# Niche Pork:
# Exploring opportunities for alternative swine production and marketing

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## ABSTRACT

Overview: Increasing global demand for livestock products is pressuring land resources already under competition with crop agriculture, biofuels, urbanization and conservation. Yield gaps within sustainable agriculture may further intensify this land competition. At the same time, consumers are becoming more particular over the practices used to raise livestock for meat products. Niche meat marketing opportunities are emerging as consumer awareness and demand increases for differentiated livestock products. Accordingly, the purpose of this project is to examine the bio-physical and socio-economical components of a niche pork value chain within a regional food system. Within this study, niche pork refers to pigs that are raised in a known location, on vegetarian feed, without sub-therapeutic antibiotics and no added growth hormones.

Methods: This three-part project used a mixed-methods approach including environmental modeling and econometrics with primary and secondary data. Part 1 focused on existing pork production to determine the performance metrics typical of niche pork production and compare to conventionally-raised swine. Primary data was collected from 176 self-identified niche pork producers across the United States and analyzed with descriptive statistics and qualitative methods. Part 2 utilized the data collected in Part 1 to estimate the land requirements typical of three systems: conventional confined environment, niche enhanced environment, and niche outdoor environment. Biophysical modeling of Part 2 were bounded by nutritional feed needs and living space allocation. Part 3 concentrated on the consumption side of the supply chain to explore retail consumers' value and knowledge of alternative animal production in New England. Part 3 gathered data from 373 specialty market retail customers in Metro-Boston to estimate their willingness-to-pay (WTP), rank production characteristics, and evaluate meat eco-labeling understanding.

Results: Examination of performance at specific life phases demonstrated that niche pork productivity can be close to conventional pork. Overall land requirements ranged from 0.85 to 1.22 hectares per bred sow per year for the three systems. Cropland was a stronger factor than living space when considering the total land needs. Niche enhanced and outdoor environments were 17% to 44% greater in total land requirements than the conventional confined environment. When considering trade-offs of alternative production, niche pork requires more land yet offers benefits for the producer, herd, consumer and environment that should be considered when evaluating swine management strategies. Significant predictors of niche pork WTP centered on tenderloin preferences. Consumer participants were strongly concerned with added hormones and sub-therapeutic antibiotics, followed by living space and outdoor access. Participants recognized federal meat eco-labels but did not understand production differences among federal and private labeling programs.

Implications: Outreach and dissemination of the study's results will provide an opportunity for niche farmers to compare their production against alternative and conventional averages in order to improve productivity and become more profitable. Similarly, project findings will suggest the market potential for niche meat that could be used to support a pork value chain for the New England region.

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# CHAPTER 1: Introduction

## Overview

The consolidation, concentration and industrialization of the swine industry, along with low prices and narrow profit margins (O'Donoghue et al., 2011; USDA GIPSA, 2008; Key and McBride, 2007; Howard, 2005; McBride and Key, 2003), led to a new vision for production and marketing, referred to as niche pork (Honeyman et al., 2006).. Niche pork is differentiated from conventional pork by claimed quality or credence attributes related to the swine breed, practices used to raise the animal, and relationships with producers (Honeyman, 2005). Consumers are paying more attention to such attributes (Dickenson and DeeVon, 2002; Umberger et al., 2009). Concerns over animal welfare, food safety, economic viability, and environmental sustainability are supported by increasing consumer demand for food with socio-environmental credence attributes, such as local, organic, humanely-raised, and grass-finished (Greene, 2013; Martinez, 2010).

Spreading across the meat supply chain from producers to consumers, Honeyman et al. (2006) state it best, "there is a pork niche market phenomenon." However, there are many questions to consider before promoting a change in production systems. For instance, how do the two production systems, niche and conventional pork, compare in terms of performance, feed efficiencies and land requirements? Related, do common benefits and barriers exist for niche producers that relate to successful practices? Finally, do retail consumers value niche meat and the process attributes to produce them? Therefore, this study established a framework to analyze niche pork in terms of performance metrics, land requirements, consumer preference and willingness-to-pay (WTP), and overall factors of viability that could be applied within food systems assessments.

**Influential literature for this dissertation**

The recent literature on niche pork production and consumption can be grouped into four categories: (1) niche development and current trends, (2) producer management strategies, (3) comparisons of pig performance, animal behavior, food safety and carcass characteristics, and (4) consumer preference and WTP.

The first category highlights factors that led to the "return" of alternative swine systems (such as pastured living conditions or heritage breeds) and factors needed for future success and growth of this industry (Honeyman et al., 2006; Hermansen et al., 2004). These studies also quantify the current status of niche production. For instance, Honeyman et al. (2006) estimate the U.S. niche market to be 500,000 to 750,000 pigs annually. Similarly, National Animal Health Monitoring System (NAHMS) reports the number of swine raised outside (pasture or lot) or within an open building that has outside access: 28.4% of gestating sows and gilts, 4.2% for farrowing, 2.3% for nursery, and 10.4% for growing/finishing (USDA APHIS, 2001). However, more current data show that the fraction of animals with outdoor access has decreased in the past decade; NAHMS 2010 reports 2.7% of gestating sows and gilts, 1.2% farrowing, 0.2% nursery, and 0.4% growing/finishing were either raised outside (pasture or lot) or in an open building with outside access (USDA APHIS, 2012).

The second category provides management instructions for producers. With the advent of niche pork, a number of organizations have provided helpful materials for the farmer. These include the Pork Niche Market Working Group (PNMWG), Sustainable Agriculture Network, Pork Industry Institute of Texas Tech University, Practical Farms of Iowa and NC Choices. These organizations provide advice on records and budget, environment, nutrition, reproduction and genetics, production flow, pork quality, and pig husbandry considerations when raising hogs alternatively (for example, refer to Lammers et al., 2007).

The third category of literature focuses on the difference in various characteristics between conventional and alternative swine systems.  Although production practices affect the animal as a whole being, characteristics are separated here into three groups: performance metrics, welfare and food quality.  The first group of comparisons, performance metrics, includes such parameters as average daily gain (ADG), mortality rates, and feed efficiency (Honeyman et al., 2005; Honeyman and Harmon, 2003; Blanton et al., 2002).  Other studies conducted life cycle assessments (LCA) of materials and energy associated with conventional and deep-bedded swine systems (Lammers et al., 2012; Pelletier et al., 2010).  More specifically, Lammers et al. (2012) assessed energy used during the growth and performance of pig production and supporting infrastructure, such as facility construction and operation, crop cultivation, feed processing, and manure application for each system.  Likewise, Pelletier et al. (2010) quantified the cumulative energy use, ecological area footprint, greenhouse gas emissions as carbon dioxide equivalents, and eutrophying emissions as phosphate equivalents for piglet production and finishing pigs, and in terms of total live-weight pig production for each system.

The parameters used in these LCA studies contribute to the production potential of the given operation.  These parameters could also be incorporated into this research's land requirements model.  However, as noted by Lammers et al. (2012), the majority of the swine herd assumptions was the same value for both conventional and hoop barn-based systems. Such reinforces the need to collect primary data on performance metrics for the alternative niche pork system.

There are several European LCA studies of conventional pork production that estimate global warming potential (Nguyen et al., 2011; Hirschfeld et al., 2008; Dalgaard et al., 2007; Williams et al., 2006; Basset-Mens and van der Werf, 2005; Cederberg and Flysjo, 2004; as reviewed in Reckmann et al., 2012). Since this collection of literature focuses on conventional production, the parameters and assumption would likely not be applicable to niche pork production. Furthermore, there are fundamental differences between hog farming in Europe and the United States; thus, limiting the application of these results to U.S. production (Lammers et al., 2012).

Other comparison studies between conventional and alternative pork production concentrate on animal welfare. These studies demonstrate that pigs with outdoor access had less aberrant behaviors, more play behaviors, and more activity (Johnson et al., 2001; Lay et al., 2000). Additional literature compares food quality and safety (Rostagno, 2011; Honeyman, 2005; Talbott et al., 2003; Blanton et al., 2002).

The final category of niche pork literature presents price premia consumers are willing to pay for meat raised in unconventional manners. Conducted domestically and internationally, these studies examine consumer preferences toward animal welfare, meat traceability and transparency, and production methods that are small-scale, natural or organic (McKendree et al., 2013; Liljenstolpe, 2010 and 2008; Umberger et al., 2009; Lusk et al., 2007; Lagerkvist et al., 2006; McMullen, 2006; Wheatley, 2003; Dickinson and Bailey, 2002; Grannis and Thilmany, 2002). Methods are based in either Contingent Valuation or Choice Experiments; data were typically collected with a mail or internet survey with sample sizes ranging from 35 to 1,400 participants. Overall, consumers are willing to pay price premia for process characteristics. Furthermore, such preferences are associated with class membership relating to purchase behavior, shopping location, agricultural awareness, and demographics.

The study most related to the research conducted here is Grannis and Thilmany (2002). The authors identified the market segment that would be willing to pay for natural, local pork at a 18% premium; such variables include weekly expenditures, income, previous purchase of natural beef, and concern for animal welfare. Although these studies are localized, specific to the Intermountain West, Iowa or European countries, they provide useful examples of data and models that were incorporated into this research.

**Specific aims of this research**

Local and regional food system assessments are becoming a popular tool for examining and planning more sustainable food production, aggregation, distribution, marketing and consumption. In order to make valuable policy recommendations and appropriate reforms, an accurate understanding of the relationships, trends and barriers among components of the system is required. Thus, this study was designed to analyze the production and consumption components of the food system for pork meat raised alternatively. The purpose of this project is to examine the bio-physical and socio-economical components of a niche pork value chain within a regional food system. Within this study, niche pork refers to pigs that are raised in a known location, on vegetarian feed, without sub-therapeutic antibiotics and no added growth hormones.

Regarding the long-term goals of this multi-disciplinary study, the newly acquired knowledge is fundamental for food system planning, modeling and marketing of an alternative meat product. This information will also present a deeper, explicit understanding of niche pork performance metrics as well as consumer demand, thereby assisting farmers with their production practices and distributors and retailers with marketing. Such goals were met through three specific objectives:

**Part 1 performance metrics comparison: To determine the performance metrics typical of niche pork production and compare to conventionally-raised swine.** Part 1 focused on existing pork production by addressing these research questions:

> *(i) What are the performance metrics of niche pork and how do they compare to conventional pork?* The goal for these question was inferential. I hypothesized that niche pork will experience performance inefficiencies as compared to conventional production. This hypothesis was based on lower production metrics for niche pork reported in the comparison literature.
>
> *(ii) What are the reasons for producers of niche pork to participate in this value chain?* I anticipated the results of this descriptive question to center on farm economic diversification and environmental reasoning, as documented in previous literature.
>
> *(iii) What production characteristics should be included under the "niche" term?* Also descriptive, I expected the outcome to vary by size. For instance, farmers of smaller herds may focus on grazed pasture and heritage breeds while the larger operations may focus on local, non-GMO feed and third-party certification. I based this expectation on previous discussions with pork producers and meat aggregators.

Part 1 research questions were answered through primary data collection and descriptive statistics analysis. The results of such analysis were tabulated by system (conventional and niche), quasi-qualitative summaries from open-ended survey questions, and relation of metrics to other studies. Results of Part 1 were targeted for publishing in *Livestock Science* and shared at the 2015 Future of our Food conference in Boston, MA (Tufts University, Friedman School of Nutrition Science and Policy).

**Part 2 feed efficiency and land requirements comparison: To estimate the land requirements typical of three systems: conventional confined environment, niche enhanced environment, and niche outdoor environment.** Part 2 utilized the data collected in Part 1 to answer these research questions:

*(iv) What are the land requirements of producing niche pork and how do they compare to conventional pork?* The goal for this question was inferential. Influenced by Part 1 expected results, I hypothesized that niche pork will require more land than conventional pork per pound of boneless meat produced. This hypothesis was based on potentially lower production metrics and feed efficiencies for niche pork potentially found in Part 1.

*(v) What are the target meat outputs and feed conversions for niche and conventional pork?* Similar to the preceding research question, I expected that niche system would result in less edible meat with higher feed needs compared to conventional production. This expectation was based on greater nutritional requirements as well as higher fat content for heritage breeds or hogs raised outdoors that are more active swine.

Part 2 goals were met through biophysical modeling of nutritional and space needs. The results included tabulated feed needs, feed conversions, space needs, and overall land requirements by system (conventional confined, niche enhanced, and niche outdoor environments). The findings of Part 2 were written for the target journal of *Renewable Agriculture and Food Systems*. In addition to the formal articles and Future of the Food presentation, I plan to summarize the overall findings for Parts 1 and 2 for a producers' conference, such as NC Choices Meat Conference 2015 or New England Meat Conference 2016.

**Part 3 consumer preferences: To explore the retail consumers' value and knowledge of alternative animal production in New England.** Part 3 concentrated on the consumption side of the supply chain by asking these research questions:

*(vi) What types of meat would retail consumers prefer local over conventional source?* The results of this question were descriptive. I anticipated chicken breast to rank highly, thus following existing consumption trends, as well as interest in local ground meat products, perhaps reflecting concern over food safety. I expected the roasts, such as beef, pork and broiler chicken to rank low possibly due to the higher preparation time.

*(vii) For customers interested in niche pork, what are they willing to pay for a niche New England product?* The goal for this question is inferential. Based on previous studies, I hypothesized that customers would be willing to pay a premium for niche pork. However, their maximum premium had the potential of falling short of the estimated retail cost projected by regional meat aggregators.

*(viii) Which animal husbandry practices (process-only attributes) are most important to retail customers?* Also descriptive, the anticipated results were expected to have a rank order of human and environmental health as most important, followed by local support, then animal welfare. I based this anticipated ranking on recent media coverage of antibiotic resistance and increased interest in the local food movement.

To achieve the goals of Part 3, primary data were collected using stated preference contingent valuation methodology. WTP was estimated using tobit regression. This study was written for the target journal *Agribusiness*. Preliminary results of Part 3 were presented at the 2015 Northeast Agricultural and Resource Economics Association (NAREA) Conference in Newport, RI.

**Rationale and significance**

Small and medium-sized farms play a vital role in the economy, environment and society. Despite these advantageous qualities, there has been steady decline in the number of mid-sized farms. Pasture-based livestock is viewed as an opportunity with strong promise to revive small and mid-sized farms (Conner et al., 2008). Furthermore, increased sales of pastured meat products as a private good also can have public good benefits such as clean water and air, reduced human health risk or improved animal welfare (Lusk et al., 2007).

Rising consumer demand is coupled with continuous growth in local food markets, such as direct marketing using farmers markets and community-supported agricultural enterprises. Although direct marketing advocates economic viability for producers, it may also have limitations, including access and affordability (Martinez et al., 2010), insufficient income generation for producers (Hinrichs, 2003), scaled-efficiency loss with transportation or production methods, and inconvenience with increased time requirements for both producers and consumers (Brown and Miller, 2008). For these reasons, I proposed to study an alternative business structure beyond direct marketing for livestock meat products.

In my opinion, the approach used to accomplish the proposed research objectives was innovative because it crossed disciplines to connect producers, aggregators, distributors and retail customers. Furthermore, the study has demonstrated need due to the lack of benchmarking references for niche performance metrics. Thus, outreach and dissemination of my results provide an opportunity for niche farmers to compare their production against alternative and conventional averages in order to improve productivity and become more profitable. Similarly, project findings will suggest the economic market potential for niche pork raised in New England. Despite dramatic increases in demand for organic and natural beef and chicken, this retail information specific to differentiated pork in not known. Therefore, my modeling and econometric analyses will develop new information to support a pork value chain for the region.

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**CHAPTER 2** (Part 1) written in the style of *Livestock Science* journal

**Title: Niche pork: Comparing pig performance and understanding producer benefits, barriers, and labeling interest**

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**Abstract**

Opportunities for alternative swine production and marketing are emerging across the value chain. Given the developing nature of the differentiated pork industry, measurements of niche performance and success are not yet fully known. For this reason, the objectives of this study were to determine performance metrics across all major life phases for niche pork production and compare such metrics with national averages of conventional commodity pork production. Additionally, this study aimed to quantify producers' reasoning and barriers to successfully raising niche swine. Niche meat producers in the United States self-identified for this study (n=176); their swine production had alternative characteristics that included small to mid-sized farms, farrow-to-finish operations, heritage breeds, housing with bedding and outdoor or pasture access, no use of antibiotics

(sub-therapeutic or never-ever), vegetarian feed, diverse agricultural enterprises, and alternative marketing avenues. This study focused on the metric categories regarding reproduction, mortality, culling, and growth characteristics. The niche system produced approximately 15% fewer weaned piglets per bred sow per year than the conventional system due to fewer breeding cycles, smaller litters, and higher piglet mortality in alternative production. Similarly, niche production finished 12% fewer hogs per bred sow per year than conventional production. Regarding age benchmarks of finishing and breeding, the niche system averaged 18 additional days to finish hogs at a standardized market weight of 124 kilograms. Likewise, niche production gilts were first bred at 283 days whereas conventional production breeds gilts at 225 days. All directly comparable metrics were found to be statistically significant with 95% confidence for the one-sample test of means. Regarding farmer attitudes toward niche pork, survey participants shared 265 personal reasons for raising swine and 237 barriers to successful niche production. Choosing niche over commodity swine, participants' reasons were grouped into 3 intra-related categories: (1) farm and producer viability, (2) animal and environmental welfare and (3) consumer preference and taste. Despite these benefits, participants were faced with numerous challenges, which were organized into 4 intra-related categories: (1) alternative production requirements, restrictions and knowledge, (2) access and affordability of credit and inputs, (3) alternative supply chain for processing, marketing and customers, and (4) non-niche production competition and governmental policies. In sum, the success of these niche pork operations equates to high welfare for the pigs, economic viability for the operation, personal satisfaction for the farmer, tasty meat for the customer, and responsible environmental practices, inclusive of many components of an alternative food system.

**Key Words:**
alternative swine, producer challenges, niche meat

## Highlights

- 176 niche pork producers were surveyed in 2014.
- Compared to conventional swine production, niche production had lower cull and mortality rates for the breeding herd, finishing gilts and barrows, higher mortality rate for pre-weaned piglets, smaller litter sizes, and fewer annual breeding cycles.
- Largest barriers to successful niche production included cost and accessibility of inputs and processing as well as differentiation requirements and restrictions.

## Introduction

The pork industry has dramatically changed since the middle of last century. In 1965, there were nearly 1.058 million swine operations in the United States (US) that raised on average 47.8 hogs per farm per year (Plain et al., 2001). For comparison, more recently in 2000, the number of national operations dropped to 85,760 with an average annual inventory of 689.6 hogs (same source). Expressed slightly differently, the 152.7 million hogs marketed in the U.S. in 2013 on 67,000 farms provided total gross receipts of $23.4 billion and about 548,000 jobs (National Pork Board, 2014; NPPC, 2013). The operations of today are larger than those of previous decades, even though they are fewer in number. In addition, the hog farms are more specialized, replacing farrow-to-finish with individual phases of production located on different farms. For instance, specialized finishing operations (post weaning feeder-to-finish) increased from 22 to 77 percent of their share of production between 1992 and 2004; while farrow-to-finish reduced from 65 to 18 percent during that same time period (McBride and Key, 2013).

Technical and economic factors contributed to this change. Technically, there were improvements to genetics, nutrition, housing and handling equipment, veterinary and medical services, and efficiency (hog performance or risk reduction) (Key and McBride, 2007). Economically, there were record low commodity hog prices in the 1990s (Honeyman et al., 2006). Around the same time period, there was also the expansion of contract production arrangements. As stated in McBride and Key (2003), capital accumulation through contract production contributed to the expansion of hog operations and adoption of new technologies, thus reaching unprecedented economies of size.

For these reasons, the hog industry was restructured, resulting in operations that are large-scale (50% have more than 5,000 head), specialized finishing (77%), organized under production contracts (28%), and geographically concentrated (the Heartland and Southeast of the US) (Key and McBride, 2007). Beyond the farm gate, the pork packers also consolidated; the four largest firms, Hormel, Tyson, Smithfield and Swift and Company have controlled 61 to 64% of sales between 2003 and 2006 (USDA GIPSA, 2008; Howard, 2005). Such concentration has nearly doubled since the 1980s, when the historic concentration ratio of the largest four firms (CR4) ranged between 34 and 37 percent (Hendrickson and Heffernan, 2002).

The consolidation and concentration of hog farming has been followed by public concern and regulatory issues concerning water and air quality as well as animal welfare. Quickly, some producers began to construct a new vision for their production -- niche pork. In other words, "the structural changes in pig production and the associated large number of pigs produced, low prices, and narrow margins for U.S. pigs led to more niche pork marketing" (Honeyman et al., 2006). Although the niche designation is not formally defined and may have multiple interpretations, Honeyman et al. (2006) state that niche pork is differentiated from conventional pork by claimed quality or credence attributes. Quality attributes develop from the breed of the animal as well as the meat quality in terms of freshness, taste or tenderness. Credence attributes embrace social welfare characteristics, including: natural, organic, outdoor access, humane treatment, environmentally-friendly production methods, feed without sub-therapeutic antibiotics, growth hormones or animal by-products, and support of local, small to medium scale farms with known origin (Honeyman et al., 2006).

On the opposite end of the meat supply chain, consumers are becoming more aware of the methods used to raise animals (Umberger et al., 2009; Dickenson and Bailey, 2002). Such awareness is tied to concerns over animal welfare, environmental pollution, food quality and safety. Accordingly, interest in alternative livestock methods is gaining from both producers and consumers as livestock products with socio-environmental credence attributes are becoming more readily available with growing consumer demand (Greene, 2013; Martinez, 2010; Honeyman et al., 2006; Wheatley, 2003; O'Donovan and McCarthy, 2002). Demonstrated in the market, U.S. organic meat sales have increased by 360% in the last decade with an estimated 2014 value of $1.141 billion USD (USDA ERS, 2015). Likewise, differentiated meat products within the restaurant sector are also emerging. For instance, locally-sourced meat and seafood were rated as the top food item from a list of 231 foods to be served in restaurants in 2015 (National Restaurant Association, 2015).

Given the growth within the differentiated meat industry, swine experts conclude that there is a pork niche market phenomenon (Honeyman et al., 2006). However, there are many considerations before converting to an alternative production system. One consideration is the difference in performance between conventional and niche swine production. System-specific parameters are used to understand the biological and economic efficiency and environmental sustainability of livestock systems. Farmers are interested in such benchmarks to evaluate their on-farm efficiency whereas planners may use the metrics to run land use analyses or life-cycle assessments.  Although performance metrics for conventional production are readily available (Haley, 2014; USDA APHIS 2015), a complete set of analogous values for alternative production for all life phases does not exist.  For instance, previous studies typically focused on one or two life phases, such as gestation and weaning (see Lammers et al., 2007), weaning and finishing (see Gentry et al., 2004), or finishing (see Morrison et al., 2007; Honeyman and Harmon, 2003).  Therefore, this study established a framework to first gather data and then compare niche performance against conventional averages for all major life phases in pork production.

In addition, this research aims to understand common attributes among niche farmers since there is no standard system or definition for alternative, niche swine production.  The characteristics under consideration of this study included  animal breeds, scale of operation, marketing outlets, benefits and barriers of non-commodity pork production.  These attributes may impact herd performance and therefore be used to contextualize the metrics comparisons.  Furthermore, the production characteristics, rewards and limitations of raising swine in an alternative manner may help characterize the niche meat label, which is currently an unregulated claim by the USDA.  Because effective labeling can be a useful tool for conveying different management practices used in alternative agriculture, it may be advantageous for niche pork to be recognized as a differentiated meat product and labeled as such.  Therefore, this study examined farm efficiency through the qualitative lens of common production characteristics, benefits and challenges to provide important information for understanding niche pork inputs and productivity.

**Methods**

*Farmer Survey*

A farmer questionnaire was designed to focus on performance metrics and producer rationale for adopting alternative production methods.  Of particular importance for assessment and comparison were the metric categories concerning reproduction, mortality, culling, and growth characteristics.  The survey was pre-tested with pork producers and academic specialists in the summer and fall of 2013, and their feedback was incorporated to improve the survey instrument.  Once finalized, the survey instrument was three pages in length and took approximately ten to fifteen minutes to complete.  It contained five sections that included questions on feeding, breeding, finishing, housing, and agricultural experience.  More specifically, the first section focused on feed rations, feed record keeping, access to the outdoors, breeds and manure management.  For those operations with breeding pigs, the second part concentrated on various aspects of their breeding program, such as productivity record keeping, cycles of farrowing, pre- and post-wean litter sizes, weaning age and weight, breeding herd size, gilt age for first breeding, culling, mortality, and artificial insemination.  In the third section, farmers provided information pertaining to the growing and finishing life phase, such as record keeping, age and weight of finished hogs, number finished, marketing outlets, culling and mortality, cull reasoning and destination.  The fourth part centered on housing type and space allocation for major life phases as well as bedding materials.  The fifth  section concluded with personal farming experiences and transitioned into qualitative responses to open-ended questions pertaining to benefits and challenges of niche production.  In this final part, producers were also asked to define success and production characteristics for the niche meat label.  Approval for this primary data collection was attained through Tufts University Social Behavioral & Educational Research

Institutional Review Board on October 31, 2013. A copy of the questionnaire is provided in the Supplemental Materials.

*Survey Implementation*

As with most primary data collection, the sampling frame is critical for obtaining a representation of the population under examination. One complication with administering this survey was the lack of a large-scale database of alternative pork producers Likewise, for privacy purposes, USDA does not release information at the farm level while state agencies and aggregating companies protect their producers' confidentiality. Thus, in order to conduct the survey with a sample of farmers, a network of niche pork research and production specialists was established for this study. These individuals were found through niche pork published and grey literature as well as producer cooperatives and meat aggregators. Most of the specialists work in the two pork centers of the U.S. (Iowa and North Carolina). Others are based in New England or the Upper Midwest. As experts in the niche pork field, this volunteer network reviewed the survey questions and suggested outlets, such as niche producer conferences or cooperatives, for farmers to participant in the study.

The survey was administered from November 2013 through May 2014 at six regional and national conferences. Farmers who participated in the study self-identified as niche pork producers. In addition to recruiting participants at conferences, surveys were sent to producers who have marketing agreements with meat aggregators or who participate in organizations associated with alternative livestock production. It was made available in both paper and online formats. The producer instrument gathered information from 176 niche pork producers The paper version worked well for in-person conferences as well as postal mail. The online version utilized Qualtrics Research Suite software, produced by Qualtrics, LLC, in Provo, Utah of the U.S. To maintain privacy, farmers were contacted via electronic mail and sent a web link to the Qualtrics survey by their organization, such as a producer cooperative or aggregator. Of the 111 surveys that were completed, 51% of participants utilized the paper version and 49% accessed the survey through the internet. Details of survey response are summarized in the Results section.

*Data analysis: performance metrics*

The majority of the survey focused on the performance metrics. The survey data for these variables were first cleaned and then analyzed. Cleaning required the conversion of categorical text to numeric values. Each variable was analyzed for outliers by calculating descriptive statistics and graphing box plots and histograms in STATA 13 software by StataCorp LP (College Station, Texas U.S.). Thus, observations identified as outliers were determined to be either (1) errors in data entry or (2) non-representative of the sampled niche pork group. Since niche productions varies widely, we strived to maintain original values. However, individual observations were omitted when they contained obvious errors or when an observation greatly skewed the mean for a given variable.

*Data analysis: niche production success, challenges and labeling*

Participants were asked via structured, open-ended questions to describe their top three reasons for raising swine in an alternative manner. Another question focused on personal definitions of success for their swine operations. After defining success, farmers described their top three barriers for raising and marketing niche pigs successfully.

These qualitative data were analyzed by first coding the verbatim responses using an inductive process. In other words, this approach was data-driven and did not attempt to fit the responses into a predetermined theoretical framework (Fade and Swift, 2010). The codes were used to develop specific themes that summarizes the "essence" of related responses (Fade and Swift, 2010; Morse, 2008). Themes with shared characteristics coalesced to form larger categories. Thus, the thematic coding built hierarchical categories as the analysis progressed. Depending upon the question, the themes and categories were summarized for quantitative descriptive purposes. Finally, the producers were stratified to examine correlation among the quantitative and qualitative data.

**Results**

*Survey participants and their operations*

Stretching from Arizona to Maine, farmers from 23 states participated in this study, with the largest responses came from North Carolina (15%), Pennsylvania (14%), Michigan (11%), and Iowa, Massachusetts, and New Hampshire (8% each). Regarding the type of operation, 63% of farms have a breeding program in addition to growing and finishing (n=109). Nearly half (49%) of producers in this survey raise either purebred heritage or cross-heritage breeds. Heritage hog breeds in the U.S. include Gloucestershire Old Spot (GOS), Guinea Hog, Hereford, Large Black, Mulefoot, Ossabaw Island, Red Wattle and Tamworth (The Livestock Conservancy, 2015). The most common breeds either as purebred or crossbred were Berkshire (49% of the reporting 99 farmers who answered this question use this breed), followed by Duroc (33%), Tamworth (27%), York (23%), Hampshire (22%), and GOS (21%). Pertaining to living conditions, 90% of the farms provide outdoor access to their hogs (n=125). More specific housing styles are detailed in Table 2.1. Looking to market outlets, farmers participate in four major categories: 68 producers directly market to consumers, 38 work with aggregators or food hubs, 25 sell to restaurants and 16 market to retailers. Hog production is the primary income for 28% of the farms (n=100). In addition to swine, study participants raise other livestock classes or grow various commodities to supplement their income (n=92). For instance, respondents also raise beef (51% of those who answered this question), broiler chickens (40%), eggs (25%), lamb/sheep (21%), grow fruit and vegetables (18%), and produce corn or soybeans (17% each). Finally, the average number of years raising niche pork was 7 years (n=102), within a range of 0.5 to 42 years. The characteristics described above are reflective of the study's sample from self-identified niche producers. Not knowing the true population of niche pork producers, these results may not be applicable to other alternative hog farmers outside of the study. Moreover, this niche sample should not be considered representative of organic pork production because certified organic was not a requirement to partake. Nevertheless, information gathered in this research could be used in future studies to identify attributes for a more accurate sample representation of niche producers.

*Performance metrics*

Niche and conventional swine systems are compared across common measures of productivity in Table 2.2. All directly comparable metrics across the various life phases were found to be statistically significant with 95% confidence for the one-sample test of means. Looking more closely at these results, many of the largest differences between the two systems center on age benchmarks. For example, piglets were weaned nearly 2.5 times faster in conventional operations. A niche piglet, having been with its mothers for 28 additional days, weighed 9 kg more at weaning than its conventional counterpart. Niche finishing gilts and barrows require 9% more time to reach market weight. Standardizing to 124 kilogram, the conventional system finished hogs 18 days faster than niche production. Likewise, there was a difference of 58 days between the time of first breeding of niche and conventional gilts.

With regard to breeding and herd management, there were mixed findings. On average, niche systems had 12% fewer breeding cycles per sow per year. Once bred, niche litters were 5% smaller compared to conventional breeding programs; likewise, niche had 10% fewer piglets per litter that survived through weaning. Integrating these metrics together on an annual basis led to approximately 19% fewer weaned niche piglets per bred sow per year than the conventional system due to fewer breeding cycles, smaller litters, and higher piglet mortality in alternative production. However, niche producers outperformed conventional on the other aspects of herd management, as evident with lower cull and mortality rates. For instance, conventional breeding sows and boars were culled 1.5 years earlier than niche stock. One drastically different metric was annual sow mortality, which was 8 times greater in conventional than niche. In this way, these results suggest that overall niche pork productivity can be close to conventional pork. This point was further explored in a subsequent analysis by the authors of this study; the metric comparisons were used to determine the overall number of finished gilts and barrows going to their intended markets along with the meat output from the two systems (refer to Chapter 3).

*Niche production reasoning, success, and barriers*

Producers' reasoning for raising niche swine can be grouped into three intra-related categories: (1) animal and environmental welfare, (2) farm and producer viability, (3) consumer preference and taste, plus other non-related responses. Of the 265 total responses, 46% focused on the farm either in terms of profitability, appropriate scale potential, personal enjoyment, family participation and tradition, or aversion to commodity pork. The second largest category, animal and environmental welfare, was covered by 26% of the responses and included individual themes of animal and herd health, heritage breeds conservation, and ecological responsibility. The third category had 19% of the responses and centered on meat quality and taste as well as customer relationships, preference and satisfaction. Thematic distribution by category is shown in Figure 2.1.

For the participants, success in niche pork production equates to high welfare for the pigs, economic viability for the operation, personal satisfaction for the farmer, tasty meat for the customer, and responsible environmental practices. Of the 89 who responded to this open-ended question, 57% defined success in terms of benefiting more than one component of the food system. For example, one producer defined niche success as "a significant number of people that are positively affected by the niche pork operations including consumers, workers, and suppliers [that] enhances the environment and ensures good welfare conditions for the animals." The other 43% focused on one factor, such as profitability, herd performance, or satisfied customers.

Despite these perceived benefits, niche pork producers like other farmers, deal with strong challenges to achieving their defined success. Each participant was asked to describe their top three barriers, which resulted in 237 total responses. These responses, classified as themes, were grouped into four intra-related categories: (1) alternative production requirements, restrictions and knowledge with 33% of the responses, (2) access and affordability of credit and inputs other than land also at 33%, (3) alternative supply chain for processing, marketing and customers at 25%, (4) non-niche production competition and governmental policies at 8%, plus 1% of non-related responses as other. Figure 2.2 depicts the specific thematic answers. The most common barrier, representing 27% of the responses, centered on the access and affordability of inputs and credit. For this analysis, inputs included hog feed, piglets and breeding herd replacements, and labor. Additional land for outdoor raising of swine was captured in the second most reported barrier, requirements for niche production, by 23% of responses. Besides additional land, this theme also included the challenges of year-round consistent performance, weather, fencing, bedding, transportation, and pasture management. The third most popular theme, reported in 13% of responses, concentrated on the difficulties associated with slaughter and processing in terms of access, cost, timing, scale, trust, or value-added product ability. Other challenges included themes of niche restrictions (described in the following section), specialty marketing and distributing, knowledge of niche pork production, competition with commodity and other producers, governmental policies that support commodity meat, and customer relationships.

*Outcomes by marketing stratification*

When organizing the data by certain characteristics, such as the marketing outlet, additional patterns emerge. For this study, the most notable differences were seen with the group of participants who market their finished hogs through a form of aggregation, such as a branded company or food hub, compared to those who do not work with aggregators or food hubs. For example, farmers who sell their pork through an aggregator finished 4.4 times more hogs than those who do not work with aggregators (410 verses 93 hogs per year). Those finished hogs raised on farms working with aggregators traveled 3.5 times further distances for slaughter (368 versus 106 km). With regard to performance metrics, farmers marketing through aggregation had higher mortality for piglets, finishing hogs, breeding sows and boars. Culling was higher for finishing hogs for the aggregation group, although culling percentages were lower for the breeding herds. Distinction can also be made with the qualitative data. In particular, farmers selling to aggregators or food hubs were five times more likely to identify production restrictions as one of their most critical barriers to success. Niche restrictions include the inability to administer antibiotics, certain vaccinations, clip pig tails, or feed grain that has not been trans-genetically altered (GMO-free). In summary, available marketing avenues may direct certain management practices for the pork producers in terms of breed, scale, and program restrictions, whereby such may influence overall performance and output.

*Niche labeling*

Given these tangible barriers and the additional land, labor and knowledge required to raise niche swine, farmers' profitability should reflect the differentiated product they are bringing to the market. In addition to brand recognition and producer/consumer relationships, labeling on the meat package is another method to convey management practices used to develop the value-added product. As previously stated, niche meat currently does not have neither a clear definition nor its own label recognized by the United States Department of Agriculture (USDA). For this reason, producers were asked what production characteristics should be part of a future "niche meat" definition that could be used for labeling purposes. Out of the 89 farmers who responded to this question, the top three most favorable requirements for niche inclusion were no use of hormones (87% of respondents), outdoor access (73%), and no tight confinement (69%). Additional rankings are in Table 2.3. Interestingly, the least popular requirement was organic certification (12% of respondents). This survey question allowed participants to enter additional production characteristics that should be part of the niche meat definition. Some mentioned that access to the outdoors was not strong enough; rather, they recommended the raising of animals entirely outdoors or on pasture. Several voiced their resistance to an additional label. In their opinion, labels could be "deceptive to the consumer", "niche meat is not monolithic", and "USDA should be kept out of niche meat labeling." Others wanted the inclusion of nutrient density as well as humane raising verification.

**Discussion**

Small and medium-sized farms play a vital role in the environment, economy and society. Furthermore, pasture-based livestock is viewed as an opportunity with strong promise to revive small and mid-sized farms (Conner et al., 2008). Benefits identified in this study demonstrate that niche pork can offer economic diversification with lower capital entry for smaller scale operations. Additional benefits extend beyond the farm gate to conserving heritage breeds and connecting with consumers. Yet, success is not guaranteed as producers must overcome various challenges in order to build and sustain their niche meat operations.

One such challenge identified by the participants is consistent high productivity of the herd. This self-reported barrier was also measured by performance metrics in terms of number and age of finished hogs for market. As highlighted in the results, smaller litter size (9.7 born alive piglets) and higher pre-weaning mortality (14.3%) reduce the total number of finished hogs when compared to conventional production. On the other hand, lower mortality (1.9%) and cull (2.1%) rates of growing and finishing niche swine contribute to more hogs going to market. These findings are similar to other niche pork studies. For instance, Lammers et al. (2007) reported a litter size of 10.0 born alive piglets and pre-weaning mortality of 15.0% within hoop barn niche pork system. Honeyman and Harmon (2003) observed mortality rates ranging between 1.8-3.8% and culling rates 1.7-1.8% for finishing pigs in hoop structures.

In contrast, these studies (Gentry et al., 2004; Honeyman and Harmon, 2003) found growth rates to be similar or even faster for niche as compared to conventional production systems. For this reason, producers participating in this study who experience slower growth potential could enhance management through various avenues such as (1) select breeding stock with strong sow maternal characteristics, (2) shared knowledge on housing and environment to reduce piglet crushing and increase feed efficiency, and (3) more detailed recording keeping of breeding, feed and growth patterns. As indicated by the study's participants, improved breeding stock and advanced knowledge of niche meat production are not always available and therefore challenge the success of the operation. However, producers can exert more individual control over record keeping. Only 64% of participants reported keeping feed records. Breeding and finishing record keeping were higher at 88% and 80%, respectively.

Additional barriers identified by this study's participants are relevant to other small to mid-scale meat producers, whether they raise animals in alternative or conventional systems. Many of the top producer concerns in this study, such as the cost and availability of inputs, slaughter facilities, value-added meat processing and markets, are also reported in the literature (see Gwin et al., 2013; Dunning et al., 2013; Bardot Lewis and Peters, 2011). Although assessing the capacity and accessibility of infrastructure is beyond the scope of this research, individual producers may be able to reduce the impact of these barriers through advance scheduling of multi-animal slaughter while building solid working relationships with aggregators, processors and customers. Through established trusted business relationships, farmers can be supported by other supply chain partners with distribution, marketing, and customer growth (Gwin et al., 2013).

**Conclusion**

This study highlighted the potential of an alternative manner to raise swine. Examination of performance at specific life phases demonstrated that niche pork productivity can be close to conventional pork. For some metrics, niche outperformed conventional, as demonstrated with lower cull and mortality rates for breeding stock and growing/finishing gilts and barrows when compared to conventional producers. Aside from system comparisons, the findings suggest that qualitative data can contribute to a deeper understanding of niche performance in view of overall goals for the farm. In particular, success within a niche pork operation is not merely measured by quantitative metrics, but rather incorporates numerous aspects within a food system including animal and environmental welfare, personal enjoyment, and customer satisfaction. Yet for those niche farmers looking to improve productivity, outreach and dissemination of this study's results can provide an opportunity to compare their production against alternative and conventional operations. Such assessment begins, however, with detailed and accurate record keeping of feeding, breeding, and finishing operations. Patterns may begin to emerge with on-farm documentation of specific practices with performance outcomes. Working with producers, further research and extension of successful management practices are needed to close the yield gap by improving the feed efficiency, litter size, and pre-weaning mortality while reducing the barriers to sustainable, economically viable niche pork production.

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**Table 2.1**
Type of housing used within major swine life phases

| | Gestating Sow | Lactacting Sow with Litter | Growing and Finishing Hogs |
|---|---|---|---|
| Housing Styles | % of farms using style within life phase | | |
| Open pasture and/or woodlands with shelter | 47 | 41 | 52 |
| Barn with outdoor access | 34 | 29 | 24 |
| Enclosed barn without outdoor access | 8 | 17 | 10 |
| Earthen or concrete feedlot | 5 | 0 | 9 |
| Other | 6 | 13 | 4 |
| Number of reporting farms (n) | 64 | 63 | 96 |

**Table 2.2**
Performance metrics comparison

| **Parameter** | **Units** | **Conventional System** | **Niche System** | **Sample Size** | **Standard Error** | **One-Sample *t*-Test** |
|---|---|---|---|---|---|---|
| Reproduction | | | | | | |
| Breeding ratio | boar sow$^{-1}$ | 0.11 | 0.16 | 44 | 0.01 | 4.4 * |
| Annual average parities | birth cycles sow$^{-1}$ year$^{-1}$ | 2.20 | 1.97 | 69 | 0.02 | -10.5 * |
| Litter size | live piglets born sow$^{-1}$ | 10.30 | 9.74 | 68 | 0.20 | -2.9 * |
| Herd management | | | | | | |
| Cull breeding sows | age, number of years | 2.6 | 4.4 | 29 | 0.32 | 5.6 * |
| Cull breeding boars | age, number of years | 2.8 | 4.2 | 29 | 0.32 | 4.6 * |
| Cull finishing gilts and barrows | % in life phase | 3.0 | 2.1 | 88 | 0.00 | -241.9 * |
| Mortality | | | | | | |
| Mortality sows | % year$^{-1}$ | 8.18 | 1.02 | 50 | 0.23 | -31.1 * |
| Morality pre-weaned piglets | % in life phase | 0.10 | 0.14 | 67 | 0.01 | 3.7 * |
| Mortality nursery piglets | % in life phase | 0.04 | *NA* | | | |
| Mortality finishing gilts and barrows | % in life phase | 0.04 | 0.02 | 94 | 0.00 | -8.8 * |
| Age and size by life phase | | | | | | |
| Piglets age at weaning | days | 20.8 | 49.1 | 66 | 1.36 | 20.8 * |
| Piglets weight at weaning | kg | 6.8 | 15.8 | 54 | 0.93 | 9.7 * |
| Finishing age to market | months | 6.6 | 7.2 | 97 | 0.18 | 3.2 * |
| Finishing liveweight | kg | 129.7 | 124.2 | 99 | 1.78 | -3.1 * |
| Gilt age at first breeding | months | 7.5 | 9.4 | 67 | 0.28 | 6.9 * |

*Note: * indicates 95% confidence level for one-sample test of means*

**Table 2.3**
Ranked production requirements for niche meat label

| Attribute | Voting % |
|---|---|
| No Hormones | 87 |
| Outdoor Access | 73 |
| No Tight Confinement | 69 |
| No Sub-therapeutic Antiobiotics | 65 |
| NeverEver Antiobiotics | 60 |
| Grazed Forage in Diet | 54 |
| Locally-sourced Feed | 45 |
| Small Herd Size | 45 |
| Proper Manure Management | 44 |
| Heritage Breeds | 43 |
| Non-GMO Feed | 37 |
| Alternative Marketing | 22 |
| Organic Certification | 12 |
| Number of respondents | 89 |

**Figure 2.1**
Reasons for niche pork production

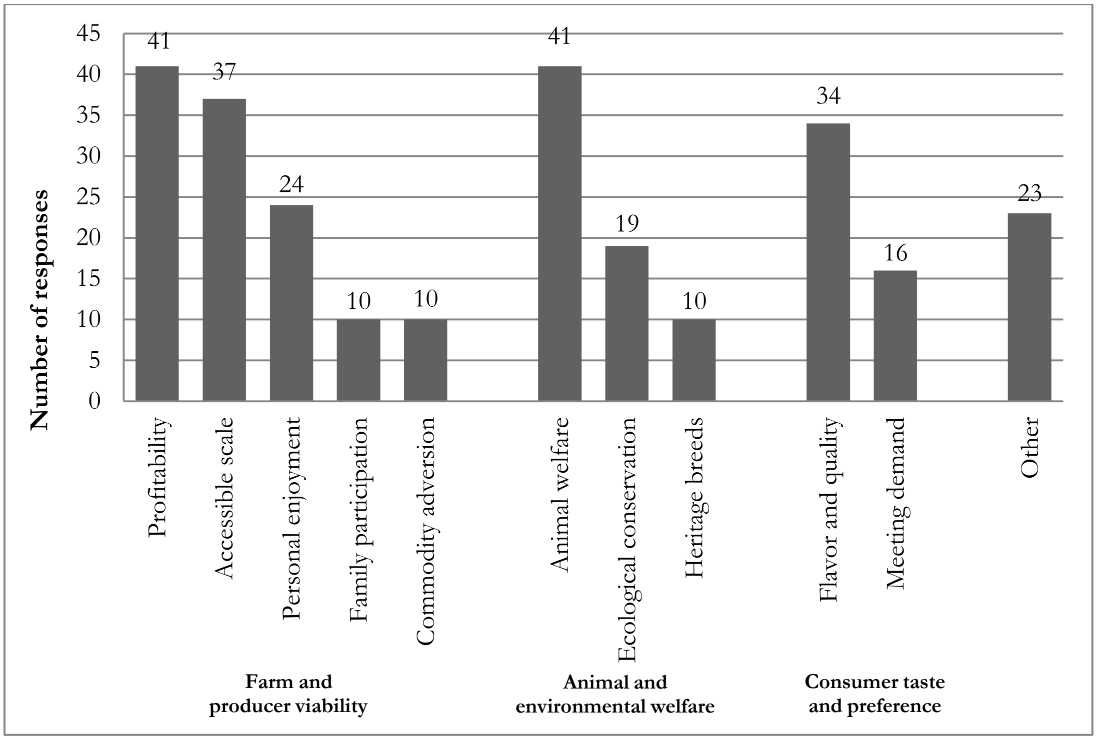
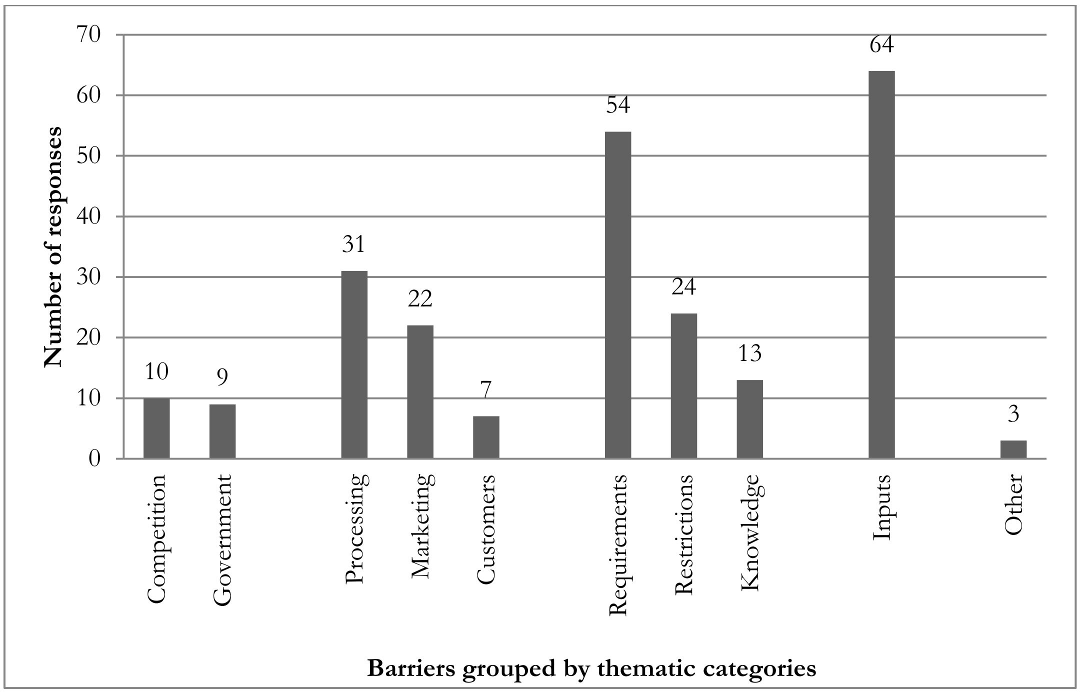


**Figure 2.2**
Barriers to successful niche pork production



## Supplemental Materials

The survey instrument

**Niche Pork Production**
**Benchmarking for Success**

Pork Study by Jamie Picardy, Tufts University Graduate Student

**Overview:**

Unlike the commodity pork producers network such as PigCHAMP, the niche market does not collect performance characteristics. Therefore, the purpose of this survey is to gather production information in order to compare performance between niche and commodity pork production.

**As a result, you will have benchmarking targets, such as weaning success and days to market, for comparing your farm with other niche producers in the study as well as commodity production averages.** *Your individual responses will be kept confidential and your participation is voluntary.*

This study is part of my dissertation Ph.D. research in Agriculture, Food and Environment at the Friedman School of Nutrition at Tufts University in Boston, Massachusetts. *If you have any questions, please contact me by phone (215-360-5885) or email (jamie.picardy@tufts.edu).*

**Directions:**

Please complete the following questions about your pork production enterprise. Feel free to expand your answers (on the back of the page or end of document if needed). The survey has 5 short parts, focusing on: feeding, breeding, finishing, housing/bedding, and experience. ***The completed survey should be returned to the Niche Pork table display (see Tufts New Entry) by the end of the conference.*** The survey should take about 10 minutes to complete. To save time, you can also complete the survey online at https://tufts.qualtrics.com/SE/?SID=SV_6u6noOYvIsoOFo1.

| **Part I: Feeding, Manure and Breeds** | Your Answer | Units of Measurement |
|---|---|---|
| Do you keep feed records? | YES or NO | *circle answer* |
| What percentage of your feed do you grow on your farm? | | % farm-grown |
| Do your hogs have access to the outdoors? | YES or NO | *circle answer* |
| If yes, is grazed pasture part of your hogs' feed ration? | YES or NO | *circle answer* |
| List all major feeds and approximate amount as-fed to your finishing pigs | | |
| *An example is provided below* | Ingredient | Amount (total lb per finished animal) |
| | | |
| | | |
| | | |
| | | |
| | | |
| *Example* | *Corn grain* | *500 lb corn total / finished hog* |
| | *Soybean meal* | *165 lb SBM total / finished hog* |
| | *Alfalfa haylage* | *150 lb alfalfa haylage total / finished hog* |
| How do you manage your hog manure?<br>*Please circle all that apply or write answer* | Rotational grazing (*left on the land*)<br>Digester or Composter<br>Holding ponds/lagoons | Apply it to own cropland<br>Apply it off-site to other's cropland<br>Other ______________________ |
| In your opinion, does your hog operation produce more manure than YOUR land can accept without environmental problems? | YES or NO | *circle answer* |
| What breeds/cross breeds do you raise? *Please list here:* | | |
| | | |

Page 1 of 3
*Please continue on next page*

**Do you have breeding pigs? If yes, go to Part II.** *If not, go to Part III.*

| **Part II: Breeding** | **Your Answer** | **Units of Measurement** |
|---|---|---|
| Do you keep records on the productivity of your breeding sows/gilts? | YES or NO | *circle answer* |
| How many times do your sows farrow per year? | | times per year<br>*example: 2 times per year* |
| What months of the year do your sows farrow? | | *example: Dec and June* |
| What is the average litter size, alive at birth? | | # of piglets born alive |
| For the average litter, how many piglets are typically weaned? | | # of piglets weaned |
| What is the average age of weaned piglets? | | days |
| What is the average weight of weaned piglets? | | pounds at weaning |
| How large is your sow breeding herd? | | # of breeding sows |
| What is the age at first breeding of replacement gilts? | | months (age at 1st breeding) |
| When do you cull your breeding sows? (age or parity) | | years (age at culling) |
| *Parity is the number of times the sow has given birth over her lifetime* | | parity # for culling |
| What is your typical death loss (mortality) of breeding sows? | | % per year that die |
| *Answer either as % (per year) or written out (# die from breeding herd)* | | *write answer: example 1 dies out of 20* |
| Do you use artificial insemination? | YES or NO | *circle answer* |
| If no, what is your ratio of breeding boars to breeding sows? | | *example: 1 boar to 20 sows* |
| At what age do you cull your breeding boars? | | age (years) |
| What is your average mortality of breeding boars? | | % per year that die |
| *Answer either as % (per year) or written out (# die from breeding herd)* | | *write answer: example 1 dies out of 55* |

| **Part III: Growing & Finishing** | **Your Answer** | **Units of Measurement** |
|---|---|---|
| Do you keep records on your finished hogs? | YES or NO | *circle answer* |
| How old are your finished hogs? | | # of months (age) to market |
| What is the weight of your average finished hog? | | pounds |
| How many niche market pigs do you finish per year? | | # per year |
| *Niche = alternative hog production and/or marketing* | | |
| To whom do you sell your finished hogs? *Please circle all that apply*<br>Other (write): ______________________ | Direct marketing to consumers<br>Aggregator / Food Hub | Restaurants/Chefs<br>Retail Grocery Stores |
| What is your typical death loss (mortality) of finishing gilts and barrows? | | % growers/finishers that die prematurely |
| What is your typical cull % of finishing gilts and barrows? | | % growers/finishers that are culled |
| What are your reasons for culling? *Write your answer* | | |
| *Examples: tail-end (too small), injured, fed antibiotics or can't sell in niche market* | | |
| Where do sell your culled pigs? *Write your answer* | | |
| *Examples: rendering plant, cull market, non-niche market, direct marketing, euthanized* | | |

| Part IV: Housing & Bedding | | | |
|---|---|---|---|
| | Sow gestation | Sow with litter | Growers & Finishers |
| List your **HOUSING TYPE** for each stage. *Example: Enclosed hoop barn, Barn with outdoor access, Grouped pasture with shelter, Earthen feedlot (no pasture), Concrete feedlot* | | | |
| What is your **TOTAL SPACE** within each stage? *Include fallow area used in grazing rotation* | ________[total square feet per breeding head] | ________[total square feet per breeding head] | ________[total square feet per growing/finishing head] |
| Describe your **BEDDING MATERIAL** for each stage. *Example: Corn stalks, straw, wood shavings, shredded newspaper* | | | |
| How many **TONS of BEDDING** did you use for the year? | ________[tons/year for all sows] | ________[tons/year for all sows with their litters] | ________[tons/year for all growing/finishing hogs] |

| Part V: Your Experiences in Alternative, Niche Production | <u>Your Answer</u> | <u>Units of Measurement</u> |
|---|---|---|
| Location: In what state is your farm located? | | *write your answer* |
| How long have you raised niche (*alternative/non-conventional*) pigs? | | # of years |
| How far do you travel for slaughter services? | | actual miles to slaughterhouse |
| What is the maximum distance you would travel for slaughter services? | | maximum distance in miles to travel for |
| For pigs raised with outdoor access, what slope is too steep? | | % slope of the land |
| In terms of net income, is niche pork your farm's primary income? | YES or NO | *circle answer* |
| What else do you raise/grow? | | |
| What are your top three reasons for raising niche pigs, as opposed to commodity pork? | 1) | |
| | 2) | |
| | 3) | |
| How do you define success in niche pig operations? | | |
| From your experiences, what are the top three barriers for raising/marketing niche pigs successfully? | 1) | |
| | 2) | |
| | 3) | |
| Unlike USDA Organic, "niche" pork production does not have a defined label. Which of the following production characteristics should be included in a "niche meat" label? *Circle all that apply* | No added hormones<br>No sub-therapeutic antibiotics<br>No antibiotics (*never ever*) | Access to the outdoors<br>Heritage breeds<br>No tight confinement |
| Other: ________________________<br>Other: ________________________ | Locally-grown feed<br>Non-GMO feed<br>Grazed forages part of diet<br>Organic certification | Small herd size<br>Proper manure management<br>Alternative Marketing |

You have reached the end of this survey.

***THANK YOU for your PARTICIPATION, KNOWLEDGE, and TIME!***

*Please return completed survey to Jamie Picardy or Niche Pork table display.*
*If you would like to receive project results and register for the raffle,*
*please PRINT your email address here:* ________________________

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**CHAPTER 3** (Part 2) written in the style of *Renewable Agriculture and Food Systems* journal

**Title: Sizing up when scaling down: the land trade-off with niche pork production**

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**Abstract**

The increasing global demand for livestock products is pressuring land resources already under competition with crop agriculture, biofuels, urbanization and conservation. Yield gaps within sustainable agriculture may further intensify this land competition. Accordingly, this study aimed to determine and compare the land resource impacts for three swine management systems. The land areas were estimated using a spreadsheet model that incorporated performance metrics, feed needs and housing for each major life phase. The life phases incorporated into the model included gestation, lactation, nursery, growing and finishing, and breeding replacements. Swine management systems were organized by three styles: (1) conventional confinement environment, typical of commodity pork production, (2) niche enhanced environment and (3) niche outdoor environment, which represented two ends on the alternative spectrum. The conventional swine diet was based on corn and soybean meal; whereas the niche swine diet also included alfalfa hay for the enhanced environment (year-round) and outdoor environment (winter season) and grazed alfalfa for the outdoor environment (summer season). Conventional production had 13% less total feed needs than niche enhanced environment and 21% less than niche outdoor environment. This annual amount of feed produced 35% more edible meat for the conventional target market as compared to the niche target market. Integrating feed needs with edible meat yielded a feed conversion for conventional production that was approximately 35% and 41% more efficient than the niche enhanced environment and outdoor environment, respectively. Regarding living space, conventional swine system was based on commodity operations where animals live entirely indoors. Both niche systems included an extensive bedded indoor space; in addition to shelter, the niche outdoor environment also incorporated pastureland. Overall land requirements ranged from 0.85 to 1.22 hectares per bred sow per year for the three systems. This allocation included land for feeding and housing the breeding stock and their offspring for the number of breeding cycles per system during one year. Cropland was a stronger factor than living space when considering the total land needs. This final comparison resulted in the niche enhanced and outdoor environments as 17% to 44% higher in total land requirements than the conventional confined environment. When considering trade-offs of alternative production, niche pork requires more land yet offers benefits for the producer, herd, consumer and environment that should be considered when evaluating swine management strategies.

**Key Words**
alternative hog system, sustainable agriculture, differentiated meat, land requirements

**Introduction**

Agriculture continues to face daunting challenges, to adequately and efficiently feed a growing global population who are demanding more livestock products. At the same time, the natural resources needed to grow such food (high quality land, fresh water, and mineral nutrients) are becoming more difficult to secure under increased competition and climate change[1,2,3]. If environmental sustainability is integrated into the goal of increasing food security, productivity should be analyzed under various management strategies that extend beyond large-scale conventional agriculture.

For decades, farmers and academics have been conducting comparative research of the performance, environmental impact, and economic feasibility of conventional and alternative farming systems[4,5,6,7]. Their basis of comparison typically focused on the yield ratios of management strategies, as well as differences in chemical and water inputs, fossil fuel usage, labor, soil organic matter and erosion. Despite knowledge gained through these field trials and meta-analyses, additional methods and data are needed to improve management decisions regarding productivity and environmental stewardship[2]. Therefore, this study aims to evaluate one component of the food system, pork production, in terms of its impact on land resources under different management systems ranging from alternative to conventional production. The land requirements concentrate on feed, crop and grazing land, and living space for major life phases in pork production. In addition to land, meat output and feed conversion comparisons are made between the different systems. This work strives to clearly state the modeling methods, parameters, and assumptions so that the findings can be used to support future decision making in sustainable livestock production.

## Methods

*Modeling Overview*

Within this research, conventional and niche pork production was modeled after management styles currently found in the United States. More specifically, conventional swine was based on typical commodity operations under confinement, in which animals live solely indoors on solid concrete or slotted flooring. On the other hand, niche swine herds have alternative rearing environments, as previously described by Honeyman (2005), including extensive bedded indoor or outdoor production[8]. With regard to outdoor pig production, there is no standard system[9]. Furthermore, primary data collected for this research also found diverse methods for raising hogs, which were tailored to the expertise of the producers, local environment, and customer preferences (please refer to Chapter 2). For these reasons, niche production was divided into two styles: *niche enhanced environment* and *niche outdoor environment*. Within the niche enhanced environment, hogs have additional spacing as compared to conventional confinement for feeding, lying and loafing areas as to fulfill their behavioral needs[10]. An example of a niche enhanced environment would be a deeply bedded hoop house. The second niche style, niche outdoor environment, was based on a pastured operation with consistent ground cover of 75% and a heavy use area of 15% of the total outdoor pasture area[11,12]. An example of niche outdoor environment would be pasture under rotational management with space where pigs are able to express their natural instinctive behaviors, like roaming, foraging and rooting.

Niche and conventional pork production styles were represented as systems of animals in major life phases with the corresponding footprint measured in terms of feed and housing needs for each life phase. By using the same modeling methodology, direct comparisons were able to be made between the different management styles. This comparative analysis was modeled as static, quantitative and deterministic, meaning numerical measurements with specific biological values were used and they remained fixed through time for each of the two systems. The conventional and niche hog production systems were modeled in a spreadsheet format that was built upon a methodology presented in an earlier study[13] that included additional livestock classes. For each system, four sets of calculations were performed, thereby determining (1) performance and life phases, (2) feed and cropland requirements, (3) living space requirements, and (4) total land requirements, all of which are explained below.

*Performance and Life Phases*

For the first set of calculations, each system was represented as a "mass balance" of pigs in different life phases, whether they are in the breeding herd, finish and go to market, are culled or die prematurely. The basis of the model starts with a breeding pair and their litter of piglets. After the piglets were weaned, the majority of the litter continue to the growing and finishing stage, at which they either were harvested (sent to market and slaughtered for meat) or entered the breeding pool to replace culled sows and boars. The life phase set of calculations, as well as the feed and living requirements, were based on one bred sow and her litter as previously done by Peters et al. (2014) and shown in Figure 3.1.

The movement of animals among the various stocks within the system was defined by different life phase performance metrics (Eqn 1).

Eqn. 1: Animal Unit at End of Phase =
*Animal Unit At End of Previous Phase * (1 - Performance Metric $_i$)*

where *i* represents culling or mortality within that life phase

These rates served as input parameters for modeling the number of animals in each life phase. This value, representing the total number of animals within each life phase, was later used to calculate the complete feed and housing needs for a given life phase. For the conventional swine system, model parameters were populated with a combination of empirical data at the national scale[14,15,16,17] and theoretical recommendations from research specialists and industry professionals[18,19]. Because the majority of performance metrics for niche pork production at every life phase was not readily available during the start of this study, primary data were collected from niche producers in 2014 and detailed in the previous chapter. The metrics for both the conventional and niche systems are shown in Table 3.1.

*Feed and Cropland Requirements*

The second set of calculations determined the feed requirements for each life phase (Eqn.2 ) and associated cropland required for growing that feed (Eqn.3 ).

Eqn. 2: Total Feed Requirements = $\sum feed\ needs_{ijk}$

where *i* denotes the individual life phase
*j* represents the number of animals in that life phase associated with 1 bred sow and her offspring during 1 year
*k* indicates the feed type

The conventional swine diet[20] was based on corn and soybean meal; whereas the niche swine diet[21,22] also included alfalfa hay for the enhanced environment (year-round) and outdoor environment (winter season) and grazed alfalfa for the outdoor environment (summer season). The niche diet ration with alfalfa was chosen because alfalfa has been the most researched swine forage crop and can be used for both pasture and silage[22]. The following niche life phases were assumed to not have an alfalfa component: lactating sow, pre-weaned and very young piglets, breeding boar and replacement breeding boar. Alfalfa is not recommended for weaned and young growing piglets weighing less than 40 pounds because of its low energy digestibility, poor palatability, and the presence of anti-nutritional factors[21].

Diet rations were obtained from the Pork Information Gateway (PIG)[23], which serves as a no-cost, online library of factsheets and references managed by the U.S. Pork Center of Excellence[24]. The diet rations provided as-fed feed composition, daily feed intake, and daily lean gain by life phase. Using that information, time on feed, total feed intake for life phase, age at end of life phase, and feed percentage by type (such as corn, SBM or hay) were derived. For example, time on feed is the quotient of weight gained in that phase divided by the average daily gain. The total feed intake for life phase is the product of time on feed and the daily feed intake. The age at end of life phase was determined by summing the time on feed for the current and previous life phases. Lastly, the feed percentage by type was the ratio of the as-fed feed component amount compared to all as-fed feed components for that life phase.

Food processing by-products that could be used for animal feed were not part of the model. Likewise, minerals, vitamin supplements, and the land associated with their harvest and mining were not incorporated into the model, although the authors recognize that minerals and vitamins used in complete feed rations are critical for production. For clarity, the conventional and niche feed intake and inventories are detailed in the Appendix (Tables 1, 2, and 3).

Eqn. 3 Total Cropland Requirements =

$$\sum\left(\frac{feed\ need * DM\ adjustment * feed\ to\ crop\ conversion}{yield}\right)_i$$

where *i* represents individual feeds associated with 1 bred sow and her offspring during 1 year.

Each feed component (as-fed grain or cut hay) was summed across all life phases for all animals involved in breeding one sow during one year. These total amounts of grain or cut hay were adjusted for dry matter content and converted from feed to crop. Then, the crops amounts were divided by the NASS national yields[25] (averaged for years 2000 through 2010) to obtain the land required to produce the grain or cut hay to be fed to the animals. The land required for grazed alfalfa was determined by using an estimated pasture productivity. This productivity yield incorporated several adjustments, including the conversion to dry matter content, the dry matter loss due to cutting, the conversion to standing forage, and a cropland harvest efficiency of the grazing animals[26,27]. Furthermore, the harvest efficiency accounted for edible plant material that would not be consumed either due to a loss from trampling by the herd or retained as managed groundcover[27]. The harvest efficiency was a best estimate from the literature, as efficiency values fluctuate depending upon stocking densities or species of grazing animals or foraged vegetation.

*Living Space Requirements*

The third set of calculations focused on the living space required for the confined and niche swine systems, as shown in Eqn. 4.

Eqn. 4: Total Living Space Land Requirements = $\sum living\ space_{ij}$

where *i* denotes the individual life phase
*j* represents the total number of animals in that life phase associated with 1 bred sow and her offspring during 1 year

Table 4 in the Appendix shows the parameter values used to calculate living space by life phase, including breeding sow and boar, gestating sow, lactating sow with litter, newly weaned pigs and growing/finishing hogs. The stocking densities for the conventional system were based on recommendations published by PIG[28,29,30]. Space allocation of 0.81 square meters per finishing pig was held constant to avoid productivity losses of growth performance[29]. The stocking densities for the niche enhanced environment were averaged from animal welfare certification programs[31,32]. For niche outdoor production, no single set of recommendations exists for stocking densities. Rather, stocking densities try to match the nutritional needs of the herd with the ability of the land to support such needs without environmental degradation. For this reason, recommendations are site specific to reflect the time of year, growth rate of the grass or ground cover, slope of the land, soil qualities (type, nutrient profile, and compaction), climate, phase of production, and feeding style[33]. Using the general principles of these recommendations, for purposes of this model, outdoor stocking densities were based on environmentally conservative estimates with 75% of the paddock having consistent ground cover and 15% under heavy use, as published by NRCS (2007).

*Overall Land Requirements*

The fourth set of calculations incorporated the previous findings to determine the overall land requirements for the three swine systems, as shown below in Eqn 5.

Eqn. 5: Total Land Requirements [per bred sow per year] = $\sum cropland + \sum living\ space - \sum pasture\ land\ adjustments$

The first and second elements of Eqn. 5 are based on Eqns. 3 and 4. The final element adjusts for alfalfa that could be grazed in the niche outdoor environment living space. Land needed for grazing alfalfa was compared against that allocated for living space. In this comparison, total land requirements were adjusted by the difference if the living space was greater than the grazing land needs. This adjustment reduces double-counting of required land for alfalfa feed.

## Results

### *Life Phase Performance*

The performance of the herd across individual life phases is critical for accessing the nutritional and housing requirements as well as the amount of edible meat produced within a certain management system. The metrics used to determine the number of animals within a phase were drawn from Chapter 2. Using those metrics, the movement of hogs throughout the system was determined for conventional and niche production, as shown in Table 3.2. At the beginning, both systems began with one bred sow. However, the differences in annual breeding cycles, liter size, culling, and mortality resulted in 12% fewer niche gilts and barrows that finished to their target market as compared to the conventional system. The critical metrics that contributed to this difference were the number of times the sow was bred in one year and the number of weaned piglets per litter, which were 10% fewer breeding cycles and 5% smaller litter sizes for niche compared to conventional.

### *Feed Needs and Meat Output*

Annual feed requirements are organized by feed component in Table 3.3. Conventional production had 13% less total feed needs than niche enhanced environment and 21% less than niche outdoor environment. This annual amount of feed produced 35% more edible meat for the conventional target market as compared to the niche target market, as reported in Table 3.4. Integrating the input (feed needs) with the output (edible meat) yielded a feed conversion for conventional production that was approximately 35% and 41% more efficient than the niche enhanced environment and outdoor environment, respectively.

*Land Requirements*

The overall land requirements for each of the three swine systems are summarized in Table 3.5. Starting with cropland, the conventional system had 14 to 23% lower land needs for feed than the niche enhanced and outdoor systems. The higher amount of cropland for niche production was largely the result of incorporating alfalfa, either as cut hay or grazed, into the ration. Although alfalfa provides some energy, thereby reducing the amount of corn, the digestibility of protein in forages is lower than that of soybean meal, thus increasing the amount of soybean meal in the niche diets[22].

The next factor contributing to the overall land requirements was living space, which is detailed by life phase in Table 3.6. Depending upon the system, this factor contributed to 0.2% of the total land requirements for the confined environment, 0.5% for the niche enhanced environment, and 27% for the niche outdoor environment, not adjusting for grazing land space. As stated earlier, the niche living space was modeled at two possible ends of the spectrum because the housing styles of niche pork production are diverse and site specific. For this reason, the living space requirements for niche were between 3 and 205 times that for confinement, non-adjusted. When analyzing individual life phases per animal, the gestating sows had the greatest range of living space when comparing conventional confined environment (1.4 square meters per sow) to the niche outdoor environment (700 square meters per sow). Within the two niche systems, the breeding and gestating sows had the greatest difference in stocking density, while the weaned piglets and breeding boar were more similar.

The final contributing factor was the pasture adjustment for the niche outdoor environment. Outdoor living space provided grazing opportunities during the growing season. Low stocking densities of the breeding stock and growing/finishing hogs led to larger living space requirements, consequently eliminating the entire alfalfa pasture feed footprint.

When incorporating all three of the above, the resulting overall land requirements per sow per year ranged from 0.85 hectares for confined conventional, to 1.00 hectares for niche enhanced and 1.22 hectares for niche outdoor environments. This allocation included land for feeding and housing the breeding stock and their offspring for the number of cycles per system during one year. Cropland was a stronger factor than living space when considering the total land needs. This final comparison resulted in the niche enhanced and outdoor environments as 17% to 44% higher in total land requirements than the conventional confined environment.

## Discussion

*Performance and Efficiency*

Using the methodology presented above, the two swine systems, niche and conventional, can be evaluated in terms of feed conversion. Although reported as a single value, feed conversions result from various factors based in performance and efficiency metrics specific to individual life phases. Principle factors contributing to efficiency differences between systems were finishing age, energy expenditure, carcass processing yield, and culling. For instance, niche required 18 additional days on feed to reach a market weight of 274 pounds. The niche herds raised heritage (also referred to as traditional) breeds that typically gain weight more slowly[9]. Furthermore, niche rations accounted for additional feed requirements resulting from increased energy expenditure due to greater climatic energy demand and physical activity[34]. Combined, these factors impacted the total amount of feed required in niche production that is 1.1 to 1.3 times the conventional amount.

Feed conversions were also impacted by processing yield, which is the amount of edible meat cut from the carcass. The model assumed processing yields from liveweight to boneless, skinless edible meat to be 52.8 %[35] of liveweight for conventional production and 46.7%[36] of liveweight for niche. The niche yield metric was calculated as a weighted average based on herd composition made of heritage and commodity breeds of swine. This yield difference contributed to an additional 312 kilograms of edible pork per bred sow per year coming from the conventional system compared to the niche system.

Improvements to niche feed efficiency could be achieved by increasing two measures, the number of finished animals per bred sow and the edible meat yield from processing. With regard to the first metric, higher output in terms of finished hogs could result from increasing the number of annual breeding cycles, increasing the litter size, or decreasing the mortality of pre-weaned piglets. The vast majority of surveyed niche producers (94% of those surveyed) breed their sows and gilts twice per year. By increasing the number of times the sow is bred, other qualities of her performance may be affected, such as time spent with piglets in lactation, or rates of mortality and culling. Such changes may not be desired by niche producers. On the other hand, increasing litter size or decreasing piglet mortality may be accomplished through improved breeding programs and sow management. Perhaps more detailed record keeping of sow behavior focusing on mothering abilities to reducing crushing, which is the most common cause of preweaning mortality[37]. Twelve percent of surveyed participants indicated that they do not keep any records of their breeding program, hence an opportunity for improvement.

With regard to the second metric, edible meat yields varied between 42% of liveweight for the purebred Berkshire niche breed and 53% for conventional breeds used in commodity production. Over a given year, that difference leads to 25% more edible meat for the targeted market. This difference in yield may be attributed to two factors. First, heritage breed processing typically skins the carcass, whereas commodity packers scald the animal[38]. Removing the skin reduces the weight of the carcass and loses some fat in the process of skinning, both of which affect yield (same source). Second, heritage breeds generally have greater amounts of fat than customers appreciate for marbling[38]. Given that intramuscular fat is recognized as a quality criterion[9], perhaps efforts for increasing overall meat output should focus on other metrics. Reducing culling is one possible strategy. Surveyed niche producers participating in never-ever antibiotic programs or in marketing agreements with aggregators had to cull animals treated with antibiotics or other restricted medications or vaccines. This culling reduced overall meat yields and feed conversions for the system. Surveyed producers indicated that these culled animals were then sold to non-targeted niche markets, such as direct to consumer. Perhaps variance in program standards could be explored to avoid this type of loss. Additional opportunities for improving niche performance, centering on breeding stock, housing and record keeping, were outlined in the previous chapter of this dissertation.

*Meat Demand and Land Trade-offs*

The global demand for food, animal protein in particular, will increase for at least another 40 years due to continuing growth in population, income and consumption[39]. With livestock being the world's largest user of land, the doubling of meat demand will have profound land and resource consequences[40]. This meat demand is expected to be met by confined, industrial livestock production, which has been associated with improved feed efficiencies, performance metrics, geographic concentration and homogenous products, as well as nutrient and pesticide water pollution, animal welfare issues, biodiversity losses, and corporate consolidation[40,41].

For these reasons, it is imperative to examine how alternative livestock systems would contribute to the land use issue. This study researched one such livestock system, niche pork, in terms of land requirements. The increased land needs of niche pork, ranging from 1.2 to 1.4 times that of conventional confined production, have implications on land use, conservation and planning. For instance, multiple rural and urban sectors are competing for limited land, clean fresh water, and energy. This mounting competition impacts the ability to produce enough food without environmental trade-offs. If the objective were simply to keep the agricultural footprint constant, switching from conventional to niche production would not meet the current demand. However, there are numerous goals and outcomes in achieving a more sustainable food system. For example, animals raised in niche outdoor systems may be able to utilize lower quality land through conservation rotational grazing. Hogs can graze on various types of pasture. In addition to alfalfa, other crop species for use in rotational swine pasture include clovers (alsike, ladino, red, and sweetclover) and grasses (bermudagrass, tall fescue, bromegrass, orchardgrass, and timothy grass)[21]. Similarly, a summer annual swine pasture can consist of crabgrass, millets, sudangrass, sorghum, corn, soybeans, cow peas, teff, and buckwheat; while a winter annual pasture includes small grains, rye grass, crimson clover, vetch, forage turnips, and rape[11]. Globally, permanent pasture and grazing lands represent two times the amount of crop acreage[42]. Through yield improvements and intensified management, pasture production may reduce competition with higher quality land suitable for food directly consumed by humans.

Furthermore, forages may reduce grain and protein costs[22] with attention paid to grazing forages at an early stage of maturity and adjustments for nutrients provided from the pasture[21].

Proper utilization of land resources as foraged pasture is based on stocking density, which largely depends upon local soil and climatic conditions. For this study, stocking density for the niche outdoor environment was estimated for alfalfa pasture in mid-western USA. Although alfalfa has been widely researched for swine, numerous forage crops listed above are advantageous for use in different climates. For example, in southeastern USA, pastured pigs are raised on the perennial forage of bermudagrass. This warm-season grass has an excellent rhizome and stolon structure to sustainably maintain ground cover[11]. With perennial forages offering more resistance to pigs' behavior of rooting, grazing, and trampling, stocking density can be increased to the ranges of 37 to 74 wean-to-finish pigs per hectare and 10 to 15 sows per hectare[11]. Modeling with Bermudagrass as the pasture crop, land requirements for living space for the herd could be reduced reduce by 31%. Conversely, annual forages are more sensitive to swine field behaviors, thereby decreasing recommended density to the lower end of the range (37 wean-to-finish pigs per hectare). This study incorporated a more conservative stocking density in order to maintain ground cover, limit soil erosion, and manage swine waste while providing nutrition via foraging. Thus, overall economic and ecological goals integrated with local physical conditions will likely direct producers to a suitable stocking density for their operation.

Depending upon the management style of hog production, living space (housing and pasture) may be a major contributor to overall land requirements. The environmental costs of land[42,43,44,45,46,47] as well as irrigation water, nutrient loading, and greenhouse gas contributions have been recently analyzed for various livestock classes. Direct comparison of this study's results with the literature proves difficult because the results are generalized to land areas for either all food categories or combined livestock classes. Furthermore, these studies likely modeled confined commodity hog production, absent of the foraging footprint. For this reason, a review of land results among alternative pork systems cannot be currently made. Nevertheless, two broad comparisons are possible. First, Gerbens-Leenes et al. (2002) reported 8.9 $m^2$/year/kg of pork compared to this study's results of 7.0 $m^2$/year/kg (conventional confined environment), 11.1 $m^2$/year/kg (niche enhanced environment), and 13.6 $m^2$/year/kg (niche outdoor environment). Second, Eshel et al. (2014) estimated approximately 5 $m^2$/year/Mcal of pork consumed, whereas this study found 2.4 $m^2$/year/Mcal consumed (conventional confined environment), 3.7 $m^2$/year/ Mcal consumed (niche enhanced environment), and 4.6 $m^2$/year/ Mcal consumed (niche outdoor environment). These modeling outcomes are similar, even if their parameter values, system boundaries, and assumptions used to establish the methodologies do not completely align with those used in this study.

Despite the land cost trade-off, the increased space allocation of niche pork has several benefits for the producer, animal, consumer, and environment, as reported in the literature. Starting with niche producers, working conditions may improve with less dust and gases as compared to confinement buildings[48]. Alternative swine systems utilizing hoop structures or pasture have reduced equipment and building costs that result in lower start up and fixed costs of production[21,48,49,50]. With regard to animal welfare, niche systems typically offer more freedom of movement and more diverse environment that allow for the expression of natural, exploratory behaviors[9,48,51,52]. Reduced stocking density is also associated with less social stress, thus less aggression within the herd[9]. For the consumers, the production characteristics of niche pork may be preferred over a commodity product.

These social or credence attributes include outdoor access and bedded rearing conditions as well as the absence of antibiotic or hormone use, certain feed types, locality of farm, and humane treatment of animals[53]. Lower stocking density, better air quality and a diet containing fermentable fiber reduce the risk of meat taint, a quality impairment that causes an unpleasant odor during cooking[9]. However for other aspects of meat quality, there has not been consistent evidence that one system fairs better for primary attributes, such as tenderness, juiciness, and muscle pH[9,52]. Environmentally, niche pork production with larger land footprints may generate less odor and water pollution[48]. When properly managed, stocking densities can match the land's capacity to assimilate manure nutrients. Even with these benefits, however, care should be taken to protect the land and water resources from swine degradation and nutrient accumulation, to safeguard the herd from extreme weather conditions (temperature and precipitation), and to provide proper nutrition given the increased energy expenditure and social competition for food.

*Implications for Further Research*

The assumptions and findings from this study have thee immediate implications for future research. First, the model's system boundaries set in this research included the land required for feed and living space. For two of the three systems (confined conventional environment and niche enhanced environment), the cropland to which swine manure would be applied was not part of the analysis. However, the stocking density used for the niche outdoor environment accounted for the manure and other environmental impacts of outdoor hog production. Specifically, this more conservative value factored in swine behavior that affects vegetative ground cover maintenance, soil disturbance, and nutrient loading, while optimizing animal growth and performance[11]. For this reason, land used to assimilate manure nutrients could be included in further analyses to be more impartial when comparing the different production styles.

Second, this study design could also be adapted to other livestock classes with alternative production, such as grass-finished beef, organic dairy, and pastured poultry. By collecting performance data, feed information, and stocking densities of these additional systems, land requirements could be estimated and aggregated for more of a complete diet analysis with regard to protein sources.

Finally, to more fully evaluate the potential for niche meat within an alternative food system, other factors within the value chain should be collectively considered. Possible inclusions would incorporate the capacity, utilization and cost of regional slaughter and processing, the efficacy of aggregation, distribution and marketing, and the support from consumers reflected in their demonstrated willingness-to-pay for differentiated livestock products.

**Conclusions**

This study analyzed and compared the land impacts of pork production, which represented one isolated component of a broader food system. Given the increasing global demand of livestock products juxtaposed with environmental goals of conserving native landscapes with increased land competition from other food crops, biofuels and urbanization, there is need to reduce the yield gap between niche and conventional pork production. As demonstrated in this research, opportunities exist to modify herd management strategies without greatly impacting the overall land requirements. Findings suggest that by increasing living space to include bedding and loafing areas, while adding a haylage component to the diet, overall land requirements increased by 17%. When evaluating the land cost of livestock extensifaction, environmental and social benefits of niche pork must be considered. These potential advantages are experienced beyond the farm gate by improving air and water quality for the ecosystem while satisfying consumer concerns regarding animal welfare and environmental sustainability. Interestingly, the consumer plays a critical role in this land debate. Consumers, impacted by higher priced differentiated meat, may actually reduce demand when shifting from commodity to niche meat products. Changing consumer diets toward less meat consumption would minimize the land cost tradeoff while achieving additional environmental and health benefits, as documented [39,45,54].

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Table 3.1: Performance metrics for niche and conventional pork production

| Parameter | Units Explanation | Conventional System | Niche System | Conventional Source | Niche Source |
|---|---|---|---|---|---|
| Reproduction | | | | | |
| Breeding ratio | boar sow$^{-1}$ | 0.11 | 0.16 | *1* | *7* |
| Annual average parities | birth cycles sow$^{-1}$ year$^{-1}$ | 2.2 | 2.0 | *2* | *7* |
| Litter size | live piglets born sow$^{-1}$ | 10.3 | 9.7 | *2* | *7* |
| Herd management | | | | | |
| Cull breeding sows | % during one breeding cycle | 22.6 | 14.0 | *2* | *7* |
| Cull breeding boars | % during one breeding cycle | 22.6 | 14.5 | *See Note 1* | *7* |
| Cull finishing gifts and barrows | % during life phase | 3.0 | 2.1 | *3* | *7* |
| Mortality | | | | | |
| Mortality sows | % during one breeding cycle | 3.9 | 0.5 | *2* | *7* |
| Mortality rate of boars | % during one breeding cycle | 3.9 | 0.1 | *See Note 2* | *7* |
| Mortality pre-weaned piglets | % during life phase | 9.7 | 14.3 | *2* | *7* |
| Mortality nursery piglets | % during life phase | 3.6 | *NA* | *2* | *See Note 6* |
| Mortality gilts & barrows | % during life phase | 4.1 | 1.9 | *2* | *7* |
| Mortality replacement gilts | % during time in phase | 0.7 | 0.2 | *See Note 3* | *See Note 7* |
| Mortality replacement barrows | % during time in phase | 1.9 | 0.1 | *See Note 4* | *See Note 8* |
| Age and size by life phase | | | | | |
| Piglets age at weaning | days | 20.8 | 49.1 | *2* | *7* |
| Piglets weight at weaning | kg | 6.8 | 15.8 | *4* | *7* |
| Finishing age to market | days | 197.1 | 214.8 | *See Note 5* | *7* |
| Finishing liveweight | kg | 129.7 | 124.2 | *5* | *7* |
| Gilt age at first breeding | days | 225.0 | 282.5 | *4, 6* | *7* |

Notes
1. Assumed cull rate is identical to sows.
2. Assumed similar mortality to breeding sows.
3. Data not found for replacement gilts. Mortality based on sow mortality and time spent in phase.
4. Data not found for replacement barrows. Mortality based on sow mortality and time spent in phase.
5. Calculated within a model by authors' additional study.
6. Nursery mortality was captured in Wean-to-finish mortality.
7. Assumed similar mortality to sow mortality and time spent in phase.
8. Assumed similar mortality to boar mortality and time spent in phase.

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5. USDA NASS (2014)
6. DeVries, Stuart (2011)
7. Primary data collection of J. Picardy dissertation (2015)

Table 3.2: Life phase performance based on one breeding cycle of one bred sow

| Number of animals | Conventional System | Niche System |
|---|---|---|
| Pre-weaned Piglets Life Phase | | |
| Bred Sow | 1.00 | 1.00 |
| Piglets born alive | 10.30 | 9.74 |
| End of phase pre-weaned piglets | 9.30 | 8.35 |
| Nursery Life Phase | | |
| End of phase nursery piglets | 8.97 | 8.35 |
| Growing and Finishing Life Phase | | |
| Culled gilts and barrows | 0.27 | 0.17 |
| Mortality gilts and barrows | 0.37 | 0.16 |
| End of phase market gilts and barrows | 8.33 | 8.01 |
| Female Breeding Replacements | | |
| Culled breeding sow | 0.23 | 0.14 |
| Mortality breeding sow | 0.04 | 0.01 |
| Mortality replacement gilts | 0.0019 | 0.0002 |
| Total sow replacements | 0.27 | 0.15 |
| Male Breeding Replacements | | |
| Culled breeding boar | 0.02 | 0.02 |
| Mortality breeding boar | 0.0043 | 0.0002 |
| Mortality replacement barrow | 0.0002 | 0.0000 |
| Total boar replacements | 0.03 | 0.02 |
| Pigs for Target or Cull Market | | |
| Finishing gilts and barrows | 8.03 | 7.84 |
| Culled original breeding sow | 0.23 | 0.14 |
| Culled orignal breeding boar | 0.0077 | 0.0048 |

Table 3.3: Feed needs by production system

| | As-fed corn | As-fed SBM | As-fed dried whey | As-fed dried alfalfa hay | Grazed alfalfa pasture | Total feed |
|---|---|---|---|---|---|---|
| | kg sow$^{-1}$ year$^{-1}$ | | | | | |
| Conventional Confined Environment | 6,147 | 1,287 | 17 | 0 | 0 | 7,452 |
| Niche Enhanced Environment | 5,872 | 1,216 | 0 | 1,477 | 0 | 8,564 |
| Niche Outdoor Environment | 5,642 | 1,412 | 0 | 749 | 1,652 | 9,455 |

Table 3.4: Meat output and feed conversion

| | Total edible meat for target market | Total Feed Conversion |
|---|---|---|
| | kg $sow^{-1}$ $year^{-1}$ | kg feed (kg edible meat)$^{-1}$ |
| Conventional Confined Environment | 1,210 | 6.2 |
| Niche Enhanced Environment | 898 | 9.5 |
| Niche Outdoor Environment | 898 | 10.5 |

Table 3.5: Land requirements

| | Corn | SBM | Dried whey* | Dried alfalfa hay | Alfalfa pasture | Total feed needs | Living space | Pasture adjustments | Total land requirements |
|---|---|---|---|---|---|---|---|---|---|
| | hectare $sow^{-1}$ $year^{-1}$ | | | | | | | | |
| Conventional Confined Environment | 0.71 | 0.14 | 0 | 0 | 0 | 0.85 | 0.00 | 0 | 0.85 |
| Niche Enhanced Environment | 0.67 | 0.13 | 0 | 0.18 | 0 | 0.99 | 0.01 | 0 | 1.00 |
| Niche Outdoor Environment | 0.65 | 0.14 | 0 | 0.09 | 0.21 | 1.10 | 0.33 | 0.21 | 1.22 |

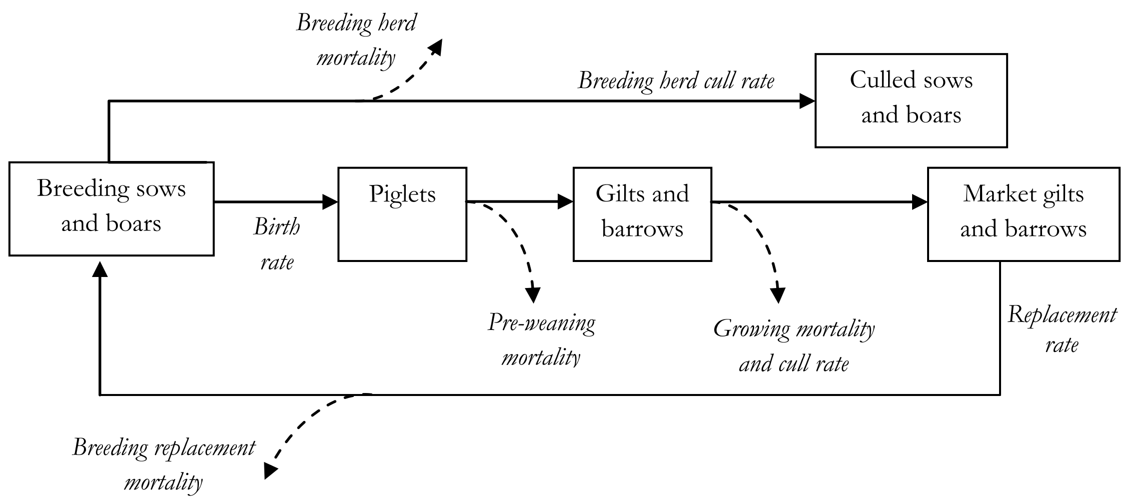
*Dried whey is a co-product of the dairy industry; thus, no additional land is needed

# Table 3.6: Living space by life phase

| | Breeding sow | Gestating sow | Lactacting sow with litter* | Weaned piglets | Growing and finishing hogs | Breeding boar | Total housing space |
|---|---|---|---|---|---|---|---|
| | $m^2$ | | | | | | |
| Conventional Confined Environment | 1.7 | 1.4 | 3.3 | 2.5 | 7.0 | 0.5 | 16.3 |
| Niche Enhanced Environment | 5.6 | 5.6 | 7.4 | 13.7 | 16.3 | 1.6 | 50.3 |
| Niche Outdoor Environment | 149.5 | 699.8 | 306.9 | 410.4 | 1,655.3 | 121.0 | 3,342.9 |
| | number of animals averaged across life phase | | | | | | |
| Conventional System | 1.0 | 1.0 | 11.3 | 9.1 | 8.6 | 0.1 | |
| Niche System | 1.0 | 1.0 | 10.7 | 8.2 | 8.2 | 0.2 | |

* Living space for this life phase includes the sow and her piglets born alive

Figure 3.1: Swine system life phases with culling, mortality and replacement



# Appendix Table 1: Confined conventional environment feed intake and inventory

| Confined Conventional Environment | Example Diet Source: | Daily Feed Intake | Assumed Daily Lean Gain | Assumed Daily Total Gain | Time on feed | Total Feed Intake for Phase | End of Phase Age | Number in Phase |
|---|---|---|---|---|---|---|---|---|
| | | kg day$^{-1}$ | kg day$^{-1}$ | kg day$^{-1}$ | days | kg | cumulative days | |
| Breeding Sow Gestation Base Diet #1 (Gestation and Resting) | Reese, Table 5 | 1.91 | | | 145.11 | 276.45 | | 1.00 |
| Breeding Sow Lactating Diet | Reese, Table 5 | 6.44 | | | 20.80 | 133.97 | | 1.00 |
| Breeding Boar Diet (181 to 272 kg) | Reese, Table 5 | 2.72 | | | 165.91 | 451.53 | | 0.11 |
| Pre-weaned Piglets (birth to 21 days) | NA | 0.00 | (assume complete nutrition from sow) | | 20.80 | 0.00 | 20.80 | 9.80 |
| Nursery Piglets Phase 1 Diet (4 to 5 kg) | Reese, Table 3 | 0.16 | 0.15 | 0.29 | 3.13 | 0.50 | 23.93 | 9.13 |
| Nursery Piglets Phase 2 Diet (5 to 7 kg) | Reese, Table 3 | 0.25 | 0.20 | 0.41 | 4.44 | 1.11 | 28.37 | 9.13 |
| Nursery Piglets Phase 3 Diet (7 to 11 kg) | Reese, Table 3 | 0.50 | 0.36 | 0.73 | 6.25 | 3.12 | 34.62 | 9.13 |
| Nursery Piglets Phase 4 Diet (11 to 20 kg) | Reese, Table 3 | 1.00 | 0.57 | 1.13 | 8.00 | 7.98 | 42.62 | 9.13 |
| Growing-Finishing Gilts Phase 1 Diet (20 to 41 kg) | Reese, Table 4 | 1.41 | 0.32 | 0.64 | 32.14 | 45.20 | 74.76 | 8.65 |
| Growing-Finishing Gilts Phase 2 Diet (41 to 61 kg) | Reese, Table 4 | 1.81 | 0.34 | 0.69 | 29.61 | 53.71 | 104.37 | 8.65 |
| Growing-Finishing Gilts Phase 3 Diet (61 to 82 kg) | Reese, Table 4 | 2.13 | 0.39 | 0.79 | 25.86 | 55.13 | 130.23 | 8.65 |
| Growing-Finishing Gilts Phase 4 Diet (82 to 102 kg) | Reese, Table 4 | 2.40 | 0.38 | 0.76 | 26.79 | 64.39 | 157.02 | 8.65 |
| Growing-Finishing Gilts Phase 5 Diet (102 to 122 kg) increased to 130 kg (2014 NASS Commercial Hog Slaughter average) | Reese, Table 4 | 2.59 | 0.34 | 0.69 | 40.13 | 103.76 | 197.15 | 8.65 |
| Replacement Breeding Females - Assuming Finishing Gilt Diet Phase 5 until her first breeding (approx. 7.5 months of age) | Reese, Table 4 | 2.59 | | | 27.85 | 72.01 | 225.00 | 0.27 |
| Replacement Breeding Boars - Assuming Growing-Finishing Phase 5 Diet from 130 to 181 kg | Reese, Table 4 | 2.59 | 0.34 | 0.69 | 75.00 | 193.91 | 272.15 | 0.03 |

# Appendix Table 2: Niche enhanced environment feed intake and inventory

| Niche Enhanced Environment | Example Diet Source: | Daily Feed Intake | Assumed Daily Lean Gain | Assumed Daily Total Gain | Time on feed | Total Feed Intake for Phase | End of Phase Age | Number in Phase |
|---|---|---|---|---|---|---|---|---|
| | | kg day$^{-1}$ | kg day$^{-1}$ | kg day$^{-1}$ | days | kg | cumulative days | |
| Breeding Sow Gestation Base Diet #1 (Gestation and Resting) | Kephart, Table 2 | 2.90 | | | 135.93 | 393.91 | | 1.00 |
| Breeding Sow Lactating Diet (no pasture supplement) | Reese, Table 5 | 6.44 | | | 49.12 | 316.39 | | 1.00 |
| Breeding Boar Diet (181 to 272 kg) (no pasture supplement) | Reese, Table 5 | 2.72 | | | 185.05 | 503.62 | | 0.16 |
| Pre-weaned Piglets (birth to 49 days & 16 kg) | NA | 0.00 | (assume complete nutrition from sow) | | 49.12 | 0.00 | 49.12 | 8.18 |
| Nursery Piglets Phase 4 Diet (Post-weaning 16 to 18 kg) (same as Nursery Phase 4 Ration) | Reese, Table 3 | 1.00 | 0.57 | 1.13 | 2.00 | 2.00 | 51.12 | 8.18 |
| Growing Diet with Alf Hay Supplement (18 to 57 kg) | Kephart, Table 3 | 2.08 | 0.32 | 0.64 | 60.71 | 126.22 | 111.84 | 8.18 |
| Finishing Diet with Alf Hay to Finishing Weight of 124 kg (57 to 109 kg) | Kephart, Table 4 | 2.77 | 0.31 | 0.62 | 108.92 | 301.92 | 220.75 | 8.18 |
| Finishing Gilts Diet with Alf Hay Supplement (109 to 124 kg) if >282 days, then can start breeding herd | Kephart, Table 4 | 2.77 | | | 61.78 | 171.26 | 282.54 | 0.15 |
| Replacement Breeding Boars - Assuming Growing-Finishing Phase 5 Diet from 108 to 181 kg (no pasture supplement) | Reese, Table 4 | 2.59 | 0.34 | 0.69 | 82.89 | 214.32 | 303.65 | 0.02 |

# Appendix Table 3: Niche outdoor environment feed intake and inventory

| Niche Outdoor Environment (summer) | Example Diet Source: | Daily Feed Intake | Assumed Daily Lean Gain | Assumed Daily Total Gain | Time on feed | Total Feed Intake for Phase | End of Phase Age | Number in Phase |
|---|---|---|---|---|---|---|---|---|
| | | kg $day^{-1}$ | kg $day^{-1}$ | kg $day^{-1}$ | days | kg | cumulative days | |
| Breeding Sow Gestation Base Diet #1 (Gestation and Resting) | Kephart, Table 2 | 4.44 | | | 135.93 | 603.71 | | 1.00 |
| Breeding Sow Lactating Diet (no pasture supplement) | Reese, Table 5 | 6.44 | | | 49.12 | 316.39 | | 1.00 |
| Breeding Boar Diet (181 to 272 kg) (no pasture supplement) | Reese, Table 5 | 2.72 | | | 185.05 | 503.62 | | 0.16 |
| Pre-weaned Piglets (birth to 49 days & 16 kg) | NA | 0.00 | (assume complete nutrition from sow) | | 49.12 | 0.00 | 49.12 | 8.18 |
| Nursery Piglets Phase 4 Diet (Post-weaning 16 to 18 kg) (same as Nursery Phase 4 Ration) | Reese, Table 3 | 1.00 | 0.57 | 1.13 | 2.00 | 2.00 | 51.12 | 8.18 |
| Growing Diet with Alf Pasture Supplement (18 to 57 kg) | Kephart, Table 3 | 2.41 | 0.32 | 0.64 | 60.71 | 146.30 | 111.84 | 8.18 |
| Finishing Diet with Alf Pasture to Finishing Weight of 124 kg (57 to 109 kg) | Kephart, Table 4 | 3.21 | 0.31 | 0.62 | 108.92 | 349.95 | 220.75 | 8.18 |
| Finishing Gilts Diet with Alf Hay Supplement (109 to 124 kg) if >282 days, then can start breeding herd | Kephart, Table 4 | 3.21 | | | 61.78 | 198.51 | 282.54 | 0.15 |
| Replacement Breeding Boars - Assuming Growing-Finishing Phase 5 Diet from 108 to 181 kg (no pasture supplement) | Reese, Table 4 | 2.59 | 0.34 | 0.69 | 82.89 | 214.32 | 303.65 | 0.02 |

# Appendix Table 4: Stocking densities by life phase

| | Breeding sow | Gestating sow | Lactacting sow with litter* | Weaned piglets | Growing and finishing hogs |
|---|---|---|---|---|---|
| Conventional Confined Environment | | | | | |
| Number of animals averaged across life phase | 1.0 | 1.0 | 1.0 | 9.1 | 8.6 |
| Stocking density for life phase [meters$^2$ animal$^{-1}$] | 1.7 | 1.4 | 3.3 | 0.3 | 0.8 |
| Land required for life phase [meters$^2$] | 1.7 | 1.4 | 3.3 | 2.5 | 7.0 |
| Niche Enhanced Environment | | | | | |
| Number of animals averaged across life phase | 1.0 | 1.0 | 1.0 | 8.2 | 8.2 |
| Stocking density for life phase [meters$^2$ animal$^{-1}$] | 5.6 | 5.6 | 7.4 | 1.7 | 2.0 |
| Land required for life phase [meters$^2$] | 5.6 | 5.6 | 7.4 | 13.7 | 16.3 |
| Niche Outdoor Environment | | | | | |
| Number of animals averaged across life phase | 1.0 | 1.0 | 1.0 | 8.2 | 8.2 |
| Stocking density for life phase [meters$^2$ animal$^{-1}$] | 1156.2 | 1156.2 | 1156.2 | 50.2 | 202.3 |
| % time in life phase on the land | 12.9 | 60.5 | 26.5 | 100.0 | 100.0 |
| Land required for life phase [meters$^2$] | 149.5 | 699.8 | 306.9 | 410.4 | 1655.3 |

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**CHAPTER 4** (Part 3) written in the style of *Agribusiness* journal

**At What Price for Niche Pork? Consumers' Value and Knowledge of Alternative Animal Production in New England**

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**ABSTRACT**

New opportunities for providing niche meat within the retail sector are emerging as consumer awareness and demand increases for differentiated livestock products. Market information, such as consumer willingness-to-pay (WTP), is needed before value chain partners can invest into new product development, distribution and promotion. This study investigates consumer valuation of regionally-raised meat in New England, with a focus on pork tenderloin. Specialty market retail customers were surveyed to estimate their WTP, rank production characteristics, and evaluate meat eco-labeling understanding. Significant predictors of WTP centered on the strength of tenderloin preferences and for regional production. Participants were strongly concerned with added hormones and sub-therapeutic antibiotics, followed by living space and outdoor access. Least critical production characteristics included production within a state boundary, farm name identification, and heritage breeds. Lastly, participants recognized federal meat eco-labels but did not understand production differences among federal and private labeling programs. [EconLit alphanumeric subject codes Q13, Q18, D12]

## 1. INTRODUCTION

Consumers are becoming more particular over the practices used to raise livestock for meat products (Umberger, Thilmany McFadden, & Smith, 2009; Dickenson & Bailey, 2002). Consumer awareness of conventional and alternative agricultural production is contributing to heightened concerns for animal welfare, food safety, economic viability of farm and community, and environmental sustainability. These broader categories of concerns are associated with socio-environmental credence attributes of meat production that include local, organic, natural, humanely-raised, pastured, grass-finished, no routine use of antibiotics, no added hormones, and raised on small to medium scale farms with known origin (Honeyman, Pirog, Huber, Lammers, & Hermann, 2006). Consequently, there is growing demand for meat produced with those process attributes (Honeyman, Pirog, Huber, Lammers, & Hermann, 2006; Wheatley, 2003; O'Donovan & McCarthy 2002). For example, between 2008 and 2010, natural and organic red meat sales in the United States increased 15%, while overall red meat sales increased only 1.7% (Curtis, McKissick, & Spann, 2011). Looking at the overall food system, sales of organic food accounts for more than 4% of total U.S. food sales (estimated value of $34.8 billion in 2014) (Greene 2015).

Without direct interaction with a producer or values-chain partner, retail shoppers can reference the meat label in order to make purchase decisions based on these credence attributes. For meat, poultry or egg products sold in the United States, the United States Department of Agriculture (USDA) Food Safety and Inspection Service (FSIS) requires up to eight specific identifiers on each label; such include the product name, inspection legend and establishment number, handling statement, net weight statement, ingredients statement, address line, nutrition facts, and safe handling instructions (USDA FSIS 2007). In addition, a meat product label may voluntarily include other process characteristics, such improved animal welfare and environmental-friendly practices used to raise the animal. Eco-labels are a typical market instrument used by food companies to reduce information asymmetry externality between the consumer and the producer (van Amstel, de Brauw, Driessen, & Glasbergen, 2007). Also a policy instrument, eco-labels can increase market transparency by verifying the product claims of socio-environmental qualities (credence attributes) that cannot easily be determined or experienced directly by the consumer.

Previous research has examined consumer's willingness-to-pay (WTP) for differentiated meat products with specific credence attributes related to farm management styles. Conducted in the US and Europe, these studies examined consumer preferences toward animal welfare, meat traceability and transparency, and production methods that are small-scale, natural or organic (McKendree, Olynk Widmar, Ortega, & Foster, 2013; Liljenstolpe 2010; Umberger, Thilmany McFadden, & Smith, 2009; Lusk, Nilsson, & Foster, 2007;; Lagerkvist, Carlsson, & Viske, 2006; McMullen, 2006; Wheatley, 2003; Dickinson & Bailey, 2002; Grannis & Thilmany, 2002). These studies are typically based in Stated Preference methods using either contingent valuation or choice experiments; data were collected with mail or internet surveys with sample sizes ranging from 35 to 1,400 participants. Overall, these studies find that consumers were willing to pay price premia for process characteristics associated with differentiated meat production. Consumers' WTP were associated with class membership relating to purchase history of local and niche meat products, shopping location, agricultural awareness, and demographics. These studies are localized, answering research questions specific to areas such as the US Intermountain West, the state of Iowa or certain European countries for explicit cuts of meat.

Given that consumer demographics as well as agricultural knowledge and preference for meat or production characteristics vary, the estimation results may not be applicable to other regions. Literature summarized by Carpio & Isengildina-Massa (2009) support the contention that WTP premia for locally grown foods vary by state and by product. For this reason, we decided to build upon these previous studies to analyze consumer preferences for niche pork raised in New England that would be sold in retail specialty markets. New England is of particular interest for this study because of the recent growth in regional aggregation for primal cuts and value-added charcuterie. Furthermore, New England continues to serve as an innovation center for the local agricultural movement of food hubs and community supported agriculture. The purpose of this study was threefold: (1) estimate the WTP for regionally-raised pork; (2) rank the production characteristics most important to retail consumers; and (3) evaluate the consumer understanding of meat eco-labeling.

Working from Grannis & Thilmany (2002), we used a contingent valuation framework for estimating consumers' WTP for a product – regionally produced pork tenderloin – that does not currently exist in the retail marketplace. Although previous work focused on ham, pork chops, or deli lunch meat, we decided upon pork tenderloin after consulting with experts who work in New England's meat value chain. As aggregators, processors, and distributors, these experts have access to various markets for selling lower cost ham and chops. Of particular interest is the potential retail marketplace for the highest-valued pork cut, the tenderloin. Thus, this study extends the meat willingness-to-pay literature by estimating premia for a high-value cut raised in New England under alternative conditions.

## 2. STUDY METHODOLOGY

### 2.1 Research Question and Hypotheses

Our overall research question centered on the level of consumer interest in a New England regionally-raised niche pork tenderloin. For the purpose of this study, niche pork referred to pigs that are raised in a known location, on vegetarian feed, without sub-therapeutic antibiotics or added growth hormones. The New England location attribute was of primary concern, thereby distinguishing this product from other niche pork products that are raised elsewhere, such as the Midwest USA.

To answer this question, we tested several hypotheses concerning consumers' willingness-to-pay for niche pork tenderloin as a function of the following: (1) previous purchase of local pork; (2) concerns with specific production practices for raising swine; (3) support for certified organic production; and (4) households without children eating at home. These potential predictors for differences in WTP were based on the literature cited above as well as from observations in the field and feedback from value chain stakeholders. The hypotheses took the general form in Equation 1 below:

$$\begin{aligned} &H_0: WTP_{localporkpurchase} = WTP_{nopurchase} \\ &H_1: WTP_{localporkpurchase} \neq WTP_{nopurchase} \end{aligned} \qquad (1)$$

### 2.2 Contingent Valuation and Econometric Framework

Consumer preference data were analyzed using stated preference methodology. For this research, there were two main reasons for using a stated preference method: first, niche pork production has associated public good characteristics, and second, regionally-produced niche pork is not currently available in the Metro-Boston marketplace through commercial retail outlet (and only in a very limited amount through direct sales on-farm or at farmer's markets). Of the various stated preference methods, the most established is the contingent valuation method (CVM) while the choice experiment method is the most extensively used in food economics (Carlsson, 2011). One likely application of the results of this proposed research is to determine whether regional niche pork can be economically produced and distributed in the region. Therefore, we chose to use CVM to estimate the total WTP, as opposed to choice experiments, which measure the marginal WTP among different product attributes. We recognize, however, that drawbacks of CVM exist. For example, since CVM estimates represent total WTP, comparisons among attributes may not be meaningful (Liljenstolpe, 2008). Furthermore, the validity of contingent valuation is potentially limited by biases induced by the stated (rather than revealed) preference nature of the exercise. Incentives to misrepresent responses can occur when participants deliberately respond to questions to shape the outcome of the study and serve their own interest (strategic bias) or to please the interviewer by providing a WTP value that differs from their true WTP amount (interviewer bias) (Mitchell & Carson, 1989). In addition, starting-point or range biases may happen with a predefined range of WTP options acting as implied value cues (Teitenberg and Lewis, 2012; Mitchell & Carson, 1989). To avoid WTP misrepresentation, we stressed with the participants the importance of truthful responses since people often overstate their amount if they are not actually buying the product. This explicit discussion of potential hypothetical bias with the participants, in other words "cheap talk" methodology, was based on earlier work by Cummings and Taylor (1999). To mitigate implied values, we based the WTP range on current pricing of similar products.

The WTP estimation for niche New England tenderloin was elicited through a payment card style, which was bounded by $12 and $18 per pound (Figure 4.1). The lower value was set at $12 to match the current price of niche Midwestern tenderloin that was available nearby at a national green grocer chain not participating in the study. The upper value was determined by two factors: first, our pre-testing concluded that \$18/lb was too expensive for non-organic pork products in our focus group; and second, certified organic pork tenderloin from outside New England (raised in Canada) was priced at \$18/lb at a nearby regional supermarket chain. In addition to these payment choices, we also offered a *would not purchase* option. Thus, the dependent variable, WTP New England tenderloin, ranged from \$0/lb to \$18/lb. WTP was estimated using tobit regression, shown in Equations 2 and 3.

$$y^* = \beta_0 + x_i\beta_i + u \tag{2}$$
$$0 \leq y \leq 18 \tag{3}$$

where

$y^*$ = latent WTP per pound of niche New England pork tenderloin

$y$ = censored WTP from above \$18 and below \$0 per pound.

$\beta$ = vector of coefficients associated with variables x

$x$ = independent variables including current pork consumption, differentiated meat purchase history, WTP Midwestern niche tenderloin, concerns with production characteristics, local and natural meat definitions, meat label recognition and demographic factors

### 2.3 Survey and Independent Variables

The customer questionnaire was developed in the fall of 2013 and pre-tested with focus groups and store owners in the spring of 2014. It was four pages in length, consisted of six sections, and was usually completed within 10 minutes. The first part started with typical consumption in the home of any type of pork product, *HomePorkConsump*. This question was followed by purchase history of local and organic pork and beef, *OrgPork, LocalPork, OrgBeef,* and *LocalBeef.* If they responded yes to any of these options, we then asked the location where they bought the meat, such as a grocery store, farmer's market, wholesale club, or butcher. We then turned focus to the pork tenderloin cut of meat. We asked whether they ever bought pork tenderloin for home consumption, *Tenderloin*. If they responded no, we then followed-up to understand why not. Their responses were organized into the following responses: not eating any meat (*Vegetarian);* not eating pork *(NoEatPork);* do not like or know how to cook meat *(NoCookMeat);* or do not like pork tenderloin *(NoLikeTenderloin).*

The second section elicited willingness-to-pay for Midwestern and New England pork tenderloin as well as preferences for various cuts of locally-raised beef, chicken and pork. We began with a hypothetical purchase question, *SupposePurchase,* that inquired about interest in buying Midwestern niche pork tenderloin for $12/lb. Transitioning from the Midwest to New England, we posed a similar WTP question for niche tenderloin (*WTPvalue)* with similar process attributes except the location of production. This question was followed by a certainty statement, *CertaintyWTP*, that asked the participants to judge confidence in their stated WTP amount for actually buying niche tenderloin. The final question of this section expanded locally-raised to 11 other cuts of pork, chicken and beef. The question was strongly influenced by gray literature from the New England region that recognized the lack of data on consumer demand for specific cuts and species of meat products (see Dickenson, Joseph & Ward, 2013 and State of Vermont, 2001).

The third part focused on customers' personal characterizations of "local" and "natural." Within this section, we asked participants to rank their agreement with different statements, such as "locally-raised meat is readily available for purchase at the grocery store where you most regularly shop" (*AgreeLocalAvail),* and "locally-raised meat means that animals were raised from birth through slaughter in the local area" (*AgreeRaiseSlaughter*). Similarly, we solicited their personal definition for local meat, as being raised within the state of Massachusetts (*LocalMA)*, the region of New England *LocalNE)*, or within 100 miles of their location *(Local100)*. Finally, we asked them to define "natural meat" using an open-ended question format.

The fourth section asked participants to prioritize meat production characteristics in terms of most and least important. In total, there were 12 characteristics that reflected general categories of animal welfare, environmental sustainability, and local production. Although the 12 process attributes were the same, we provided two separate opportunities for participants to identify their top three characteristics that are most important and least important to them.

The fifth section concentrated on recognition of meat eco-labels associated with some of the production characteristics from the previous section in the questionnaire. As shown in Figure 4.2, the eco-labels included USDA Process Verified, USDA Organic, Animal Welfare Approved, Certified Humane, Global Animal Partnership, as well as a fabricated label. We first inquired about participant recognition for each of the six labels. Next, we asked whether the labels represented the same guidelines for raising animals (*SameGuidelines)*. In a similar manner, participants responded on whether they know the differences between the labels (*KnowDiffLabel)*. If they found the eco-labels confusing, we followed up with possible reasons for such uncertainty. The reasons included (1) not knowing what the labels represents with regard to animal agriculture (*DontKnowProd*); (2) not trusting the label as it could be misleading or dishonest (*DontTrust*); or not understanding the relationship between the label and the meat company or farmer (*DontKnowRelationship*). They could choose any of the reasons that applied to themselves.

The sixth and final part contained socioeconomic questions regarding household size, gender, education level, income, and race. Regarding size, we asked participants to write in the number of adults (*EatHomeAdults*) and children *(EatHomeKids)* who typically eat dinner together in the home. They also self-identified their gender and race. Because most of the study's participants were white females, we created two dummies for these demographic variables (*Female* and *White).* The highest level of education completed was another variable (*YrsEd).* The last demographic variable was total household income (*Income*). We based the mean of the five categories on the US Census average of household income for the area. Although the participants selected from a range of categories, we calculated the average value for the range given their categorical response.

### 2.4 Data Collection

The customer-intercept questionnaire was administered in the summer of 2014 at three specialty retail grocery stores in Metro-Boston, Massachusetts (USA). Of the three stores, one was located in Boston and the other two were in suburbs near Boston. The stores were chosen based on their current availability of regionally-produced food products, such as fresh fruits and vegetables, bakery items, dairy, and non-pork livestock products. These stores already had value chain partnerships established with other local and regional purveyors, thus being receptive of alternative supply chain structures should niche pork products be marketed in the future. We collected data for one week in each of the three stores. We strived to reach diverse populations by administering the survey during all major periods of business hours (early morning, lunch hour, late afternoon, evening rush hour and late night). By being physically present in the stores, we were available to answer questions from the participants, thus potentially reducing information bias for unknown attributes. We used a computer tablet-assisted survey administered with Qualtrics Research Suite software (Qualtrics, LLC), which was both an appealing format for potential respondents and simplified data entry. Study participants were compensated with a small thank-you gift (a beeswax-based lip balm with an estimated value of $1 US). We had 388 initial participants, with 100, 141, and 147 surveys attempted at the three stores.

For cleaning the data, we tried to preserve as much original information as possible yet removed surveys with series of unanswered questions. For minor omitted responses in otherwise complete responses, imputation was performed by using representative averages for individual blank answers. Such resulted in a final sample size of 373 completed surveys. This sample size came very close to our 385 target, which was based on Mitchell and Carson's Table 10-1, where Type 1 Error Probability ($\propto$) = 0.05, Coefficient of Variation (V) = 2.0 their recommendation for CVM, and Percentage Difference $\Delta$ = 0.20 between true WTP and estimated WTP (Mitchell & Carson, 1989, page 225).

## 3. RESULTS

### 3.1 Descriptive Statistics

#### Demographics

As shown in Table 4.1, our study's participants form a relatively homogenous group, as we anticipated based on the type and location of retail stores where data were gathered. On average, participants come from small households with 2.1 adults and 0.6 children eating dinner at home. They are college educated, having earned at least an undergraduate college degree. Likewise, they have relatively high household income ($95,783 mean). The majority of respondents self-identified as being female (66%) and white (82%). This sample does not represent the general population of New England, nor those who shop at conventional supermarkets. Nevertheless, this sample embodies the population that shops at specialty retail markets in the greater Boston area where differentiated meat products would be available.

**Purchase History**

Regarding previous meat purchases for home consumption, 39% of our participants have previously purchased organic pork and 58% have purchased organic beef. Fewer reported having bought locally-raised pork and beef, 33% and 40% respectfully. For the organic meats, most customers purchased the products at a retail grocery store (72% for pork and 74% for beef). The second most popular method for buying organic meat was through direct marketing (DM), such as a farmer's market or community supported agricultural enterprise (25% for pork and 20% for beef). However, for local meats, the opportunity with direct marketing increased. Local beef purchases were similar between the grocery store (47%) and DM (44%). As anticipated, the majority sourced local pork through direct marketing (49% DM versus 43% for grocery store). We expected locally-sourced pork to be purchased through DM, as retail fresh pork was not available at any of the three stores when the survey was conducted, nor to the best of our knowledge, at any similar venues in the region. This observation was affirmed by the participants, 74% of whom believe local meat is not readily available at the grocery store where they typically shop. Focusing on the pork tenderloin cut, nearly half have purchased tenderloin in the past for home consumption. For the others, they described reasons for not buying tenderloin. For this sample, 11% do not eat pork, 11% are vegetarian, 4% do not cook meat at home or know how to prepare meat, and 3% do not like tenderloin.

**WTP for Midwestern and New England Niche Meat Products**

Within the survey, niche process attributes were explicitly bundled as animals that were raised in a certain region, on vegetarian feed, without sub-therapeutic antibiotics or added growth hormones. Nearly 40% stated they would purchase Midwestern niche tenderloin at $12/lb. This price is approximately double the retail cost of commodity pork tenderloin during the time the survey was administered. Shifting to local production while keeping constant the other process attributes, the average WTP price for niche New England tenderloin was $9.46/lb, which includes nearly 33% who stated they would not buy this product at any price. The majority (79%) reported certainty in their New England WTP decision. The implied demand curve of specialty market customers for New England tenderloin is show in Figure 3.3; this implied demand curve is derived from the inverse cumulative distribution function for responses to the WTP question in our survey. The y axis represents the proportion of respondents willing to pay at least the indicated amount on the x axis. Finally for these related questions, we expanded the list of locally-raised cuts of meat beyond pork to include beef and chicken. Although specific premiums were not provided, participants responded with each cut of meat knowing it would be sourced locally with an additional cost. Chicken dominated the list, following by beef, then pork, which are shown in rank order in Table 4.2.

**Process Attributes Preferences**

The most important production characteristics for animal agriculture centered on the use of technology, such as no added hormones (68% of participants who indicated this attribute within Top 3), no sub-therapeutic antibiotics (57%), followed by no genetically-engineered feed (39%), as shown in Table 4.3. Secondary concerns emerged with the themes of housing and space allocation as attributes of no tight confinement and access to the outdoors were chosen by 40% of the population. On the other hand, raising the animals in Massachusetts (8%), knowing the name of the farm (8%), and using heritage breeds (4%) scored the lowest.

The location process attribute was asked in two areas of the survey: production characteristics described above and personal definitions of local agriculture. The findings were similar. For instance, the attribute of animals being raised in the region of New England was more important than raised within the state boundaries of Massachusetts. This result parallels how participants defined local. Our sample viewed the attribute "local" as raised in New England (60%), as opposed to Massachusetts (17%) or within 100 miles (23%). Culturally, strong regional identity and place attachment exist in New England as demonstrated in this study and others (Conforti, 2001; Walker and Ryan, 2008).

**Meat Eco-Labeling Knowledge**

When presented with the visual labels, the majority of participants recognized the two labels from the USDA (Organic 89% and Process Verified 72%). However, the third-party certification programs were not as popular even though they are used on numerous livestock products, ranging from bacon to eggs. Of these three icons, Certified Humane was the most familiar (26%), followed by Animal Welfare Approved (16%). Interestingly, more respondents acknowledged the fictitious Cage-free Meat Certified label (15%) than the extant Global Animal Partnership icon (10%). When examining the meat eco-labels as a whole, 88% of participants do not know the production differences among the labels. We asked about possible sources of confusion; they could list more than one reason. More than half (55%) do not know what the label represents with regard to animal agriculture, 32% do not understand the relationship between the label (certification) and the meat company or farmer, and 26% do not trust the label because they see it as misleading or dishonest.

### 3.2 Tobit Regression Models

The WTP dependent variable was censored from above $18 and below $0 per pound. With ordinary least squares regression, the lower and upper bounds would have been treated as actual values and not limits, therefore leading to inconsistent parameter values. For this reason, the tobit model was used to estimate linear relationships among variables.

When testing the basic individual hypotheses that did not control for other variables, the results varied, as shown in Table 4.4. We found significant relationships between WTP New England niche tenderloin and purchase history, hormone usage, regional production preference, and organic certification at a level greater than $\propto = 0.05$ level. Of these independent variables, the strongest predictor was *LocalPork;* customers who have previously purchased local pork were willing to pay $5.71 more per pound as those who have not previously purchased local pork ($p \approx 0.000$). Also significant with similar coefficients were *OrgPork, LocalBeef and OrgBeef.* Purchase history had positive response findings in Grannis & Thilmany (2002). Although difficult to compare between studies due to different meat cuts and species, Grannis & Thilmany found a higher propensity to buy natural pork chops and ham by those customers who purchased natural beef in the past. Regarding production characteristics, customers with top concerns of New England production (*MoreNEProd )* and no added hormones (*NoHormones)* were willing to pay - an additional $4.64 and $2.40 per pound, respectively. While those who regard organic certification (*LessOrganic)* as a bottom concern were willing to pay $2.87 more per pound than those who did not rank that production characteristic as least important ($p$ <0.05). The other process attributes of no sub-therapeutic use of antibiotics (*MoreNoAntibiotics)* and non-GMO feed (*MoreNoGMO)* were not significant ($p$ = 0.274 and 0.372, respectively). Lastly, none of the six demographic variables were significant, either tested individually on WTP or jointly as a group comparing models with and without restrictions. Socio-economic variables such as *EatHomeAdults, EatHomeKids*, *Income,* and *YrsEd* did not significantly impact WTP outcome as found in other work, such as Grannis & Thilmany (2002), Umberger, Thilmany McFadden & Smith (2009), Dickinson & Bailey (2002). These studies surveyed customers who shop at conventional supermarkets, whereas our specialty-market sample was more homogeneous and may not have enough variation in the data to explain differences in WTP.

Integrating the results from these basic regressions and correlations with WTP, we examined a more complex model that controlled for multiple factors, as reported in Table 4.5. Additional independent variables included the purchase history for other differentiated meats, tenderloin preferences, WTP Midwestern tenderloin, personal local definitions, recognition of meat labels and retail store location. Significant variables generally focused on tenderloin preferences. In particular, participants who would be -willing to pay $12/lb for Midwestern tenderloin (*SupposePurchase)* have positive premia on WTP New England pork. Conversely, those who do not eat pork *(NoEatPork)*, are vegetarian *(Vegetarian)*, or do not like tenderloin (*NoLikeTenderloin)* have negative impacts on New England niche pork. Although there were no statistically significant process attributes, the production characteristic of being raised in New England (*MoreNEProd*) had the smallest $p$-value ($p$ = 0.060). Of these four variables, *NoEatPork* had the greatest absolute impact on WTP at negative $8.21 per pound. Looking closer at *SupposePurchase* results, the customers who valued the niche pork management style (vegetarian feed, without sub-therapeutic antibiotics or added growth hormones) and regional location of production would be willing to pay an additional $6.07 per pound for this niche New England product. Please refer to the tobit results in Tables 4.4 (uncontrolled) and 4.5 (more complex).

## 4. IMPLICATIONS and CONCLUSIONS

We designed this study to not only examine the potential retail market interest in regionally-produced meat products but also develop a better understanding of consumer knowledge of meat eco-labels. Regarding our original WTP hypotheses, we anticipated and found meat purchase history and tenderloin preferences to be strong predictors for differences in WTP New England tenderloin. We were intrigued with the process attributes results. Starting with organic certification, our findings suggest that those customers seeking regional pork are not looking for both niche attributes and organic. Organic production would require many of the production characteristics of niche meat, plus additional certified organic feed and housing space requirements. These customers may not value the organic process standards or may be skeptical of the organic label.

Related to organic preferences are the use of hormones, antibiotics and GMO feed within livestock production. Since some of our participants do not consume pork, we asked them to respond to the production characteristic questions for any livestock product that they purchase. "Raised without added hormones" was a top concern for our sample and a significant predictor of WTP. Although USDA federal regulations prohibit the use of added hormones in pork or chicken, these findings may be important for regional beef producers and aggregators who market to specialty retail grocers. Immediately following added hormones, the second most important ranked production attribute was raised without sub-therapeutic antibiotics. Although antibiotic use was an important factor in other studies (such as Grannis & Thilmany, 2002), it was not a strong predictor for differences in WTP here. Because this attribute was a top concern for most participants, we believe that the null outcome here (i.e., failure to reject $H_0$) reflects the lack of variation in our sample of specialty food market customers. Finally, we expected concern with use of GMO feed, such as transgenetic corn and soybean meal, to contribute significantly to WTP estimation. Informed by our supply chain stakeholders, GMO-free feed is a critical factor for New England producers and aggregators who market directly to consumers (such as farmer's markets or on-farm sales). Our results imply that different customer bases have different priorities. For this reason, New England producers can utilize this information to prioritize management options to meet customer preferences for specific markets. Process attributes may cost additional time or money. For instance, within New England, GMO-free feed is typically more expensive and can be difficult to source. Hence, we believe that such preference information is valuable to supply chain partners for allocating limited resources.

Reflecting upon our WTP methodology and results, we can evaluate the design and survey implementation to improve future studies as well as draw market implications. Some respondents may have been confused by asking about premia amounts rather than total price. To remedy potential confusion, enumerators were available and trained to clarify survey questions and participant interpretation. Despite possible hypothetical bias, we can examine the feasibility of introducing this niche meat product into specialty grocery stores. Looking to the strongest positive coefficient by magnitude,, we conclude that those interested in Midwest niche tenderloin are willing to pay an additional $6.07/lb for a similar niche product from New England. This $6.07 premium above the $6/lb commodity price for tenderloin is more than the $12 minimum estimated by an industry informant to successfully retail this product (Buchanan, 2013). Should industry costs reduce through scale of production or increased efficiency or consumer awareness increases through marketing outreach, it is plausible that retail niche tenderloin may be economically viable in the future. At this time, regional suppliers may instead focus retail efforts on other cuts of pork (such as lower priced chops or sausages) or different species (e.g., chicken or beef). Further exploration is needed to estimate the WTP for these other meat products, but our preliminary results from Table 4.2 provides some insight into priorities for product introduction.

Concerning eco-labeling, our findings support recent literature. The meat eco-labels that we tested do not make the market more transparent because consumers do not have sufficient knowledge (also found in van Amstel, de Brauw, Driessen, & Glasbergen, 2007). Furthermore, our participants did not understand the complexities of agricultural practices and process attributes (also reported by USDA ERS 2012). For these reasons, information asymmetry is not reduced because consumers do not know what eco-labels represent.

Our results suggest that consumers referencing meat eco-labels would benefit from information that clearly describes the practices associated with process attributes and the relationships between the certification agency and meat company or farmer. Additional outreach effort is needed to gain consumer trust of the labeling claims or certification agencies. Such trust, though, may be challenged by a range of terms and claims that are not regulated by a governmental agency, possibly leading to company misuse (Animal Welfare Approved, 2011). Confusion compounds when unapprovable claims are similar to commonly approved claims. Within the US, unapprovable claims include *naturally-raised, naturally grown, antibiotic free* and *hormone free* (USDA FSIS) while the term *humane* is currently unregulated by the USDA (USDA AMS 2015). As recommended by Thilmany, Umberger, & Smith (2009), all value chain partners have the responsibility to provide credible, transparent evidence of their labeling claims to avoid deceit. Further research and coordination are needed to develop and transmit explicit information that retail consumers can use for purchase decisions involving pubic goods.

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# Table 4.1: Descriptive Statistics

| Variable | Description | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Demographics | | | | | |
| EatHomeAdults | Number of adults eating dinner at home | 2.1 | 0.8 | 1 | 6 |
| EatHomeKids | Number of children eating dinner at home | 0.6 | 1.1 | 0 | 5 |
| Female | Equals 1 if female | 0.7 | 0.5 | | |
| Yrs_Ed | Total number of years of education | 16.7 | 1.6 | 10 | 18 |
| White | Equals 1 if white | 0.8 | 0.4 | | |
| Income | Total household income | $95,783 | $42,863 | $12,500 | $150,000 |
| Purchase History | | | | | |
| HomePorkConsump | Number of weeks per year consume pork at home | 20.4 | 21.8 | 0 | 52 |
| OrgPork | Equals 1 if purchased organic pork in the past | 0.4 | 0.5 | | |
| LocalPork | Equals 1 if purchased local pork in the past | 0.3 | 0.5 | | |
| OrgBeef | Equals 1 if purchased organic beef in the past | 0.6 | 0.5 | | |
| LocalBeef | Equals 1 if purchased local beef in the past | 0.4 | 0.5 | | |
| AgreeLocalAvail | Equals 1 if strongly agree or agree with statement | 0.3 | 0.4 | | |
| Tenderloin | Equals 1 if purchased tenderloin for home consumption | 0.5 | 0.5 | | |
| Vegetarian | Equals 1 if vegetarian | 0.1 | 0.3 | | |
| NoEatPork | Equals 1 if does not eat pork | 0.1 | 0.3 | | |
| NoCookMeat | Equals 1 if does not cook meat or know how to cook meat at home | 0.0 | 0.2 | | |
| NoLikeTenderloin | Equals 1 if does not like pork tenderloin | 0.0 | 0.2 | | |
| WTP Midwestern and New England Niche Meats | | | | | |
| SupposePurchase | Equals 1 if WTP $12/lb for Midwestern tenderloin | 0.4 | 0.5 | | |
| WTPvalue | WTP New England tenderloin | 9.5 | 6.7 | 0 | 18 |
| WTPnobuy | Equals 1 if would not purchase New England tenderloin at any price | 0.3 | 0.5 | | |
| CertaintyWTP | Equals 1 if very certain or somewhat certain in WTP decision | 0.8 | 0.4 | | |
| Local Meat Definition | | | | | |
| AgreeRaiseSlaughter | Equals 1 if strongly agree or agree with statement | 0.7 | 0.4 | | |
| LocalMA | Equals 1 if local was defined by state boundaries | 0.2 | 0.4 | | |
| LocalNE | Equals 1 if local was defined by regional boundaries | 0.6 | 0.5 | | |
| Local100 | Equals 1 if local was defined within 100 miles of farm | 0.2 | 0.4 | | |
| Meat Eco-Labeling Knowledge | | | | | |
| USDAProcesLabel | Equals 1 if specific label was recognized | 0.7 | 0.5 | | |
| AWALabel | Equals 1 if specific label was recognized | 0.2 | 0.4 | | |
| USDAOrgLabel | Equals 1 if specific label was recognized | 0.9 | 0.3 | | |
| CertHumLabel | Equals 1 if specific label was recognized | 0.3 | 0.4 | | |
| GAPLabel | Equals 1 if specific label was recognized | 0.1 | 0.3 | | |
| WrongLabel | Equals 1 if specific label was recognized | 0.1 | 0.4 | | |
| SameGuidelines | Equals 1 if labels represent same guidelines for raising animals | 0.0 | 0.2 | | |
| UnsureGuidelines | Equals 1 if unsure whether the guidelines are the same for raising animals | 0.5 | 0.5 | | |
| KnowDiffLabel | Equals 1 if guidelines were known | 0.1 | 0.3 | | |
| DontKnowProd | Equals 1 if production practices of label were not known) | 0.5 | 0.5 | | |
| DontTrust | Equals 1 if label was not trusted | 0.3 | 0.4 | | |
| DontKnowRelationship | Equals 1 if relationship between certification and farmer was not known | 0.3 | 0.5 | | |

Table 4.2: Preference for Locally-raised Meat Cuts

| Meat Cut | Preference for Local Sourcing (% of sample) |
|---|---|
| Chicken: Whole | 66 |
| Chicken: Breast | 60 |
| Beef: Ground | 58 |
| Beef: NYstrip | 41 |
| Beef: Sirloin | 41 |
| Pork: Bacon | 39 |
| Pork: Tenderloin | 34 |
| Pork: Sausage | 32 |
| Pork: Chop | 32 |
| Beef: Chuck | 32 |
| Pork: Ground | 28 |
| Pork: Shoulder | 23 |

Table 4.3: Ranking of Production Characteristics

| Most Important Attribute | Preference for Attribute (% of sample) |
|---|---|
| No added hormones | 68 |
| No subtherpuetic antibiotics | 57 |
| No tight confinement | 40 |
| Outdoor access | 40 |
| No GMO in feed | 39 |
| Raised in New England | 25 |
| Organic certification | 15 |
| Proper manure management | 14 |
| Small herd size | 12 |
| Raised in Massachusetts | 8 |
| Knowing farm name | 8 |
| Heritage breed | 4 |

Table 4.4: Uncontrolled Tobit regression results of WTP for New England Pork Tenderloin

| Variable | Coefficient | SE | *p value* | 95% CI | |
|---|---|---|---|---|---|
| Purchase History | | | | | |
| HomePorkConsump | 0.117 | 0.025 | 0.000 *** | 0.069 | 0.165 |
| OrgPork | 5.330 | 1.085 | 0.000 *** | 3.197 | 7.463 |
| LocalPork | 5.713 | 1.113 | 0.000 *** | 3.524 | 7.901 |
| OrgBeef | 4.719 | 1.094 | 0.000 *** | 2.569 | 6.869 |
| LocalBeef | 4.217 | 1.094 | 0.000 *** | 2.066 | 6.367 |
| Tenderloin Preferences | | | | | |
| SupposePurchase | 9.076 | 1.001 | 0.000 *** | 7.107 | 11.044 |
| NoEatPork | -13.396 | 1.970 | 0.000 *** | -17.271 | -9.522 |
| Vegetarian | -7.023 | 1.859 | 0.000 *** | -10.677 | -3.368 |
| NoCookMeat | 0.040 | 2.690 | 0.988 | -5.249 | 5.329 |
| NoLikeTenderloin | -7.550 | 3.209 | 0.019 ** | -13.860 | -1.240 |
| Local Preferences | | | | | |
| BeefNYstrip | 2.901 | 1.103 | 0.009 *** | 0.731 | 5.071 |
| BeefGround | 4.435 | 1.095 | 0.000 *** | 2.282 | 6.588 |
| BeefChuck | 1.711 | 1.170 | 0.144 | -0.589 | 4.010 |
| PorkGround | 4.741 | 1.177 | 0.000 *** | 2.426 | 7.056 |
| PorkSausage | 4.687 | 1.135 | 0.000 *** | 2.455 | 6.919 |
| PorkShoulder | 4.931 | 1.264 | 0.000 *** | 2.446 | 7.417 |
| PorkChop | 5.474 | 1.122 | 0.000 *** | 3.268 | 7.681 |
| PorkBacon | 5.499 | 1.081 | 0.000 *** | 3.374 | 7.624 |
| ChickenBreast | 2.600 | 1.113 | 0.020 ** | 0.410 | 4.789 |
| ChickenWhole | 4.857 | 1.147 | 0.000 *** | 2.602 | 7.112 |
| BeefSirloin | 2.755 | 1.105 | 0.013 ** | 0.581 | 4.928 |
| PorkTenderloin | 6.975 | 1.082 | 0.000 *** | 4.846 | 9.103 |
| Local Definition | | | | | |
| LocalMA | 0.857 | 1.443 | 0.553 | -1.981 | 3.694 |
| LocalNE | -0.397 | 1.118 | 0.723 | -2.595 | 1.801 |
| Local100 | -0.159 | 1.307 | 0.903 | -2.729 | 2.411 |
| Production Characteristics | | | | | |
| LessFarmName | 1.774 | 1.157 | 0.126 | -0.502 | 4.050 |
| MoreFarmName | 0.673 | 2.068 | 0.745 | -3.392 | 4.739 |
| LessNEProd | 1.403 | 1.548 | 0.365 | -1.641 | 4.448 |
| MoreNEProd | 4.645 | 1.222 | 0.000 *** | 2.242 | 7.048 |
| LessMAProd | 0.027 | 1.255 | 0.983 | -2.441 | 2.496 |
| MoreMAProd | 1.248 | 1.989 | 0.531 | -2.663 | 5.159 |
| LessNoHormones | 0.295 | 5.248 | 0.955 | -10.025 | 10.614 |
| MoreNoHormones | 2.397 | 1.175 | 0.042 ** | 0.088 | 4.707 |
| LessNoAntibiotics | 2.735 | 4.243 | 0.520 | -5.608 | 11.077 |
| MoreNoAntibiotics | 1.216 | 1.109 | 0.274 | -0.964 | 3.396 |
| LessNoGMO | 1.118 | 1.886 | 0.554 | -2.591 | 4.826 |
| MoreNoGMO | 1.005 | 1.124 | 0.372 | -1.206 | 3.216 |
| LessOrganic | 2.870 | 1.333 | 0.032 ** | 0.248 | 5.491 |
| MoreOrganic | 0.943 | 1.540 | 0.541 | -2.085 | 3.970 |
| LessManureMang | 2.855 | 1.611 | 0.077 | -0.313 | 6.022 |
| MoreManureMang | 1.649 | 1.573 | 0.295 | -1.444 | 4.741 |
| LessNoConfine | 2.394 | 2.677 | 0.372 | -2.869 | 7.657 |
| MoreNoConfine | -0.319 | 1.118 | 0.775 | -2.517 | 1.878 |
| LessOutdoors | 3.214 | 3.543 | 0.365 | -3.753 | 10.181 |
| MoreOutdoors | -0.051 | 1.121 | 0.964 | -2.255 | 2.154 |
| LessSmallHerd | 0.636 | 1.259 | 0.614 | -1.839 | 3.110 |
| MoreSmallHerd | 1.277 | 1.677 | 0.447 | -2.020 | 4.574 |
| LessHeritage | 2.186 | 1.173 | 0.063 | -0.119 | 4.492 |
| MoreHeritage | 4.309 | 2.637 | 0.103 | -0.876 | 9.495 |
| Meat Eco-labeling | | | | | |
| USDAProcessLabel | 1.210 | 1.224 | 0.324 | -1.197 | 3.616 |
| AWALabel | 2.088 | 1.486 | 0.161 | -0.834 | 5.011 |
| USDAOrgLabel | 3.067 | 1.793 | 0.088 | -0.459 | 6.593 |
| CertHumLabel | 0.945 | 1.246 | 0.449 | -1.505 | 3.396 |
| GAPLabel | 1.341 | 1.802 | 0.457 | -2.203 | 4.885 |
| WrongLabel | 1.015 | 1.540 | 0.510 | -2.013 | 4.043 |
| SameGuidelines | 0.654 | 2.990 | 0.827 | -5.227 | 6.534 |
| UnsureGuidelines | 1.428 | 1.094 | 0.193 | -0.724 | 3.579 |
| KnowDiffLabel | 1.382 | 1.698 | 0.416 | -1.958 | 4.721 |
| DontKnowProd | 0.727 | 1.102 | 0.510 | -1.439 | 2.893 |
| DontTrust | -1.407 | 1.262 | 0.265 | -3.888 | 1.074 |
| DontKnowRelationship | -0.405 | 1.174 | 0.730 | -2.714 | 1.904 |
| Demographics | | | | | |
| EatHomeAdults | 0.160 | 0.687 | 0.816 | -1.191 | 1.511 |
| EatHomeKids | 0.240 | 0.509 | 0.638 | -0.761 | 1.241 |
| Female | -1.132 | 1.156 | 0.328 | -3.405 | 1.141 |
| Yrs_Ed | -0.443 | 0.336 | 0.188 | -1.104 | 0.217 |
| White | 1.223 | 1.442 | 0.397 | -1.612 | 4.059 |
| Income | 0.000 | 0.000 | 0.156 | 0.000 | 0.000 |
| Stores | | | | | |
| Store1 | -2.212 | 1.124 | 0.050 ** | -4.423 | -0.001 |
| Store2 | 2.417 | 1.239 | 0.052 | -0.019 | 4.852 |
| Store3 | 0.232 | 1.144 | 0.839 | -2.017 | 2.482 |

Notes:
Results were estimated from uncontrolled regression models. All represent individual regression output.
Double and triple asterisks (*) denote significantly different than zero at the 5% and 1% levels, respectively.
122 left-censored observations at WTP value <= 0
236 uncensored observations
15 right-censored observations at WTP value >= 18

Table 4.5: Tobit regression model of WTP for New England Pork Tenderloin

| Variable | Coefficient | SE | *p value* | | 95% CI | |
|---|---|---|---|---|---|---|
| HomePorkConsump | 0.031 | 0.023 | 0.173 | | -0.014 | 0.075 |
| LocalPork | 1.889 | 1.256 | 0.134 | | -0.582 | 4.360 |
| OrgPork | -0.090 | 1.127 | 0.937 | | -2.307 | 2.127 |
| LocalBeef | 1.025 | 1.107 | 0.355 | | -1.152 | 3.201 |
| OrgBeef | 1.046 | 1.056 | 0.322 | | -1.030 | 3.123 |
| OrgPorkDM | 0.969 | 1.797 | 0.590 | | -2.567 | 4.504 |
| LocPorkDM | -0.561 | 1.644 | 0.733 | | -3.794 | 2.673 |
| Tenderloin | 1.141 | 1.116 | 0.307 | | -1.054 | 3.337 |
| NoEatPork | -8.211 | 1.820 | 0.000 | *** | -11.792 | -4.631 |
| NoLikeTenderloin | -7.180 | 2.666 | 0.007 | *** | -12.424 | -1.935 |
| Vegetarian | -3.635 | 1.737 | 0.037 | ** | -7.051 | -0.218 |
| SupposePurchase | 6.074 | 0.946 | 0.000 | *** | 4.213 | 7.936 |
| PorkTenderloin | 1.540 | 1.012 | 0.129 | | -0.451 | 3.531 |
| LocalMA | 0.832 | 1.396 | 0.552 | | -1.914 | 3.579 |
| LocalNE | -1.262 | 1.091 | 0.248 | | -3.407 | 0.883 |
| MoreNEProd | 1.916 | 1.017 | 0.060 | | -0.084 | 3.916 |
| MoreNoHormones | 0.453 | 0.967 | 0.640 | | -1.449 | 2.354 |
| LessOrganic | 1.506 | 1.101 | 0.172 | | -0.659 | 3.672 |
| MoreOrganic | 0.675 | 1.270 | 0.595 | | -1.823 | 3.173 |
| USDAOrgLabel | 1.610 | 1.533 | 0.294 | | -1.405 | 4.626 |
| USDAProcessLabel | -1.474 | 1.030 | 0.153 | | -3.499 | 0.551 |
| AWALabel | 1.784 | 1.254 | 0.156 | | -0.682 | 4.250 |
| CertHumLabel | -0.573 | 1.059 | 0.589 | | -2.655 | 1.509 |
| GAPLabel | 1.041 | 1.507 | 0.490 | | -1.923 | 4.005 |
| Store1 | -1.483 | 1.113 | 0.183 | | -3.671 | 0.705 |
| Store3 | 0.052 | 1.150 | 0.964 | | -2.210 | 2.314 |
| Constant | 2.850 | 2.196 | 0.195 | | -1.470 | 7.169 |

Notes:

Double and triple asterisks (*) denote significantly different than zero at the 5% and 1% levels, respectively.

122 left-censored observations at WTP value <= 0

236 uncensored observations

15 right-censored observations at WTP value >= 18

Figure 4.1: WTP Payment Card

| **Pork tenderloin raised in the Midwest costs $12.00/pound** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Additional cost premium per pound of LOCAL pork tenderloin -->** | **$0** | **$0.50** | **$1** | **$1.50** | **$2** | **$3** | **$4** | **$5** | **$6** | **Would NOT purchase** |
| Reasonable to pay this amount | | | | | | | | | | |

Figure 4.2: Meat Eco-labels


Labels (clockwise from top left):

1. USDA Process Verified obtained from website http://www.ams.usda.gov/AMSv1.0/processverified [accessed February 16, 2014].

2. Animal Welfare Approved obtained from website http://animalwelfareapproved.org [verified August 18, 2015].

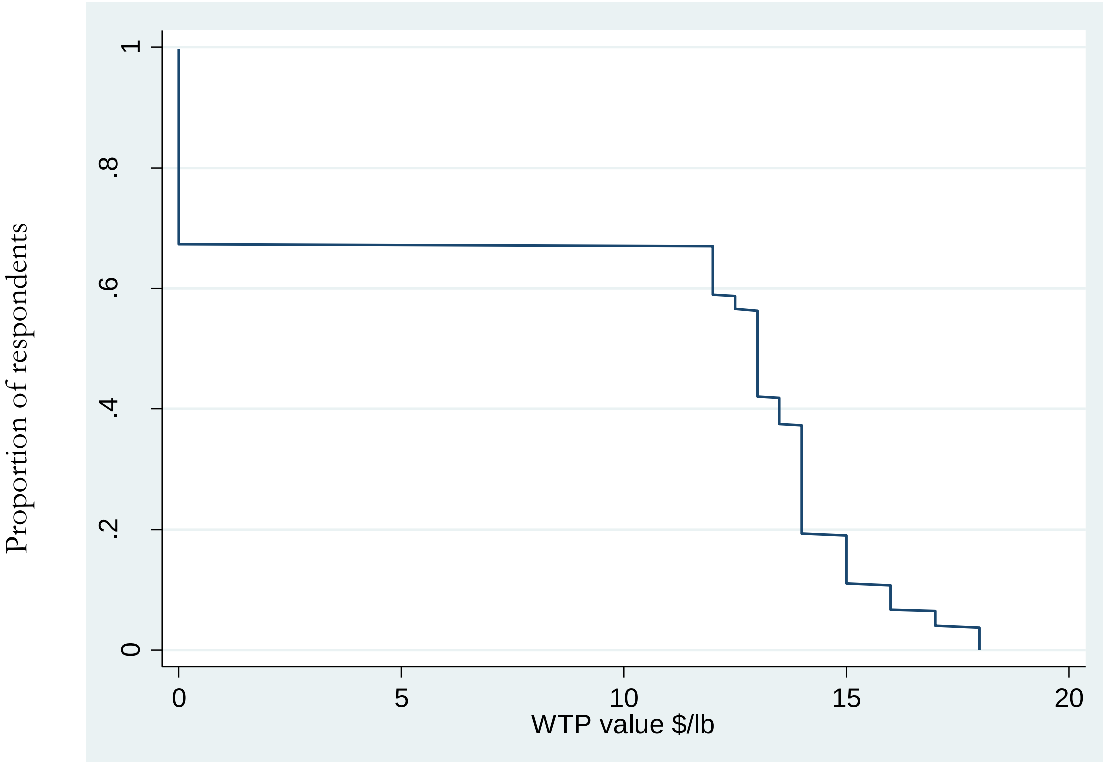
3. Certified Humane obtained from website http://certifiedhumane.org [verified August 18, 2015].

4. Cage-Free Meat Certified created by authors for the purpose of this study

5. Global Animal Partnership obtained from website www.globalanimalpartnership.org [verified August 18, 2015].

6. USDA Organic obtained from website www.usda.gov/wps/portal/usda/usdahome?navid=organic-agriculture [verified August 18, 2015]

Figure 4.3: Implied Demand Curve for New England Pork Tenderloin




Notes:

x axis represents respondents' WTP value ($/lb)

y axis represents the proportion of respondents who would be willing to pay that amount or less per pound of niche pork tenderloin

# APPENDIX

The survey instrument

## Meat Consumer Survey

**Directions:**
**PLEASE ANSWER ALL QUESTIONS TO THE BEST OF YOUR KNOWLEDGE.** Feel free to ask us any questions that you may have. Thank you for your time.

1. How often does your family consume pork (*such as pork tenderloin, chops, bacon, roast or ground pork*) at home? *Please circle your answer*

   **Never** **Once a year** **Once a month** **Once a week** **Other:** ___________

2. In the past, have you ever purchased any of the following? If yes, where did you *last purchase* the meat?

Organic pork: **YES** **NO**........................ Location: ____________________
Local pork: **YES** **NO**........................ Location: ____________________

Organic beef : **YES** **NO**........................ Location: ____________________
Local beef: **YES** **NO**........................ Location: ____________________

3. Do you agree with this statement? *Mark the circle that best represents your opinion.*

   ***Locally-raised meat is readily available for purchase at the grocery store where you most regularly shop.***

   ○ strongly agree ○ agree ○ neutral ○ disagree ○ strongly disagree

4. Do you ever buy pork tenderloin for home consumption? **YES** **NO** *Circle your answer*

   *If yes, please go to the next question.* If no, why not? ______________________________

5. Now, suppose you are considering purchasing boneless pork tenderloin that is **raised in the Midwest** on vegetarian feed with no sub-therapeutic antibiotics or growth hormones. The cost for this pork in the Metro-Boston area is $12/lb.

   Would you be willing to pay $12/lb for this meat? **YES** **NO** *Circle your answer*

6. Compared to the average price ($12/lb), how much of a premium would you pay for a similar pork tenderloin product that was **raised in New England** on vegetarian feed with no sub-therapeutic antibiotics or growth hormones. The ONLY difference between the two products is the location WHERE the animals were raised.

   *Keep in mind that people often overstate their amount willing to pay because they are not actually buying the product. For this reason, please respond truthfully, as if you are buying the pork tenderloin.*

| **Pork tenderloin raised in the Midwest costs $12.00/pound** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Additional cost premium per pound of LOCAL pork tenderloin –>** | **$0** | **$0.50** | **$1** | **$1.50** | **$2** | **$3** | **$4** | **$5** | **$6** | **Would NOT purchase** |
| Reasonable to pay this amount | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

How certain are you of your answer above? *Please mark the circle*

○ very certain ○ somewhat certain ○ not certain

7. What cuts of meat would you prefer come from a more **LOCAL source**, knowing it may cost more?
*Please circle all that apply*

| | | | |
|---|---|---|---|
| beef NY strip | ground beef | pork tenderloin | pork bacon |
| beef top sirloin | ground pork | pork chop | whole chicken |
| beef chuck roast | pork sausage | pork shoulder roast | boneless chicken breast |

8. Do you agree with this statement?
***Locally-raised meat means that the animals were raised from birth through slaughter in the local area.***

*Mark the circle that best represents your opinion.*

◯ strongly agree ◯ agree ◯ neutral ◯ disagree ◯ strongly disagree

9. How would you define "local" meat?

◯ Raised within Massachusetts
◯ Raised within New England region
◯ Raised within 100 miles
◯ Other: ______________________________

10. If you were to buy FRESH (not frozen) local meat, what is its shelf life? *In other words, how long will it safely last in your home's refrigerator?*

◯ 1 to 3 days ◯ 7 to 9 days
◯ 4 to 6 days ◯ 10 days or more

11. What does "natural meat" mean to you? or how would you define "natural meat"?

______________________________

12. For this question, think about a pig farm that produces the meat you consume. In order to align with YOUR priorities and values, which production practices should they focus on? **Please circle the 3 characteristics as MOST IMPORTANT to you.**
*Ask us if you want explanations or need clarification for any of these items! Please identify your priorities even if you don't eat pork!*

| | |
|---|---|
| ***Knowing the farm's name that raised the pork*** | ***Certified organic pig farm*** |
| ***Regionally-produced in New England*** | ***Proper management of manure*** |
| ***Locally-produced in Massachusetts*** | ***No tight confinement (no crates)*** |
| ***No use of growth hormones*** | ***Raised with access to the outdoors*** |
| ***No use of sub-therapeutic antibiotics*** | ***Small herd size (small to mid-size farm)*** |
| ***No genetically-modified (GMO) feed*** | ***Heritage breed of pig*** |

Now, please circle the 3 characteristics as **LEAST IMPORTANT** to you:
*Ask us if you want explanations or need clarification for any of these items! Please identify your priorities even if you don't eat pork!*

| | |
|---|---|
| ***Knowing the farm's name that raised the pork*** | ***Certified organic pig farm*** |
| ***Regionally-produced in New England*** | ***Proper management of manure*** |
| ***Locally-produced in Massachusetts*** | ***No tight confinement (no crates)*** |
| ***No use of growth hormones*** | ***Raised with access to the outdoors*** |
| ***No use of sub-therapeutic antibiotics*** | ***Small herd size (small to mid-size farm)*** |
| ***No genetically-modified (GMO) feed*** | ***Heritage breed of pig*** |

13. Please look at the following labels and indicate whether you recognize the label on a meat product.

| | | |
|---|---|---|
| ◯ Yes, I have seen this label | ◯ Yes, I have seen this label | ◯ Yes, I have seen this label |
| ◯ No | ◯ No | ◯ No |
| ◯ Yes, I have seen this label | ◯ Yes, I have seen this label | ◯ Yes, I have seen this label |
| ◯ No | ◯ No | ◯ No |

14. Do these labels represent the same guidelines for raising animals? **YES NO UNSURE** *Circle your answer*

15. Do you know what each of these labels (below) means? *In other words, do you know the differences between these labels?*

**YES NO** *Circle your answer*

16. If no, what about the above labels is confusing? *Check all that apply*

- ◯ I don't know what the labels represent with regard to animal agriculture
- ◯ I don't trust the label (could be misleading/dishonest)
- ◯ I don't understand the relationship between the label (certification) and the meat company/farmer
- ◯ Other: ______________________________

17. Typically, how many people eat dinner together in your home? _____# of adults _______# of children

18. What is your gender? *please circle* FEMALE MALE OTHER

19. What is the highest level of education that you have completed? *please check appropriate circle*

| | | |
|---|---|---|
| ◯ primary school | ◯ high school degree/GED | ◯ undergraduate degree |
| ◯ some high school | ◯ some undergraduate college | ◯ graduate degree |

20. What is your total household income? *please check appropriate circle*

| | | |
|---|---|---|
| ◯ Less than \$25,000 | ◯ \$50,001 to 75,000 | ◯ \$100,001 to \$150,000 |
| ◯ \$25,000 to \$50,000 | ◯ \$75,001 to \$100,000 | ◯ More than \$150,000 |

21. What is your race? *please check the most-appropriate circle for which you self-identify*

- ◯ Asian
- ◯ Black or African American
- ◯ Hispanic, Latino or Spanish origin
- ◯ Native American (American Indian)
- ◯ Pacific Islander or Hawaiian
- ◯ White or European American
- ◯ Some other race: ____________

You have reached the end of this survey.

***THANK YOU for your PARTICIPATION, KNOWLEDGE, and TIME!***

*Please return completed survey to Jamie Picardy or Emily Nixon before you leave the grocery store.*

*If you would like to receive project results and register for the raffle,*
*please clearly PRINT your email address here:* ____________________

*If you have any other feedback for Jamie, please add here:*

______________________________

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# CHAPTER 5: Conclusion

## Summary and integration

This study highlighted the potential of alternative methods to raise swine and market pork products. Looking at the production side of the value chain, the performance results suggest that niche pork productivity can be close to conventional pork. With continual improvements to litter size and weaning survival, the number of finished gilts and barrows in niche systems could possibly match conventional output. Converting from conventional to niche pork production would require additional land resources while current barriers would need to be mitigated. Interestingly, the most common set of barriers, access and affordability of inputs and credit, impedes both niche and conventional production. Instead of pitting one management style against another, perhaps collaboration among livestock farmers could find common solutions to reduce hurdles to their operational success. Establishing such partnerships along the value chain would benefit the growing consumer demand of differentiated meat products. Furthermore, creating retail opportunities beyond direct marketing may attract new farmers and consumers. Such additional supply and demand may synergistically lead to production innovations that further reduce the yield gap between niche and conventional pork. Niche production can offer economic diversification with possibly lower capital entry for smaller scale operations. Additional benefits, some of which are public goods, extend beyond the farm gate to include heritage breed conservation and consumer education. Yet, success is not guaranteed as producers must overcome various challenges in order to build and sustain their niche meat operations.

Results from this study may prove helpful to those looking to produce and supply niche meat products in four ways. First, regional farmers will know which production characteristics are most important to the specialty retail market sector of Boston. Such information may influence or prioritize on-farm management decisions for meeting this demand. Second, performance metric results can provide an opportunity for niche farmers to examine their own production and compare their farm performance with alternative and conventional averages. Third, aggregators can utilize the WTP estimation and favored meat cuts in viability determination. Since regional niche pork is currently not available in retail stores, this information could be helpful for developing a marketing plan beyond direct marketing. Fourth, participating stores will have access to data collected from their individual locations. This data include price premia, favored meat cuts and production characteristics, gaps in meat eco-labels, and demographics. Store managers could apply this information for offering new products based on participatory feedback or for educating their customers on the process characteristics specific to differentiated meat products. At this time, I plan to disseminate the study's findings to producers and niche swine cooperatives who have participated in the study. Likewise, I anticipate presenting an abbreviated form of Parts 1 and 2 at the 2016 New England Meat Conference, which is co-organized by one member of the technical team. For Part 3, I will share both store-specific and general results of consumer responses to the three managers who allowed us to gather data in their specialty retail stores.

When integrating the three studies of this dissertation, an intrinsic meaning of the "niche" eco-label emerges. Such an identity is formed by the producers and consumers who were asked to define or rank production characteristics important for differentiated meat products. Both consumers and producers indentified the same four top attributes for niche livestock: no added hormones; no tight confinement; no sub-therapeutic antibiotics; and access to the outdoors. Also finding common ground was the option for organic certification. This attribute ranked low for both groups, supported by 12% of producers and

15% of consumers. For farmers, organic certification was least important for inclusion into a niche label. Disparate attributes included small herd size and heritage breeds; both of which were more important to the producers than the consumers. Although not offered as options for the producers, the attributes that contribute to a narrative for small family farms were not valued by the consumers of this study. Given our hyper-local culture, it is surprising that consumers placed the characteristics of knowing the farm name and being raised within the state boundaries near the bottom of their list.

These findings collectively suggest that an intermediate label, which would contain commonly-preferred characteristics and fall between certified organic and conventional commodity products, could be viable. These process claims, however, are already defined and audited by third party certifiers such as Animal Welfare Approved (AWA). Despite interest in these production methods, the consumers of this study did not recognize the established AWA label and others. At this time with reasons highlighted above, producers and meat aggregators may benefit from explicitly stating USDA FSIS-approved animal production claims on their meat label. Such marketing, if honest and transparent, would reduce information asymmetry experienced by the consumer. Challenges associated with a FSIS review process for these claims and space competition on the relatively small label must be balanced by economic benefits for incorporating consumer outreach on the label to market niche meat.

**Acknowledgements and reflection**

This dissertation project was made possible by the guidance and training provided by my committee members Drs. Christian Peters, Barbara Parmenter, Sean Cash and Tim Griffin. They all were active participants in the project, from formulating the research

questions to applying appropriate methods and interpreting the data analyses. They also reviewed numerous grant and job applications on my behalf. I sincerely appreciate their support and expertise. Starting with the committee chair, Dr. Peters has been my professor and major research advisor for the past 5 years. During this time, he taught me his *foodprint* and *foodshed* models, which provided the foundation for this project. Dr. Parmenter has been a key advisor for primary data collection for Part 1 given her previous experience engaging stakeholders and serving on technical teams; as a non-agriculturalist, Dr. Parmenter also provided critical feedback on finished articles in order to reach a larger audience. Dr. Griffin provided mentoring in Parts 1 and 2 through network connections, survey design and implementation, modeling, analysis and publishing. Dr. Cash served as the expert advisor for Part 3; as an agricultural economist who studies consumer behavior, Dr. Cash taught me the necessary econometric methodology for Part 3. He also provided crucial structure and guidance for the NAREA presentation.

To implement the research, I formed a technical team to assist with several key areas of the project that would benefit from their knowledge, connections and experience working in alternative agriculture and marketing. First, the team provided necessary networking opportunities to recruit participants for primary data collection in Parts 1 and 3. Technical team members also offered helpful feedback of the survey instruments. In fact, several of the questions were either initiated or greatly improved by these experts. The technical team included farmers, aggregators, slaughter/processing, retailers, extension agents and academic researchers. Their individual contributions were acknowledged in each of the three parts (please refer to Chapters 2, 3 and 4).

Reflecting upon the complete dissertation process, I am pleased with this project's potential contribution to the niche meat community. Although niche tenderloin may not be one of the first New England pork products in Metro-Boston stores, I believe that regional aggregators and specialty retail grocers will benefit from the list of consumer favored meat cuts for determining new product viability. When I originally designed this study with my dissertation committee, I had three main goals for the project: (1) to analyze more than one component within a food system and utilize my AFE curriculum preparation; (2) to build upon my *foodprint* assistantship with my advisor, Dr. Peters; and (3) to continue learning geospatial analyses. The intention of these three goals were not only for the immediate doctoral program, but also for contribution to my pre-existing career in education and outreach.

Within this dissertation project, I directly met two of my three personal goals. Regarding the first goal, I examined the supply (pork production) and demand (retail consumers) within one alternative food system (niche meat). I applied classroom lessons of data collection and analysis, which were learned from Survey Research Methods and Multivariate Regression courses, for exploring actual issues in our New England community. Perhaps the most challenging aspect of this project pertained to data cleaning and statistical analyses for Parts 1 and 3. In the past, I either used pre-processed secondary data or performed basic summary statistics or geospatial analyses on my primary data. However, this project offered the opportunity to apply all major aspects of the research process: data collection, cleaning, analyzing, summarizing, and presenting. There have been only two other times in my academic career where I initiated and executed the entire process, those being my swine biofilter design-build Engineering Capstone and Master's thesis in Geography, in which I worked with organic farmers, retail supermarkets and community farm participants to answer how distance impacts involvement in the local agriculture movement.

Pertaining to the second goal, this dissertation aligned well with my previous work for my major advisor, Dr. Chris Peters. For nearly four years as his research assistant, I learned his methodology for analyzing *foodprints* and *foodsheds*. Together, we created bio-physical and geospatial models to calculate the land required to produce food that meets the nutritional needs of a given population. Through this training experience, I extended Dr. Peters' methodology into an alternative livestock system while incorporating a portion of my original swine model and related parameters developed for his *foodprint* project. Furthermore, the land requirement calculations for this project broadened beyond feed needs to include housing and space allocation, not previously modeled in *foodprint*.

The third project goal was achieved through an unexpected opportunity presented during my doctoral program. Originally proposed as the final paper for the dissertation, the geospatial suitability modeling was extremely optimistic on my part. Working with my committee, we decided that the producer part of the dissertation was better represented as two analyses, performance metrics and land requirements. Thus, the suitability analysis was removed from the dissertation. Nevertheless, I was able to practice geographic information systems (GIS) through a unique teaching-preparation program offered at Tufts and initiated by one of my committee members, Dr. Parmenter. Although not part of my original curriculum plan, it was fortuitous that I was accepted into Tufts Graduate Institute For Teaching (GIFT) program. Mentoring under Dr. Parmenter as part of GIFT, I designed GIS assignments, delivered lecture presentations, and led hands-on laboratory activities thereby continuing practice of GIS.

Taking into consideration the past five years at Tufts, perhaps this GIFT experience may be most applicable to my career goal of returning to academic teaching and curriculum development. In terms of my career, I believe that previous work experiences contributed to

the success of this multi-disciplinary project. Whether it was engaging community stakeholders, collecting data via surveys, applying for grants, or forming advisory teams, employment at the Florida Department of Transportation, Maryland Agricultural Education Foundation, Community College of Philadelphia, and three farms in Michigan provided an excellent foundation to develop and fulfill the goals of this dissertation project. I sincerely appreciate the mentoring provided by my dissertation committee, technical team, and previous employers for the support and guidance to complete the AFE doctoral program and return to my career in education and community outreach. Finally, I am grateful for the financial funding provided by Annie's Pasta and Tufts University (Friedman School of Nutrition Science and Policy, Tufts Institute of the Environment, and the Graduate Institute for Teaching), and support provided by my husband (Will Tilton) my parents (Pat and Chuck Picardy), family (Tom and Lea Picardy, Laurie and Tom Tilton, and aunts), close friends and colleagues. Thank you.

## Outreach Materials

## Part 1: Performance, Benefits/Barriers, Niche Labeling

Research questions:

- *What are the performance metrics of niche pork and how do they compare to conventional pork?*
- *What are the reasons for producers of niche pork to participate in this value chain?*
- *What production characteristics should be included under the "niche" term?*

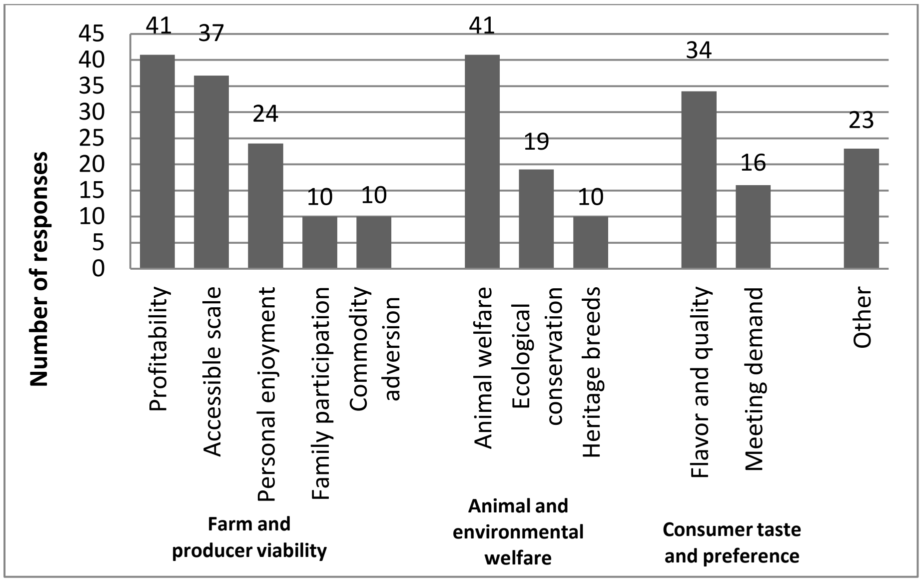
Methods:

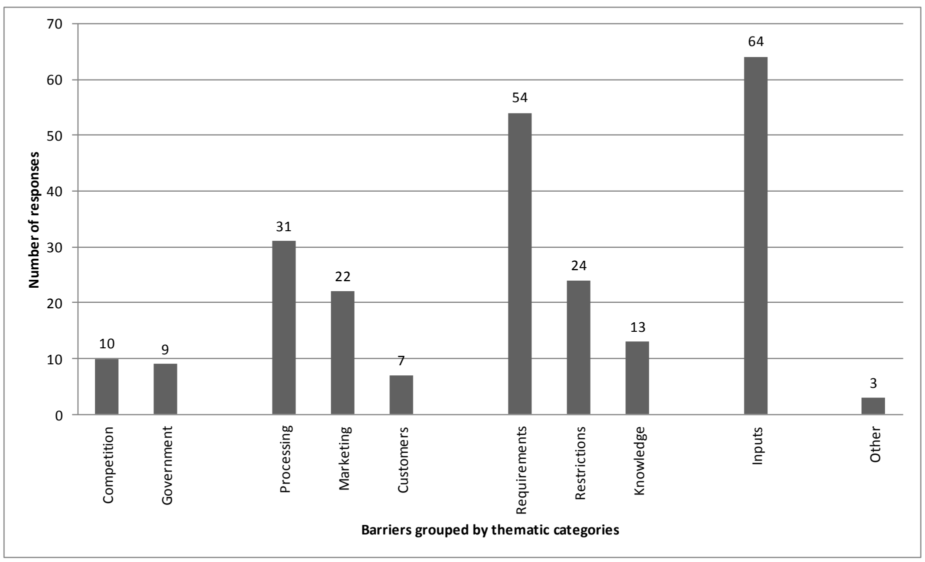
- Primary data collection with 176 self-identified producers (111 usable surveys)
- Quantitative data first cleaned and then analyzed for outliers and representative averages
- Qualitative responses were first coded to develop common themes, then formed larger categories (thematic coding)

Results:

| Parameter | Units | Conventional System | Niche System | Sample Size | Standard Error | One-Sample *t*-Test |
|---|---|---|---|---|---|---|
| Reproduction | | | | | | |
| Breeding ratio | boar sow$^{-1}$ | 0.11 | 0.16 | 44 | 0.01 | 4.4 * |
| Annual average parities | birth cycles sow$^{-1}$ year$^{-1}$ | 2.20 | 1.97 | 69 | 0.02 | -10.5 * |
| Litter size | live piglets born sow$^{-1}$ | 10.30 | 9.74 | 68 | 0.20 | -2.9 * |
| Herd management | | | | | | |
| Cull breeding sows | age, number of years | 2.6 | 4.4 | 29 | 0.32 | 5.6 * |
| Cull breeding boars | age, number of years | 2.8 | 4.2 | 29 | 0.32 | 4.6 * |
| Cull finishing gilts and barrows | % in life phase | 3.0 | 2.1 | 88 | 0.00 | -241.9 * |
| Mortality | | | | | | |
| Mortality sows | % year$^{-1}$ | 8.18 | 1.02 | 50 | 0.23 | -31.1 * |
| Morality pre-weaned piglets | % in life phase | 0.10 | 0.14 | 67 | 0.01 | 3.7 * |
| Mortality nursery piglets | % in life phase | 0.04 | *NA* | | | |
| Mortality finishing gilts and barrows | % in life phase | 0.04 | 0.02 | 94 | 0.00 | -8.8 * |
| Age and size by life phase | | | | | | |
| Piglets age at weaning | days | 20.8 | 49.1 | 66 | 1.36 | 20.8 * |
| Piglets weight at weaning | kg | 6.8 | 15.8 | 54 | 0.93 | 9.7 * |
| Finishing age to market | months | 6.6 | 7.2 | 97 | 0.18 | 3.2 * |
| Finishing liveweight | kg | 129.7 | 124.2 | 99 | 1.78 | -3.1 * |
| Gilt age at first breeding | months | 7.5 | 9.4 | 67 | 0.28 | 6.9 * |

*Note: * indicates 95% confidence level for one-sample test of means*




| Attribute | Voting % |
|---|---|
| No Hormones | 87 |
| Outdoor Access | 73 |
| No Tight Confinement | 69 |
| No Sub-therapeutic Antiobiotics | 65 |
| NeverEver Antiobiotics | 60 |
| Grazed Forage in Diet | 54 |
| Locally-sourced Feed | 45 |
| Small Herd Size | 45 |
| Proper Manure Management | 44 |
| Heritage Breeds | 43 |
| Non-GMO Feed | 37 |
| Alternative Marketing | 22 |
| Organic Certification | 12 |
| | |
| Number of respondents | 89 |

**Part 2: Land Requirements & Output**

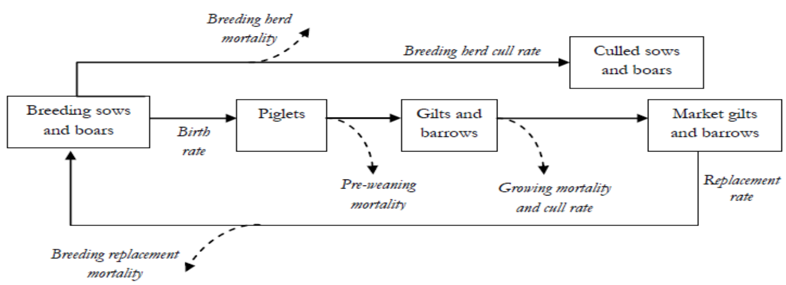
Research questions:

- *What are the land requirements of producing niche pork and how do they compare to conventional pork?*
- *What are the target meat outputs and feed conversions for niche and conventional pork?*

Methods:

- Calculations determined (1) **life phase throughput**, (2) **feed & cropland requirements**, (3) **living space requirements**, (4) **total land requirements**, and (5) **meat output**
- Comparative analysis was modeled using measurements from Part 1 specific to each system
- All major life phases were considered, based on previous experiences working for my advisor Dr. Christian Peters

Results:




| Number of animals | Conventional System | Niche System |
|---|---|---|
| Pre-weaned Piglets Life Phase | | |
| Bred Sow | 1.00 | 1.00 |
| Piglets born alive | 10.30 | 9.74 |
| End of phase pre-weaned piglets | 9.30 | 8.35 |
| Nursery Life Phase | | |
| End of phase nursery piglets | 8.97 | 8.35 |
| Growing and Finishing Life Phase | | |
| Culled gilts and barrows | 0.27 | 0.17 |
| Mortality gilts and barrows | 0.37 | 0.16 |
| End of phase market gilts and barrows | 8.33 | 8.01 |
| Female Breeding Replacements | | |
| Culled breeding sow | 0.23 | 0.14 |
| Mortality breeding sow | 0.04 | 0.01 |
| Mortality replacement gilts | 0.0019 | 0.0002 |
| Total sow replacements | 0.27 | 0.15 |
| Male Breeding Replacements | | |
| Culled breeding boar | 0.02 | 0.02 |
| Mortality breeding boar | 0.0043 | 0.0002 |
| Mortality replacement barrow | 0.0002 | 0.0000 |
| Total boar replacements | 0.03 | 0.02 |
| Pigs for Target or Cull Market | | |
| Finishing gilts and barrows | 8.03 | 7.84 |
| Culled original breeding sow | 0.23 | 0.14 |
| Culled orignal breeding boar | 0.0077 | 0.0048 |

# Meat output

| | As-fed corn | As-fed SBM | As-fed dried whey | As-fed dried alfalfa hay | Grazed alfalfa pasture | Total feed |
|---|---|---|---|---|---|---|
| | kg sow$^{-1}$ year$^{-1}$ | | | | | |
| Conventional Confined Environment | 6,147 | 1,287 | 17 | 0 | 0 | 7,452 |
| Niche Enhanced Environment | 5,872 | 1,216 | 0 | 1,477 | 0 | 8,564 |
| Niche Outdoor Environment | 5,642 | 1,412 | 0 | 749 | 1,652 | 9,455 |

| | Total edible meat for target market | Total Feed Conversion |
|---|---|---|
| | kg sow$^{-1}$ year$^{-1}$ | kg feed (kg edible meat)$^{-1}$ |
| Conventional Confined Environment | 1,210 | 6.2 |
| Niche Enhanced Environment | 898 | 9.5 |
| Niche Outdoor Environment | 898 | 10.5 |

***Annually, conventional is 35% to 41 % more efficient than niche at feed conversion.***

# Land needs

| | Breeding sow | Gestating sow | Lactacting sow with litter* | Weaned piglets | Growing and finishing hogs | Breeding boar | Total housing space |
|---|---|---|---|---|---|---|---|
| | m$^2$ | | | | | | |
| Conventional Confined Environment | 1.7 | 1.4 | 3.3 | 2.5 | 7.0 | 0.5 | 16.3 |
| Niche Enhanced Environment | 5.6 | 5.6 | 7.4 | 13.7 | 16.3 | 1.6 | 50.3 |
| Niche Outdoor Environment | 149.5 | 699.8 | 306.9 | 410.4 | 1,655.3 | 121.0 | 3,342.9 |
| | number of animals averaged across life phase | | | | | | |
| Conventional System | 1.0 | 1.0 | 11.3 | 9.1 | 8.6 | 0.1 | |
| Niche System | 1.0 | 1.0 | 10.7 | 8.2 | 8.2 | 0.2 | |

* Living space for this life phase includes the sow and her piglets born alive

| | Corn | SBM | Dried whey* | Dried alfalfa hay | Alfalfa pasture | Total feed needs | Living space | Pasture adjustments | Total land requirements |
|---|---|---|---|---|---|---|---|---|---|
| | hectare sow$^{-1}$ year$^{-1}$ | | | | | | | | |
| Conventional Confined Environment | 0.71 | 0.14 | 0 | 0 | 0 | 0.85 | 0.00 | 0 | 0.85 |
| Niche Enhanced Environment | 0.67 | 0.13 | 0 | 0.18 | 0 | 0.99 | 0.01 | 0 | 1.00 |
| Niche Outdoor Environment | 0.65 | 0.14 | 0 | 0.09 | 0.21 | 1.10 | 0.33 | 0.21 | 1.22 |

*Dried whey is a co-product of the dairy industry; thus, no additional land is needed

***Niche enhanced & outdoor environments have 17% to 44% greater total land requirements than conventional***

## Part 3: Consumer Preferences and Knowledge

Research questions:

- *What types of meat would retail consumers prefer local over conventional source?*
- *For customers interested in niche pork, what are they willing to pay for a niche New England product?*
- *Which animal husbandry practices (process-only attributes) are most important to retail customers?*

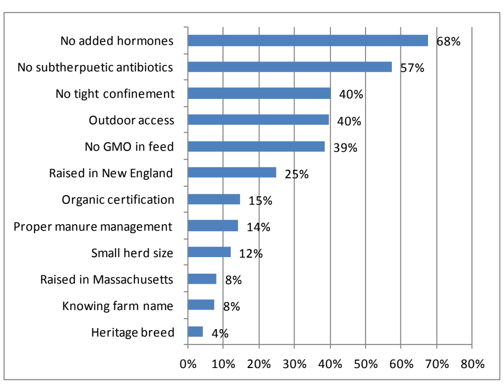
Methods:

- primary data were collected from 388 specialty retail customers (373 usable surveys)
- WTP elicited using stated preference contingent valuation methodology and estimated using tobit regression

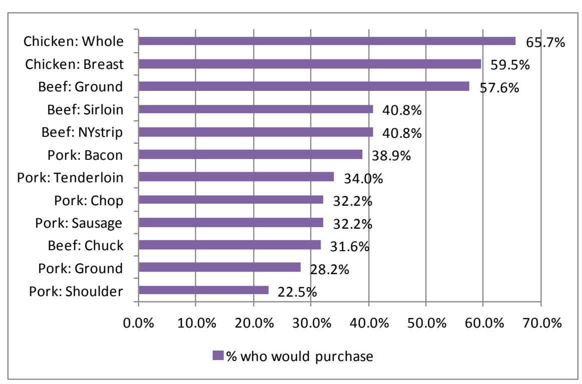
Results:

| Demographic Variables | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|
| Adults eating at home | 2.1 | 0.8 | 1 | 6 |
| Children eating at home | 0.6 | 1.1 | 0 | 5 |
| Female (dummy 1 = female) | 0.7 | | | |
| Total years of education | 16.7 | 1.6 | 10 | 18 |
| White (dummy 1 = white) | 0.8 | | | |
| Income | $95,783 | $42,863 | $12,500 | $150,000 |

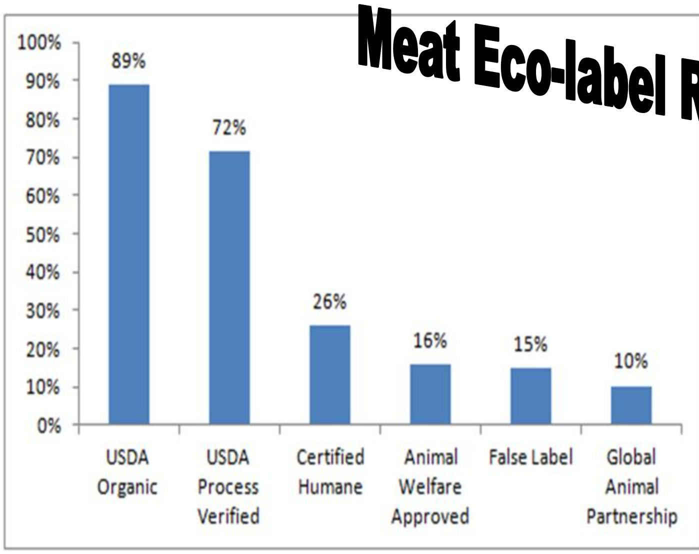
Top preferences for production characteristics




Top cuts -- Willing to pay more for locally-raised



# Meat Eco-label Recognition




Tobit regression

Number of obs = 373
LR chi2(26) = 182.67
Prob > chi2 = 0.0000
Log likelihood = -927.50001
Pseudo R2 = 0.0896

| WTPvalue | Coef. | Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| HomePorkConsump | .0308365 | .0226043 | 1.36 | 0.173 | -.0136222 | .0752953 |
| LocalPork | 1.889358 | 1.256358 | 1.50 | 0.134 | -.581677 | 4.360393 |
| OrgPork | -.0896941 | 1.127286 | -0.08 | 0.937 | -2.306867 | 2.127479 |
| LocalBeef | 1.024607 | 1.106576 | 0.93 | 0.355 | -1.151834 | 3.201048 |
| OrgBeef | 1.046478 | 1.056004 | 0.99 | 0.322 | -1.030496 | 3.123453 |
| OrgPorkDM | .9685395 | 1.797414 | 0.54 | 0.590 | -2.566657 | 4.503736 |
| LocPorkDM | -.5605537 | 1.643999 | -0.34 | 0.733 | -3.794011 | 2.672904 |
| Tenderloin | 1.141403 | 1.116373 | 1.02 | 0.307 | -1.054306 | 3.337113 |
| NoEatPork | -8.211346 | 1.820273 | -4.51 | 0.000 | -11.7915 | -4.631189 |
| NoLikeTenderloin | -7.179516 | 2.666369 | -2.69 | 0.007 | -12.4238 | -1.935236 |
| Vegetarian | -3.634522 | 1.737251 | -2.09 | 0.037 | -7.051389 | -.2176538 |
| SupposePurchase | 6.074303 | .9464758 | 6.42 | 0.000 | 4.212752 | 7.935854 |
| PorkTenderloin | 1.540118 | 1.012406 | 1.52 | 0.129 | -.4511059 | 3.531342 |
| LocalMA | .8320561 | 1.396404 | 0.60 | 0.552 | -1.914424 | 3.578537 |
| LocalNE | -1.262052 | 1.090612 | -1.16 | 0.248 | -3.407094 | .8829897 |
| MoreNEProd | 1.916178 | 1.016821 | 1.88 | 0.060 | -.0837291 | 3.916085 |
| MoreNoHormones | .4525356 | .9665986 | 0.47 | 0.640 | -1.448594 | 2.353665 |
| LessOrganic | 1.506491 | 1.100831 | 1.37 | 0.172 | -.65865 | 3.671632 |
| MoreOrganic | .675118 | 1.269995 | 0.53 | 0.595 | -1.822739 | 3.172975 |
| USDAOrgLabel | 1.610349 | 1.533299 | 1.05 | 0.294 | -1.405381 | 4.626079 |
| USDAProcessLabel | -1.473815 | 1.029517 | -1.43 | 0.153 | -3.498694 | .5510644 |
| AWALabel | 1.783605 | 1.253749 | 1.42 | 0.156 | -.6822982 | 4.249508 |
| CertHumLabel | -.5728537 | 1.058661 | -0.54 | 0.589 | -2.655054 | 1.509347 |
| GAPLabel | 1.041277 | 1.507056 | 0.69 | 0.490 | -1.922836 | 4.00539 |
| Store1 | -1.48306 | 1.112507 | -1.33 | 0.183 | -3.671165 | .7050456 |
| Store3 | .0519516 | 1.150122 | 0.05 | 0.964 | -2.210136 | 2.314039 |
| _cons | 2.849838 | 2.19611 | 1.30 | 0.195 | -1.469523 | 7.1692 |
| /sigma | 7.652249 | .3910932 | | | 6.883038 | 8.421461 |

Obs. summary: 122 left-censored observations at WTPvalue<=0
236 uncensored observations
15 right-censored observations at WTPvalue>=18

Significant factors ($p<0.05$)

- Positive impact on WTP
  - WTP $12/lb Midwest niche tenderloin
- Negative impact on WTP
  - don't eat pork, vegetarian or don't like tenderloin

Implications

Those interested in Midwest niche tenderloin are WTP an additional $6.07/lb for a similar regional niche product. This $6.07 premium above $6/lb commodity price is > $12 minimum estimated to successfully retail this product!