullock, K., C. Davidson, and J. Robb. 2014). Standard reporting from the AMS does not exist due to limited fiscal funding as well as a highly regionalized product. The authors state the importance of understanding

buyers at an auction and identify three buyer groups: beef, dairy, and equine. All three groups participate in commercial and hobby production (McCullock, K., C. Davidson, and J. Robb. 2014). Identification of buyer types can use market characteristics to make farm management decisions. Three varieties of hay from the report were analyzed: alfalfa, grass, and alfalfa/grass mix. Constructed data consisted of the following characteristics: year, month, grade, bale size (type), tonnes per size/grade, and total tonnes offered auction-wide (McCullock, K., C. Davidson, and J. Robb. 2014). Due to the emergence of ethanol in the market, feed crops have experienced general inflation, therefore, weighted average prices were deflated using monthly feed indexes from USDA-NASS. All prices were adjusted to a baseline from 2011 data. The three varieties were evaluated based on the following coefficients: year, tonnes, month (1-12 for respective year), grade, small square, dimensions (3’ by 4’ or 4’ by 4’), large rounds, and small rounds. Modeling also included three interactive terms which evaluated small square with supreme grade, small square with premium grade, and finally large round with supreme grade. Size, grade, year, tonnes, and some of the months proved to be consistently significant. Interactive term significance implies that some buyers prefer specialized combinations of size and grade. McCullock et. al. states that the convenience of small bales and high quality are more important than either of the two attributes separately. It is highly likely that buyers who prefer high quality small square bales have on average less livestock to feed and lack necessary equipment to transport larger bales. Quality and grade were important to all three categories, but less important to alfalfa

growers. They assume that the natural differences in quality between the varieties offer a wider margin for the grades of the alfalfa variety, as compared to others.

Factors Affecting Hay Prices at Auction: A Hedonic Analysis

Peake at. al (2019) examine data from an auction in Central Kentucky. The study builds on existing literature by evaluating the price impact of large round versus small square bales, quality measures of total digestible nutrients (TDN), relative feed value (RFV), lot size, and bale weight. Similar to McCullock et. al., this study uses a hedonic model to unveil what factors have an impact on sale price but for individual lots of hay. The available dataset comes from an auction in Richmond, KY, and ranges from 2012-2013 and 2015-2017. Peake speaks on the inconsistency of reporting from auctions and acknowledges excluded data. Respondents in this study actually saw the physical product, in which they were show lots of hay as well as the respective weight, TDN, CP, and RFV. They were also provided with a pamphlet that interprets the qualities outlined nutrient requirements for cattle and horses, which are commonly found livestock in the region (Peake et. al. 2019) A study by Grisley et. al. (1985) states that intended use has a significant impact on prices for hay buyers. Similar to McCullock's study, hay prices were adjusted to a baseline from 2017. Four hedonic models were used, where each one estimated a different combination of parameters. Model 1 evaluates adjusted prices based on forage type, average bale weight, lot size, and form/quality. The second model segments round versus square bales to allow for separate analysis. Models 3 and 4 are exactly the same as models 1 and 2, except for the quality metric changes from TDN to RFV. The two additional models allow Peake et. al. to analyze the effect of TDN and

RFV against each other. Hay quality and variety did have an impact on prices. However, it is important to interpret results within the scope of the respective sale. The auction where the study was conducted is in an area where cattle and horses are the dominant livestock produced (Peake et. al. 2019). They also note that this auction is held each January; a unique seasonal effect where producers are selling excess hay from a high yield season, or buyers are trying to purchase hay in a time of short supply.

These pieces of literature offer great insight to what is significant in prices, but do not reveal much in terms of personal preferences. An important goal of this project is to better understand buyers and sellers. Seller's preferences have not been found from any of the literature mentioned. By conducting an experiment on a disaggregated level where buyers and sellers place a valuation on bales, the interaction occurring on the spot market can be observed. This will be the first hypothetical auction and choice experiment conducted on buyers and sellers' preferences of hay attributes, to the best of our knowledge. Results could lead to a more attainable price discovery and equip buyers with the proper information for purchasing. We hope to bridge the gap that surrounds the price determination of hay as a commodity and forage.

Materials and Methods

Field Experiment and Survey Design

This study aims to assess what characteristics are important to individual buyers and sellers of hay products. Unlike existing literature that used publicly available data, this

project uses experimental data collected from four University of Tennessee Institute of Agriculture (UTIA) field days ; two in 2023 and two in 2024.

The participant sample for this experiment is anyone over the age of 18 that has produced, sold, bought, or fed hay in the year prior to taking the survey. Participants have no prior knowledge of the bales included in the experiment and it is assumed their respective bids are placed using the information provided. Respondents participating in the experiment begin by taking a survey, which first provides basic information regarding the project, the research team, institutional review standards, and then asks consent. Respondents then move to screening questions. These questions address respondent age, if they produced, purchased, sold, or fed hay in the past year and if they are the primary decision maker for an operation. Respondents that meet the criteria move to the next block of questions titled "About Your Farm." These questions ask about what segments of the market they are involved in, if they are primarily a buyer or seller, size and dimensions preferred, weight preferred, and if they buy or sell by the bale or per ton. At the end of this block, respondents are randomly placed in the control or treatment group and are asked to evaluate the bales.

A photo shows a respondent evaluating bales at one of the 2023 experiments. The table is set up for participants to begin the survey prior to evaluation. The bales are labeled 1-4 so respondents can match the bale to their packet. The bales in Figure 1 from left to right are ordered 2, 3, 1, and 4. **Figure 1** shows the setup of the experiment.



Figure 1. Experiment at 2023 Plateau AgResearch Field Day

Each respondent views and bids on all four bales. The same four bales were used across both field experiments during 2023, and four new bales were selected for the experiments in 2024. It is important to utilize the same lot of bales for the field experiments within the respective year, as this allows for analysis of both experiments as one dataset. A complete forage analysis test was conducted for all 8 bales used in the study. The bales contents were measured using Near-Infrared Spectroscopy Analysis (NIRS) which provides rapid analysis of multiple constituents within hay (Shenk, 1981). For analysis and discussion of bales each bale is referred to as “Bale” followed by the number of the bale, 1 through 8. Bales 1 to 4 were used in 2024 and 5 to 8 in 2023.

The bales used are ranked by species, weight, and the six nutritive values we commonly refer to throughout the project. Dry matter (DM) is the percentage of the bale that is not water or the existing nutrients within the bale that do not include water. Crude protein (CP) refers to the percentage of protein within each bale based on the nitrogen content. ADF and NDF are Acid-Detergent Fiber and Neutral-Detergent Fiber, and both are measures of fiber, where ADF measures cellulose and lignin while NDF measures hemicellulose, cellulose, and lignin (Penn State Extension, 2023). ADF is a measure of fiber that is digestible and NDF measures fiber that is slowly digestible or indigestible entirely. “Relative Feed Quality (RFQ) is an index for ranking cool-season grass and legume forages based on combining digestibility and intake potential, derived from ADF and NDF (USDA-Livestock, Poultry, and Grain Hay Terms).” Total Digestible Nutrients (TDN) are the sum of CP, fat, and non-structural carbohydrates present within a bale, which is a measurement of energy. **Table 1** shows these measures.

Table 1. Forage Analysis of Bales used for Field Experiments

Bales	Species	Weight (lbs.)	DM	CP	ADF	NDF	RFQ	TDN	Quality*
Bale 1	Crabgrass	1050	87.00	10.64	39.23	66.07	85.00	57.51	Good
Bale 2	Tall Fescue	890	88.00	10.29	36.87	63.94	92.00	59.99	Good
Bale 3	Crabgrass	1010	83.00	7.34	34.98	57.86	104.00	61.97	Fair
Bale 4	Crabgrass	870	90.00	10.97	38.32	68.81	83.00	58.47	Good
Bale 5	Orchardgrass/Mixed Grass	982	89.83	11.71	35.78	63.77	93.52	61.13	Good
Bale 6	Orchardgrass/Tall Fescue	582	88.59	8.51	36.03	65.04	91.30	60.87	Fair
Bale 7	Mixed grass/Weeds	584	92.89	11.1	38.53	64.51	88.09	58.25	Good
Bale 8	Orchardgrass	856	90.04	8.36	39.55	72.06	77.41	57.18	Fair

Notes: DM is dry matter, CP is crude protein, ADF is Acid-Detergent Fiber, NDF is Neutral-Detergent Fiber, RFQ is Relative Feed Quality, TDN is Total Digestible Nutrients, Quality* as measured by grass hay guidelines

The USDA Agricultural Marketing Service provides Hay Quality Designation Guidelines from Livestock, Poultry, and Grain Market News (USDA-Livestock, Poultry, and Grain Hay Terms). One of the guidelines is designated for alfalfa hay used for domestic livestock and contains less than 10% grass mix, while the other is for grass hay. These guidelines are used to grade the bales used in experiments. Additionally, these guides are utilized in auction sales to grade hay. Literature examined in this paper uses these guidelines for analysis as well. Both guidelines are measured as percentages. **Table 1** shows the grade of bales used in the experiment as per the guidelines for grass hay. Five of the eight bales are graded as good due to the levels of crude protein and the remaining three are graded fair. While the remaining nutritive metrics are still important in grass hay, the values do not compare to hay that is less than 10% grass. When ranking the bales based on all of the metrics and not just USDA-AMS metrics for crude protein (CP) for grass hay, bale 3 and bale 5 rank first and second, respectively. Bale 2 and 6 are ranked third, as the values are not significantly different. The remaining bales are ranked nutritively as follows: bale 7 is fourth, bale 4 is fifth, bale 1 is sixth, and bale 8 is seventh. These rankings will help in determining which bale is the best in nutritional values and can be evaluated alongside respondents bids for bales. **Table 1** and the rankings will be analyzed alongside results to determine if any unseen relationships may exist that were not included in modeling. The USDA Agricultural Marketing Service Hay Quality Designation Guidelines for Alfalfa hay and grass hay are shown in **Table 2** and **Table 3**, respectively.

Table 2. Hay Quality Designation Guidelines (%) for Alfalfa (domestic livestock; <10% grass)

Quality	ADF	NDF	RFV/RFQ	TDN-100%	TDN-90%	CP
Supreme	<27	<34	>185	>62	>55.9	>22
Premium	27-29	34-36	170-185	60.5-62	54.5-55.9	20-22
Good	29-32	36-40	150-170	58-60	52.5-54.5	18-20
Fair	32-35	40-44	130-150	56-58	50.5-52.5	16-18
Utility	>35	>44	<130	<56	<50.5	<16

Source: USDA Agricultural Marketing Service (USDA-Livestock, Poultry, and Grain Hay Terms) Hay Quality Designation Guidelines; Livestock, Poultry, and Grain Market News

Table 3. Grass Hay Guidelines (%)

Quality	Crude Protein (%)
Premium	>13
Good	9-13
Fair	5-9
Utility	<5

Source: USDA Agricultural Marketing Services (USDA-Livestock, Poultry, and Grain Hay Terms) Hay Quality Designation Guidelines; Livestock, Poultry, and Grain Market News

Experiment participants were randomly placed in the control or treatment group. Each packet is denoted by a 4 digit code in which the first two digits indicate the control (00) or treatment (01) group and the final two are respondents ID number. Participant ID number 0001 would indicate participant 1 in the control group, where 0102 indicates participant 2 in the treatment group. Both groups are provided the forage species of the hay bale, However, the treatment group are also provided the forage analysis or nutritional content and actual weight of the bale**.** Where forage type or species is provided to both groups. The information treatment includes the forage analysis metrics as well as the actual weight of the bale. Including weight may prove to be important as participants may have strong preferences regarding weight. This could be explained by the type of operation and the ability to transport or utilize bales at the given weight. A good example would be that an operator with less capable equipment will prefer lighter bales.

Figure 2 shows the bales included at the 2024 Spring Hill field day. The bales numbered from left to right are: 1, 2, 3, and 4. **Figure 3** and **Figure 4** are what a control group participant and a treatment group participant is provided during the experiment for the same bale, respectively.



Figure 2. Bales at 2024 Spring Hill Field Day

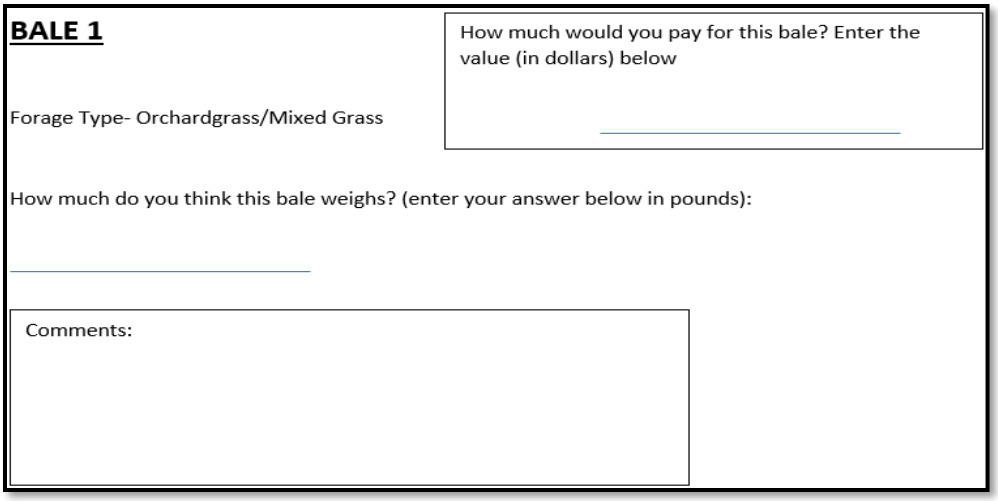


Figure 3. Control Group Information Sheet

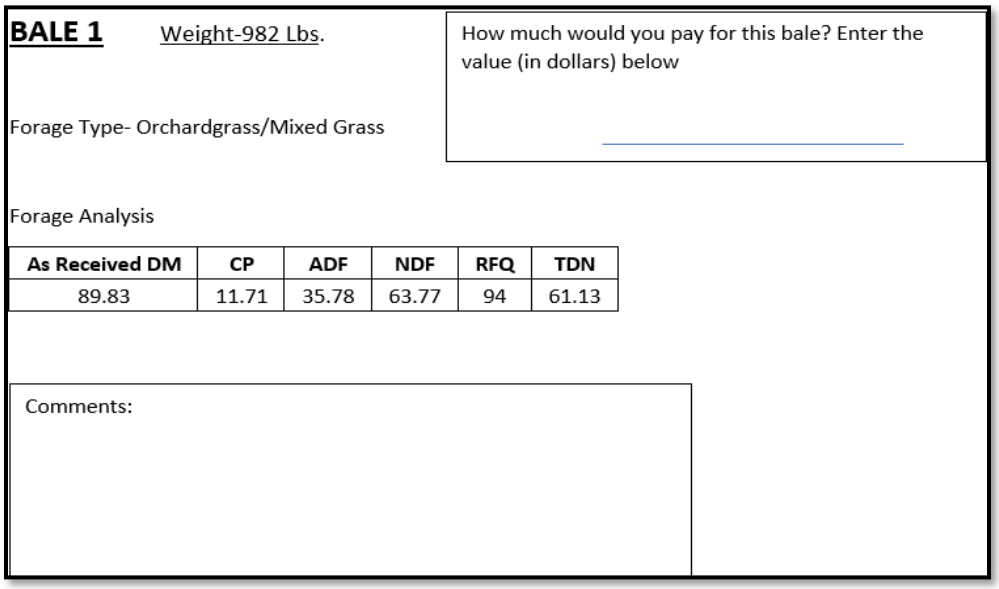


Figure 4. Treatment Group Information Sheet

Both groups are asked how much they would be willing to pay for each bale and an additional field asks the control group respondents to estimate bale weight. Both groups are allowed to make comments.

After evaluating the bales, respondents returned to finish the survey. The next block is titled "About Your Farm 2" and asks participants things such as the nature of their business (sole proprietor, LLC, corporation, etc.), total head of each livestock, acreage farmed (cropland, pasture, hay), how they source or market hay (auction, internet, word of mouth, etc.), preferred species, average days feeding, and if they test hay nutritive value or know the bale weight prior to selling, buying, or feeding. They are also asked to rank the importance of the following attributes: specie, size/dimension, weight, volume, quality, storage method, intended use, transport costs, delivery services, price of alternative feed, and prices set by other industry participants. The ranking is on a scale of 1 to 5, where 1 is not at all important and 5 represents extremely important. They are also asked to rate the importance of the following nutritive values: moisture (DM), protein (CP), carbohydrates (ADF/NDF), crude fat, energy (TDN), minerals, and RFV. During analysis, these questions will be helpful in developing a baseline of what is important to respondents in terms of hay attributes.

Conceptual Framework and Hypotheses

It has been established that the hay market has a certain degree of ambiguity, and we are interested in the valuation of a novel product. Lusk et. al. (2004) state that agribusinesses are interested in two factors: production costs and consumer demand and discuss the relevance of WTP measures in agribusinesses and valuation of differentiated agricultural

products. In this application, WTP is used as a more direct value that represents what the bales are worth to the respondents and from this, factors influencing the bids can be determined. Each respondent's bid in the hypothetical auction experiment represents their WTP for each of the four bales, respective to the year and experiment. While elicited WTP is stated by the respondents' opinions regarding each bale, they are also influenced by additional information. Participants in the treatment group (*Information* Treatment) may use the provided forage analysis, which should influence the bid they place on a certain bales. It is hypothesized the information treatment participants should increase or decrease bids dependent upon the metric and quality levels of the bale. Control group participants must rely on their own judgement or any prior experience in the hay industry to place their bids. Additional variables that are likely to impact WTP are the bales (*Observed Bales*), farm and producer characteristics (*Farm Characteristics*), and demographics of the respondent (*Producer Demographics*).

Based on these predictors, it is hypothesized that producer *i*'s WTP for bale *j* in year *k* (wtp_{ijk}) can be expressed by function (f) using the following factors:

(1) $wtp_{ijk} = f\big(ObservedBales_{ijk}, Treatment_{ik}, FarmCharacteristics_{ik}, ProducerDemographics_{ik}\big)$,

Where wtp_{ijk} is the price (\$/bale), $ObservedBales_{ijk}$ represents respondents *i*'s observation of bale *j* in year *k*, $Treatment_{ik}$ is if respondent was provided the treatment information, $FarmCharacteristics_{ik}$ is the farm and producer characteristics of respondent *i* (12 predictors regarding operative decision making and quantities of

product), and $ProducerDemographics_{ik}$ is three demographic measures of respondent i.

Each of these factors can be further broken down into the variables they include. *Observed Bales* is derived from creating stacked binary variables of the eight bales observed in the two years. It is the summation of each respondents input for bale 1 to bale 7 (bale 8 dropped due to multicollinearity) in 2023 and 2024. *Treatment* is also a binary variable created to indicate a 1 if a respondent was randomly provided the forage analysis and actual weight of bales. *FarmCharacteristics* is a factor of 12 independent variables that include three measures of head (i.e. bovine, small ruminants, horses), number of hay and pasture acres, estimated average days feeding hay, a dummy to indicate if hay is tested for nutritive value, and an average measure of the importance of eight metrics used to measure hay (ranked 1 to 5 for not at all important to extremely important). Additionally, a measure of a participant's willingness to accept risk in financial matters related to the hay business was included, as well as three other binary variables indicating if the respondent is a buyer of hay, if they primarily deal with square bales, or if they primarily deal with large round bales. Finally, *ProducerDemographics* include measures of age, education (bachelor's degree or higher), and percent of taxable income from farm operations, where 1 is equal to 0%-20% and 10 equals 80%-100%. The specific names and definitions of the variables in these categories appear in **Table 4**.

Table 4. Names and Definitions of Dependent & Independent Variables

Variable	Description	Hyp. Sign
Dependent Variable		
Bale WTP	Stated willingness to pay/bale ($)	NA
WTP/Ton	Bale WTP divided by tonnage of bales	NA
Independent Variable		
Information Treatment	1 if information treatment was provided, 0 otherwise	
Observed Bales		
Bale1	1 if bale 1 is observed, 0 otherwise	NA
Bale2	1 if bale 2 is observed, 0 otherwise	NA
Bale3	1 if bale 3 is observed, 0 otherwise	NA
Bale 4	1 if bale 4 is observed, 0 otherwise	NA
Bale 5	1 if bale 5 is observed, 0 otherwise	NA
Bale 6	1 if bale 6 is observed, 0 otherwise	NA
Bale 7	1 if bale 7 is observed, 0 otherwise	NA
Bale 8	1 if bale 8 is observed, 0 otherwise	NA
Farm Characteristics		
TotalHeadBovine	Head of beef cattle	+/–
TotalSmallRuminants	Head of sheep and goats	+/–
Horses	Head of horses	+/–
Hayacres	Acres used for hay production	–
PastureAcres	Acres used for pasture	–
DaysFeed	Number of days respondent feeds	+/–
TestNutritiveValue	1 if tested prior to buying, selling, feeding; 0 otherwise	+
AverageImportanceMetrics	Average of ranking 1-5 for quality metrics[a]	+
RWFHay	Financial risk willingness in hay business[b]	+
Buyer	1 if primarily a buyer, 0 otherwise	+
Square	1 if primarily handles square bales	–
Large Round	1 if primarily deals with LR bales	+
Producer Demographics		
PercentTaxableIncome	Percent of taxable income from farming[c]	+/–
Age	Respondents age	–
BAorHigher	1 if bachelor's degree or higher, 0 otherwise	+

[a]1 = not at all important to 5 = extremely important; [b]1 = not at all willing to 10 = very willing; [c]1 = 0-20% to 10 = 80%-100%;

The factors included are hypothesized to either negatively or positively influence WTP. For some predictors, such as if a respondent tests hay for nutritive value, a positive impact is expected. Increased bids from respondents who test for nutritive value are expected because this analysis gives the buyer an idea of what to expect from the product (Marsalis et. al., 2009). Additional literature states that forage quality analysis is currently the best basis for hay pricing (McCullock, Davidson, Robb. 2014).

The hypothesized impact on bids from total head of bovine, small ruminants, and horses is listed as positive or negative. It is important to note that these experiments were hosted at field days where the area of focus is beef production. While there is not an absence of participants with small ruminants and horses, bovine representation is most prevalent within the population. It is expected that the quantity of livestock will impact stated WTP, but there is no certain theoretical reasoning to decide which, prior to modeling. It could be argued that large cattle operations will have lower bids on WTP if they opt to produce their own feedstuff. Opposingly, this same operation may not have the land to produce hay and will have higher bids. Acreage of hay and pastureland is hypothesized to have an inverse relationship with WTP. Ideally, in livestock production, the more pasture available results in less mechanically harvested feed being fed to the animals. Large acres of hay land present could indicate a producer that may be willing to pay less since they can produce their own. The variable *DaysFeed* is hypothesized to have an inverse relationship to bids as well.

Producer demographics provide additional information about the respondent that could impact operative decision making and WTP. Three demographic predictors are

included for analysis. *PercentTaxableIncome* is a measure of the respondents total taxable income estimated from farming operations. The levels for this measure are seen in the notes in **Table 1**. This variable is hypothesized to increase or decrease bids, based on the percentage level of farm income. A measure of education is also included. Higher education level is expected to increase bids as we assume a higher degree yields more income and job opportunities. Finally, WTP is expected to decrease due to the effects of respondent age.

It is likely that within the population, there is a mix of commercial producers and hobby farm enterprises. While it is unknown which of these a producer is, we could assume that commercial enterprises would place more emphasis on feed quality. Building producer profiles could be beneficial in the future to understand various levels of emphasis placed on willingness to pay for livestock inputs.

Econometric Model

Using data collected from the experiments, a panel dataset was created. By conducting a hypothetical auction, we elicit respondents' WTP for bales that differ by attributes and characteristics. Modeling and results reveal the relationships between stated WTP and the attributes for the bales. Since the experiment followed the same two sets of product across two years, a pooled panel data set was utilized for the model. The dataset was created by compiling all respondents from each year and extrapolated across the four bales in each experiment. This allows for all eight bales to be analyzed separately as well as the ability to differentiate between years 2023 and 2024 (Bales 1-4: 2024, Bales 5-8: 2023). WTP was included by manually inputting elicited WTP from the packets

respondents completed. WTP per ton is then calculated from WTP bids. This is simply a result of finding the tonnage of each bale from the actual weight and then dividing Bale WTP by the tonnage. WTP per ton is a more suitable metric compared to WTP/pound as reported auctions sell by the ton. After including these variables, the Qualtrics survey data is imported, and responses are matched by the Participant ID assigned to respondents by their package.

The Qualtrics survey includes many questions that can be used for analysis, but further data cleaning is required. For example, questions that asked what dimensions are preferred are transformed to dummy variables. Other questions that were transformed to dummy variables include but are not limited to: primarily buyers or sellers, what sector of the industry they participate in (buying or producing to feed, sell, or other uses), if they test for nutritive value (prior to buying, selling, feeding), whether or not they have experienced drought, and what outlets they source or market hay to. Quantitative variables were also used, and these include predictors such as head of each livestock group, acreage (cropland, pastureland, hay land), average days feeding, preferred weight of bales, age, and total taxable household income as well as percent of taxable income from farming activities. Likert scaled questions were utilized where respondents ranked the importance of attributes or metrics from 1 to 5, 1 being not at all important to 5 being extremely important.

The specific variables of interest are WTP per ton of hay and individual bale characteristics. Two models are used to evaluate the dependent variables and the included predictors. There is no change in the two functions aside from the dependent variable. All

predictors remain consistent across both models. The OLS panel regression for bale WTP is represented by:

$$(2)\ BaleWTP_{ijk} = \beta_0 + \beta_1 Treatment_{ik} + \sum_{j=1}^{7} \beta_j X_{ijk} + \beta_8 TotalHeadBovine_{ik} + \beta_9 TotalSmallRuminants_{ik} + \beta_{10} Horses_{ik} + \beta_{11} HayAcres_{ik} + \beta_{12} PastureAcres_{ik} + \beta_{13} DaysFeed_{ik} + \beta_{14} TestNutritiveValue_{ik} + \beta_{15} AverageImportanceMetrics_{ik} + \beta_{16} RWFHay_{ik} + \beta_{17} Buyer_{ik} + \beta_{18} Square_{ik} + \beta_{19} LargeRound_{ik} + \beta_{20} PercentTaxableIncome_{ik} + \beta_{21} Age_{ik} + \beta_{22} BAorHigher_{ik} + v_i + \mu_{ijk}$$

And WTP/ton is represented by:

$$(3)\ WTP/Ton_{ijk} = \beta_0 + \beta_1 Treatment_{ik} + \sum_{j=1}^{7} \beta_j X_{ijk} + \beta_8 TotalHeadBovine_{ik} + \beta_9 TotalSmallRuminants_{ik} + \beta_{10} Horses_{ik} + \beta_{11} HayAcres_{ik} + \beta_{12} PastureAcres_{ik} + \beta_{13} DaysFeed_{ik} + \beta_{14} TestNutritiveValue_{ik} + \beta_{15} AverageImportanceMetrics_{ik} + \beta_{16} RWFHay_{ik} + \beta_{17} Buyer_{ik} + \beta_{18} Square_{ik} + \beta_{19} LargeRound_{ik} + \beta_{20} PercentTaxableIncome_{ik} + \beta_{21} Age_{ik} + \beta_{22} BAorHigher_{ik} + v_i + \mu_{ijk}$$

Where $BaleWTP_{ijk}$ is the unobserved latent variable for producer *i*'s WTP for bale *j* in year *k*. *Treatment* is the indicator variable equal to 1 if the participant was provided the information treatment, and 0 otherwise. The summation function represents the sum of seven bales, where one is dropped due to multicollinearity during modeling. It measures the parameter of bale *j* based on variable *X* for producer *i* in year *k.* This captures each bale in the experiment and all the characteristics that were measured for that bale and response. In Model 2, equation (3) is modified by replacing dependent variable *BaleWTP*

with *WTP/Ton*. The β's are the parameter coefficients to be estimated by the model. The random effects, v_i, are independent and identically distributed (i.i.d.), and distributed normally with mean zero and variance of σ_v^2 (i.e., $v_i \sim N\,[0, \sigma_v^2]$); and the error term, μ_{ik}, is also i.i.d, distributed normally with mean zero and variance of σ_μ^2 (i.e., $\mu_{ik} \sim N\,[0, \sigma_\mu^2]$), independent of v_i. The subscript $i = 1, 2, \ldots, N$ represents the observation from respondent i who is bidding on bales $k - 1, 2, \ldots, 8$.

In Model 1, the null hypothesis is that access to forage analysis for those in the treatment group will not significantly influence bid price for bales ($\beta_1 = 0$). It is assumed that additional information regarding the product will influence respondents to bid higher or lower for bales, depending on the respective nutritive quality of each bale. However, if the null hypothesis ($\beta_1 \neq 0$) is rejected, then the information treatment is found to have a significant impact on participants' bid price. If we fail to reject the null, then producers bids are not influenced statistically by their access to forage analysis.

A pooled panel regression is used to estimate factors influencing respondents bids for bales in the hypothetical auction. The pooled panel regression is an OLS regression, and we are able to use this model due to only 2.2% of respondents placing a zero bid. Due to the normal distribution, we select an OLS model. **Figure 5** shows the normal bell-shaped distribution of bale willingness-to-pay bids.

Similarly, in Model 2, the null hypothesis is that access to forage analysis information will not significantly influence WTP bids per ton. Rejecting this null hypothesis indicates that the treatment information has a significant impact on WTP/ton bids. Failure to reject the null in Model 2 means that producers bids are not influenced

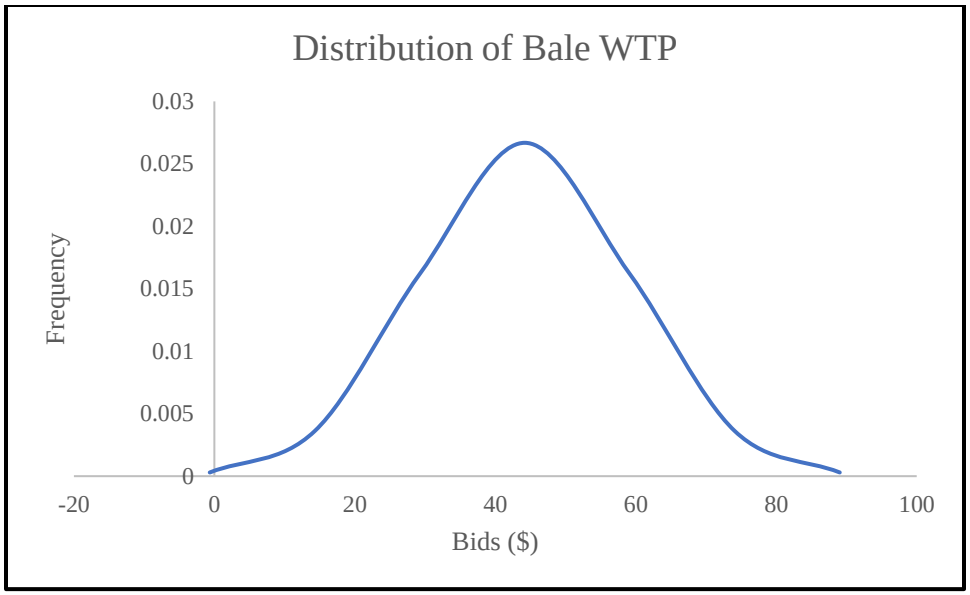


Figure 5. Bell Curve for Bale Willingness-to-pay

by their placement in the treatment group. Evaluation of the results from summary statistics compared to panel OLS modeling will allow us to decide whether or not to reject the null hypothesis for both models

Results

Survey Descriptive Statistics

The initial sample size for 2023 was 68 respondents, but after data cleaning, 35 responses were deleted due to missing information. We determined which respondents had to be deleted based on the two sets of data received from them: the Qualtrics survey and the information packet they were required to fill out during the experiment.. After cleaning we were left with 33 and 45 responses from 2023 and 2024, respectively. Each year's data was then stacked and extrapolated across the eight dummy variables for bales and then combined into one dataset. After stacking, we are able to analyze 312 responses, or

the initial number of respondents multiplied by four bales in each experiment. Responses are separated by participant ID and year.

The summary statistics consists of 160 and 152 responses for the control and treatment group, respectively. The participants in the control group make up 51.2% of the total population. Treatment respondents represent the remaining 48.8%. We consider the percentage of control versus treatment responses to be satisfactory for analysis. On average, producers bid $43.65 per bale if in the control group and $44.75 per bale if in the treatment group. While the treatment respondents paid $1.10 more on average, these values are not significantly different from one another. *TestNutritiveValue* indicates if a respondent test nutritive value prior to buying, selling, or feeding hay; 32.9% of control respondents test hay while 41.55% of respondents in the treatment group test. This is an increase of 8.64% if given treatment information. In comparison to cash bids between the groups, this is interesting as access to forage reports does not significantly impact WTP. Questions regarding testing for nutritive value are not introduced until after evaluation, where information treatment is provided, so this may be indicative of bias.

Participants bid $103.30 and $103.91 per ton for the control and treatment group, respectively. All respondents averaged 78.9 head of cattle. *TotalHeadBovine* includes the sum of beef cattle, weaned calves, finished cattle, dairy cattle, and one respondent with a herd of 33 bison. *TotalSmallRuminants* combines head of sheep and goats, and the average is 1.58 per respondent. The average for this variable between control and treatment is 4.3 and 2, respectively. Overall average for horses is 1.41 per respondent. The low number of small ruminants and horses is not due to the absence of producers

with these type of livestock within the region, but more likely representative of the population attending the field day. The mean pasture and hay acreage for control respondents are 97.18 and 104.00, respectively. Treatment response yield slightly higher results for hay acreage at 81.71 and pastureland at 110.2 acres. The average days feeding hay are 140 and 124.8 for control and treatment, respectively. The average ranking for importance of metrics was 3.6 and 3.5 for control and treatment, respectively. This value is the average of seven nutritional metrics (3.5 out of 5 mean Likert score) and represents moderately important (3) to very important (4). *RWFHay* is also a scaled question that asks respondents willingness to take risks in financial matters related to the hay business. Control and treatment scores were 4.68 and 5.01(4.84 out of 10), respectively. This question is scaled from 1 being not at all willing to 10 being very willing. 56.4% of all respondents classify themselves as buyers of hay products while 5.1% of these buyers prefer square packaged bales and 47.4% prefer large round bales (5'x5' and 4'x6'). The age of respondents is 52.7 years old, which is slightly below the average age of Tennessee farmers at 58.9 years old (USDA NASS, 2022). A bachelor's or higher degree was obtained by 55.1% of all respondents. We expected this measure to have a positive impact on WTP and will evaluate those results. Percent of total income from farm (*PercentTaxableIncome*) is between 20% and 39.99%, on average. Dependent and independent variable means, and standard deviations are presented in **Table 5**.

Table 5 shows summary statistics for independent and dependent variables. More specifically, it provides the mean of bale WTP and WTP per ton. These values represent the mean of WTP for all respondents bids for all bales. Also of interest is the mean and

Table 5. Dependent & Independent Variable Means & Standard Deviations

	Control (*N*=160)		**Treatment (*N*=152*)***	
Variable	Mean	Standard Deviation	Mean	Standard Deviation
Dependent variable:				
Bale WTP	$43.65	$16.33	$44.75	$13.43
WTP/Ton	$103.30	$38.74	$103.91	$28.52
Independent Variables				
Farm Characteristics				
TotalHeadBovine	69.69	72.31	88.36	112.30
TotalSmallRuminants	4.30	14.38	2	7.08
Horses	1.41	4.03	1.40	3.07
HayAcres	97.18	119.72	81.71	93.06
PastureAcres	104	82.91	110.20	92.67
DaysFeed	140	46.11	124.8	57.58
TestNutritiveValue	32.91%	0.47	41.55%	0.49
AverageImportanceMetrics[a]	3.6	0.5	3.5	0.61
RWFHay[b]	4.68	2.07	5.01	2.34
Buyer	54.4%	0.5	58.4%	0.49
Square	2.53%	0.15	7.79%	0.26
LargeRound	46.8%	0.5	48.05%	0.5
Producer Demographics				
PercentTaxableIncome[c]	2.67	2.54	3.96	3.60
Age	53.27	17.2	52.22	15.84
BAorHigher	58.2%	0.49	51.94%	0.50

Notes: [a]1 = not at all important to 5 = extremely important; [b]1 = not at all willing to 10 = very willing; [c]1 = 0-20% to 10 = 80%-100%

standard deviation of individual bales for the control and treatment group. This is important because it shows how respondents bid on bales separately and these results can be compared to the forage analysis of each bale (**Table 1**). Respondents bid the highest on Bale 4 in the control group for bale WTP at an average of $49.78. For the same measure in the treatment group, respondents bid highest on Bale 2 at a value of $52.10. Treatment participants bid higher than the control group on bales 1 through 5, but lower on bales 6 through 8. Treatment bids for bale WTP were only higher, on average, by $0.07. Some conclusions can be drawn by referring to the forage analysis of bales (**Table 1**). The measures of bales 6, 7, and 8 are similar to the others in DM, ADF, NDF, RFQ, and TDN; however, they vary by a large magnitude in weight. Bales 6 and 8 have lower levels of crude protein compared to the average (9. 86), but neither are the lowest in CP (Bale 3). **Table 6** reports these values. 7 had the lowest bids at $35.51 and $31.48 across both the control and treatment group, respectively.

For WTP/ton, Bale 3 had the lowest bids at $75.34 and $89.11 for control and treatment, respectively. The highest bids were for bale 6 at $119.20 and $123.16 for the

Table 6. Means and Standard Deviations of Bale WTP & WTP/Ton for Control and Treatment

Bales	Bale WTP				WTP/Ton			
	Control		Treatment		Control		Treatment	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Bale 1	$41.41	$18.35	$49.29	$12.38	$82.87	$46.41	$93.88	$23.58
Bale 2	$48.70	$23.75	$52.10	$9.39	$89.76	$48.14	$117.07	$21.10
Bale 3	$44.02	$17.27	$45.00	$11.29	$75.34	$44.74	$89.11	$22.36
Bale 4	$49.78	$16.20	$50.48	$13.12	$87.92	$41.53	$116.04	$30.17
Bale 5	$46.19	$11.12	$48.56	$11.34	$98.30	$95.75	$98.91	$23.09
Bale 6	$42.49	$12.23	$35.84	$7.86	$119.20	$102.65	$123.16	$27.02
Bale 7	$35.51	$10.81	$31.48	$10.24	$95.28	$83.98	$107.82	$35.08
Bale 8	$44.46	$11.03	$40.35	$12.42	$106.04	$91.95	$94.29	$29.02

We may be able to conclude that weight has a large influence on bale WTP. Bale

control and treatment. For reference, previous studies have found price per ton at auctions to be $113 (Grisley, 1985) to $150.23 (McCullock, 2014). Additionally, an AMS report from March of 2025 lists the average price per ton for grass hay with a grade of good at $120 (USDA-AMS, 2025). Reported prices and previous studies show that prices have been volatile but may not follow the same trendlines as other commodities across multiple decades. Treatment participants bid higher on all bales except bale 8 as opposed to the control group. The treatment bids for all bales were higher than the control group by $10.70, on average. Based on bale means from **Table 6**, treatment participants place higher bids on bales than the control group. Whether or not the increased bids are significant and due to access to forage analysis can be determined by regression modeling.

Pooled Panel Regression Results

Due to a high number of variables in both models, tests for multicollinearity were completed. All predictors were tested using Variance Inflation Factor (VIF) and returned a score of less than 2.49 for all variables. Given the VIF scores, multicollinearity was not considered to be an issue for either model. The estimated coefficients of the panel OLS regression for Model 1 and Model 2 are reported in **Table 7.**

Intercept values for the baseline prices are positive and significant ($P < 0.01$) at values of $43.49 and $86.77 for Bale WTP and WTP/ton, respectively. Across both models, *Treatment* was found to be positive but insignificant and allows us to reject the null hypothesis. Although the treatment yielded an increase between$1.70 and $2.20, information treatment has no statistically significant impact on WTP per bale or per ton.

Table 7. Marginal Effects from Bale WTP & WTP/Ton Panel OLS Regression

	Model 1 Bale WTP		Model 2 WTP/Ton	
Variable	Coefficients	Std. Error	Coefficients	Std. Error
Intercept	43.49***	7.496	86.77***	17.03
Treatment	1.701	1.642	2.202	3.73
Observed Bales				
Bale 1	-3.632	3.324	-12.78*	7.551
Bale 2	2.047	3.337	15.50**	7.582
Bale 3	-4.077	3.324	-10.25	7.551
Bale 4	1.274	3.337	16.37**	7.582
Bale 5	0	.	0	.
Bale 6	-9.955***	3.238	33.36***	7.357
Bale 7	-18.12***	3.238	4.943	7.357
Bale 8	-7.773**	3.238	-3.689	7.357
Farm Characteristics				
TotalHeadBovine	-0.004	0.0126	-0.0159	0.0286
TotalSmallRuminants	0.101	0.0843	0.289	0.192
Horses	0.286	0.22	0.649	0.5
HayAcres	0.008	0.00973	0.021	0.0221
PastureAcres	-0.014	0.0142	-0.0326	0.0322
DaysFeed	0.023	0.0173	0.0579	0.0394
TestNutritiveValue	-2.399	1.902	-4.836	4.322
AverageImportanceMetrics	0.81	1.423	2.36	3.233
RWFHay	0.226	0.422	0.576	0.958
Buyer	-7.949***	2.08	-18.28***	4.725
Square	-0.937	4.009	-2.881	9.107
LargeRound	4.293**	1.903	8.956**	4.324
Producer Demographics				
PercentTaxableIncome	0.698**	0.274	1.703***	0.622
Age	-0.068	0.0548	-0.166	0.124
BAorHigher	4.190**	1.888	7.733*	4.289
Obs.	*n=310*		*n=310*	

Notes: Significance levels are *P<0.1, **P<0.05, ***P<0.01

Model 1 results show that only three bales were statistically significant. Bales 6,7, and 8 all have significant negative effects at values of \$9.95 ($P < 0.01$), \$18.12 ($P < 0.01$), and \$7.73 ($P < 0.05$); respectively. This aligns with what is portrayed by bale means (**Table 6**) as we saw the bids for those bales were below average. Additionally, bale 6 and 8 were graded fair as opposed to other bales. Interestingly, bale 7 is graded higher than 6 and 8, but has the largest negative marginal effects, where respondents WTP decreased by \$18.12 in relation to the baseline, ceteris paribus. We know that bales 6 through 8 had the lowest weights as compared to the rest of the lot and while these models did not include bale weight as a parameter, other studies have found weight to be statistically significant for price received at auctions (Peake et. al. 2019). Similarly, bale 7 had the lowest average bids for Bale WTP. In Model 2, Bale 1 is significant ($P < 0.1$) and negative at a value of \$12.78. Bales 2 and 4 are significant ($P < 0.05$) and positive with values of \$15.50 and \$16.37, respectively. Finally, for observed bales, bale 6 is highly significant ($P < 0.01$) and positive in Model 2 at \$33.36. This is interesting when compared to the same parameter for Model 1 that is negative. We may assume there is some nuanced relationship between the two models and the difference is likely due to how WTP/ton is measured.

Only two predictors classified as Farm Characteristics are statistically significant. While some of the variables were predicted to be significant in theory, the results align with previous studies. Smith et. al. (2022) found that factors such as herd size and measures of risk willingness related to farm decisions had no significant impact on WTP bids for bulls. Similarly, *TotalHeadBovine* and *RWFHay* are not statistically significant

in Models 1 or 2. *Buyer* proved to be significant ($P < 0.01$) and negative in both models with Bale WTP at $7.94 and WTP/ton at $18.28. *LargeRound* is also significant with a confidence level of 95% ($P < 0.05$) at $4.23 and $8.95 for Bale WTP and WTP/ton, respectively. Peake et. al. (2019) found that round bales, while positive, slightly missed the significance interval of 90% and they infer this is due to the sample size of round bales sold at the studied auction. This study sees large round bales being highly significant and we could contribute this to three reasons: the experiment only included large round bales, the field day was designed for commercial beef producers, and the geographical location of the experiments. We assume commercial beef production prefers to feed larger packaged volumes of hay. A similar study by Feuz at. al. (2025) found large round bales to also be significant at the 1% level, except large rounds were discounted in their model.

Producer Demographics includes three independent variables. Of the three, *PercentTaxableIncome* and *BAorHigher* were significant ($P < 0.05$) with a confidence interval of 95% for bale WTP. *PercentTaxableIncome* measures total taxable household income from farming operations. For a 1% increase in the level of taxable income, bids increased by $0.69. While the magnitude of change is not very high, the model confirms that it is significant to WTP. *BAorHigher* is a binomial measure of education that equals 1 if the respondent has obtained a bachelors' degree or higher (i.e. masters' or doctorate). The value of this coefficient is positive at $4.19. For WTP/ton, both of these variables were also significant but at different confidence intervals. *PercentTaxableIncome* is significant ($p < 0.01$) and increases bids by $1.70. The measure of education is significant

($P < 0.1$) and positive at $7.73; therefore, if a respondent in the treatment group holds a bachelors' degree or higher, they were willing to pay $7.73 higher for bales, on average. The third independent variable was *Age* and it did not significantly impact WTP. Producers age being insignificant aligns with other studies evaluating WTP for agricultural products (Boyer et al., 2020; Feuz et al., 2025; Smith et al., 2023).

Discussion

Hay as a feedstuff is an important input to livestock production. Despite its wide use, there is no standard pricing model for hay products and this can be contributed to a number of reasons. While previous studies have examined prices for lots of hay sold at auctions, this is the first study to evaluate WTP at the consumer level. Additionally, we determine how WTP is impacted by several predictors including bale characteristics, farm characteristics, and producer demographics. Existing literature has proven that bale traits such as quality, size, form, and weight have impacted prices received at auctions. The findings of this study remain mostly and by including other factors, we can better understand how hay is valued in the cash market.

This research provides further information on the value buyers and sellers of hay place on the product, based on the independent variables included in the models. Of the eight bales included, only one had no significant impact on bids across both models. By comparing the forage analysis of the eight bales to the modeling results, we can draw conclusions on what qualities of the bales most influence WTP. Also, the forage analysis allows us to rank the bales from best to worst which is useful in conceptually analyzing respondents ability to read the forage reports. Two variables from farm characteristics

significantly impacted WTP. While more significant variables for farm traits would be desired, we can learn as much from variables with no significant impact. Based on the results, respondents either do not consider these variables when placing bids, or do not care. Interestingly, respondents who classify themselves as buyers of hay bid less on bales in both models. We could assume that these respondents have more experience in purchasing bales, thus they are more sensitive to the qualities and traits of the bales.

Participants were randomly placed in a control or treatment group prior to evaluating bales and stating their WTP. The treatment group was provided additional information on the bales, which included weight and forage analysis reports. We were interested to see if access to these metrics would impact WTP. Treatment had no significant impact on bids in either model and we fail to reject the null hypothesis that treatment information does not influence bid price. Treatment respondents did place slightly higher bids on average, but the magnitude is not significant either. We could assume that other characteristics overshadow the information treatment or that respondents cannot accurately use the information provided. Both of these assumptions may be true. For example, weight was not included in modeling; however, when evaluating mean prices for bales, the three lightest bales held the three lowest average bid prices. This finding gives reason to further evaluate weight in future models.

Whether or not respondents understand the forage reports could be tested in future experiments, where all respondents receive treatment information, but one group also receives hay quality guidelines. These guidelines would serve as a key to valuation depending on the forage metrics included. Another approach would be to utilize eye-

tracking technology to quantify a producers fixation duration on forage analysis values (Smith et al., 2022). Eye-tracking technology would allow us to measure the time spent viewing forage analysis information and time spent to state WTP. If we found that respondents had longer viewing times of the quality values and hay guidelines, it would suggest they are unfamiliar to that information.

Other caveats to this study do exist. The aim is to better understand individual valuation, but also to assess and/or develop existing markets. Including a measure of supply and demand for the products would help to develop baseline prices for different hay products. A majority of hay is sold on the cash market and through private-treaty transactions so this measure would not be easily obtained, but successfully measuring the market could lead to standardized pricing models for hay. The nature of the products means prices would fluctuate in any model based on included characteristics.

While modeling yielded significance, more participants in the study would produce more significant variables and a higher R-squared. Total responses for the experiments was 78. These responses were stacked and extrapolated across the eight bales which results in a sample of 312 for modeling. Another issue in experimental design is that the experiments were hosted at field days where the focus was usually beef production. While this would be fine to measure on its own, other users of hay are excluded. If the goal is to better understand the hay industry and markets, the project should have better representation for all industry participants. Additionally, this experiment only includes a regional sample. Future research using a nationally

representative survey would be beneficial to understanding producer and consumer preferences for hay products.

CONCLUSION

The goal of this study is to reveal consumer and producer preferences for hay used as a feedstuff. These preferences are measured by eliciting survey participants WTP for eight bales of hay across four field day experiments. Relationships between WTP and different hay characteristics are more easily seen when analyzing the results from both the experiment and paired surveys. Using WTP as a valuation method helps determine what traits in hay, buyers and sellers place emphasize on. Participants in the experiment and survey were regional hay industry hay participants, within proximity to the four experiments, that were hosted by University of Tennessee field days. The sample size was 310.

One objective of the study was to determine if access to forage analysis information would significantly impact bid prices. Consequently, a control and treatment group was included where the treatment group received forage analysis reports, weight of bales, and species; the control group were given bale species only. On average, treatment bids were higher than control bids by $1.10. For individual bales, treatment respondents bid higher on five of the eight bales. Although access to treatment information seems to increase bids, modeling results showed no significance in the treatment variable and the magnitude of change likely holds no relevance. Instead, the difference in bids may be contributed to the weight of the bales.

The results show that farm characteristics such as head of livestock, acreage of hay and pasture, days feeding hay, and willingness to accept risk regarding hay have no significant impact on WTP. Participants that consider themselves to be primarily buyers

of hay were willing to pay $7.94 less on average. Additionally, participants were willing to pay $4.29 more on average for large round bales. Respondents that hold a bachelors' degree or higher were willing to pay $4.19 more on average. A secondary model was utilized where WTP/ton was evaluated as the dependent variable. Both models produced similar results for all significant farm characteristics and producer demographic variables. However, for observed bales, the two models yielded different results: both in different signs and significance levels. The most extreme case was Bale 6, where Model 1 shows that participants bid $9.95 less. In Model 2, Bale 6 saw a premium of $33.36, the highest of any other included variables. The contrast between the models for observed bales can be contributed to a discrepancy in the unit of measurement. Model 1 shows that the bale itself is not desirable but may contain characteristics that become significant and desirable, in smaller units.

Hay as an input is important to livestock production. While it is often a necessary input, the number of studies on hay remain limited. Literature that does exist has focused only on hay sold in auction settings where data is aggregated. While beneficial, these studies do not provide direct insights into preferences of buyers and seller at the farm level. Better understanding what factors impact the prices of hay has many useful economic implications for both producers and consumers. Additionally, future research could aid in creating a standard price determination model to create a price basis for hay differentiated by variety and form. This study specifically could benefit buyers and sellers understanding of how hay is priced and valued in the spot market, where a

majority of hay is sold. This study would produce more significant results with a higher sample size and the inclusion of a nationally representative dataset.

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