SARE # LS11-246, Saving Endangered Hog Breeds

Final Report

Summary

Rare breeds of pigs are a vital part of our agricultural resource and serve as a genetic reservoir for regional adaptations, biological fitness, maternal skills, foraging ability, lard production, and disease resistance. These fitness traits make heritage breed pigs a good choice for sustainable farms and pastured pork production, but at the outset of this project there was little information in the literature on the heritage breeds in North America or their pork. This project has extended our understanding of the current genetic status of heritage breeds, provided data on their growth and carcass characteristics, and yielded education and marketing tools for the benefit of farmers and breeders. This wholistic approach examines multiple issues important to successful pasture-based, independent, market-driven swine production and conservation. These results demonstrate how heritage pork production can be an economically viable enterprise for small and mid-scale farmers, whose success will increase endangered breed swine populations to that they are numerically and genetically secure.

Introduction

About half of the swine breeds that existed at the beginning of the 20th century had disappeared by its conclusion. Two major changes impacted these breeds. The first was consolidation of agriculture into fewer larger farms. Indeed, by the 1990's the pork industry was almost entirely vertically integrated, controlled by large producers who contract out aspects of production to independent growers. This had a consolidating effect on swine breeds. Second and equally important was the impact of a reversal of consumer demand to favor lean meat. This change began with urbanization and a shift in production away from small homesteads, and was completed when hydrogenated vegetable oil and petroleum products replaced lard in cooking and industrial uses. Today eight breeds dominate pork production, namely the Duroc, Yorkshire, Hampshire, Poland China, Berkshire, Chester White, Spot, and Landrace. Market hogs raised in large scale operations are crosses of these.

Consumer interest in pastured pork products has increased dramatically in the past 2 years, with specific interest in the flavorful meat of rare breed pork. Interest is being driven by overlapping interest in locally produced foods, flavor and the rise of the "foodie", and interest in humane production, healthier products, and food safety. With the rise of niche produced pork, there is a growing understanding that the genetic variation found in swine breeds may be useful to the future of swine production. Agriculture needs the full breadth of genetic resources that provide the world with food and fiber, and rare breeds of pigs are a vital part of this nation's agricultural resource. Purebred seed stock is a genetic reservoir for climatic adaptations, biological fitness, fecundity, maternal skills, foraging ability, lard production, and disease resistance. However, ten hog breeds are endangered due to extremely low populations, six of which are only found in the US: Choctaw, American Guinea Hog, Mulefoot, Ossabaw Island, Red Wattle, and

Hereford. Internationally endangered rare breeds with important US populations are Gloucestershire Old Spots, Large Black, Tamworth and Saddleback.

Breed conservation. Conservation of genetic diversity is essential to the survival of endangered breeds, and there are few resources for new farmers to learn how to incorporate conservation into their breeding plans. Breed associations manage registries for endangered breeds and stand at the front lines of educating the breeders. Associations and their member are, therefore, a keystone in both managing genetic data and sharing best practices.

Pastured husbandry. Endangered breeds of pigs are well adapted to pasture or silvopasture production systems, and forages and foraged feeds can substitute for 10-30% of the diet (Wheaton and Rea, 1993). Well-managed pasture-based production improves environmental quality by utilizing local feed resources, minimizing concentrated waste disposal issues, and enhancing soil fertility. Raising pigs on pasture also improves the quality of life for the farm family and the community in which they live by reducing noxious odors and providing independent economic opportunities for pork production.

Providing experienced and novice farmers with the tools for managing rare breeds are essential, as rare breeds have different needs than pigs reared in confinement. They do not reflect the genetics of and are not raised in the production systems used for mainstream production. That, coupled with the fact that most breeders are only part time pig farmers, has led to the situation where educational materials for rare breed breeders is sparse. Many older materials begin to be useful, but do not reflect the increased knowledge gained since their original publication. In recent years, materials that address some of the educational needs of niche producers have emerged, and the guides produced in this study build upon those resources.

Marketing and Carcass Characteristics. In order for endangered breeds to survive, the animals must bring a profit to the farmer. Developing viable access points into market niches is essential for the product to reach its fans. Marketing demand has developed with new trends, often created by chefs. As chefs have experimented with heritage pork, they have renewed interest in charcuterie. Charcuterie, or old-world cured meats, takes advantage of the carcass characteristics of older breeds. Interest in endangered breed pastured pork is high, but farmers need additional tools to successfully market their animals.

Prior to this SSARE study, almost no published information existed on the carcass characteristics of rare breeds. Using the carcass data sheets for rare breeds and direct marketing prices, producers can construct an enterprise budget before entering into production, add a niche product to their operation and further diversify their farms. Producers who direct market will be better able to sell their animals to chefs, retailers and consumers as the buyers will know what to expect and expand the market for rare breed pork. Chefs and retailers can use the data sheets to calculate food cost and profit margins for each breed prior to purchasing directly from producers.

In November of 2008, The Livestock Conservancy convened a meeting of representatives from each of the rare breed swine associations and others representing conservation, marketing, and scientific study of the rare swine breeds. Its purpose was to better understand the status of and issues faced by each of the endangered swine breeds. Three critical, commonly shared needs were identified: marketing (breeding

stock & products), bloodline conservation, and breed association support (member education, breed promotion, and registration). These formed the basis of the current project.

Objectives/Performance Targets:

1. Quantify the genetic variability and genetic relationships within and among rare swine breeds using DNA and pedigree analysis.

2. Assist swine breeders in the development of long-term breeding strategies to maintain genetic health.

3. Develop educational materials for old-type swine management practices and modern health information, educate breeders about breeding stock selection of endangered swine breeds.

4. Produce and disseminate Pork Carcass Percentage Datasheets for the following breeds: Guinea Hog, Gloucester Old Spots, Large Black, Mulefoot, Ossabaw Island, Red Wattle, Tamworth, and Hereford

5. Define economic models (value chains) in the South for Heritage Pork products.

Materials and Methods

DNA analysis. Research was conducted at the Candian Animal Genetic Resources Program, Agriculture and Agri-Food Canada, Saskatoon, SK, Canada. Blood and hair samples were collected from 196 individuals representing 9 endangered breeds. Multiple bloodlines are represented within most breeds. Twenty two samples of Meishan pigs were added to the study because, unlike the endangered pigs, Meishan are a common breed in China. They are expected to be relatively unrelated to the domestic pig breeds, but Chinese pigs did influence some European breed development. DNA was extracted from blood or hair samples and genotyped for 33 microsatellite markers. Within breed diversity was determined by calculating Number of Alleles (Na), Allelic Richness (AR), observed heterozygosity (Ho), unbiased expected heterozygosity (He), and Inbreeding Coefficient (Fis). Relationships between breeds were evaluated by Nei's Standard, and portion of shared alleles (POSA).

Census and Herdbook analysis. Research was conducted at TheLivestock Conservancy, Pittsboro, NC. Breed associations for eight heritage breeds were contacted to share census figures in 2011 and 2014, and offered the opportunity to submit their herdbooks for analysis. Census information was obtained for all of the breeds in 2010, and 6 in 2014. Five associations provided herd books for analysis, American Guinea Hog Association, Gloucestershire Old Spots of America, Large Black Hog Association, Ossabaw Island Hog Registry, and Red Wattle Hog Association. Herdbooks were received in electronic form, and evaluated for number of breeders, number of registrations, coefficient of inbreeding, and sire usage.

Carcass characteristics of heritage pigs. In year 1 and 2 of the project, seven piglets from each of eight breeds were transported to Berea College and grown out on pasture to market weight. The 1.5-acre pasture consisted primarily of fescue with some other grasses and broadleaf weeds present. Three hoop shelters and one shade tree provided protection from sun, wind, and rain. Deep bedding was maintained in the hoop shelters through April. Free-choice feed, consisting of ground corn, soybean, and Fertrell swine premix, and water were available at all times.

All pigs were grown to market weight. They were harvested and processed in three groups based on when they achieved market weight. Each carcass was processed by American style cuts on one side and European style cuts on the other side. The European style break-out is favored by chefs in some high-end restaurants, and this could be a lucrative market for heritage pork. Live weights and hot carcass weights were measured. Each meat cut was weighed and photographed.

Economic modeling for heritage pork. Successful enterprises incorporating pastured heritage pork were identified through networking and internet research and interviews were recorded. Farmers, farm cooperatives, distributors, retailers, and chefs were interviewed. An online survey supplemented the information.

Results and Discussion

Objective One.

Samples of blood, hair, or both were collected from eight rare breeds (Table 1). Samples represented multiple bloodlines in order to capture a snapshot of the diversity within the breed. Nine samples were included from an additional endangered breed, Choctaw, and 22 samples of Meishan pigs were included. Meishan is a breed from China, imported to the US in the 1980s. They are expected to be relatively unrelated to the domestic pig breeds, but Chinese pigs are known to have influenced breed development of some European breeds.

Genetic Diversity Within Breeds.

Polymorphic genes are those that have more than one allele, that is, more than one possible expression. For example, the gene for black color in purebred Angus cattle is fixed, it is not polymorphic within the population because all purebred Angus cattle have two copies of the same allele. In a genetically diverse population, most genes have several or many alleles possible, especially when a relatively random bit of the genome is tested, such as the microsatellite gene loci evaluated in this study. The percentage of the loci tested that were polymorphic (Table 2) is the first indicator of the diversity within these breeds. More than 90% of loci were polymorphic for all breeds except the Mulefoot.

Within-breed diversity was then assessed by calculating the allelic frequency, or mean number of alleles (**Na**), in each population. Allelic richness (**AR**) corrects for sample size to provide an estimate of the number of alleles in the population.

Mean number of alleles (Na) was relatively low across all populations studied (Table 3), ranging from 1 to 12 at different loci. Na was lowest in Choctaw pigs (2.33 + 0.13) and highest in Meichan pigs (4.36 ± 0.23). Allelic frequency is affected by sample size, and indeed some of the populations with few samples

had few alleles. Only eleven samples were available from Choctaw pigs, and all were from a single herd, which explains much of the similarity.

Other breeds such as Gloucestershire Old Spots and Large Black were well represented in the study, yet the number of alleles per locus was low (Table 3). By comparison, Rodriganez et al. (2008) found a mean number of alleles of 7.11 for Duroc hogs, which are very common compared to the breeds in this study. A comparison of 17 breeds of Criollo pigs in the Americas yielded a mean Na of 6.25 ± 2.30 across breeds (Revidatti et al., 2014), and Na for three of the breeds sampled here, MF, RW, and AGH, were higher in that study than the present. Nidup and Moran, 2011, found Na ranging from 3.22-5.84 in more than 20 breeds of European origin, and all but one of these breeds had Na >3.4. Based on these values, the Na for many of the breeds in this study were at the low end of the published ranges, indicating there may be an overall dearth of alleles in heritage breeds in North America.

Allelic richness (AR) corrects for differences in sample size. Hereford hogs had the lowest AR (Table 3). All of the samples were from a single herd and may not be representative of the breed as a whole. Allelic richness of three of these breeds, Guinea Hog, Mulefoot and Red Wattle, were also evaluated by Revidatti et. al., 2014, at 3.87, 2.62, and 3.28, respectively. These represented slightly higher values for AGH and RW but not for MF. Fourteen other Criollo breeds from throughout Latin America in were also tested by Revidatti, and had AR from 4.15 to 5.55. Rodriganez et. al. (2008) reported AR of 6.11 for Duroc pigs in Spain. AR for all of the breeds in this study were below these published values, again indicating poor allelic richness in North American heritage breeds.

Measures of Heterozygosity (H) indicate the frequency of animals that have two different alleles at a particular gene locus. Herds or breeds with low heterozygosity (that is, many animals that have two copies of the same allele) are less genetically diverse, and have lost diversity due to isolation or historical bottlenecks. **Ho** is the observed heterozygosity while **He** is the expected heterozygosity, because heterozygosity may be expected to be lower for gene loci that have fewer alleles. The ratio of observed to expected is the **Fis**, also called the inbreeding co-efficient, and tells us whether heterozygosity in the breed is higher or lower than expected. If Fis is greater than zero, it indicates a loss of heterozygosity, which may be caused by inbreeding. A negative Fis indicates an excess of heterozygosity in a population and may be explained by outbreeding and possibly outcrossing.

Ho ranged from a low of 0.34 for Mulefoot to 0.61 for Tamworth (Table 4). This range is consistent with literature reviews for a large number of breeds, although MF and GOS are at the low end of global populations. Most European and Latin American pigs had Ho >0.46 (Nidup and Moran, 2011) and the global mean Ho for European origin pigs was 0.542 (Zhang and Plastow, 2011).

Five breeds exhibited an inbreeding coefficient (Fis) significantly different from zero, HER, LB, MF, OSS, and RW (Table 4). This corresponds with breeds low in AR, and indicates inbreeding in the pigs sampled. This is likely indicative of a degree of inbreeding in the breeds themselves, so the coefficients of inbreeding (CI) that were derived from herdbook analyses under Objective 2 are also shown in Table 4. CI in Table 4 are from 2011, the year when DNA samples for this study were collected. When Fis and CI are compared, both indicate inbreeding for LB and OSS, and breeders of these should follow breeding practices that ensure that genetic diversity is maintained in both individuals and the breed as a whole

(Sponenberg and Bixby, 2006). Fis and CI estimates for GOS indicate that inbreeding was under control in 2011, perhaps due to the cyclic breeding pattern used by many breeders.

CI indicates inbreeding in the AGH breed as a whole that is not observed in the Fis of the animals tested in this study (Table 4). However, Roberts et al., 2013, observed a very high degree of relatedness in SNP analysis of AGH pigs, and Fis of 0.141 was reported for AGH by Revidatti et al.,2014. These indicators corroborate the coefficient of inbreeding, and a need for close attention to genetic diversity in breeding decisions. The herdbook analysis of RW, on the other hand, indicated a low degree of inbreeding while the Fis was significantly greater than zero. Revidetti et al., 2014 reported Fis of .028 for RW, which aligns more closely with the lower CI. These two breeds demonstrate the challenges of obtaining samples for DNA studies that are truly representative of the entire breed.

Together, the measures of allelic frequency and richness, heterozygosity, and inbreeding point to inbreeding in several of the breeds tested. This is not unexpected given the small population size and geographic and economic challenges to managing diversity. Genetic analysis using SNP showed a high degree of inbreeding in five of the heritage breeds used in this study (Roberts et al., 2013). Sponenberg and Bixby (2006) provide strategies for maintaining diversity in breeds, such as alternation of inbreeding and outbreeding.

Summary By Breed.

Choctaw. Only a small number of samples were available for DNA analysis of Choctaw, all from a single herd. Still, 91% of loci were polymorphic. Number of alleles was low; when corrected for sample size, AR was moderate. Heterozygosity of .51 is average for pigs, and Fis was negative, which may indicate outbreeding or crossbreeding. This is not unexpected as these were wild-caught pigs from a feral population of Choctaw hogs, so the possibility for introgression is high. No herdbook analysis is available.

American Guinea Hog. A wide sample formed the basis of the DNA analysis, and 100% of the 33 loci tested were polymorphic. Na, AR, and Ho were moderate for this study, though low for European and Latin American pigs as a whole (Nidup and Moran, 2011). Revidatti et al., 2014, reported higher Na and AR, and equivalent Ho for AGH. Fis was not significant in this study, but the literature points to more inbreeding than this would indicate, as does the herdbook analysis of CI.

Gloucestershire Old Spots. Sampling was broad, and 97% of loci were polymorphic. Na and AR were moderate for this study, but Ho was low. All three were low relative to the literature. The Fis was not indicative of inbreeding, and the CI from herdbook analysis was 8.9 in 2011, the year the DNA samples were collected. All these indicate a modest amount of inbreeding relative to other breeds in the study, presumably due in part to the cyclic breeding strategy employed by the majority of breeders to minimize inbreeding and maintain bloodlines.

Hereford. Sample size was limited and all were from the same herd. 94% of loci were polymorphic. Na was moderate, but AR was very low. Ho showed a good degree of heterozygosity. Although Fis was significant, because of limited sampling, no clear conclusions can be drawn for the breed. No herdbook analysis was available.

Large Black. Twenty four samples were tested, originating from two herds. Na, AR, and Ho values were average for this study. Fis indicated lower heterozygosity than expected, indicative of inbreeding, and this is corroborated by the CI.

Mulefoot. Sampling was limited and a herdbook was not available. This breed had the lowest degree of polymorphism observed in this study at 85%. This undoubtedly affected all the other parameters measured, as Na, AR, and Ho were all low. Fis was significant. All indicators point to inbreeding, however, Revidetti et al. found a slightly rosier situation. Broader sampling for additional analysis is recommended.

Ossabaw Island. Sample size was 24 from 3 different populations, and 97% of loci were polymorphic. Na was moderate, but AR was low. Ho was reasonably high. These indicators would seem to disagree with each other, but Fis was significant and analysis of the herdbook showed a high CI for this breed. This breed is discussed further under Objective 2.

Red Wattle. There was a large sample size for the Red Wattle, and all the loci tested were polymorphic. Na was one of the highest in this study, however AR was low. Ho was high. In general these indicate better genetic diversity than other breeds in this study. Although the Fis was significant, the CI corroborates the Na, AR and Ho, and Revidetti et al. observed much lower Fis in their study.

Tamworth. Few samples were obtained, and 94% of the loci were polymorphic. Na and AR were moderate for this study, though all of the Na and AR values in this study were low relative to more common breeds of pigs. Heterozygosity (Ho) was very high, and higher than He, so Fis was negative. This may indicate recent crossing between distantly related bloodlines, but could indicate crossbreeding to another breed, which would come as a surprise. Additional sampling would be needed to determine whether outbreeding is of recent origin and its impact on the breed as a whole. The herdbook was not available for analysis.

Meishan. This Chinese breed was included in the study as a relatively unrelated breed. It is abundant in China, less so in the United States. There were 22 samples, and 100% of the loci tested were polymorphic. Na, AR, and Ho were all high, indicative of healthy diversity within the sample, and probably the breed as well. Fis was not significant, again showing a lack of inbreeding. Herdbook analysis was not available.

<u>Relationships Between Breeds</u>.

Phylogenetic trees were created from the DNA analysis (Figures 2 and 3), using several methods. Two of the more common methods are discussed here, Nei's Standard (Figure 2), and Portion of Shared Alleles (POSA, Figure 3). The trees show the level of relatedness between each breed. Breeds on the same branch are more related and have a more recent common ancestor.

There are some areas of agreement in the different methods of analysis. Gloucestershire Old Spots and Guinea Hogs always cluster as a pair. There is evidence that Guinea Hogs descend from another British breed, the improved Essex hog, and this analysis may support that history. Large Black and Meishan cluster as a pair. Farming literature of the late 1800's confirms that Chinese and "Neapolitan" pigs,

themselves descended from Asian pigs, were used to cross with the English breeds of the time in the development of the Large Black breed and others.

Other clusters disagree between the Nei's Standard and POSA analyses, or yield unexpected results. Red Wattles appear to be related to Tamworth in one analysis but completely unrelated in the other. Breed history would not suggest a relationship. Ossabaw Island hogs seem to want to cluster with Hereford, or Hereford and Tamworth, more closely in the Nei's analysis and more distantly in POSA. This relationship is completely unexpected as the origin of Ossabaws is Iberian and Canary Island whereas Tamworth originated in Ireland and Hereford was created from European breeds in the United States.

In the Nei's analysis (Figure 3), Mulefoot is somewhat related to Guinea Hogs and Gloucestershire Old Spots, again defying the history. However, in the POSA analysis (Figure 4), it clusters more closely to Choctaw, as expected, as both descend from Iberian hogs of the Southeastern U.S. They share the mulefooted trait (monodactyly) but are genetically distinct breeds in these analyses. Larger sample sizes would help tease this relationship apart.

Further analysis of these results will be needed to determine what they are telling us about these breeds, taking into account the very small sample sizes for some of them. A paper for scientific publication is being prepared that will undertake these comparisons.

Objective Two.

Pedigree information was obtained for Guinea Hog, Gloucestershire Old Spots, Large Black, Ossabaw Island, and Red Wattle hogs. Herdbook analyses evaluated number of breeders, number of registrations, coefficient of inbreeding, and sires. All breed showed an upward trend for number of breeders, and Guinea Hogs saw the most significant rise (Figure 4). Numbers appeared to level in 2013 for all breeds except Guinea Hog.

Number of pigs registered was relatively consistent with number of breeders (Figure 5), that is, as the number of breeders rose, so too did the number of pigs registered. Since 2009 the number of Gloucestershire Old Spots pigs registered has risen more rapidly than the number of breeders, and Ossabaw registrations rose in 2013 despite a leveling out in the number of breeders. As expected, Guinea Hog registrations rose more than the other breeds

Endangered breeds have a small population size (Figure 4), and some endangered pig breeds went through a period when their numbers were very greatly reduced (bottleneck). In 2013, the breed average coefficient of inbreeding (CI) was greater than 10% for four of the five breeds studied (Table 5). Furthermore, there is no way to test the assumption that the foundation animals were unrelated to each other, so inbreeding for all of these breeds could be higher than indicated. Trendlines (Figure 6) showed a significant rise in inbreeding for GOS and OSS between 2004 and 2013. The number of foundation animals for both of these breeds was small, for example, Gloucestershire Old Spots were reestablished in the United States in 1995 from a small importation of 20 pigs from England. From this narrow foundation the number of animals has grown significantly, but inbreeding is evident and must be managed.

For all breeds, there was great variability in the CI for individual herds, typically ranging from 0 to 35%. This also caused variability in the CI for the breeds from year to year, depending on which breeders registered more animals in a particular year (Figure 6). This variability from herd to herd indicates that different breeders are paying more or less attention to diversity in their herds. Proximity to other breeders is often a significant barrier to breeders in acquiring new genetics for their herds. For this reason, educational materials and workshops developed for this project have included strategies for reducing inbreeding and training for artificial insemination. This latter tool is now helping some breeders to acquire and share genetics over greater geographic distances. The most valuable of these exchanges are breeder to breeder, because only a few boars from endangered breeds are available through semen companies. Strategies that can be used by all breeders to maintain genetic diversity are described by Sponenberg and Bixby (2006).

Maintenance of bloodlines and sire usage was evaluated for each herdbook. Some bloodlines have been lost, either through loss of breeders, lack of registration, or crossing with other bloodlines, which happens when not enough stock is available for an individual bloodline. For example, nine distinct founding groups were identified for Ossabaw Island hogs. Of these founding groups, only three are now well represented. Therefore, a recovery program to recover well-documented but unregistered animals into the herdbook was established in 2014.

Tracking bloodlines is easier for breeds of British origin that use naming conventions that include the bloodline in the name. We observed that these breed associations actively monitor breeding trends and promote use of bloodlines that are greatly diminished. As a result of this project, efforts are underway to import additional bloodlines for Large Black and Gloucestershire Old Spots pigs.

There was no evidence for "popular sire syndrome" among breeders of endangered hogs, and overall there is a healthy trend of lots of boars siring moderate numbers of offspring, with very few siring a great many. Caution will be needed for imported semen to avoid popular sire and over-use.

The absence of popular sires, together with the broad range of CI seen between breeders, indicate that it may be possible to reduce inbreeding within the breeds through attention to the farms with the highest degree of inbreeding. Breeding recommendations for the five breeds whose herdbooks were analyzed were distributed to the breed associations. They in turn promised to make the information available to their breeders, and most have done so. Several breed associations have made "trial matings" calculator available on their websites to help breeders calculate coefficient of inbreeding for proposed matings. Additional emphasis on education and facilitating exchange of genetics will help all breeders reduce inbreeding.

A census of heritage breeds was conducted at the beginning of this study and repeated in 2014 (therefore the last year for which complete records are available is 2013; Table 6). The number of registered Red Wattles, Guinea Hogs, Gloucestershire Old Spots, and Large Black hogs has risen in the past three years, In 2014 and 2015 these four breeds moved from Critical (fewer than 200 annual registrations) to Threatened (fewer than 1000 annual registrations). Large Black hogs have experienced turnover among breeders and their population is no longer growing. The other three breeds continue to grow, with the Guinea Hogs growing the fastest. They are on track to move soon to the Watch category (fewer than 2500 annual registrations). These improvements reflect efforts on the part of breed associations to

promote their breeds and encourage registration, and are indeed a success for these heritage breeds, who have captured the opportunity created by the current popularity of heritage pork.

Objective Three.

Success of farms is critical to saving endangered hog breeds, and many farmer who value the characteristics of these breeds are relatively new to farming. Education is critical to their success, and educational materials that address their needs are scattered, although these have improved during the course of this project. Endangered hog breeds are best adapted to living and breeding in extensive farm systems including pasture or silvopasture. To complement existing educational materials for niche swine producers, a series of guides were developed. The Modern Heritage Swine Guides (Table 7) address husbandry, nutrition, health, breeding, economics, and marketing of endangered breeds raised on pasture. A series of webpages were developed for educational swine materials from this SSARE project, and can be accessed at:

http://www.livestockconservancy.org/index.php/heritage/internal/heritage-pig-husbandry

An enterprise budget for heritage swine was developed in 2011-2012 and has been distributed to more than 50 heritage swine breeders and has received favorable reviews. It was designed to assist in planning new enterprises, beginning with a very small herd, and can be used to predict the economic impact of changes such as increasing herd size, purchase of equipment, loans, and changes in cost of feed and supplies.

Heritage Pigs and Heritage Pork definitions were developed for the marketplace and approved by project participants and heritage pig breed associations. Surging interest in heritage pork, particularly among chefs, has created market opportunities for heritage breed farmers. Defining these market terms, together with the carcass data sheets described under Objective 4, will help with farmers develop markets for Heritage Pork and Heritage Pigs. Improved markets enables some farmers to expand their herds and encourages additional breeders to become engaged, thereby contributing to saving endangered breeds of swine. The definitions for Heritage are available on the Livestock Conservancy's website: http://www.livestockconservancy.org/index.php/heritage/internal/heritage-swine

Further educational avenues were created during the course of this three year project. Over 20 seminars, 4 workshop and field events, and several heritage pork tastings have been held for Heritage swine producers, breeders, and chefs, and many of these materials are available for future use.

Objective Four.

In year 1 and 2 of the project, seven piglets from each of eight endangered breeds were raised on pasture to market weight at Berea College. Pigs were harvested and processed in three groups based on when they achieved market weight. Each carcass was processed by American style cuts on one side and European style cuts on the other side. The European style break-out is favored by chefs in some high-end restaurants, and this could be a lucrative market for Heritage pork.

Average Daily Gain (ADG) was the best measure of growth to compare between breeds, because of the differing growth rates, sexes and body composition. ADG was lowest for the American Guinea Hog and Ossabaw Island hog, the breeds that have probably experienced the least selection for yield (Table 8). The Gloucestershire Old Spots group experienced some bacterial ileitis which probably affected their growth, and one pig in that group died while in quarantine. The Tamworth, which has been used in mid-scale pork production, had the fastest average daily gain. Slow growth of the heritage breeds is believed to contribute to the flavor, together with the influence of diet from being raised on pasture (e.g., Talbott et al., 2005).

The Coefficient of Variation (C.V.) measures variability in a way that allows us to compare how uniform or variable the pigs are one from another, across breeds that are very different from each other. The C.V. was lowest for Large Black, Red Wattle, and Mulefoot breeds. Consistency can be valuable in predicting growth for market planning.

Several sources of variability are worth noting in this study. Sample size within breed is quite small, so that separate analysis cannot be done within sex, which has a powerful impact on growth. Because of the challenges of conducting a controlled experiment on rare breeds, further variability came from age of the piglets within and between breeds, bloodline within breed, and age at harvest. To some extent the Average Daily Gain corrects for some of this variability. In raising different breeds with different growth rates, and challenges that arose in scheduling processing, quite a few of the pigs were larger than the target weight when harvested. The Herefords in particular all exceeded 300 lbs at harvest, and the largest pig in that group was 378 lbs, well above the target weight.

Carcass data were evaluated for all breeds, and the yield of hot carcass weight as a percentage of live weight ranged from 63-77% across the breeds (Table 9), which falls within range of expected average yield of 72% for swine. Yield was not affected by age at slaughter or average daily gain. Lean cut yield for American style processing (Ham + Loin + Boston Butt + picnic / hot carcass weight) was greatest for TAM, GOS, and HER and lowest for Guinea Hogs. This is not surprising, as Guinea Hogs are a small lard pig with excellent bellies, and would not be expected to conform to yield expectations for lean pigs! TAM and HER, on the other hand, are known for good lean meat production among the heritage breeds. This comparison allows the farmer to select the breed that will best meet the interests of their customers.

Interest has grown in the European cuts for breaking down the carcass. This method follows the musculature more closely, and is of interest for charcuterie (cured meats). The European method also utilizes more parts, including cuts such as necks and cheeks that go into sausage when the carcass is broken down by the American style. In this study, both methods were compared as half of each pig was broken down by each method. Breeds were more similar for overall yield when processed in the European style than the American style.

By both American and European processing styles, the American Guinea Hog had larger bellies than other breeds. Hereford, Tamworth, and Gloucestershire Old Spots had the largest hams (Tables 10 & 11). Loins and shoulders depended on the style of butchery.

Chef Craig Deihl of Charleston, SC has worked extensively with he Guinea Hog and was interviewed for this project as to the characteristics and quality of this breed.

Like

Overall Chef Deihl likes that the Guinea Hog has a small frame and is easy to work with in the kitchen without lots of equipment. "You barely need a handsaw to even get the chine bone off for rack of pork," says Deihl. The flavor profile is great and the fat tastes incredible.

For cooking Chef Deihl likes an 8 to 9 month old hog that yields approximately a 55 lb carcass. He will menu plates offering a duo or trio of different cuts and preparations. The meat has great marbling and fat cover, with rich red muscle and dense flavorful fat. It is similar in size and yield to a lamb carcass; the smaller cuts, especially the chops, are great for a tasting menu.

For curing, Chef Deihl likes a 12-14 month old hog yielding a carcass of approximately 150 lbs. At this age they are more muscular, with tight fibers and even redder meat. He likes to keep the loins whole with the skin and fat intact because the loin eye is so small. He has a hard time selling lardo but says customers will eat the fat if cured on the loin. Deihl has found that the Guinea has huge jowls, twice as thick as other pigs.

Dislike

On the downside Chef Deihl points out that the belly has limited muscle, it is predominantly pure fat and doesn't make good bacon. He uses it for flavor and fat in other products from lean meat animals like beef salami, hamburgers, meatloaves.

Suggestions

Chef Deihl suggests combining pork from leaner pigs with lard pigs to utilize the fat, he likes a ratio of 2 lean to one lard pig.

Heritage breeds on the whole are more marbled and have more backfat than today's production pigs, and the pasture raised, free-fed heritage pigs in this study had more back fat than industry averages (Table 9). Modern breeds are highly selected for lean meat production and a 2010 study of production gilts averaged 2.33-3.18 cm back fat at the 10^{th} rib (Meers et al., 2010). In comparison, in 1975, backfat averaged about twice as much as reported in 2010 (Cross et al., 1975). Selection for lean meat reflects the shift away from lard in cooking and industrial uses in the early 20^{th} century as hydrogenated vegetable oil and petroleum products replaced historical uses.

Heritage breed pigs lost favor when they did not "fit" in confinement swine operations, and consequently most of the heritage breeds have not been selected for lean production. Indeed, having been left behind by confinement rearing and large scale commercial selection began, these breeds have struggled to survive and it is likely that many farms do no selection for production characteristics. It is interesting that the breeds most likely to have been selected for productivity, HER, LB, GOS, and TAM, averaged about 10 % greater lean cut yield than the unselected breeds (AGH, MF, OSS, RW). The pigs in this study were raised on pasture, which is how most heritage pigs are raised. There are strong suggestions that the fat from pigs raised on pasture has higher levels of fat-soluble vitamins and a heart-healthy profile of fatty

acids (e.g. Reig et al., 2013, Talbott et al., 2005, Timon et al., 2002) as has been found for grass-fed beef (Duckett et al., 2009). Consumers are rapidly rediscovering the health and flavor benefits of pasture raised heritage pigs.

The performance of GOS differed somewhat from expectations. Carcass yield and % backfat were the lowest of the eight breeds (Table 9), perhaps due to the ileitis they experienced as piglets. Lean cut yield of GOS was favorable at 55%. Make-up growth favors lean over fat, and the lower yield and greater lean composition of the pigs in this study may not be representative of the breed's performance in the absence of disease challenge.

Pasture raised heirloom breeds of pigs are becoming extremely popular across the south and the nation and this research will be the first to quantify yields from eight of the old breeds. To translate this carcass information into a form that can be used in marketing, data sheets for individual breeds were constructed by a professional graphic artist using the high-resolution photographs taken during processing. The data sheets summarize and demonstrate each cut, and are available on the web:

https://dhn-hes.ca.uky.edu/content/heritage-hog-carcass-yields

These data sheets can be used to learn about each breed and plan for success before committing significant resources and capital, especially for small farms seeking to diversify their farm products. Breeders also use the sheets to cultivate chefs as new customers for heritage pork.

Objective 5.

A "Values-Based Food Supply Chain" or "value chain" is simply a supply chain with a conscience. It seeks to replace the win/lose or buy low/sell high relationship between participants in the chain with win/win relationships that take into account each side's profitability (Agriculture of the Middle, accessed 2013)[1] The impetus to develop a value chain can come from any participant of the chain or from interested parties outside the chain such as advocacy groups. A heritage pork value chain could look like the following:

Feed -> Farm -> Processor -> Restaurant or Retail -> Guest or Customer

Two questions must be posed: can the market niche for pastured endangered breed pork be organized and expanded, and what are hindrances to that effort and can these be overcome?

The market demand for heritage pork is growing rapidly. A google search for "heritage pork" yields over nine million hits and a search for "heritage pork for sale" yields over two million hits. A closed Facebook group for curing heritage pork products, "The Salt Cured Pig", surpassed one thousand members in less than two years and has spun out other heritage pork groups. One of these, "Southern Pig Farmers", grew to over one hundred farmers in less than one week after it began December 16, 2013.

[1] In depth research on value chains and case studies can be found on the Agriculture of the Middle website at http://www.agofthemiddle.org/

Large distributors that have organized value chains for pork include Heritage Foods USA[2] and Niman Ranch[3]. About half of the pork products that Heritage Foods offer come from some of the endangered breeds in this study, while Niman utilizes hybrids that are raised on pasture. Both these companies purchase primarily from farms in the Midwest centered around Iowa, where a large percentage of commodity pigs are concentrated and processed, due to the existing networks for feed, processing and shipping. Most of the meat produced for Heritage and Niman is shipped to the coasts, very little stays local to the farms, much less the region. These two examples benefit from economies of scale because of the existing infrastructure in their region.

In the South, one of the largest hurdles to the growth of value chains is processing capacity. Markets are expanding but volume coming from small processors must be maintained to satisfy these markets. Farmers also report that distance to the processor is also a major problem, along with selling the whole carcass and public knowledge of the nature of pastured heritage pork. An examination of three existing heritage pork value chains will illustrate different methods for overcoming the infrastructure obstacles and can be emulated across the southern states. The three examples are Marksbury Farm Market in Garrard County, KY; The Fatback Pig Project in Eva, AL; and the North Carolina Natural Hog Growers in central and eastern North Carolina.

Marksbury Farm Market[4] is a processor in Garrard County, KY begun by four partners with a passion to increase the supply of pasture raised meats in central Kentucky. Since opening in 2010, they have succeeded in their original intention to sell retail through their own butcher shop and directly to restaurants and small grocers. The company has also expanded to sell to institutional buyers and they now count Whole Foods and Chipotle Restaurants as major customers.

Their value chain is short, consisting only between Marksbury and the farmers they buy animals from, they do not have contracts with customers. Farmers are directly responsible for feed, and Marksbury serves as both processor and retailer/distributor.

NC Natural Hog Growers Association[5][6] is an evolving enterprise begun by small farmers who collaborated after Niman Ranch ceased operations in NC. Jeremiah Jones is the President of the group and coordinates all of the logistics. Approximately 30 members of the cooperative raise their pigs on pasture, many with just a small number of animals. All of the farms are Animal Welfare Approved. With only a few niche processors near them, the group schedules delivery to the processors and market cooperatively to grocers such as Whole Foods and Earth Fare, and other restaurant and retail customers. Another customer is Firsthand Foods[7], a small North Carolina distributor of pasture raised meats. NC Natural Hog Growers Association sells 80-100 animals each week[8]

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[2] http://www.heritagefoodsusa.com/
[3] http://www.nimanranch.com/Index.aspx
[4] http://marksburyfarm.com/
[5] http://www.animalwelfareapproved.org/2009/04/02/north-carolina-hog-growers-association-members-to-all-become-animal-welfare-approved/
[6] Telephone interview with Ben Filippo, Food Systems Coordinator, Carolina Farm Stewardship Association
[7] http://www.firsthandfoods.com
[8] http://www.nytimes.com/2014/01/21/business/demand-grows-for-hogs-that-are-raised-humanely.html

This value chain is more complex than Marksbury Farm Market. Value is first created by small farmers working together to coordinate processing and marketing, and then additional customers are reached through targeted marketing by Firsthand Foods.

The Fatback Pig Project [9] is a project of the Fatback Collective,[10] made up predominantly of chefs and restaurateurs across the southern states. The spatial dispersion and concept diversification of this group facilitates utilizing the whole pig, as operations have differing needs for fresh and cured pork meat and products. The Fatback Collective provides a stable, unique and diverse final link in this value chain.

In the middle is the processing facility in Eva, AL, owned by Jim 'N Nick's restaurant group. This value chain is currently recruiting farmers in proximity to the processing facility to raise heritage breed pigs. All pigs are required to be raised hormone- and antibiotic-free, must be allowed to range freely, and following the Whole Foods animal welfare standards"[11]. The Fatback Pig Project has developed a calculator for farmers to assure their profitability. The formula requires the farmers to enter the number of piglets in a little and the cost of feed. The base price paid for finished pigs is $1.00 lb live weight, which is adjusted based on feed costs, and a premium is offered if the pigs are raised totally on pasture.

At the time of this interview in 2013 the Project was seeking to provide 100 pigs per week and had outlets in their partners' restaurant and retail operations for the whole carcass. Unlike commodity operations, the only waste is the offal. They even have a buyer for the heads.

The Fatback Collective has tremendous potential to affect farms raising heritage breeds. One partner, Jim 'N Nicks BBQ Restaurant, cooks over three million pounds of pork a year. As the value chain matures they plan to switch from using primarily shoulders for barbeque to whole hog as the numbers of participating farmers grow to where the needed quantities can be provided.

Small value chains. The above three value chains work in volumes that may be best suited to farms with larger production and cooperatives that can provide a consistent volume of product. For smaller farms, heritage pigs are most profitable when sold through niche marketing rather than trying to adapt them to compete in wholesale markets. As seen in Objective 4, heritage breed pigs have more backfat and marbling than modern breeds, have significantly different yields, and most of the heritage breeds are slow-growing. This provides variety to the marketplace, just as heirloom fruits and vegetables have added variety to the produce market. There is evidence that slower growth results in a different flavor profile, particularly when the diet differs (Talbott et al., 2005). One value chain that has developed to take advantage of the unique characteristics of heritage pigs and pork is Carolina Heritage Farms.

Gra Moore is the owner and operator of **Carolina Heritage Farms** in Pamplico, South Carolina. Moore's family has a long history with livestock farming in the region. When Moore returned to the area with an interest in raising food sustainably for his family, he was looking for a small breed of pigs that would forage well on his property and be gentle around his kids. He first heard of Guinea Hogs after becoming a

[9] Telephone interviews with Nick Phikas, Donald Link and other partners and management of the Fatback Collective on 12/17 & 18/2013

[10] http://www.jimnnicks.com/community/fatback-collective/

[11] http://www.wholefoodsmarket.com/about-our-products/quality-standards/animal-welfare-standards

member of The Livestock Conservancy, and it seemed that their small size and mild temperament might be the best hog breed for his small farm.

Moore established a close relationship with Williamsburg Packing, a processor in Kingstree, SC. To keep his costs down, he began growing his own heritage corn, scoured the local woods for acorns, and asked for what would have otherwise been "waste" products from canneries, peanut growers, vegetable farmers, dairies, and more. In 2009 the time had come to begin thinking about ways to market the meat of these pigs. He partnered with Chef Craig Deihl[12] in Charleston. Chef Deihl loved what he saw, and soon began experimenting with the Guinea Hog for charcuterie – old world cured meats. Word began to spread through Moore's and Deihl's blogs and other publicity about this wonderful pork, and other chefs began buying. Working together with chefs and with his processing plant, Moore determined the best harvest weight and age for his pigs that would provide the most desirable product for the chefs. Since then Moore has been persistent in finding new chefs and retailers to sell to. He engages new chefs by donating meat for special events and educating those who haven't tried heritage pork about what to expect in the kitchen. He has developed a sizeable herd at Carolina Heritage Farms, using several heritage breeds to diversify his offerings, and has established a significant market for his pork with restaurants and small local stores.

Impact of Results and Outcomes

The Saving Endangered Hog Breeds project approached the subject holistically, examining multiple issues important to economically successful pasture-based conservation of rare breed swine. No other project has critically examined the genomic resources and tied them directly to breed stewardship and market development.

The genetic and herdbook analsyses demonstrated the genetic status of eight breeds, and showed that some have experienced inbreeding. Breeding recommendations developed for five of these breeds have helped raise breeder awareness and education. Engaging breed associations in the education process further ensures the impact on future breeders. Greater awareness of bloodlines and beneficial breeding practices are benefiting the genetic health of the breeds. Because of these analyses, a recovery project was launched for Ossabaw Island pigs to find lost bloodlines and reintroduce them to the registered breeding population. Efforts are also underway to diversify bloodlines for Large Black and Gloucestershire Old Spots pigs through semen importation, while the American Guinea Hog Association launched an awareness campaign to prevent too-close matings within herds.

Educational guides and supplemental resources developed for Objective 3 will soon be published on The Livestock Conservancy's website. In 2014, the website received nearly 125,000 page views by visitors seeking information about pigs, making this a valuable resource for beginning pig farmers. Marketing heritage pigs has already received over 500 views since between February – April 2015.

Carcass data sheets, enterprise budgets, value chain models, and educational guides covering financial and marketing topics are important tools for farmers to assess costs and revenues. Meanwhile, outreach to the general public and to chefs in particular, including the tasting events conducted during this study, raise awareness and demand for heritage pork. Greater consumer demand has engaged more farmers to

[12] http://therealdeihlchef.com/

raise more endangered pigs. It has been said, "we need to eat them to save them," because the economic success of small farms will impact the long term success of endangered pig breeds.

This project will contribute to sustainability in the South by providing Southern producers with education and tools to facilitate their success as producers and marketers of the rare swine breeds they love and steward. The results of this study and its products are leading to better quality and more consistent animals for the marketplace, a greater understanding of that marketplace, and tools for farmers to better educate their customers, whether they are chefs, distributors, or consumers.

Economic Analysis

An enterprise budget developed for rare breed swine was developed under this project. Producers can enter factors affecting profitablibility such as land and building improvements, capital equipment and loans, breeding stock, harvest weight & carcass yield, feed costs, services, and labor. This tool calculates profitability over 10 years, providing a useful tool for planning and timing significant changes such as a new tractor purchase, and impact of production improvements such as higher weaning rates.

An educational Guide on cost management was also prepared, and will be available in coming weeks.

The largest factor affecting profitability with rare breed swine is feed cost, especially when slower growth rates are considered. Therefore husbandry measures that reduce feed wastage, and opportunities for low cost/ no cost forage supplements, are important to the small producter. Other important elements of profitability include controlling facilities and infrastructure costs, particularly in early years, and managing factors that maximize the number of market pigs harvested per sow, such as fertility of sows and boars, husbandry from farrowing through weaning, and herd health.

Publications and Outreach

Publications

The following publications from this project are available at:
http://www.livestockconservancy.org/index.php/heritage/internal/heritage-pig-husbandry
and links on that page:

- Feeds and Feeding of Heritage Breed Pigs, by Dale Rozeboom
- Keys to Cost Management for Extensive Pork Production, by David Stender
- Heritage Pigs: Selecting Breeding Stock, by Mark Knauer and Alison Martin
- Biosecurity for Pastured Pigs, by Joshua Schaeffer
- Common Health Concerns of Pastured Pigs, by Joshua Schaeffer
- Control of Inbreeding for Productivity and Genetic Conservation in Swine, by Mark Knauer
- Detection of Estrus in Pigs, by Wayne Singleton
- Artificial Insemination Basics for Pastured Pigs, by Wayne Singleton
- Preparation for Farrowing, by Wayne Singleton
- Heritage Hog Processing and Products, by Gregg Rentfrow
- Marketing Your Heritage Pork Products, by Alison Martin
- Enterprise budget for heritage swine
- Definitions of Heritage Pigs and Heritage Pork

- Breeding recommendations for Guinea Hog, Gloucestershire Old Spots, Large Black, Ossabaw, and Red Wattle breeders
- Porcine Epidemic Diarrhea (PEDv)
- Pick-a Pig, the pig breed comparison chart

and:
https://dhn-hes.ca.uky.edu/content/heritage-hog-carcass-yields
- Heritage Pig Carcass Characteristics (data sheets for eight breeds)

Poster
"Saving Endangered Hog Breeds", Livestock Conservancy Annual Conference, November 2014
A copy of this poster was shared with the Candian Animal Genetic Resources Program, Agriculture and Agri-Food Canada, for their use at upcoming conferences.

Presentations
- "Is a heritage pig enterprise right for you?", NC Extension Service Blueprint for a Profitable Mountain Farm Workshop, Feb 3, 2012, Spruce Pine NC
- "Hobby Gone Hog Wild", ALBC's "From Service to Stewardship" workshop for veterans, May 4, 2012, Pittsboro NC
- "An Introduction to Heritage Pigs", Mother Earth News Fair, June 3, 2012, Puyallup, WA
- "An Introduction to Heritage Pigs", Mother Earth News Fair, Sept 21, 2012, Seven Springs, PA
- "Hobby gone hog wild", ALBC Annual Conference, Nov 10, 2012, Cary NC
- "The Principles of Pigs", Mother Earth News Fair, June 2, 2013, Puyallup, WA
- "Importance of AI for Heritage Breeds", presented at Boar Semen Collection Workshop, New Bolton, PA, 2013.
- "The Principles of Pigs", Mother Earth News Fair, Sept 22, 2013, Seven Springs, PA
- "Introduction to Heritage Pig Enterprises", Mother Earth News Fair, Sept 21, 2013, Seven Springs, PA
- "The Principles of Pigs", Mother Earth News Fair, Oct 12, 2013, Lawrence, KS
- "Saving Endangered Hog Breeds," Butchers Guild, January 2014, Atlanta, GA
- "Heritage Hog Production", The Livestock Conservancy's "From Service to Stewardship" workshop for veterans, June 6, 2014, Warrenton, VA
- "Introduction to reproduction and artificial insemination," Growing Farmers Workshop: Heritage Pigs. March 23-24 2014,. Pocantico Hills, NY
- "Considering reproductive management," Growing Farmers Workshop: Heritage Pigs. March 23-24 2014,. Pocantico Hills, NY
- "Heritage populations and genetics," Growing Farmers Workshop: Heritage Pigs. March 23-24 2014. Pocantico Hills, NY.
- "Pig Pickin' - An Introduction to Heritage Breeds," Mother Earth News Fair, April 12, 2014, Asheville, NC
- "Pig-Pickin' Part 2: The husbandry and marketing of heritage hogs. Mother Earth News Fair, April 12, 2014, Asheville, NC
- "Pig Pickin' - An Introduction to Heritage Breeds," Mother Earth News Fair, June 1, 2014, Puyallup, WA
- "Pig Pickin' - An Introduction to Heritage Breeds," Mother Earth News Fair, September 12, 2014, Seven Springs, PA
- "Pig Pickin' - An Introduction to Heritage Breeds," Mother Earth News Fair, October 25, 2014, Topeka, KS

- "Grain free, Forage Based Swine Production," The Livestock Conservancy Annual Conference, Nov 10, 2014, Austin TX
- "Pigs in the Woods," The Livestock Conservancy Annual Conference, November 9, 2014, Austin TX.

Workshops

- Semen Collection, Evaluation, Processing and Preservation for Heritage Breed Hogs. ALBC Annual Conference, November 10, 2012, Cary NC
- The ABC's of Pasture Pork. Florida Small Farms and Alternative Enterprises Conference. August 1, 2014, Kissimmee FL.
- Management Strategies for Sustainable Pastured Pork Production. The Livestock Conservancy Annual Conference, November 8, 2013, Cary NC
- Carcass Fabrication. The Livestock Conservancy Annual Conference, November 9, 2014, Austin TX.

Heritage Pork Tastings

- Several events at University of Kentucky and Berea College in 2012 and 2013
- June 20, 2014. Tasting of ham and charcuterie from Ossabaw Island and Red Wattle hogs. Slow Meat Conference, Denver, CO.
- September 20, 2014. Tasting comparison of 8 heritage breeds. Butcher's Guild Conference, Napa, CA.
- October 7th, 2014. Tasting of ham and charcuterie. Southern SAWG Fundraising Dinner, Midway KY.

Farmer Adoption:

In this project, over 1100 farmers were reached directly by presentations and many more were and will be reached indirectly. The project partners continue to interact with the sustainable agriculture community, promote the results of this project, and encourage breeding of heritage hogs.

Several of the activities under this project have long tails that should lead to even greater adoption by farmers.

1. The five breed associations that provided herdbooks for analysis received breeding recommendations to share with their members, approximately 200-300 breeders. Some of these breeders have already expressed the usefulness of this information. Educating current breeders improves their opportunities for success, and enables them to educate new breeders to whom they sell breeding stock. Breeder education is also key to ensuring continued survival of the breeds by maintaining genetic diversity.
2. The educational guides are in the process of being formatted for publication. When they are completed, they will be available on the Livestock Conservancy's website, which receives 800-1200 visitors per month for pig information. Promotion has been planned for launching the guides to at least 35,000 sustainable farmers.
3. In 2015, representatives of the Large Black Hog Association approached The Livestock Conservancy to discuss importing semen from the UK. This project has now expanded to include Gloucestershire Old Spots, and USDA's National Animal Germplasm Project and the Rare Breeds Society Trust of England. The latter are acting on our behalf to bring in representatives of the British Pig Association, the registry for rare pig breeds in Great Britain. The first import of semen from

British pigs (Large Black and Gloucestershire Old Spots) is scheduled for June 2015. Careful management of semen imports will be needed to ensure that the new genetics add to rather than replace American genetics. The Livestock Conservancy, USDA's NAGP laboratory, University of Missouri, Virginia Tech, and the two breed associations are developing usage guidelines. These guidelines will assure that the semen is used in a way that maximizes its contribution to genetic diversity of these two breeds. Some of the semen will remain in the NAGP repository as a conservation reserve, and breeders who receive it will be required to contribute to the repository from offspring of the imported boars and from their current boars.

4. In 2014 a recovery program was launched for Ossabaw Island hogs to provide a pathway for unregistered pigs with strong histories and phenotypes indicative of purebred status to perhaps re-enter the herdbook. Since establishing this program, six breeders have registered pigs through the recovery program, including one herd of significant size that was largely unregistered but well documented.
5. Through additional market promotion for pastured and endangered breed pigs continues to grow.

Areas Needing Additional Study:

- DNA analysis of two breeds, Mulefoot and Tamworth, was conducted on a small number of samples and the data must be considered preliminary, yet it points to potential issues for these two breeds that merit additional investigation. Results for Mulefoot hogs were indicative of inbreeding, while those for Tamworth hogs were indicative of crossbreeding, possibly outside the breed.
- While preparing educational guides it became clear that there is little information available to heritage hog breeders about handling and husbandry basics on pasture, particularly about the critical phase from farrowing to weaning.
- The "ag in the middle" problem still plagues farmers, many of whom have found that the demand for their heritage pork exceeds their ability to expand their enterprises. Factors affecting expansion include cost of additional land and labor, as well as the interest level of the farmer, many of whom enjoy the lifestyle of small farming and don't wish to expand. This means that market demand alone is not enough to expand supply, an area that would benefit from survey and additional study. A pilot study could be used to determine whether micro-grants or -loans would help farmers overcome initial hurdles to expansion.

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