

# Update to the Nontraditional Lamb Market in the United States 2010 Study

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## Executive Summary

There is an ongoing sentiment in the U.S. sheep industry that the animal inventory is greater than that captured by federal and state lamb slaughter data. The belief is these “missing lambs” are being diverted to nontraditional or ethnic marketing channels and are therefore not being captured in the post-lamb crop inventory and slaughter data. These lambs slaughtered in the nontraditional market, are believed to be either slaughtered on farm or in custom-exempt slaughter facilities, and not in federally-reported slaughter plants. The lambs that are channeled into ethnic markets are characterized as being lightweight – less than 140 lbs. at slaughter, many about 100 lbs. – younger feeder lambs and hair sheep.

In 2010, the American Sheep Industry Association prepared the “Nontraditional Lamb Market in the United States: Characteristics and Marketing Strategies” by Shiflett, et al. It was a broad look at what was termed the nontraditional lamb market. The 2010 study found that about 1 million head of lambs were missing each year, nearly one-half of federally inspected lamb slaughter. This was calculated by taking the difference between the higher U.S. lamb crop (less some death losses) and federally inspected sheep and lamb slaughter data. In 2020, 10 years later, it is time to revisit the nontraditional lamb quantitative estimate. The U.S. sheep industry has experienced dynamic changes that affect the nontraditional calculation. For example, the number of lambs slaughtered by state and custom-exempt slaughter facilities nearly doubled from 2010 to 2019.

Two models were developed to estimate the number of lambs channeled into the nontraditional market. The first model constrained lamb slaughter to the year of birth. This is how the 2010 estimate was modeled, and thus serves as a comparison. The second model relaxed the constraint that lambs must be slaughtered in the year of their birth, revising the nontraditional lamb estimate with the allowance for lambs to be slaughtered in the following year from the year of birth. Most lambs are born in the spring but may be slaughtered later in the same year or early the following year.

The first model, similar to the 2010 model, constraining slaughter to year of birth, found that the number of lambs channeled to the nontraditional lamb market was reduced sharply as changing market dynamics were incorporated into the model. During 2010 to 2019 the average nontraditional estimate per year was 96,686 head. The revised model also revealed that in 2018 and 2019 the nontraditional volume was negative meaning the total lamb slaughter exceeded available lamb inventory. The second model accommodating for different birth and slaughter years produced very similar estimates to the model that constrained slaughter to the year of lamb birth. It also concluded that the number or percentage of nontraditional or “disappearing lambs”, based on data currently available, is significantly lower than estimates using the methodology described in the 2010 study.

As the nontraditional estimate turned negative, it became evident that the opportunity to identify “missing” lambs is challenged by survey methods and measurement error. It is important to acknowledge the potential (and likely) impact of measurement error on any inferences and/or conclusions drawn based on the U.S. Department of Agriculture National Agricultural Statistics Service (NASS) data employed. The NASS Survey Procedures sampled large operations more heavily than small operations. Lambs from these smaller operations are likely, to a large extent, destined for the nontraditional type of markets.

In spite of uncertain data reliability, this research indicates that lambs that originally “fell through the cracks” or were “missing” were being increasingly slaughtered in federal or state inspected facilities. The growth of Halal slaughter facilities, the growth of smaller plants and the average lower live weight at slaughter of lambs in non-federally inspected slaughter suggests that the

industry might be developing into two distinct commercial markets, commercial lambs slaughtered by the largest lamb packers with a live weight at slaughter over 140 lbs. and lightweight lambs averaging 100 lbs., slaughtered primarily by state, and increasingly by federally inspected facilities. This research recommends continued monitoring of NASS inventory data and state slaughter to help design programs to promote U.S. lamb market growth.

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## Introduction

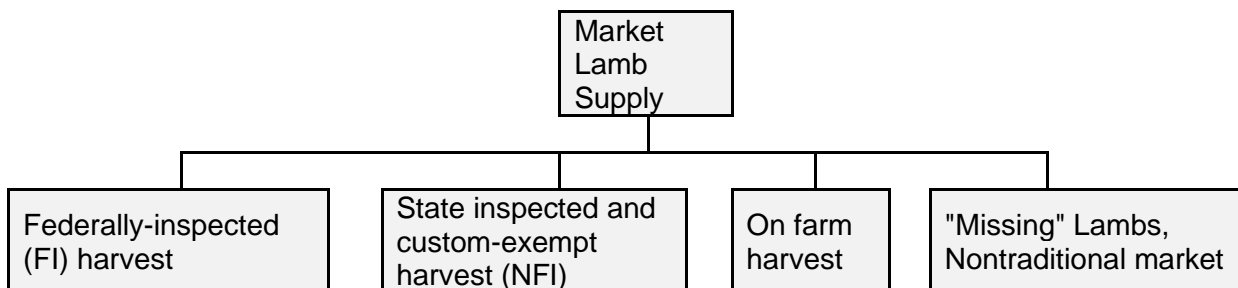
An ongoing hypothesis in the U.S. sheep industry is that the number of lambs is greater than that being captured in the federal and state lamb slaughter data. The theory is that these “missing lambs” are being diverted to nontraditional or ethnic marketing channels and are therefore not being captured in post-lamb crop inventory and slaughter data. Tighter lamb supplies reported by the largest lamb packers helped fuel this theory.

This study is an interrogation of federal inventory and slaughter data and how the data describes the U.S. lamb industry. The U.S. Department of Agriculture (USDA) National Agricultural Statistical Service (NASS) reports four categories of slaughter lambs: commercial, federally inspected (FI), non-federally inspected (NFI), and on farm. Federally inspected slaughter is meat inspection required under the Federal Meat Inspection Act. These facilities employ a federal meat inspector to inspect the livestock on slaughter days, and the meat can be sold. Non-federally inspected (NFI) slaughter, as reported by NASS, includes state inspected slaughter from all states and includes all custom-exempt slaughter from all states. State inspected slaughter is livestock that is slaughtered and processed and can, with the proper licensing and labeling, be wholesaled or retailed within the state (it may not be sold or shipped outside of state lines). For example, a livestock owner could sell state inspected meat at a farmer's market or to a local restaurant. A custom exempt slaughter facility is not inspected regularly by federal inspectors, but rather will be inspected by the state departments of agriculture and USDA once or twice a year. The meat and meat products is stamped "not for sale," and must go back to the owner of the livestock.

Commercial slaughter is the sum of FI and NFI slaughter. On farm slaughter is reported by producers in annual surveys. This study tests whether an increasing share of lambs are either slaughtered on farm or in custom-exempt slaughter facilities<sup>1</sup> that are not captured by federal reporting. These lambs are often characterized as being lighter weight, younger feeder lambs, and hair sheep.

The farm to slaughter marketing channel directs lambs from the farm/ranch to federal, state, or on farm slaughter, with the feeding complex finishing many lambs along the lamb supply channel. However, we know from the 2010 NASS data investigation, there is also a volume of lamb that appears to be missing, or unaccounted for in federal databases (Figure 1). This research recalculates the “missing lambs” and determines whether nontraditional lambs have increasingly been assimilated into traditional or commercial marketing channels.

**Figure 1. Lamb Slaughter Channel**



<sup>1</sup> Many lamb consumers, including those from ethnic backgrounds, prefer to select a lamb live when choosing lamb. A buyer will select a lamb from a farm and then often slaughter the lamb onsite, which is referred to as on farm slaughter. Custom-exempt slaughter is slaughter at facilities that process meat exclusively for the owners' use, and not to be sold, and are not inspected on a regular basis.

This hypothesis of “missing” lambs was tested in 2010 to find a significant volume of nontraditional lambs within the broader, traditional, or commercial market. Ten years later in 2020 this hypothesis is revisited to determine whether the 2010 conclusions are still valid. The “Nontraditional Lamb Market in the United States: Characteristics and Marketing Strategies” was prepared by Shiflett et al. for the American Sheep Industry Association (ASI) in February 2010. In this study the nontraditional volume was estimated through a survey of sheep producers, but also by calculating the lambs unaccounted for in NASS data. The “missing”, or nontraditional lamb market is defined as the quantity of lambs found in the discrepancy between the NASS-reported lamb crop and the lower, NASS-reported slaughter numbers.

There is a sentiment among industry stakeholders that the 2010 methodology to estimate nontraditional lambs is now outdated. The sheep and lamb industry has seen some dynamic structural changes in the last ten years, in part, spurred by the growth in production of lightweight smaller-framed wool and hair breeds. The relative proportion of state and custom slaughter has increased relative to federally inspected slaughter, and slaughter of lightweight lambs has increased within the carcass trade. Where the 2010 study was comprehensive and broad reaching, this current research is more focused, aiming primarily at updating the volume of nontraditional lamb supplies that are missing, or unaccounted for in the NASS data.

In the 2010 study it was projected that what was once counted as a parallel nontraditional market would be increasingly assimilated into more commercial marketing channels and therefore would be captured by federal inventory and slaughter lamb statistics. The American Lamb Board (ALB) 2018 “Seasonality of the U.S. Lamb Industry” supported this projection when it reported that over time immigrant purchasing habits are expected to shift from nontraditional to more traditional purchasing methods, and thus result in a decrease in lambs diverted into the nontraditional market. This research thus queries federal data to determine the trend in “missing” lambs. The specific research objectives are as follows:

1. Provide an overview of the 2010 nontraditional lamb market research.
2. Define how the 2010 nontraditional market volume is calculated.
3. Reevaluate the method of calculation of the ASI nontraditional lamb market volume. That is, ensure that the ASI nontraditional definition adheres to current industry dynamics.
4. In revisiting the current nontraditional lamb volume estimation, define how NASS estimates lamb and yearling commercial slaughter, federally inspected slaughter, state inspected slaughter, custom slaughter, on farm slaughter, lamb crop, and ewe and ram inventory with the understanding that NASS definitions and survey methods may affect the nontraditional estimate.
5. Calculate how many lambs are currently “disappearing;” that is, are unaccounted for in the USDA data through an analysis of the NASS data.
6. Explore the validity of the revised nontraditional lamb market estimate.

## Overview of Nontraditional Lamb Market Literature

In February 2010, ASI published the “Nontraditional Lamb Market in the United States: Characteristics and Marketing Strategies” prepared by Shiflett, Williams and Rodgers. The report was broad-based in capturing nontraditional estimates by surveying various industry stakeholders. The study estimated the ethnic market sales volume by the top lamb packers including Halal, Kosher, and other custom, ethnic slaughter. The study also estimated marketing volume and characteristics of nontraditional sales at the two largest sheep auctions in San Angelo, Texas and New Holland, Pennsylvania. In addition, the research estimated direct sales by sheep producers to nontraditional lamb buyers. The study also conducted a survey of lamb consumption by minority consumers, by estimating the incidence of lamb consumption among a surveyed profile of minority, or foreign speaking, consumers.

From the 2010 study:

*There is a growing sentiment that the nontraditional lamb market is siphoning off an increasing portion of the commercial slaughter-lamb market away from traditional retail and foodservice sectors. The nontraditional market may thus slow the ability of the commercial lamb market to increase supplies and production in a time of sheep inventory contractions. Yet the volume of sheep marketed to the nontraditional market is largely unknown.*

*This research was motivated, in part, by the discovery that there is a large statistical difference between the U.S. Department of Agriculture (USDA)-published lamb crop (plus losses) and USDA federally inspected slaughter numbers. Between 2004 and 2008, this difference was estimated at nearly 1.2 million head per year, 48 percent of FI slaughter or 2.5 million head per year. This research proposes to define, quantify, and predict the growth of the nontraditional lamb market in the United States.*

*This research utilized a multi-prong survey approach to meet its research objectives given a hypothesis that the market is fragmented and heterogeneous. Informal phone surveys were used to interview the marketing managers at the top lamb packers as well as number of select smaller ethnic packers. Informal phone surveys were also used to interview U.S. Department of Agriculture market reporters that report on sheep and lamb auctions.*

*A formal producer survey was also implemented to estimate the volume of the nontraditional market at the farm gate, determine the ethnicity of consumers that buy direct from the farm and determine what motivates producers and buyers to engage in direct marketing. Producers were contacted via e-mail as well as through the American Sheep Industry Association newsletter, Sheep Industry News. The survey resulted in 488 responses from a distribution to 20,467 producers.*

*The research also conducted an online survey to a select group of minority or ethnic consumers. Non-Hispanic White consumers were omitted from the study unless they spoke a pre-identified foreign language at home. A total of 410 consumers responded that they had eaten lamb, mutton, or goat in the past year out of a total 878 consumers surveyed.*

In sum, the 2010 report estimated the volume of nontraditional lamb sales through two separate methods. The first was the statistical discrepancy of the NASS lamb crop less slaughter data. The nontraditional volume estimate was computed by calculating the numeric difference between the USDA federally inspected lamb and mature sheep slaughter numbers and the USDA estimated lamb crop (less 5 percent for losses). It was found that the lamb crop numbers historically exceeded the FI slaughter numbers by a wide margin, and this discrepancy was called

nontraditional slaughter, for it was hypothesized that this volume wasn't captured in USDA data, and therefore "fell through the cracks." This "missing" volume was an estimated at 1.2 million head per year between 2004 and 2008, or the equivalent of 48 percent of the 2.5 million head per year processed through federally inspected plants.

The second nontraditional estimate was developed through a sheep producer survey in 2009 that asked producers their perception of the purpose of the sales to individual buyers. The survey was nationally representative of sheep producers across the U.S. Producers were asked to choose among the following: the buyer buys for personal/family use; the buyer buys for a slaughterhouse or packer; the buyer buys for one or more restaurants; the buyer buys for more one more grocery stores; the buyer buys for packers, restaurants, and grocery stores; don't know; or other. The producer selection that "the buyer buys for personal/family use" is what defined the nontraditional estimate due to the assumption that many lambs consumed for personal or family use are slaughtered on farm or in custom-exempt slaughter facilities that are not necessarily captured by state and thus federal reporting.

The survey asked producers how many lambs were sold for personal or family use to each demographic group of buyers including Hispanic/Latino, Middle Eastern, White/Caucasian, Unknown, or Other in 2009. On average, survey results revealed that producers sold an average of 21 lambs through the year ending November 2009 for customers' personal, or family use. Most lambs were sold to buyers of an unknown ethnicity followed by Muslim buyers.

For each known ethnicity, the average number of lambs sold was multiplied by the percent of sales to personal/family use to get a subtotal of nontraditional lambs sold to a given ethnicity. The lambs were then totaled across each ethnicity to arrive at the estimated number of nontraditional lambs. In sum, the nontraditional estimate represented the total number of lambs sold by lamb producers for customers for personal/family use. This volume totaled 995,370 head in 2009. The authors viewed this estimate as a validation of the 1.2 million head calculated using USDA data.

## **Recent Sheep Industry Structural Changes**

The sheep and lamb industry has seen some dynamic structural changes in the last ten years, in part, spurred by the growth in production of lightweight smaller-framed wool and hair breeds, which warrants an update to the methodology applied in the 2010 nontraditional study.

In 2010, a standardized formula for calculating the nontraditional, "missing" lambs was developed that would be applicable year-after-year to analyze trends in the market. It has since been recognized that annual adjustments to the nontraditional formula are warranted to capture changes more accurately in the U.S. nontraditional market. There are additional industry-specific characteristics such as the inclusion of on farm slaughter and the addition of replacement lambs and a recalibration of the death loss estimate – characteristics not captured in the 2010 model -- that also warrant a revised nontraditional estimate.

The revision to the methodology applied includes the following:

- State inspected slaughter
- Lamb and yearling slaughter separate from mature sheep slaughter
- Include replacement lambs
- Include on farm slaughter
- Allow death loss to adjust annually



## Capturing State Inspected Slaughter in Estimate

It is hypothesized that as the slaughter of lightweight lambs increased in recent years, the number of lightweight lambs slaughtered in state inspected slaughter plants increased relative to those slaughtered in federally inspected (FI) slaughter facilities. The 2010 nontraditional estimate used FI slaughter data. An important revision of this nontraditional market estimate is to include state inspected slaughter, or non-federally inspected (NFI) slaughter.

Research revealed that as the number of head captured by NFI slaughter grows, it is critical to use commercial slaughter (FI and NFI slaughter data) in the nontraditional estimate. Most sheep and lambs are slaughtered in federally inspected facilities. However, NASS also collects the numbers of lamb slaughtered in state inspected, and custom-exempt facilities, known as non-federally inspected slaughter. FI slaughter averaged 92 percent of commercial slaughter for the 2000-2019 period, while the remaining 8 percent is slaughtered by state inspected facilities.

The threshold for counting sheep at FI plants is one head. That is, NASS includes any sheep slaughtered at FI facilities in its slaughter count. In 2019, 521 FI plants reported at least one head of sheep slaughtered. The threshold for NFI facilities is also one head. NFI plants are not required by law to report, but state inspected facilities report to their state departments of agriculture and NASS reports that it has a good response rate for custom-exempt facilities.<sup>2</sup> NASS statisticians use a non-response adjustment to account for missing facilities.

The U.S. sheep and lamb industry has contracted in recent decades and thus the lamb packing subsector has seen many changes. Large lamb plants in Texas and Iowa have gone out of business.<sup>3</sup> It is believed smaller lamb plants have thrived in other parts of the country, driven, in part, by ethnic lamb demand. When Superior Farms closed its lamb plant in Hawarden, Iowa in May 2011 it was commonly believed that it did not have sufficient slaughter numbers to continue to operate efficiently. The nontraditional lamb market was partly to blame, siphoning off lambs that otherwise would be channeled into one of the industry's largest lamb processing plants, and creating a short supply of lamb. Superior spokeswoman Angela Gentry said, "At the moment, we're not getting enough lambs to even get half of the capacity of the plant," (Dreeszen, D., 2011). The plant had a capacity to slaughter up to 240,000 lambs annually (over 4,000 head per week).

In January 2020, ewe inventory totaled 2.98 million head, down 4 percent in 5 years, down 7 percent in 10 years, and down 30 percent in the 20 years since 2000. As ewe numbers contracted, the lamb crop followed (Figure 2). In 2019, the lamb crop was 3.23 million head, down 2 percent in 5 years, down 10 percent in 10 years and down 30 percent since 2000.<sup>4</sup>

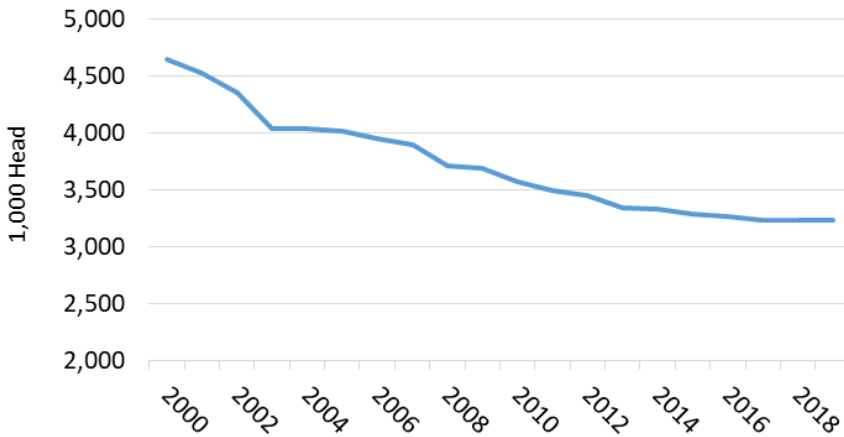
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<sup>2</sup> Personal communication, Agricultural Statistician, U.S. Department of Agriculture, National Agricultural Statistics Service, 5/6/20.

<sup>3</sup> As of July 31, 2020 Mountain States Rosen – the 2<sup>nd</sup> largest lamb plant in the U.S. – was expected to cease operations at its Greeley, Colorado plant.

<sup>4</sup> Given that sheep often have multiple births, it is not expected that ewe and lamb crop inventory have a one-to-one decrease, but a consistent pattern is expected. The unexpected trends in inventory of ewes and lamb crop gives rise to questions regarding NASS survey methods, a point covered later in the report.

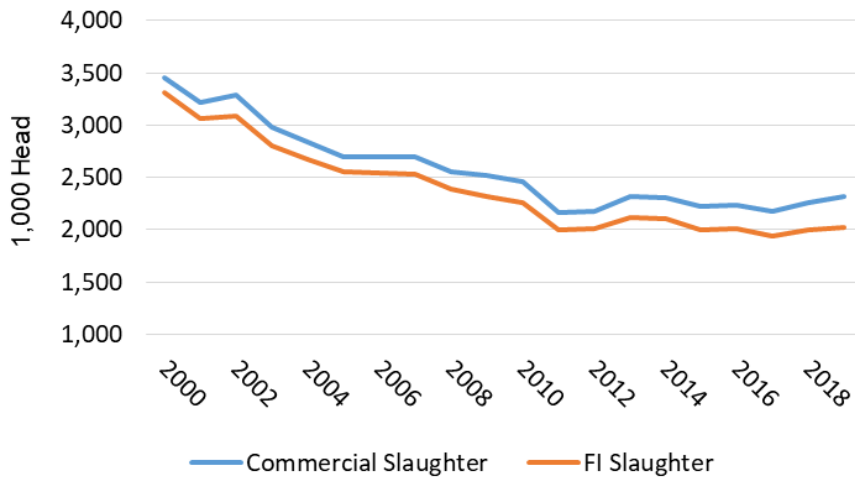
**Figure 2. U.S. Lamb Crop**



Source: USDA/NASS

It follows that as the lamb crop contracts, fewer lambs are slaughtered and reported by NASS. In general, both commercial and FI slaughter have declined over time (Figure 3), but the proportion of NFI, or state slaughter in the total commercial slaughter, has increased. In 2019, commercial slaughter (NFI and FI) totaled 2.32 million head, up 4 percent in five years and down 6 percent in ten years. In 2019, FI slaughter was 2.02 million head, up 1 percent in five years and down 11 percent in ten years in 2010 to 2019.

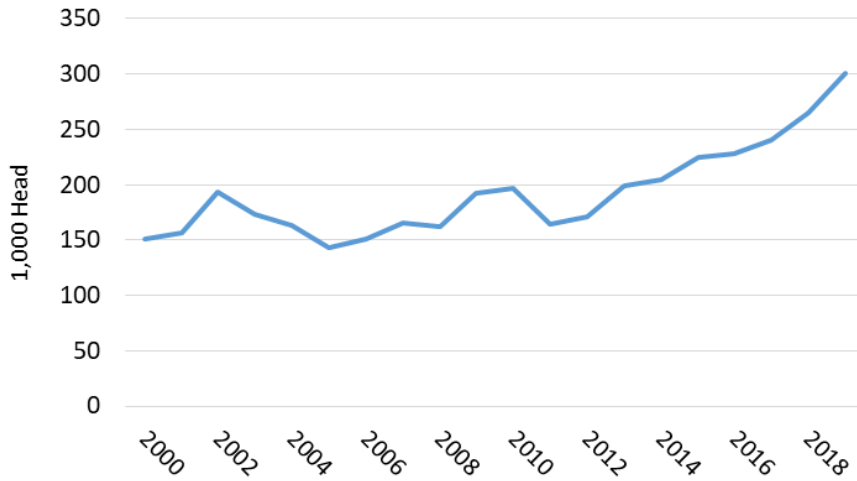
**Figure 3. Commercial and Federally Inspected (FI) Sheep and Lamb Slaughter**



Source: USDA/NASS

The difference between commercial and FI slaughter was 301,300 head in 2019, which was up 34 percent from 2015 and up 53 percent from the 2000-2010 period (Figure 4).

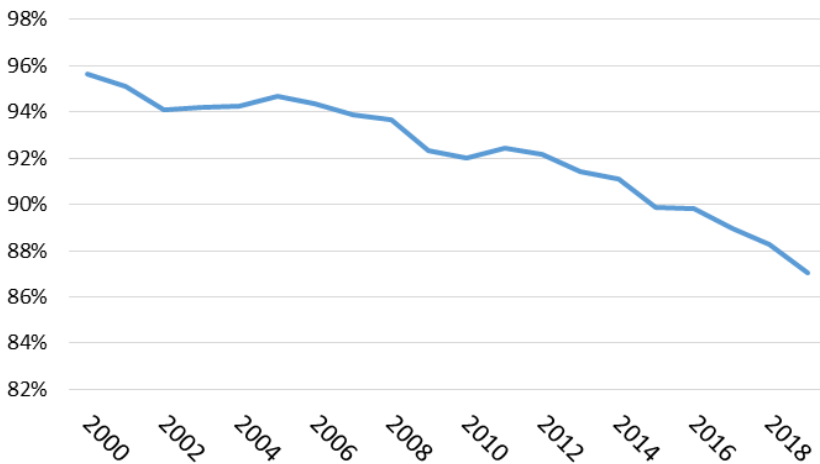
**Figure 4. Commercial Slaughter less Federally Inspected (FI) Slaughter**



Source: USDA/NASS

In the early 2000s, FI slaughter represented about 94 percent of commercial slaughter, but declined to 87 percent by 2019 (Figure 5). This reveals that an increasing share of sheep and lambs are being slaughtered in state inspected facilities. More and more lambs were being captured in federal livestock reporting efforts outside of FI slaughter data. The increased evidence in state inspected slaughter *could, in part*, reflect a growth in commercial, state inspected Halal slaughter, but unfortunately the data is not available at this time to substantiate this theory.

**Figure 5. Percentage of Federally Inspected (FI) Slaughter of Commercial Slaughter**



Source: USDA/NASS

Coincidentally, as the ethnic lamb market has expanded in the U.S., the proportion of smaller packing plants has grown in the U.S.<sup>5</sup> From 2005 to 2019, the number of small to mid-sized FI plants increased while the larger FI plants declined in number. The smallest plants, slaughtering

<sup>5</sup> NASS does not keep records of plant sizes of state-inspected facilities.

less than 200 head per week (up to 999 head annually), increased from 2005 to 2018 by 4 percent (Table 1). These plants slaughtered 28 percent more lambs and sheep in this period. By contrast, the largest plants (slaughtering 250,000 head per year) contracted by 25 percent and slaughtered 42 percent fewer head over 2005 to 2018. Plants – sized between the largest and smallest – processed 30 to 78 percent more lambs over 2005 to 2018.

**Table 1. Federally Inspected (FI) Lamb Plants**

No. of Head	2005		2010		2016		2018		2005-18 Percent Change	
	No. of plants	Head (thousands)	No. of plants	Head (thousands)	No. of plants	Head (thousands)	No. of plants	Head (thousands)	No. of plants	Head (thousands)
1-999	420	50.1	413	58.3	430	63	438	64	4%	28%
1,000-9,999	59	212.7	73	232	80	288.2	73	276.5	24%	30%
10,000-24,900	7	125.3	12	193.2	12	184.5	13	213.5	86%	70%
25,000-99,999	4	155	3	183.2	5	224.8	8	276.1	100%	78%
100,000-249,999	2	308.3	1	155.6	1	164.7	1	178.2	-50%	-42%
250,000+	4	1703	4	1438.8	3	1084.4	3	991.5	-25%	-42%

Source: USDA/NASS, 2005, 2010, 2016, 2018

Another dynamic structural change that is occurring in the U.S. lamb industry is that there are contemporaneous regions of live animal inventory contractions and pockets of growth. In general, lamb slaughter in the Mountain states has declined in recent years while slaughter has increased across the Northwest, Midwest, Northeast and Southeast. Unfortunately, the location of plants needed to compare slaughter growth to inventory growth is unknown.

As sheep inventory expanded in some regions, and costs per head in the marketing channel came down, plant sizes likely grew and thus more likely came under the radar of state or FI inspection and reporting. A working hypothesis is that the nontraditional lambs that were initially calculated as “missing” would be assimilated over time by state and FI slaughter. *However, as will be shown later, the “missing” data in the initial nontraditional quantitative estimate cannot be explained solely by actual missing lambs that were slaughtered outside of state and FI plants, but by structural industry dynamics that have become more significant over time.*

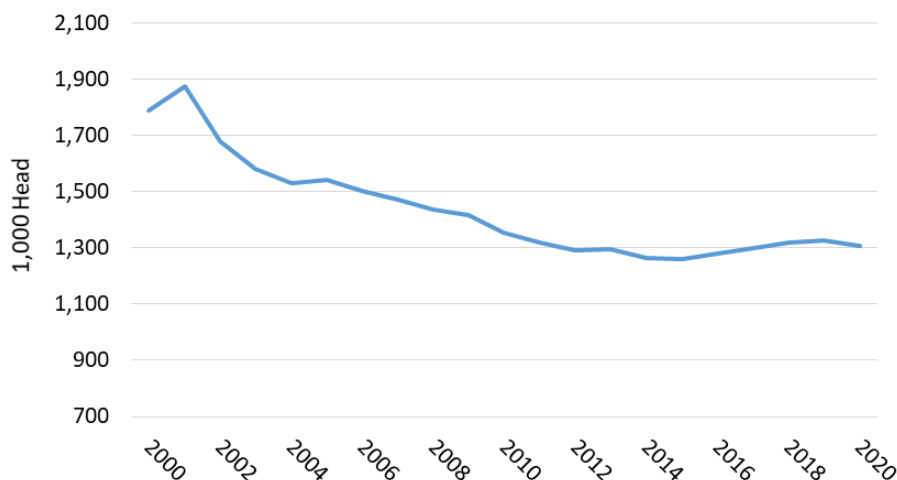
### **Increase in Lighter Weight Slaughter Lambs**

Two parallel lamb markets exist in the U.S., the traditional commercial lamb market, and a smaller market, comprising of lighter-weight lambs. The existence and growth of this lightweight lamb market is an indicator of the importance of using state inspected slaughter data in the nontraditional estimate.

In 2020, the number of market lambs in the U.S. totaled 1.31 million head, up 2 percent from five years earlier, down 1 percent over the last ten years and down 30 percent since 2000 (Figure 6). Market lambs are reported on January 1 of each year as reported by sheep producers. It is not a tally of total number of lambs slaughtered or marketed each year (which is about 2 million head). We know that during the year more market lambs enter the system as the year progresses given the bulk of lambs are born in the spring. What this data does give us though is a snapshot of

marketed lambs by live weight. Although total numbers of lambs marketed is down, the weight distribution of marketed lambs has shifted over time.

**Figure 6. January 1 U.S. Market Lambs Inventory**



Source: USDA/NASS

The ethnic or hair-lamb market is popularly believed to favor lightweight lambs compared to the more traditional commercial market. From the ALB seasonality white paper (2018):

*The traditional market prefers a 120 to 160 lb. live weight lamb. Most of these lambs are sold off the ranch as feeder lambs and sent to a feeding facility for 50 to 150 days. The lambs are slaughtered at a large commercial slaughter plant and sold to retail or foodservice outlets as primal or further-processed cuts. The nontraditional market prefers a 50 to 100 lb. live weight lamb. Most of these lambs are sold off the farm or ranch as slaughter lambs.*

However, the ethnic or lightweight lamb market may be changing as it grows. It is hypothesized that many hair sheep in the ethnic trade are increasingly slaughtered above 100 lbs. The USDA Agriculture Market Service (AMS) has coined the livestock auction of New Holland Sales Stable, in New Holland, Pennsylvania as a “nontraditional” market.<sup>6</sup> AMS reports many hair lambs selling over 100 lbs. at New Holland. Reportedly, an estimated 35 percent of lambs selling out of the New Holland auction are sold at 90 to 150 lbs.<sup>7</sup> Most of these lambs weighed 90 to 110 lbs.<sup>8</sup>

Overall, the 100-150 lbs. hair sheep weight sees a lot of volume at New Holland, but most hair sheep slaughter lambs fall in the 100-115 lbs. range. The auction also sees smaller-framed wool breeds including Cheviot and Southdown/Babydolls. By comparison, the slaughter lamb wool breeds consistently sell at 100 to 150 lbs.

The distinct differences in average live weight at slaughter between FI and NFI plants also illustrates the importance of tracking state inspected data (Figure 7). The live weight at slaughter at

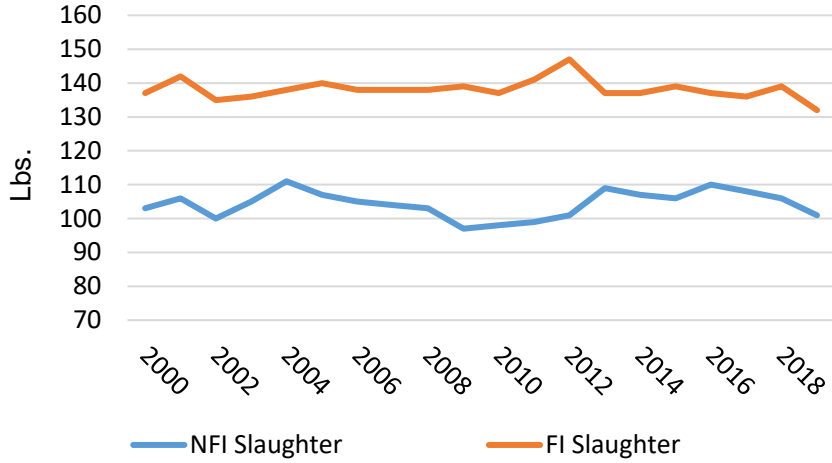
<sup>6</sup> New Holland is likely the second largest lamb auction market after Producers Livestock Auction in San Angelo, Texas.

<sup>7</sup> Email correspondence with AMS reporter at the New Holland Sales Stable, 2019.

<sup>8</sup> Within this spread, 10 percent were sold in the 110 to 130 lbs. range. Only 1 percent sold at 130-150 lbs.

FI plants was an average 138 lbs. between 2000 and 2019 while the average NFI slaughter weight was 104 lbs.

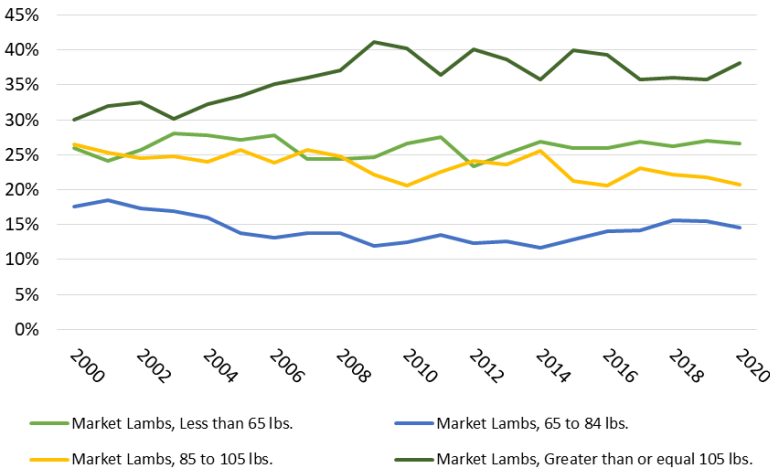
**Figure 7. Average Federally Inspected (FI) and Non-Federally Inspected (NFI) Sheep and Lamb Weights**



Source: USDA/NASS

It is hypothesized that as the ethnic lamb market has grown, average slaughter weight has increased. According to NASS Census data, in the years 2000 to 2020, the percentage of market lambs weighing 105 lbs. and heavier increased from around 30 percent to 38 percent (Figure 8).

**Figure 8. Percent of Market Lambs by Weight**



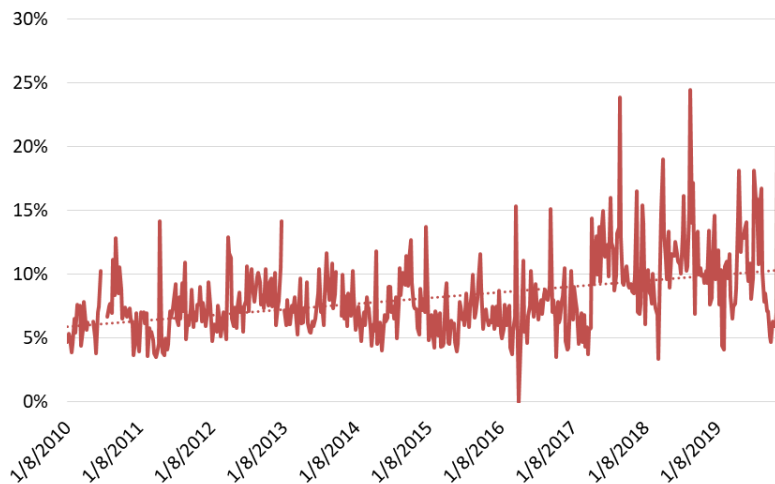
Source: USDA/NASS

Other weight classes have either remained relatively steady or declined. It is theorized that as the nontraditional lamb market matures, the average live weight at harvest of hair sheep breeds and lower-weight maturing wool breeds increased to above 105 lbs.

## Increased Lightweight Lambs within Carcass Trade

The share of lightweight lambs in the carcass trade is another indicator that the industry has transitioned to increased slaughter of lightweight maturing lambs. The number of carcasses traded has declined sharply in the last 10 years from about 20 percent of total FI slaughter to about 5 to 10 percent in 2019. It is theorized that the largest commercial lamb packers are processing fewer carcasses while the smaller packers still sell carcasses. In the past 10 years, the share of carcasses weighing 55 lbs. and less increased from 7 percent to 10 percent of total carcasses (Figure 9).

**Figure 9. Carcasses Weighing 55 lbs. and Less**



Source: USDA/AMS

## Revised Estimate of “Missing” Nontraditional Lambs

This study presents a revised nontraditional lamb market estimate, an estimate that is dynamic to industry changes and more accurately mirrors available industry inventory and slaughter data. Graphs of key inventory and slaughter lamb data and trends are available in Appendix A.

Structural industry changes include:

- Growth in on farm slaughter,
- Growth in the number of replacement lambs,
- Adjustments in lamb death rate,
- Differentiation between lamb and yearling slaughter and mature sheep slaughter, and
- Inclusion of both federally inspected and state inspected slaughtered lambs (discussed in previous section),

### Capture lamb and yearling slaughter separate from mature sheep slaughter

The 2010 study referenced FI slaughter which combines lamb and yearling slaughter and mature sheep slaughter. The revised methodology endeavors to differentiate between lamb and yearling slaughter and mature sheep slaughter by assuming and applying the same relative percentages of lamb and yearling slaughter and mature sheep slaughter reported for FI slaughter to commercial

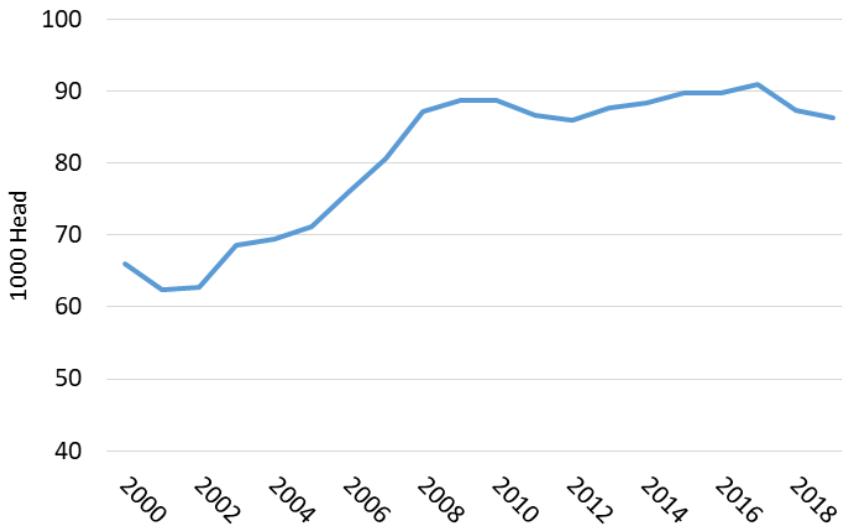
slaughter – and by extension, to state inspected slaughter.

NASS breaks down FI slaughter into lamb and yearling FI slaughter and mature sheep FI slaughter. Using the portion of lamb and yearling FI slaughter in total FI slaughter allows for the revised model to account for lambs and yearlings only, separate from the smaller, mature sheep market. On average, lambs and yearling account for about 96 percent of total FI slaughter. This percentage of lambs and yearlings in total FI slaughter was used to estimate the lamb portion of NFI slaughter. The same proportion was used to estimate the number of lambs in the on farm slaughter volume.

### Inclusion of on farm slaughter

When first studied in 2010, on farm slaughter was considered inconsequential to the final nontraditional calculation and thus not included; however, on farm slaughter has since grown (and contracted) which warrants a closer look at its inclusion in estimating the size of the nontraditional model. The revised methodology includes an estimate of farm slaughter as reported by NASS (on farm slaughter for personal consumption). The farm slaughter estimate again assumes the same relative percentages of lamb and yearling slaughter and mature sheep slaughter reported for FI slaughter. From 2010 to 2019, the on farm lamb slaughter contracted by 3 percent to 86,310 head (Figure 10). On farm lamb slaughter peaked in 2017 before falling in 2018 and 2019. In 2017, slaughter lamb prices in the traditional, commercial market were relatively high, so perhaps buyers believed they could get a more competitive price in buying lambs on farms and slaughtering them on farm.

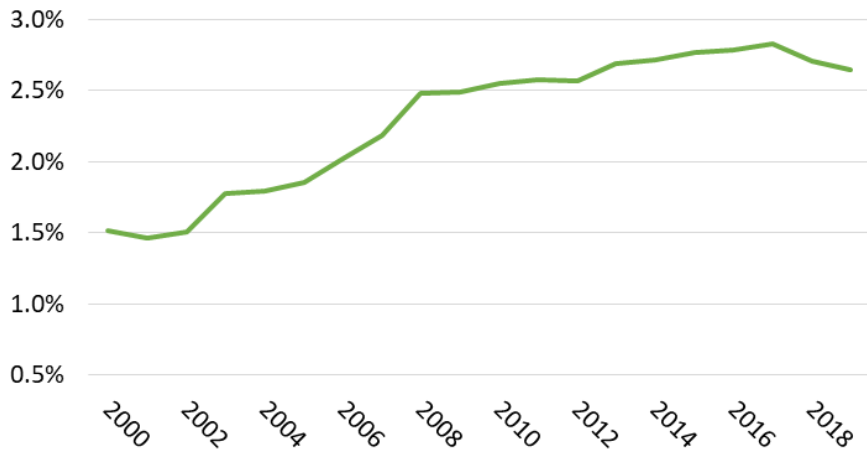
**Figure 10. On Farm Lamb Slaughter**



The number of lambs slaughtered on farm – as captured from NASS producer surveys – accounted for 1.6 percent of the total annual lamb crop (less lamb deaths) from 2000 to 2004. This percentage increased to nearly 2.5 percent from 2010 to 2019 (Figure 11).



**Figure 11. On Farm Slaughter as Percentage of Total Lamb Crop**

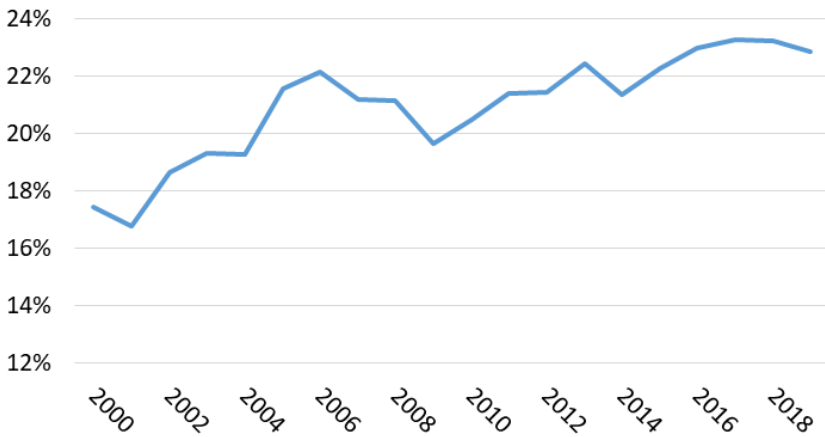


Source: USDA/NASS

Growth in share of replacement lambs

Lambs retained as replacements – from the NASS producer surveys – were included in the revised nontraditional calculation. *The inclusion of replacement lambs in the calculation had the greatest impact on enhancing the number of “missing” lambs.* Between 2000 and 2014 the share of replacement lambs in the total lamb crop (less lamb deaths) was 18.3 percent and gained over 4 percent to 20 percent from 2015 to 2019 (Figure 12). As prices strengthened, particularly in 2017, producers retained a greater percentage of lambs back for flock rebuilding.

**Figure 12. Percentage of Replacement Lambs in Total Lamb Crop**



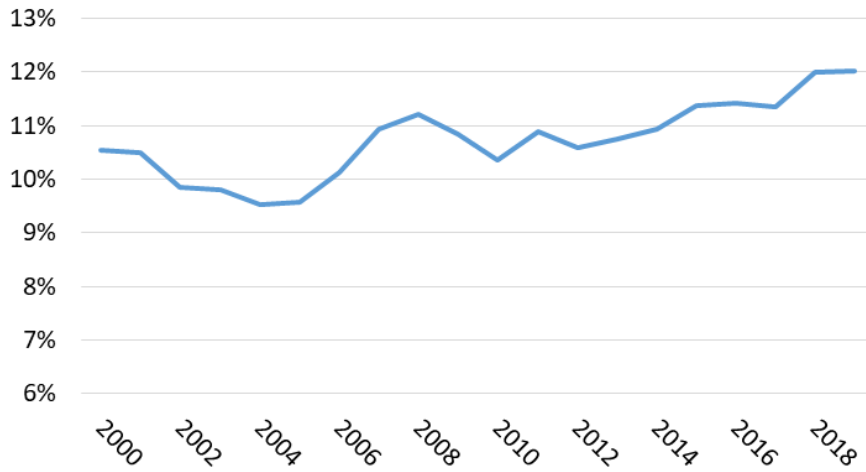
Source: USDA/NASS

Adjustable lamb death loss

The 2010 study assumed a constant lamb death loss of 5 percent. The revised methodology utilized annual lamb death loss estimates reported by NASS, which averaged 11 percent over the 2000-2019 range, – approximately double the death loss estimate applied in the 2010 study. By

2019, the death rate among lambs had reached nearly 12 percent of the total lamb crop (Figure 13).

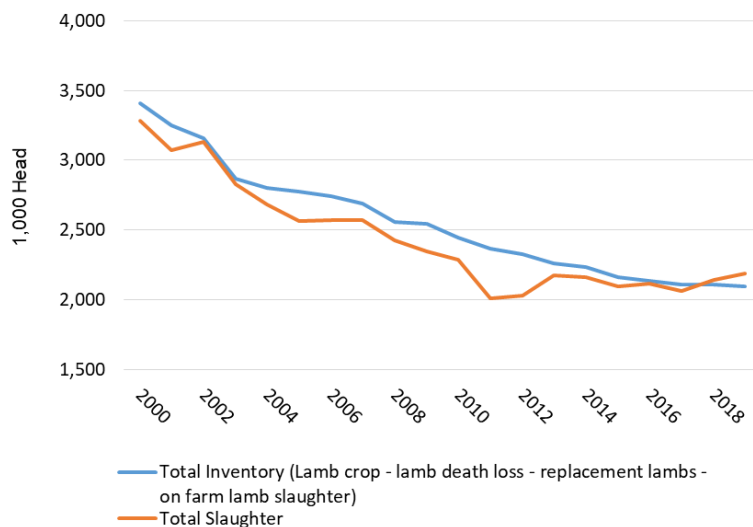
**Figure 13. Lamb Death Loss as Percentage of Total Lamb Crop**



Source: USDA/NASS

Figure 14 depicts the total estimated number of lambs marketed and the estimated commercial lamb slaughter. The estimated number of lambs marketed (also called market lamb inventory) was calculated by subtracting the lamb death loss, replacement lambs,<sup>9</sup> and on farm lamb slaughter from the total lamb crop. The estimated commercial slaughter is calculated by summing together the FI lamb and yearling slaughter and the lamb portion of state inspected slaughter and custom-exempt slaughter (NFI slaughter).

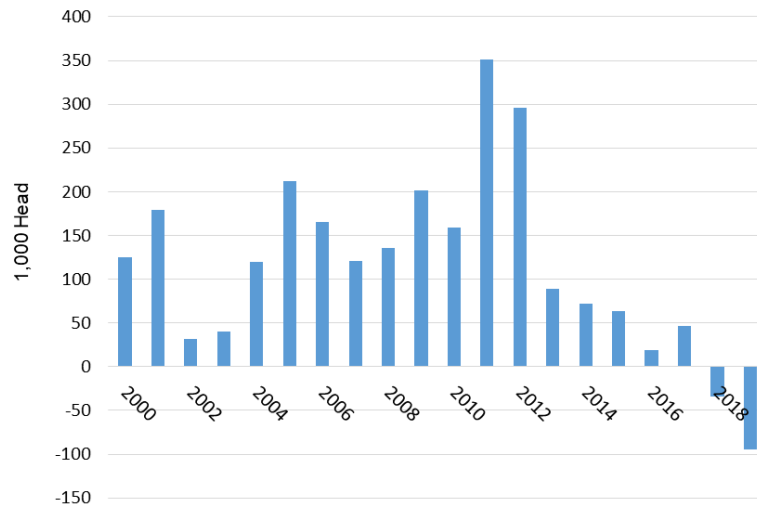
**Figure 14. Estimated Total Lambs Marketed and Commercial Lamb Slaughter**



<sup>9</sup> NASS reported replacement lambs for January 1, 2020 are actually replacement lambs for 2019, so the data was lagged one year. The 2020 replacement data was entered in the spreadsheet for the revised nontraditional calculation as 2019 replacement lambs.

The revised nontraditional lamb market volume estimate is contained in Figure 15 and Table 2. It is calculated as the numeric difference between the assumed higher net lamb crop inventory and the expected lower lamb slaughter. *The revised nontraditional estimate is sharply lower than the 2010 calculation.* In 2000 to 2009, the average annual nontraditional estimate was 133,000 head per year and between 2010 and 2019 it averaged 97,000 head per year. This is down from an estimated 1.2 million head per year from the 2010 study. At a maximum, the nontraditional, or “missing” lambs were an estimated 351,000 head in 2011. This calculation method yielded a negative volume of 94,000 head in 2019.

**Figure 15. Revised Nontraditional Lamb Volume Estimate**



In 2018 and 2019, the total number of lambs marketed was less than the number slaughtered which produced a negative nontraditional estimate. The total number of lambs marketed declined by 0.4 percent in 2018 and then increased 0.4 percent in 2019. However, the total lambs slaughtered jumped 4 percent in 2018 and then an additional 2 percent in 2019. Data measurement errors may account for the calculation that the number of lambs slaughtered exceeded those available to market. This hypothesis will be explored further later in this study.

Both the replacement rate and on farm slaughter – both not previously included in the nontraditional estimate – accounted for 700,000 to 800,000 head in recent years, comprising about 75 percent of the “missing” nontraditional lambs. The most significant revision to the current nontraditional estimate is the inclusion of replacement lambs in the revised calculation. Replacement lambs averaged 719,000 head from 2000 to 2009 and 657,800 head during 2010 to 2019. As the lamb crop contracted over time, replacement lambs grew from about 16 percent of the lamb crop in the early 2000s to 20 percent by 2019. On farm slaughter averaged about 1 percent of the total lamb crop in 2000 to 2009, and 2 percent during 2010 to 2019. These replacement lambs could be diverted to the slaughter channel if the producer changed their mind after the report survey was submitted due to market or production factors.

The allowance for an annual adjustable death rate, rather than a fixed death loss as in the original 2010 study accounted for some of the reduction in the revised nontraditional estimate. Overall, the death loss grew from about 10 percent of the lamb crop in 2000 to 12 percent by 2019.

**Table 2. Nontraditional Lamb Volume Estimate, Number of Head**

	INVENTORY				Total Inventory	SLAUGHTER			Nontraditional/ "Missing" Total
	Lamb Crop	Lamb Death Losses	Replacement Lambs	Lambs on farm slaughter		FI Lambs and Yearlings	NFI Lambs and Yearlings	Total Slaughter	
2000	4,645,000	490,200	679,000	65,991	3,409,809	3,141,000	143,852	3,284,852	124,957
2001	4,519,500	474,800	732,000	62,334	3,250,366	2,921,300	149,734	3,071,034	179,332
2002	4,355,000	428,800	703,000	62,746	3,160,454	2,944,300	184,715	3,129,015	31,439
2003	4,035,000	395,300	704,500	68,514	2,866,686	2,662,000	164,738	2,826,738	39,948
2004	4,040,000	385,000	783,000	69,455	2,802,545	2,529,000	154,029	2,683,029	119,517
2005	4,015,000	384,700	786,000	71,109	2,773,191	2,425,100	136,141	2,561,241	211,950
2006	3,950,000	400,100	734,500	76,008	2,739,392	2,429,000	144,481	2,573,481	165,911
2007	3,895,000	426,000	697,000	80,637	2,691,363	2,413,100	157,552	2,570,652	120,711
2008	3,710,000	416,000	646,500	87,200	2,560,300	2,271,100	153,716	2,424,816	135,484
2009	3,690,000	400,000	655,000	88,733	2,546,267	2,165,300	179,704	2,345,004	201,263
2010	3,570,000	370,000	665,000	88,712	2,446,288	2,104,800	182,824	2,287,624	158,664
2011	3,490,000	380,000	660,000	86,644	2,363,356	1,859,500	152,557	2,012,057	351,299
2012	3,445,000	365,000	670,000	85,926	2,324,074	1,869,100	158,661	2,027,761	296,313
2013	3,345,000	360,000	635,000	87,657	2,262,343	1,987,600	186,188	2,173,788	88,555
2014	3,335,000	365,000	650,000	88,375	2,231,625	1,968,200	191,807	2,160,007	71,617
2015	3,290,000	374,000	665,000	89,708	2,161,292	1,885,100	212,338	2,097,438	63,854
2016	3,265,000	373,000	666,000	89,701	2,136,299	1,901,500	215,925	2,117,425	18,875
2017	3,230,000	367,000	662,000	91,055	2,109,945	1,835,500	228,253	2,063,753	46,192
2018	3,235,000	388,000	650,000	87,281	2,109,719	1,893,100	251,050	2,144,150	-34,431
2019	3,230,000	388,000	660,000	86,301	2,095,699	1,905,600	284,180	2,189,780	-94,081

Note: Replacement lambs lagged on year. Replacement lambs reported Jan. 1, 2020 for 2019 replacements.  
Source: All data sourced from USDA/NASS.

### Accommodating for Differences in Birth Year and Slaughter Year

The 2010 study implicitly assumed that lambs were born and slaughtered in the same calendar year. The first nontraditional model in this study made the same assumption. However, this is not always the case and warrants the need to assess whether allowing lambs to be slaughtered either in the same calendar year that they were born, or the following calendar year significantly affects the nontraditional estimate. Relaxing the constraint that lambs are born and slaughtered in the same year will also test validity of the nontraditional estimate in the previous section.

Most lambs in the U.S. are born in the spring and remain on pasture throughout the summer and early fall.<sup>10</sup> These lambs may not be slaughtered until the first quarter of the following year. This is because many lambs are maintained on a slow or constant growth rate after weaning to target specific production dates. Many lambs are thus pastured to slow their rate of gain and are then sent to feedlots at around 10 to 12 months of age which would be early the following year. Feedlots serve to manage supply and therefore spring-born lambs may be placed on feed in the fall and not slaughtered until the following calendar year – particularly if targeting the spring holiday market including Passover, Western Easter, Greek Orthodox Easter, and Muslim holidays which fall on different dates each year. Adapting the model to a more realistic lambing/slaughter sequencing may better reflect the impact of seasonal lambing patterns and feedlot placements on slaughter lamb availability.

<sup>10</sup> There are areas of the U.S. where fall lambing occurs.

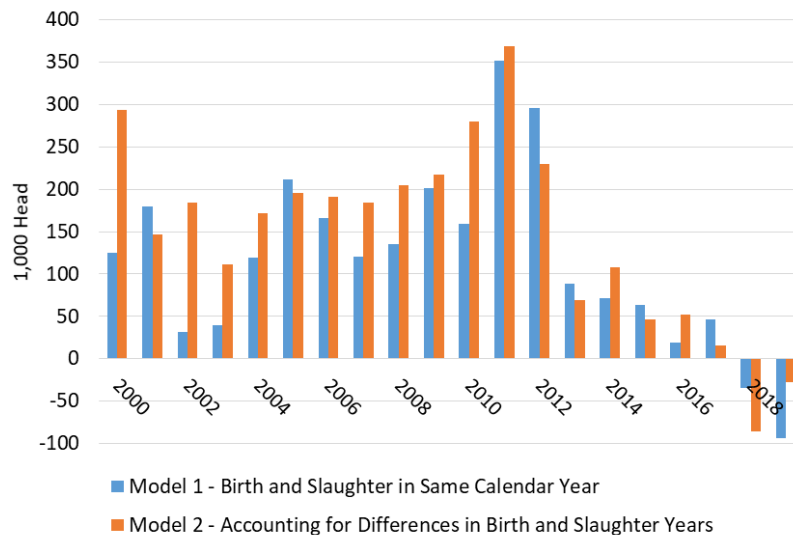
To calculate the nontraditional lamb supply estimate, total lamb slaughter is subtracted from total lamb availability by producers. The assumption is the inventory of lambs available is larger than that captured by state and federal slaughter reports. To relax the constraint that all lambs must be born and slaughtered in the birth year, a revised calculation was developed. The revision allows all lambs available in the current year or year  $x$  to be slaughtered in year  $x$ , but also in the following year. On average, the NASS data indicate that approximately 46 percent of market lambs are slaughtered in the same year they were born (range: 40 to 51 percent) and 54 percent are slaughtered the following calendar year (range: 49 to 60 percent).

The supply of nontraditional lambs is estimated as follows: the total lamb crop in year  $x$ , less the death loss, replacement lambs, on farm slaughter and the third and fourth quarter lamb slaughter (FI and NFI) in year  $x$ , less lamb and yearling slaughter for the first and second quarters of the following year (year  $x+1$ ). The model is as follows:

$$\text{Total lamb crop}_x - \text{on farm slaughter of lambs}_x - \text{replacement lambs}_x - \text{lamb death loss}_x - \text{lamb/yearling slaughter third quarter}_x - \text{lamb/yearling slaughter fourth quarter}_x - \text{lamb/yearling slaughter first quarter}_{x+1} - \text{lamb/yearling slaughter second quarter}_{x+1}.$$

The revised nontraditional supply estimate and the adjusted estimate taking into account differences in birth and slaughter years are very similar (Figure 16). At most, the estimates differ by 169,000 head and at a minimum, 16,000 head. Both estimates revealed an inversion in 2018 and 2019, whereby the lamb slaughter number exceeded the number of available market lambs, or inventory.

**Figure 16. Nontraditional Estimates: Model 1 vs. Model 2**



A t test of the two estimated series – accounting for the differences in birth and slaughter year, and constraining slaughter to birth year – revealed that one cannot reject the null hypothesis that the means of the two series are equal.<sup>11</sup> Thus, the observed difference between the sample means of

<sup>11</sup> The F test of two sample variances could not reject the null hypothesis of equal variances. A two tailed t test assuming equal variances was thus estimated to find a two-tailed p-value of 0.34 which is higher than the standard significance level of 0.05. Therefore, one cannot reject the null hypothesis, the observed differences between the means is not enough to say that the average annual nontraditional estimate between Model 1 and Model 2 differ significantly. Normal distribution was assumed for both series.

the two models is not sufficient enough to say that the two methods differ significantly. Therefore, the nontraditional volume estimate accommodating for a different slaughter year than birth year, while factually accurate, does not make a significant difference to the revised nontraditional estimate. This is important because constraining slaughter to birth year (while not practiced in the industry) facilitates a current year estimate of the nontraditional market.

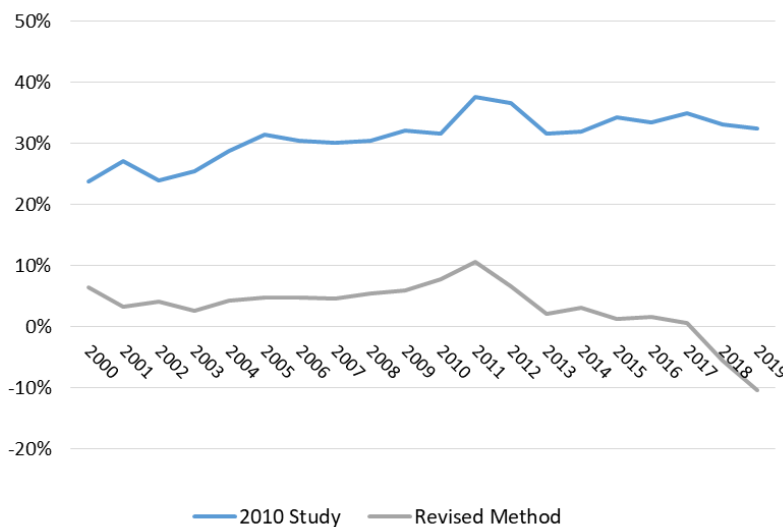
### A Look Back: How the Revised Estimate Differs

Figure 17 contains the percentage of annual lamb crop that could not be accounted for based on the NASS slaughter data using the 2010 study methodology with FI slaughter and the revised methodology. To have a common basis for comparison, lambs that could not be tracked using each methodology are shown in the figure below as a percentage of the annual lamb crop. Across the extended 2000-2019 range, on average, approximately 31 and 3 percent of the annual lamb crop could not be tracked of the two methods, respectively.

### Measurement Error

It is important to acknowledge the potential (and likely) impact of measurement error on any inferences and/or conclusions drawn based on the NASS data employed. The revised nontraditional estimate produced a negative number whereby lamb slaughter exceeded calculated lamb availability, or inventory. This finding gave rise to an investigation into NASS data collection methods. The annual NASS Sheep and Goat Reports provide information about the statistical methodology used, including survey procedures and reliability.

**Figure 17. Percent Lamb Crop that could not be tracked through NASS Summary Data**



From the NASS Sheep & Goat Report 2020:

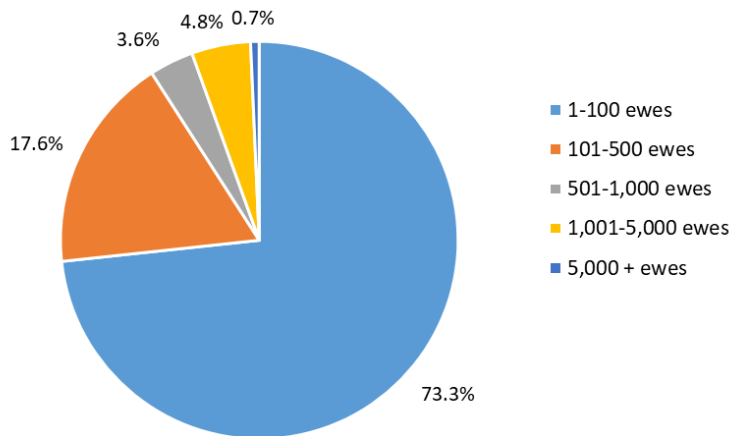
**Survey Procedures:** A random sample of United States operations was surveyed to provide data for these estimates. Survey procedures ensured that all sheep and goat operations, regardless of size, had a chance to be included in the survey. Large operations were sampled more heavily than small operations. About 21,600 operators were contacted during the first half of January by mail, telephone and face-to-face personal interview and 66 percent of the reports were usable.

The sampling of large operations more heavily than small operations could suggest the possibility that smaller sheep producers are underrepresented in the NASS survey of inventory (lamb crop, on farm slaughter, replacement lambs, and lamb death loss), and hence the nontraditional estimate. *NASS does not publish the inventory breakdown of the 21,600 operators in the January Sheep and Goat Report.* It is assumed that smaller sheep producers are more likely to sell lambs into nontraditional markets that are not captured in the federally or state inspected slaughter data. It is also possible that some small, newer producers have not been identified by NASS and asked to respond to the annual inventory survey.

The USDA Animal and Plant Health Inspection Service Veterinary Services (APHIS- VS) found that 20 percent of small (20-99 head) and 12 percent of medium-sized (100-499 head) operations “sold directly to consumer or ethnic market” in 2010 (APHIS, 2012:15). By comparison, only 5 percent of the larger flocks (500 or more head) directly sold to consumers or ethnic market.

In 2009, APHIS found that 93 percent of all U.S. sheep operations had 1-99 head of breeding sheep. Another 6 percent had 200-499 head and a total of 1 percent operations had over 500 head (AHPIS, 2012:150). In 2015, a survey of producers by the American Sheep Industry Association revealed that 73 percent of U.S. sheep operations had 1-100 ewes (ASI, 2016) (Figure 18). Nine percent of operations had 500+ ewes according to ASI.

**Figure 18. Percent of Operations by Flock Size**



Source: American Sheep Industry Association, 2016

The two sources above of operations by flock size represent different survey methods and thus should not be compared to establish a trend over time. It is unlikely that the sheep industry went from 1 percent of producers having 500+ ewes in 2009 to nearly 10 percent of producers having 500+ head in 2015. It is possible that the APHIS numbers skew toward the smaller flocks and the ASI data skew toward the larger ones.

The NASS regional breeding ewe and lamb crop data reveal that while Mountain and West regions are contracting in inventory, there are pockets of growth across Texas, parts of the Midwest and East and Southeast. However, regionally where the inventory shows growth is not necessarily mirrored in regional FI slaughter data. *This suggests that there are pockets of inventory growth that are “missing” and not captured in NASS slaughter data.* For example, in 2015-2019 the lamb crop grew 23 percent or 7,000 head (after accounting for death loss and replacement rates) in Region 1,

the Northeast,<sup>12</sup> but FI slaughter data only captured 16 percent of this growth, or 5,300 head. It is possible, however, that the lambs were slaughtered in other areas, such as in New York and New Jersey.

A recent Cornell University study reveals that perhaps the supply of lambs for slaughter/processing by producers exceeds the demand by slaughter plants in New England. In 2019 Cornell published *The State of the USDA Inspected Red Meat Slaughter and Processing Industry in New York and New England*.<sup>13</sup> The general conclusion is that lamb slaughter and processing is not as profitable as other species, such as cattle and hogs. “Respondents stated that lambs are inconsistent to slaughter, and (they) have decreased the slaughter and processing of lambs in order to increase the slaughter and processing numbers of other livestock that bring in more revenue,” (2019:10). “The survey found that 87.8 percent of plants would slaughter and process more lambs if the lambs were brought in shorn and clean,” (2019:10). A parallel concern that adds costs to lamb processing is that there was no market for lambskins resulting in their disposal as waste. “Plants are turning away business in the busy months due lack of cooler space and labor constraints,” (2019:15). The survey found that between 2016 and 2017 the surveyed livestock plants in New England processed 849 fewer head of lambs, or down 1 percent. In the same period, cattle numbers were up 318 head and hog numbers were up 3,491 head.

Another example of potential mismatched data is in the regional reported slaughter data for Region 6 which includes Texas and New Mexico.<sup>14</sup> From 2015 to 2019 the lamb crop grew by 18,000 head, however regional slaughter numbers only reflected a 5,500 head gain during this time. It is believed that lambs from this region are slaughtered, but not necessarily captured in the state and federal slaughter numbers.<sup>15</sup> It is possible that many lambs are transported out of the region to the East and Southeast for slaughter.

In another example, while the lamb crop in Region 2 (New York and New Jersey) was down 3,000 head in 2015-2019, FI slaughter was up 42,400 head in this same period. Appendix B lists the Regional FI slaughter, lamb crop, and breeding ewe data. The number of live sheep imported from Canada increased 114 percent between 2015 and 2019, which might explain some of the uptick in New York and New Jersey slaughter numbers. These sheep are primarily slaughter lambs which is believed to be the reason for the difference.

The following paragraphs and “Reliability Table” (Table 3) were excerpted from the NASS 2020 Sheep and Goat Report.

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<sup>12</sup> Region 1 includes New England (CT, ME, NH, VT, MA, RI).

<sup>13</sup> The research surveyed 52 livestock slaughter and processing plants in New England in 2017.

<sup>14</sup> Region 6 includes Texas, New Mexico, Arkansas, and Louisiana; however, state data was not published for Arkansas and Louisiana and therefore could not be added to the regional total. NASS reports that all states receive surveys for the annual sheep producer survey, so it is unclear to why individual state totals are not published for each state.

<sup>15</sup> An additional concern is whether what is anecdotally called “bird” slaughter – custom-exempt facilities that primarily slaughter poultry but will reportedly also slaughter lambs – is lamb slaughter that is reported to the state.



**Table 3. NASS 2020 Reliability of January Sheep and Lamb Estimates**

[Based on data for the past 10 years]

Item	Root mean square error	90 percent confidence level	Difference between first and latest estimate				
			Average	Smallest	Largest	Years	
						Below latest	Above latest
	(percent)	(percent)	(1,000 head)	(1,000 head)	(1,000 head)	(number)	(number)
All sheep and lambs .....	0.7	1.2	27	0	70	5	4
Breeding sheep .....	0.6	1.1	19	0	45	4	4
Lamb crop .....	1.8	3.3	38	0	150	2	6
Sheep shorn .....	1.2	2.3	24	0	140	0	7
	(percent)	(percent)	(1,000 pounds)	(1,000 pounds)	(1,000 pounds)	(number)	(number)
Wool production .....	1.1	2.0	169	0	870	2	7

From the NASS Sheep & Goat Report 2020:

**Reliability:** *Since all operations raising sheep and goats are not included in the sample, survey estimates are subject to sampling variability. Survey results are also subject to non-sampling errors, such as omissions, duplications, and mistakes in reporting, recording, and processing the data. The effects of these errors cannot be measured directly.*

*The "Root Mean Square Error" for sheep and lamb inventory estimates over the past 10 years is 0.7 percent. This means that chances are 2 out of 3 that the final estimate will not be above or below the current estimate of 5.20 million head by more than 0.7 percent. Chances are 9 out of 10 that the difference will not exceed 1.2 percent.*

The Root Mean Square Error (RMSE) can be interpreted as the standard deviation of the unexplained variance. Lower values of RMSE indicate better fit. The RMSE for breeding sheep, including ewes which were included in the revised nontraditional estimate, is 0.6 percent. A value of 0 represents a perfect fit, although this is rarely achieved, and a lower RMSE is better than a higher value. Chances are 9 out of 10 that the difference in breeding ewes will not exceed 1.2 percent. The RMSE for lamb crop, also included in the nontraditional revision, is 1.8 percent. Chances are 9 out of 10 that the differences in lamb crop will not exceed 3.3 percent.

From the NASS Livestock Slaughter 2019 Summary (April 2020):

*Computer imputation may be necessary for incomplete reports. The imputation of live and dressed weights is based on the current week reported data of plants of similar size and location. Imputation for live and dressed weight data for cattle and hogs is less than 10 percent and 7 percent, respectively. The imputation for calves and sheep is more frequent and variable. If no data is received electronically or by other means, for plants slaughtering fewer than 50 total head weekly of only one species, data are imputed. The imputation of head for any plant is based on the historical data for that particular plant. The imputation of head slaughtered is rare but when necessary, the imputed head kill for missing plants usually is less than 1 percent of the United States head kill totals.*

Note that for six of the past ten years, the initial lamb crop estimates were greater than the final estimates, with the largest initial over-estimate of lamb crop at 150,000 head (Table 3). Since the NASS Final Estimates are only published every five years, initial estimates may also contribute to the estimated number of "missing" (or excess) lambs.

## What's Next

Because there are so many unknowns in the data and so many opportunities for measurement error, it is doubtful that NASS "missing" lamb accounting can provide a legitimate quantitative estimate of the number of lambs that have been or are being diverted to nontraditional marketing channels. Industry insiders believe that some portion of lambs are falling through the cracks and not being counted in federal reporting. What this research revealed is that the lightweight lamb market, primarily channeled to ethnic markets, is growing and warrants continued monitoring.

It is believed that the up-tick in state inspected slaughter may reflect an increase in Halal slaughter as a [major] portion of nontraditional slaughter. It is also likely that a greater percentage of FI slaughter is currently Halal certified than was the case at the time of the 2010 study. This is likely due in part to Halal lamb becoming more "mainstream" in the retail market, but also to provide greater marketing flexibility for the major packers.

This research revealed that what was once known as the nontraditional market as defined originally by NASS data discrepancies and by a 2009 producer survey of personal and family slaughter, is sharply lower than initially estimated. Indeed, the revised estimate found that there is a relatively small, and sometimes negative difference between the lamb inventory and lamb slaughter, which gave rise to the data unknowns and measurement error.

As the demand for lightweight lambs grows, more ethnic lambs are being captured in state and custom-exempt processing facilities. This market is rapidly becoming one that can be tracked, with slaughter and prices monitored, and demand and supply analyzed to help sheep producers and stakeholders in the marketing channel improve margins and expand inventory.

This research highlights the importance of monitoring the lightweight lamb market, the market that is channeled through state inspected and custom-exempt slaughter facilities, but increasingly by FI slaughter facilities. The lighter weight, and often called ethnic market, is a significant segment of the U.S. lamb market. It is forecasted that the traditional, commercial lamb market of heavier-weight lambs and the ethnic lamb market will gradually assimilate over time as the largest commercial packers adopt Halal slaughter and the processing of lightweight lambs.

The implications of the study results are that the sheep industry is dynamic and seeing structural changes that are not necessarily captured in federal data reporting. This challenges industry research and development priorities, and programs to promote growth. This study highlighted several unknowns when assessing the NASS inventory and slaughter data and researching the relatively unknown lightweight lamb market:

- NASS reported that in its annual inventory survey (to gather breeding ewes, market lambs and on farm slaughter) large operations were sampled more heavily than small operations. NASS reported that it does not publish the inventory breakdown, but perhaps a follow-up discussion could be held to discover why NASS decided to overweight larger sheep operations in the industry survey and learn more about the statistical weighting process applied.
- The USDA Food Safety and Inspection Service (FSIS) collects state inspected and custom-exempt slaughter data from the states which is then reported to NASS. The reporting of livestock slaughter is voluntary by these facilities which thus warrants further research into the NASS response rate. Is it possible that there are small facilities processing lamb that do not report to their respective states?

- The increase evidenced of state inspected slaughter *could, in part*, reflect a growth in Halal slaughter. It would be interesting to be able to identify changes in the number of state inspected slaughter operations (increase/decrease) over the 20 year range of the data, and changes in the number of state inspected plants that are Halal certified. This, however, would only provide anecdotal evidence of an increase in the “more mainstream” Halal market, rather than provide a quantitative measure of market size.
- The U.S. lamb market is currently comprised of two distinct markets: the smaller market of lightweight hair and small-framed wool breeds channeled primarily into the ethnic market; and the larger commercial market of heavier maturing wool/meat breeds. Are these two markets destined to continue in separate, but parallel paths of growth, or will they assimilate into a more flexible lamb processing industry that utilizes a wider range of slaughter lambs, and utilizes the same infrastructure to reduce costs to meet the needs of lamb consumers with a myriad of different tastes? Currently, prices in the two markets appear to move together which suggests that the two markets are not uniquely different, but further study is warranted.

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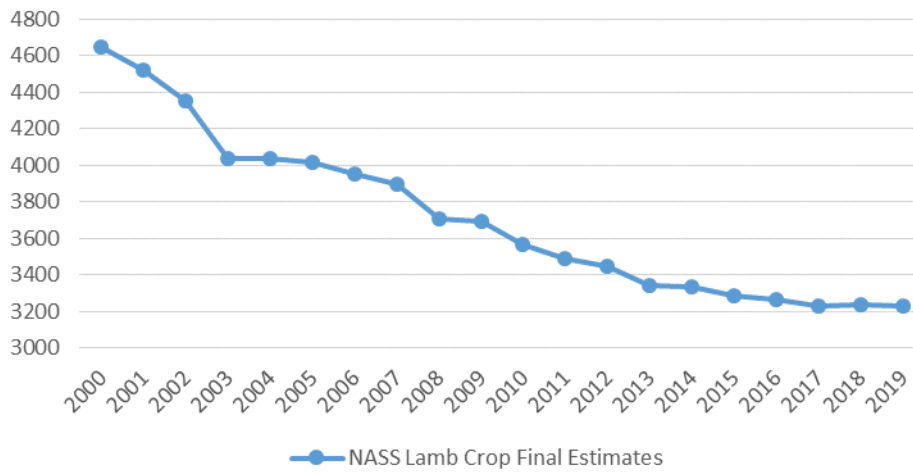
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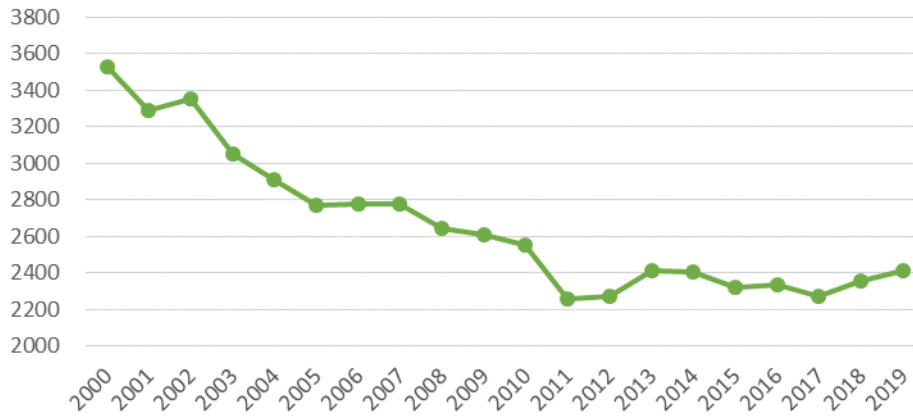
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## Appendix A – Data Charts

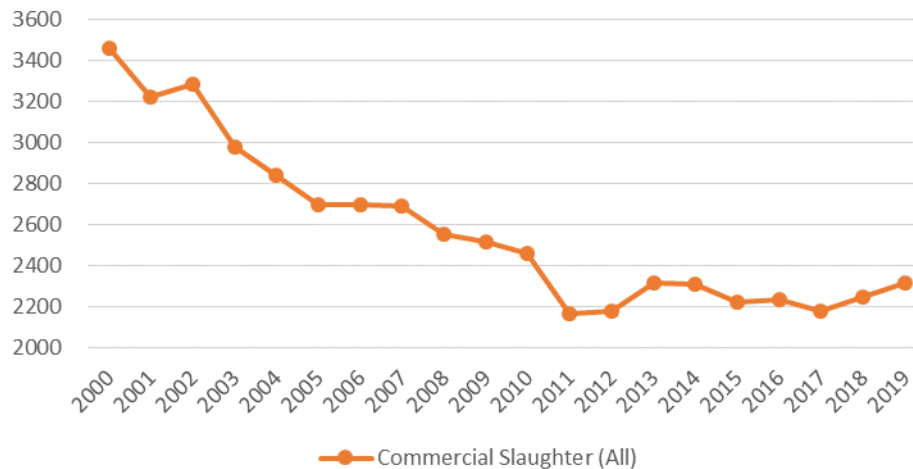
### NASS Lamb Crop Final Estimates (1000 hd)



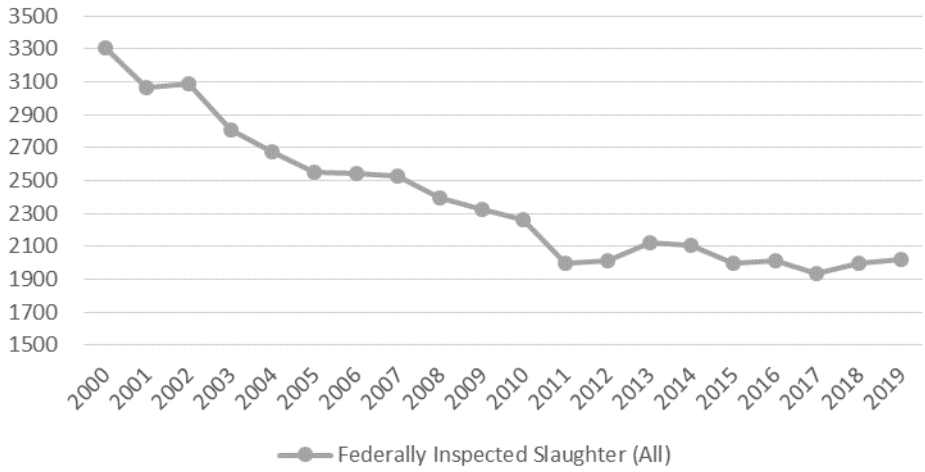
### Total Slaughter (1000 hd)



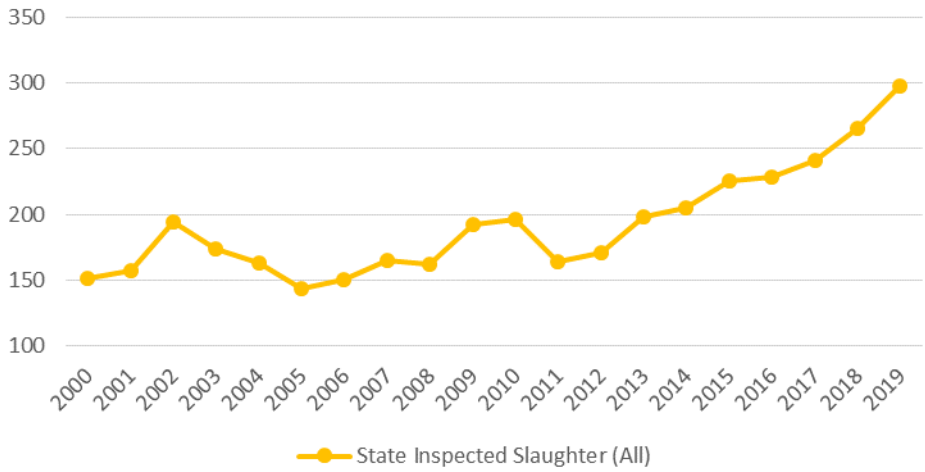
### Commercial Slaughter (All) (1000 hd)



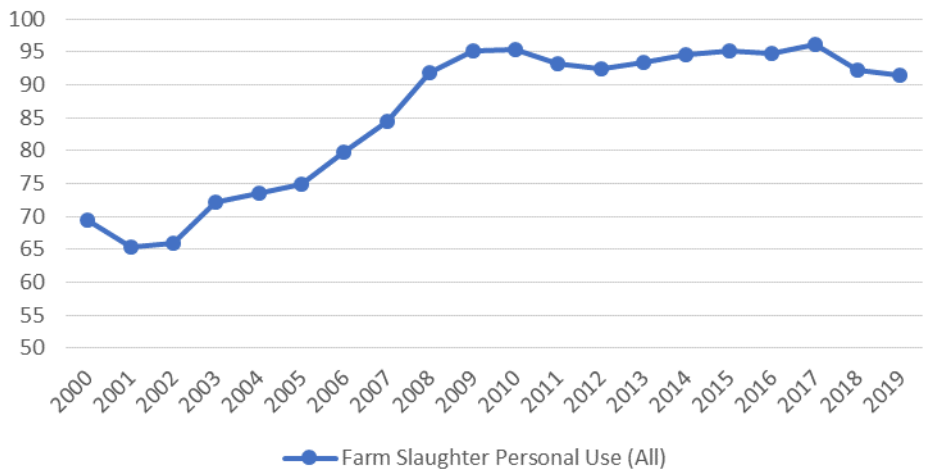
Federally Inspected Slaughter (All) (1000 hd)



State Inspected Slaughter (All) (1000 hd)



Farm Slaughter - Personal Use (All) (1000 hd)



## Appendix B – Regional Federally Inspected Slaughter (FI), Region Breeding Ewe Inventory, and Regional Lamb Crop

**Table 1. FI Sheep and Lamb Harvest, No. of Head**

	REGION 1		REGION 3		REGION 4		REGION 5		REGION 6		REGION 7		REGION 8		REGION 9		REGION 10	
	(CT ME NH VT MA RI)	REGION 2 (NY NJ)	(DE-MD PA WV VA)	(AL FL GA KY MS NC SC)	(IL IN MI MN OH WI)	(AR LA NM OK TX)	(IA KS MO NE)	(CO MT ND SD UT WY)	(AZ CA HI NV)	(AK ID OR WA)								
2000	23,800	133,000	95,200	19,400	435,700	463,400	497,600	1,240,000	389,600	10,200								
2001	23,100	137,100	91,300	19,800	413,700	436,300	461,600	1,115,800	350,600	15,500								
2002	24,500	138,100	112,300	26,100	415,800	303,400	477,400	1,188,000	386,000	20,700								
2003	22,300	135,300	114,200	29,100	391,500	360,900	421,600	778,500	531,100	20,800								
2004	21,500	141,200	108,000	31,500	396,100	262,100	402,400	987,100	307,400	19,100								
2005	NA	140,400	102,900	35,600	374,600	51,200	420,500	1,053,800	NA	20,600								
2006	NA	144,500	98,800	36,800	348,200	43,300	421,800	1,093,600	NA	23,900								
2007	NA	154,000	99,800	36,700	368,100	12,500	399,500	1,085,600	NA	29,200								
2008	26,800	167,400	110,900	42,400	357,300	NA	359,800	983,500	NA	27,600								
2009	36,200	165,100	115,400	43,000	280,600	NA	393,100	948,100	NA	26,900								
2010	27,700	173,500	110,300	48,100	326,400	39,700	280,200	926,800	301,100	27,400								
2011	27,100	148,100	96,200	42,300	317,900	31,500	55,300	977,900	277,400	26,600								
2012	30,800	147,600	107,800	47,700	344,000	29,600	7,600	983,800	283,900	29,200								
2013	35,200	174,500	119,200	64,000	390,300	38,500	9,600	958,700	300,900	29,200								
2014	35,300	164,400	129,500	62,900	377,600	42,500	9,700	967,400	278,800	36,500								
2015	33,700	180,500	114,200	67,100	356,200	38,100	9,600	885,700	275,500	37,700								
2016	34,100	195,200	122,500	77,400	344,600	38,900	9,200	849,800	297,600	40,300								
2017	34,000	193,100	138,500	78,000	343,600	37,700	14,000	769,600	285,000	43,500								
2018	30,700	209,200	152,700	89,500	345,600	46,000	13,900	755,800	304,900	51,600								
2019	39,000	220,900	143,900	104,900	340,500	43,600	13,800	760,900	299,000	53,900								
2000-19 Percent Change	63.9%	66.1%	51.2%	440.7%	-21.8%	-90.6%	-97.2%	-38.6%	-23.3%	428.4%								
2010-19 Percent Change	40.8%	27.3%	30.5%	118.1%	4.3%	9.8%	-95.1%	-17.9%	-0.7%	96.7%								
2010-14 Percent Change	27.4%	-5.2%	17.4%	30.8%	15.7%	7.1%	-96.5%	4.4%	-7.4%	33.2%								
2015-19 Percent Change	15.7%	22.4%	26.0%	56.3%	-4.4%	14.4%	43.8%	-14.1%	8.5%	43.0%								

Note: USDA/NASS does not report commercial or FI lamb and yearling harvest by states or regions.

Source: USDA/NASS

**Table 2. Breeding Ewes, 1 year and older, No. of Head**

	REGION 1 (CT ME NH VT MA RI)--NA, Used		REGION 3 (DE-MD PA VA) (No DE, VA)		REGION 4 (AL FL GA KY MS NC SC) (No AL, FL, GA, MS, SC)		REGION 5 (IL IN MI MN OH WI)		REGION 6 (AR LA NM OK TX) (No AR, LA)		REGION 7 (IA KS MO NE)		REGION 8 (CO MT ND SD UT WY)		REGION 9 (AZ CA HI NV) (No HI)		REGION 10 (AK, ID, OR, WA) (No AK)	
	New States	REGION 2 (NY NJ) (No NJ)	MD (2003-08)	VA (No DE, VA)	AL, FL, GA, MS, SC	IN MI MN OH WI	LA NM OK TX	KS MO NE	MT ND SD UT WY	CA HI NV	(No HI)	(No AK)						
2000	34,000	40,000	127,000	NA	344,000	993,000	315,000	1,480,000	438,000	360,000								
2001	34,000	41,000	125,000	NA	362,000	873,000	326,000	1,424,000	431,000	350,000								
2002	32,000	40,000	126,000	NA	363,000	880,000	299,000	1,347,000	399,000	354,000								
2003	29,000	43,000	139,000	17,500	354,000	825,000	299,000	1,246,000	394,000	351,000								
2004	28,000	41,000	130,000	16,000	325,000	818,000	296,000	1,108,000	397,000	328,000								
2005	29,000	43,000	133,000	18,000	334,000	788,000	291,000	1,093,000	394,000	334,000								
2006	30,500	41,000	144,500	22,500	349,000	818,000	298,000	1,103,000	401,000	332,000								
2007	31,000	43,000	146,000	22,000	346,000	786,000	298,000	1,124,000	409,000	319,000								
2008	32,000	43,000	151,000	23,000	335,000	725,000	292,000	1,110,000	407,000	318,000								
2009	31,000	40,000	149,000	25,000	330,000	649,000	271,000	1,087,000	409,000	304,000								
2010	30,000	42,000	138,000	23,000	337,000	637,000	259,500	1,059,000	387,000	309,000								
2011	32,000	43,000	141,000	22,000	331,000	624,000	240,000	966,000	394,000	305,000								
2012	29,000	38,000	137,000	27,000	332,000	522,000	258,000	997,000	395,000	308,000								
2013	33,000	42,000	136,000	31,000	324,000	509,000	243,000	989,000	400,000	294,000								
2014	27,000	47,000	138,000	31,000	316,000	529,000	240,000	935,000	405,000	286,000								
2015	26,000	51,000	128,000	30,000	308,000	524,000	249,000	961,000	399,000	291,000								
2016	26,000	50,000	133,000	33,000	307,000	532,000	252,000	970,000	376,000	278,000								
2017	27,000	51,000	131,000	33,000	308,000	528,000	248,000	937,000	386,000	267,000								
2018	30,000	55,000	128,000	36,000	310,000	554,000	243,000	908,000	370,000	262,000								
2019	30,000	51,000	129,000	37,000	314,000	546,000	233,000	909,000	357,000	253,000								
2020	31,000	54,000	130,000	37,000	311,000	535,000	244,000	890,000	366,000	241,000								
2000-19 Percent Change	-11.8%	31.7%	4.0%		-14.1%	-38.7%	-25.2%	-37.5%	-15.1%	-31.1%								
2010-19 Percent Change	-6.3%	25.6%	-7.8%	68.2%	-6.0%	-14.3%	1.7%	-7.9%	-7.1%	-21.0%								
2010-14 Percent Change	-18.8%	18.6%	-9.2%	36.4%	-6.9%	-16.0%	3.8%	-0.5%	1.3%	-4.6%								
2015-19 Percent Change	15.4%	8.0%	-2.3%	12.1%	1.3%	0.6%	-3.2%	-8.2%	-2.7%	-13.3%								

Source: USDA/NASS

**Table 3. Lamb Crop by Region, No. of Head**

	REGION 1 (CT ME NH VT MA RI)--NA, Used New England States		REGION 2 (NY NJ) (No NJ)	REGION 3 (DE- MD PA WV VA) (No DE)	REGION 4 (AL FL GA KY MS NC SC) (No AL, FL, GA, MS, SC)	REGION 5 (IL IN MI MN OH WI)	REGION 6 (AR, LA, NM OK TX) (No AR, LA)	REGION 7 (IA KS MO NE)	REGION 8 (CO MT ND SD UT WY)	REGION 9 (AZ CA HI NV) (No HI)	REGION 10 (AK, ID, OR, WA) (No AK)
2000	39,000	46,000	164,000	NA	510,000	747,000	449,000	1,700,000	418,000	460,000	
2001	37,500	49,000	166,000	NA	522,000	724,000	433,000	1,620,000	382,000	473,000	
2002	38,000	51,000	172,000	NA	519,000	694,000	421,000	1,535,000	368,000	449,000	
2003	33,000	50,000	172,000	NA	490,000	648,000	419,000	1,358,000	346,000	424,000	
2004	35,000	53,000	172,000	34,000	463,000	641,000	397,000	1,367,000	370,000	436,000	
2005	36,000	50,000	174,000	38,000	473,000	636,000	391,000	1,357,000	356,000	437,000	
2006	36,000	50,000	181,000	36,000	472,000	582,000	409,000	1,353,000	355,000	400,000	
2007	37,000	44,000	171,000	36,000	492,000	548,000	414,000	1,324,000	333,000	407,000	
2008	36,000	44,000	178,000	41,000	468,000	474,000	381,000	1,277,000	319,000	400,000	
2009	33,000	45,000	154,000	42,000	469,000	496,000	366,000	1,241,000	344,000	405,000	
2010	36,000	49,000	165,000	42,000	461,000	464,000	348,000	1,140,000	350,000	413,000	
2011	34,000	43,000	155,000	42,000	465,000	415,000	344,000	1,148,000	345,000	392,000	
2012	32,000	50,000	153,000	47,000	467,000	387,000	334,000	1,145,000	333,000	386,000	
2013	32,000	48,000	158,000	50,000	434,000	394,000	321,000	1,110,000	327,000	355,000	
2014	29,000	55,000	145,000	58,000	411,000	421,000	313,000	1,105,000	336,000	347,000	
2015	30,000	60,000	148,000	59,000	375,000	426,000	307,000	1,105,000	335,000	333,000	
2016	33,000	60,000	151,000	54,000	376,000	420,000	312,000	1,086,000	332,000	317,000	
2017	33,000	58,000	153,000	57,000	373,000	438,000	306,000	1,084,000	310,000	305,000	
2018	35,000	57,000	151,000	53,000	372,000	445,000	297,000	1,085,000	317,000	305,000	
2019	37,000	57,000	153,000	54,000	387,000	444,000	312,000	1,057,000	308,000	300,000	
2000-19 Percent Change	-5.1%	23.9%	-6.7%		-24.1%	-40.6%	-30.5%	-37.8%	-26.3%	-34.8%	
2010-19 Percent Change	2.8%	16.3%	-7.3%	28.6%	-16.1%	-4.3%	-10.3%	-7.3%	-12.0%	-27.4%	
2010-14 Percent Change	-19.4%	12.2%	-12.1%	38.1%	-10.8%	-9.3%	-10.1%	-3.1%	-4.0%	-16.0%	
2015-19 Percent Change	23.3%	-5.0%	3.4%	-8.5%	3.2%	4.2%	1.6%	-4.3%	-8.1%	-9.9%	