United States of America
Country Report for FAO's
State of the World's Animal Genetic Resources

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Executive Summary

State of Diversity and Utilization

Livestock, with the exception of the turkey, are not indigenous to the United States. For over 500 years there have been periodic waves of importations resulting in a wide range of genetic diversity. Over time, as with other OECD countries, there have been transitions in breed popularity as changes in consumer demand and production systems have occurred. Despite a breed's popularity it is apparent that all breeds in the U. S. face genetic diversity issues in the near and long term. Therefore there is a need for greater awareness and action.

Breeds within species are placed into one of three categories: major, minor and rare. Each category has genetic resource issues that should be addressed by the public and private sector. Across species some of the most popular and numerous breeds are currently confronted with a contracting genetic resource base. However, genetic resource issues are more apparent with minor and rare breeds. These issues include total population size, small effective population size, increased rate of inbreeding, and a lack of infrastructure for addressing genetic resource and utilization issues. The issues confronting major breeds include: small effective population size (even though the actual population can be quite large), limited genetic diversity, and genetic erosion resulting from intense selection for some production traits (often at the expense of biological fitness).

The report uses current and past breed association registration numbers and species surveys conducted by National Animal Germplasm Program (NAGP) and the American Livestock Breeds Conservancy as an indicator of a breed's economic role and genetic diversity. Several trends across species emerge. By-in-large there has been a reduction in the number of animals registered for all species. In some cases numbers registered per breed have decreased during the past decade by 30 to 60%. There are several breeds that had increases in registration numbers, for example, Angus cattle and Berkshire hogs. Large registration increases observed with Angus and Berkshire are due to increased marketability of the breed. As both Angus and Berkshire have carcass characteristics which are currently deemed desirable in national and international markets. Non-industrial breeds of chickens and turkeys have large numbers of breeds classified as critical or rare due to small bird population sizes and the small number of breeders raising the breeds in question.

Utilization of genetic resources in the U.S. is driven by market forces and a policy of providing consumers with low cost food which in turn stimulates economic activity in other sectors of the national economy. U. S. producers have demonstrated the ability to meet shifts in consumer demand by altering breeding programs or breed utilization. As a result of market and policy actions, animal genetic resources have been influenced in the following ways:

1. Development of technologies for genetic evaluation;
2. A continual assessment of animal performance within and across breeds;
3. Continued introductions followed by evaluations of new genetic resources for productive advantages;
4. Increased uniformity and product quality and/or lower production costs, along with a narrowing of the genetic base of many species and breeds; and
5. Reduction in the number of primary breeds and increased utilization of selected families within a breed.

State of Capacity
Since 1999 and the inception of the NAGP, a laboratory facility has been established, cryopreserved collections have been initiated, and assessments of in-situ populations have been begun. ARS and university scientists in conjunction with industry and non-governmental organizations have formed species committees and are addressing genetic resources issues through NAGP. While over sixty people are involved with NAGP, there are only two full time federal scientists working on animal genetic resources issues. For the national program to reach full potential additional human and physical resources are needed. At the state level there is significant need for human and financial resources to address conservation and utilization of genetic resources. In general, breed associations and their members need to develop a greater capacity to assess the status of the genetic diversity of their respective breeds; this is problematic for minor and rare breed associations due to limited human and financial resources.

State of the Art
For all livestock species genetic evaluations are routinely performed at the breed level. In addition to quantitative genetic analysis, a number of molecular markers have been identified and are utilized by the respective industry. While some breed associations have the ability to evaluate the impact of genetic diversity, via relationship and inbreeding coefficients, such analysis is not routinely performed. Public sector research continues to add new traits to genetic analysis, improve predictive power of estimated breeding values and identify and utilize new molecular markers. Work is needed do develop procedures and algorithms for identifying which animals to have represented in the cryopreserved collection. In addition efforts are needed to assist breed associations with strategies and techniques to maintain genetic diversity while increasing a breed's market position.

Cryopreservation for cattle is advanced and enables the routine collection of germplasm for the national repository. For swine and small ruminants there is a need to increase the effectiveness of cryopreserving semen and embryos (especially for swine). There is a significant need to vastly increase the ability to cryopreserve chicken and turkey semen with much greater post-thaw viability and fertilization capacity than what currently exists. This short coming has significant ramifications on the confidence that can be placed on material stored by NAGP. Significant work is also needed to increase the ability to cryopreserve other tissue types (e.g., oocytes, primordial germ cells).

The information system associated with the genetic resource management effort provides the ability to link an array of information together concerning the cryopreserved collection, in-situ population status and the phenotypic and genetic differences that exist between breeds and environments where breeds are produced. The information system being developed will incorporate these elements. An important component of the information system is linking collection and phenotypic information to various molecular genetic information systems.

Conservation Strategies
The U. S. conservation strategy consists of in-situ and ex-situ elements. In-situ conservation is primarily a private sector activity with some key research populations being maintained by universities and federal research locations. The NAGP will support in-situ efforts by collaborating with universities, breed associations and non-governmental organizations in the development of mating plans, assessing the status and rate of change in genetic diversity, and facilitating collaboration between potential partners.

The development and maintenance of cryopreserved collections of genetic resources is a uniquely federal responsibility. The NAGP is the responsible federal program charged with developing ex-

situ cryopreserved collections of all breeds within the U.S. The collections being developed will be updated at strategic times to capture shifts in a breed's genetic composition. The developed collections will serve three roles:

1. A secure reserve of genetic resources for the industry and public at large, which can be used in times of need;
2. A source of germplasm for industry to use in the formation of new lines with production characteristics to meet changing consumer demand; and
3. A source of germplasm and/or DNA to be used by public and private researchers.

Critical Needs and Priorities for Action

Priorities are subdivided into biological issues and physical capacity issues. Biologically the priorities and action include:

1. Complete breed level collections of cryopreserved germplasm and tissue;
2. Increase levels of in-situ conservation by the private and public entities;
3. Create a more thorough understanding of within and between breed genetic diversity; and
4. Develop more efficient and reliable cryopreservation protocols for semen, embryos and oocytes.

Physical capacity priorities include:

1. Continue development of NAGP infrastructure and staffing;
2. Increase awareness and support of university conservation efforts;
3. Leverage the complementarity of different federal agency programs; and
4. Increase industry awareness and involvement with various aspects of managing animal genetic diversity.

Part 1.0
The state of agricultural biodiversity in the farm animal sector of the United States of America

The U. S. and the agricultural sector
The United States of America encompasses 9,629,091 km^2. The country has a broad range of geographic and climatic conditions. Temperate, arid, semi-arid, arid and subtropical conditions exist within the 48 contiguous states. The population in 2000 was 281,421,906, with a per capita GNP of $29,240. In 2000 consumers spent $460 per person for animal products or 1.6% of per capita GNP.

U.S. census data are reported by metropolitan and nonmetropolitan areas. Between 1990 and 2000 nonmetropolitan counties grew by 10.3%, resulting in 20% of the U.S. population living in nonmetropolitan areas. Much of this growth is fueled by persons wishing to increase their quality-of-life and not from agricultural interests. Counties dependent upon agriculture or mining experienced job losses during the past decade and did not show the same rate of growth in population as counties that were not as dependent upon agriculture.


Inbred Hereford bull (circa 1960).

Eighty-one percent of U.S. farms are between 1 and 499 acres, 60% are full owner (meaning they are owned by the person operating them), and 89.9% are individual/family farms.

The country's diverse ecological conditions enable the production of a broad range of crop and animal agriculture. The top five agricultural commodities are: cattle and calves, dairy products, corn, broilers and greenhouse/nursery products. Agricultural revenue exceeds $218 billion per year from the animal (45%), crop (43%), and services and forest (12%) sectors. Agriculture (farm and farm related jobs) employs approximately 15% of the population. Of the 15% only 2% are involved in production while 9.9% are involved with wholesale and retail trade of agricultural products.

During the past decade (1990-2000) the export share (percent of total domestic production) of agricultural products has held steady at 21%. However, within the agricultural sector livestock (poultry meat and red meat) exports have increased while crop exports have decreased. In the late 1990s, the annual total value of livestock exports was approximately $10.6 billion. The amount exported in 2000 for the various livestock subsectors is given in Table 1.

Table 1. Livestock product exports in 2000.

Commodity	Amount
Beef, million kg	1,050
Pork, million kg	545
Young chicken, million kg	2,125
Turkey, million kg	177
Eggs, million dozen	170

U.S. livestock and poultry have approximate farm gate cash receipts of $98 billion per year. This value does not include the multiplier effect of the livestock sector. Livestock are used to produce:

meat, milk, eggs and fiber. Other products such as down feathers and leather for clothing are also produced.

During the past decade there was a trend for value added livestock products. Consumers have driven this demand by wanting products that save food preparation time. As a result there has been a shift in consumption patterns between livestock meat products. There has also been greater demand by consumers and retailers for livestock products of greater consistency and uniformity. This change in consumer preference has resulted in an increase of branded products that strive to provide consistency and uniformity as a mechanism for increasing market share.

1.1 Overview of Animal Production in the U.S.A. (production systems, species and related animal biodiversity)

Animal production occurs across a diverse set of environmental conditions and at varying levels of intensity. Following the nomenclature of de Haan et al. (Livestock and the Environment: Finding a Balance,1997), three primary production systems exist in this country: grazing, mixed farming and industrial. Ruminant species utilize all three of these production systems. Poultry and swine are almost exclusively produced in highly intensive industrial production systems.

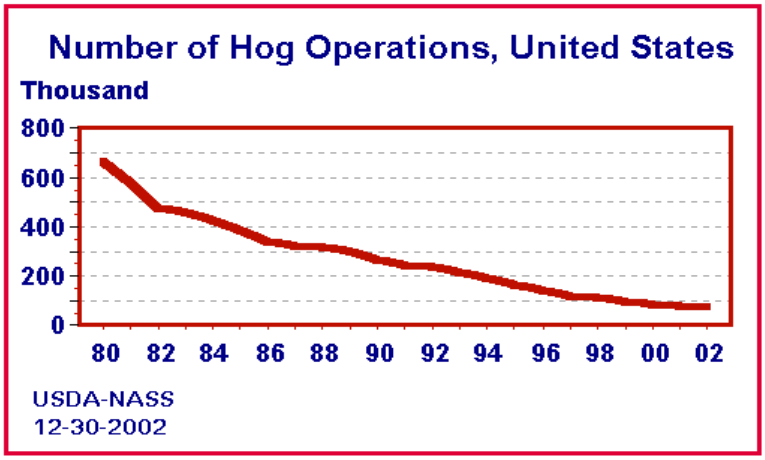
Grazing production systems are typically practiced with beef cattle, sheep and goats. They are implemented in semi-arid or arid areas and are extensive in terms of land utilization. In grazing production systems, intensification is used in the context of cost reduction, due to a lack of value added to livestock produced in extensive production systems. Mixed crop-livestock farming systems combine livestock and cropping activities. The ecosystems in which mixed farming systems exist can be very diverse (subtropical to arid). In the mixed crop-livestock system, producers combine a variety of crops with livestock production. Examples range from corn-alfalfa-pasture dairy systems to winter wheat-beef cattle production systems.

Both monogastric and ruminant production is practiced in industrial systems. These types of systems are strongly market driven and depend upon outside supplies of feed, energy and other inputs. Poultry and swine production are primarily practiced in intensive, vertically-integrated, industrial systems. In such systems, consistency in rates of gain, feed efficiency and product quality at the retail level is paramount. Dairy production is tending toward a similar scenario where large numbers of cows are maintained in drylots and fed roughage and concentrate feeds. Slaughter beef cattle and, to a lesser extent, lambs are placed in feedlots and fed high quality diets to standardize weight and body composition in preparation for harvest. In some instances beef and dairy heifers are placed in feedlots as a means of increasing body weight and condition to lessen the time to first breeding.

Swine Industry

United States per capita consumption of pork has not changed greatly during the 20th century, however, due to population growth, total pork consumption and domestic production tripled from 3,000 to 9,000 billion kg of carcass pork. Even though pork production has increased, the number of breeding animals has not changed dramatically, but the number of farmers producing pork decreased to less than 100,000 producers in 2002 (Figure 1).

Figure 1. Twenty year trend in the number of hog operations.



Individual swine herd size has increased with approximately 50% of national pig inventory being on farms with over 5,000 pigs. These farms represent approximately 3% of pork producers (Figure 2).

Figure 2. Current percent of swine operations and number of animals by operation size groups.

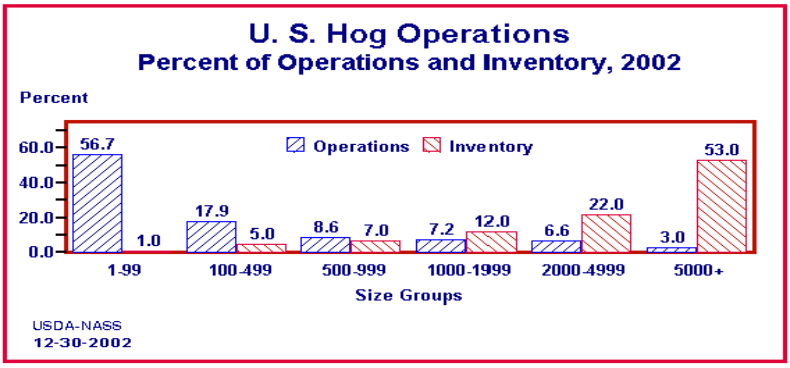


Figure 3 shows the trend towards fewer farms accounting for a higher percentage of the National pig crop. In just 7 years, large farms have moved from producing approximately 25% of U.S. pork production to 75%. Large farms account for a greater production share than pig inventory might suggest because of higher levels of productivity associated with the management practices. This is demonstrated in the average litter size trends contrasted with size of farm in Figure 4.

Public and industry concerns over waste and odor are increasing, and the issue of manure runoff or leaching into ground and surface water are the focus of regulations with which the industry has to comply. In some instances, when the cost of modifying the production system is prohibitive, the industry has chosen to move to alternative production sites where the regulations are less restrictive. Animal welfare issues are also a production system concern which swine producers are contending with in some states.

Figure 3. The change in annual pig crop distribution by herd size.

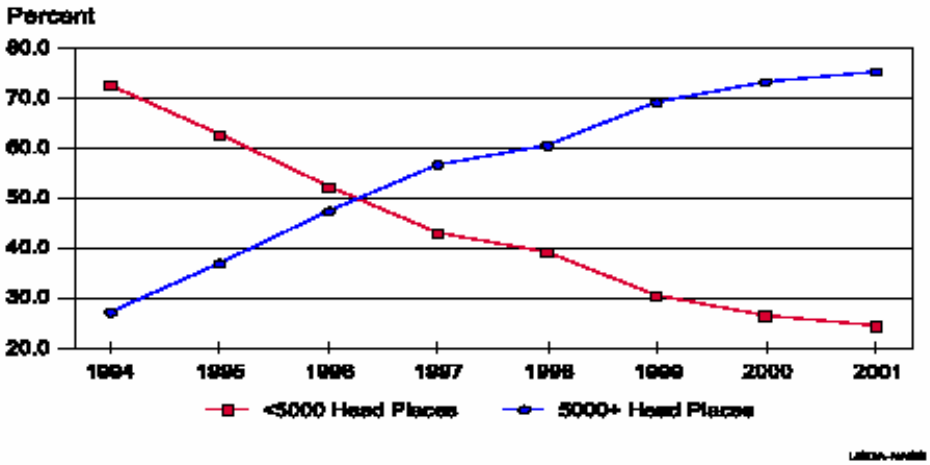
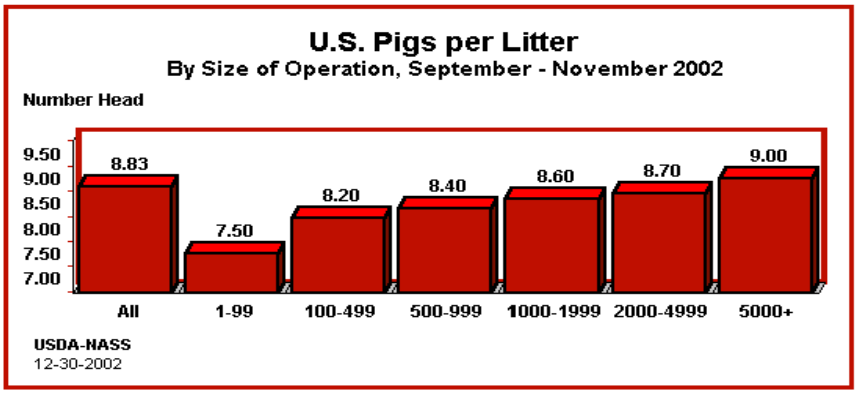


Figure 4. Average size of pig litters by operation size.



Poultry Industry

The $22 billion poultry sector is the third largest agricultural commodity and consists of turkeys, broiler chickens and layer chickens (Table 2). Production of broilers, eggs and turkey meat has increased linearly over the past decade with a growth rate between 2 and 3% per year. Companies developing breeding stocks for the industry are large and often multinational. These companies tend to employ the same type of strategy in developing product for their customers: the establishment of several pedigreed lines that are subsequently crossed to form a four-way cross that is sold to commercial producers. Poultry breeding firms disseminate breeding stocks by vertical transmission and multiplication. This process may be completed within a company or through a range of joint ventures and contractual arrangements. For the broiler industry in particular, a multiline cross utilizing specifically developed sire and dam lines is utilized at the commercial production level. The combination of economies of scale, uniformity of product and adding value to the base product have all contributed to the increased viability of the poultry industry.

Poultry are raised almost exclusively in an industrial system where major environmental modifiers of production have been minimized. The industry has been able to develop uniformity

in production conditions that in turn increases product quality, uniformity, and consistency. In this system, production is highly dependent upon concentrate feeds. Disease management is critical for all segments of poultry production. Environmental issues (manure, feathers, packing house waste) and animal welfare issues (debeaking, battery cages) are important externalities in poultry production.

Table 2. Poultry production, farm gate value and key producing states.

Poultry Sub-sector	Number of birds (millions)	Quantity of product produced (billions)	Value ($ in billions)	Top 4 States
Broiler chickens	8,000	19.5 kg	13.8	Georgia, Arkansas, Alabama, Mississippi
Layer chickens	330	84.4 eggs	4.6	Iowa, Ohio, Indiana, Pennsylvania
Turkeys	272	3.2 kg	2.8	Minnesota, North Carolina, Arkansas, Virginia

Beef Cattle Industry

The U.S. cattle industry recorded cash receipts on cows and calves of $40.8 billion in 2000. These revenues were generated from 33.6 million head of beef cows, a number that has remained stable during the past decade. Cattle production is dispersed throughout the U.S. The following states have the greatest inventories of brood cows: Texas, Missouri, Nebraska, Oklahoma, and South Dakota. However, since 1990 Texas, Missouri, and Oklahoma have experienced a decrease in inventory ranging from 5 to 9%. South Dakota reported a loss of between 1 to 4% during the same time period; while Nebraska, Wyoming, California, New Mexico and Idaho reported increases, ranging from 6 to 15%.

The number of operations raising beef cattle decreased from over 900,000 in 1990 to 830,000 in 2000. The distribution of herd size is presented in Table 3.

Table 3. Distribution of beef cow herd size in 2000.

Herd size	1-49	50-99	100-499	500-999	1,000-1,999	2,000-4,999	5,000+
% of herds	29.3	19.2	36.8	7.6	3.7	2.0	1.4

U.S. beef production occurs in extensive, mixed crop-livestock and industrial systems. As with other ruminant species, utilization of extensive production systems involves limited external inputs with emphasis on forage utilization. Various segments of the beef cattle industry utilize mixed crop-livestock production systems. For cow/calf operations, cattle are integrated into the farming system by utilizing land unsuitable for crop agriculture, crop-aftermath, and/or grazing small grains early in the plant's growth cycle. In addition to cow/calf production in the mixed system, producers in the midwest and south acquire weaned calves for "stocker" programs. This segment of the industry takes recently weaned cattle and places them on forage resources until the calves have reached targeted weights and are ready to enter the feedlot phase of production. For the beef industry, the industrial production system consists of the final stage of growing and

fattening cattle with concentrate feeds in feedlots. This segment of the industry plays a vital role in standardizing carcass composition and quality.

Dairy Industry

The U.S. dairy industry produces approximately 74 billion kg of milk per year from 9 million dairy cattle distributed across the country. Generally, the production of milk has shifted westward from the midwest and southeast during the past decade. States with the largest number of cows include: California, Minnesota, Wisconsin, New York, Pennsylvania, Texas and Idaho. States with increasing numbers of dairy cows, over the past decade, include: California, Arizona, New Mexico and Idaho, while Minnesota, Wisconsin, New York, Pennsylvania, and Texas all show losses of between 20 and 30% from 1990 to 2000.

Table 4 shows the distribution of herd size. Over 50% of the cows are located in herds of more than 100 head. The number of operations with more than 500 head has been increasing at approximately 3% per year, while herds with less than 500 head have decreased by 7% per year. Significant differences for milk production by herd size also exist. Herds with more than 500 head produce approximately 9,500 kg per head per year vs. 7,727 kg per head per year for those with less than 500 head.

Table 4. Distribution of dairy cow herd size in 2000.

Herd size	1-29	30-49	50-99	100-199	200-499	500+
% of herds	2.9	9.1	22.0	18.0	16.6	31.4

Milk production occurs in two production systems. The industrial system produces cows in dry-lots and utilizes a range of roughage and concentrate feeds. In this system, generation interval and replacement rate are critical elements contributing to long term economic sustainability. Mixed crop-livestock systems are also used. In these systems cows are maintained in drylot and on pastures for varying portions of the year depending on pasture availability. Smaller herds tend to be common in this system. For both systems environmental regulations are a factor in managing and concentrating cattle. There is a small component of grass-based seasonal milk production where cattle are maintained on forage during lactation and then dried-off as forage conditions decline.

Sheep Industry

Per capita consumption of lamb and wool has dramatically decreased during the last half of the 20th century, and, as a result, the industry has lower revenue levels than cattle, pig or poultry industries (Table 5). Breeding ewes have dropped to approximately 5 million head in 2000, a 40% decrease from 1990. Among the often cited reasons for this decline are: labor availability, predation, elimination of the wool subsidy, lack of strong promotional programs, increased production costs, decreased access to public grazing lands, and a strong U.S. dollar.

Table 5. National production of sheep, lambs and wool for 1999 and 2000.

Product	Kg produced (1,000)	Revenue, $ (1,000)
Sheep and lambs	229,997	478,891
Wool	21,158	17,852

The majority of U.S. sheep are found in extensive production systems in the western half of the U.S. The states of Texas, Wyoming, Utah, California, South Dakota and Montana, which are considered extensive production system states, have over 50% of the nation's breeding ewes.

From these states 0.1% of the operations have flock sizes of 5,000 head of sheep or more which equates to 14.8% of the national inventory (Table 6).

Table 6. Percent of breeding sheep operations and inventory by flock size.

Item	1-99 head	100-499 head	500-4999 head	5000+ head
Operations, %	91.2	7.2	1.6	0.1
Inventory, %	27.9	22.0	35.2	14.8

Sheep are produced in extensive, mixed crop-livestock and industrial production systems. Extensive production systems are subdivided by utilization of public and/or private land. Sheep produced on private land tend to be sedentary with stocking rates adjusted to carry the flock through the year. Sheep produced on a combination of public and private land follow migratory patterns taking advantage of different forage growth and maturing patterns. Sheep production in the extensive production system is dependent upon both lamb and wool production, with lamb being the primary source of revenue.

Across extensive production systems, the Rambouillet or a composite breed with significant Rambouillet influence is the most prevalent breed type (Columbia, Targhee). A combination of flocking ability, environmental adaptability, fiber diameter and sufficient lamb production contribute to this breed type's use. In the northwestern states it is common for Rambouillet-type ewes to be bred to Suffolk rams and the resulting F_1 offspring marketed as slaughter lambs.

As with all global mixed crop-livestock systems there is considerable variation in production practices and how sheep production is combined with varying cropping enterprises. The mixed crop-livestock farming system has the greatest variety of breeds. In the mixed system, lamb production is the primary product with wool production often relegated to by-product status. Across mixed crop-sheep systems, the degree to which sheep are integrated into the cropping system varies from planned grazing of small grains in the early growing season to maintaining sheep numbers to manage forage in portions of the farm unsuitable for crop production.

Level of management inputs are variable, based upon flock size and considered importance of the sheep enterprise. Most flock sizes below 500 head and some of the operations with 500 to 4,999 head are mixed crop-livestock operations (Table 6).

A proportion of market lambs pass through commercial feedlots before slaughter. During this phase of production lambs are fed a high concentrate diet until they reach targeted market weights and body condition.

Goat Industry

The U.S. goat industry is small compared to the other livestock industries. It is comprised of three sub-sectors: fiber (mohair), dairy and meat goats.

Mohair Industry: The U.S. produces 1.3 million kg of mohair annually with a value of approximately $10 million. Angora goats are the only breed of goats used to produce mohair. Production occurs in the following five states Texas, New Mexico, Oklahoma, Michigan and Arizona. Ninety percent of the mohair industry

Typical example of Angora goats.

is in Texas. Mohair is a specialty fiber with extremely variable use by the garment industry. As a result of market and policy conditions, numbers of Angora goats declined by 70, 65 and 31% for Texas, New Mexico and Arizona, respectively, during the last decade. Mohair production occurs almost exclusively in a semi-arid extensive production system with minimal purchased inputs. Depending upon market and range vegetation conditions, producers may retain ownership of castrated males (muttons) for mohair production.

Dairy Goats: Dairy goat production is present in most states. The Dairy Herd Improvement Program has enrolled herds in 44 states. California and Wisconsin have the largest number of breeders and does enrolled in the program. Compared to the mohair industry and other livestock species, there is a lack of marketing and processing infrastructure in this sub-sector. Producers often develop their own processing, packaging and marketing of milk or cheese. The lack of infrastructure and volume has served to constrict the growth of this sector. Dairy goat production occurs in the context of the mixed crop-livestock system. Herd sizes range from 14 to 140 does. Seasonality of production, due to forage and/or climatic conditions, and the seasonal breeding pattern of the species is an issue.

Meat Goats: Principal production of meat goats is located in the southern and southeastern U.S. As with goat milk production, there is marginal processing and marketing infrastructure. In Texas, while Angora goat numbers have decreased, the number of meat goats has increased by approximately 20% per year, in part due to producers shifting from mohair production to meat goat production. Goats are produced in either extensive or mixed crop-livestock systems. In both these systems there is an increased appreciation that goats can be utilized to control noxious weeds and control brush encroachment. The extensive meat goat production of west Texas is traditionally coupled with manipulation of vegetation types. This is an important strategy due to its cost effectiveness, (when compared to mechanical removal or herbicide use) and increasingly, is important for urban communities as brush control. It has been shown to increase water infiltration into underground aquifers and to prevent catastrophic fires that endanger semi-urban homes. There are situations arising where meat goats are being used to clear underbrush and restore forest land in the southeast and southwest. Such arrangements involve either a state or federal agency contracting with a producer.

1.2 Assessing the state of conservation of farm animal biological diversity.

During the past decade there has been a substantial increase in interest and activities conserving animal genetic resources. Throughout the decade private sector and non-governmental organizations have been engaged. Also during the 1990s some universities became active in this issue and took steps to assess the status of genetic resources maintained at public institutions. This was particularly true for poultry. However, at the same time, public collections were being abandoned as a result of budget constraints. During the last years of the 1990's the National Animal Germplasm Program was formed and has been assessing and involved in conserving animal genetic resources across species. Program priorities have been: initiation of cryopreserved breed collections, understanding breed population trends over time, and the status of genetic diversity within breeds. Conservation activities are limited at this time by:

- public and industry awareness,
- human and financial resources, and
- conservation activities given lower priority when compared to livestock industry issues that need immediate action.

Across the private and public sectors, all species (cattle, sheep, goats, swine, and poultry) are being conserved. Cryo-conservation is a primary ex-situ conservation activity being executed by the national program. Collections on 42 breeds have been initiated with semen and embryo tissue types. In-situ conservation is performed by the private sector and some public sector institutions.

State of the art techniques are utilized in cryopreserving animal genetic resources. While these techniques are advanced, research still needs to be performed to optimize protocols for specific breeds and individuals within a breed and to increase the probability of success when cryopreserved material is used. Cryopreservation techniques for turkeys have not been developed and those used for chickens need considerable improvement.

In-situ breed conservation, particularly rare breeds, is primarily a private sector activity. Maintenance of breeds in rare and critical condition by the private sector is feasible. Cursory evaluations of selected breeds to date have shown inbreeding levels to be increasing at linear rates. This implies that the private sector is able to execute this activity. However, there is a clear need to increase the private sector's capacity to maintain breeding programs and to evaluate pedigree information in planning matings that minimize inbreeding. Across species there is a lack of long term selection goals and strategies. The absence of such goals may help to maintain genetic diversity but it will not increase the marketability of rare breeds, which will in turn limit the utilization of such breeds.

Except for the domesticated turkey, the U.S. has no indigenous livestock species. Therefore conservation of animal genetic resources focuses upon maintaining and/or enhancing the diversity of breeds imported or developed in the U.S. There are three primary breed categories across livestock species that include commercially significant breeds (or major breeds), minor breeds and rare breeds. Commercially significant breeds have large populations and are influential in national production. Minor breeds are still found in significant numbers and producers use them in main stream production systems and marketing, but their overall role in the industry is considerably less than those breeds considered commercially significant. Rare breeds include those with relatively small population sizes, do not play a major role in production and have a greater probability of having genetic resource issues. In general, all groupings have genetic resource issues including: decreasing number of registrations per year, increasing inbreeding level, and a decrease in breeder longevity. Selection intensity and reproductive technology is serving to reduce genetic variance in the commercially viable breeds. In the minor breeds the lack of selection intensity may serve to maintain genetic variation. For both groups there is not a direct measure of genetic erosion (actual loss of alleles). However, across both groups, inbreeding levels have increased. This has been demonstrated with several populations from both categories (Hereford, Red Angus, Navajo Churro, Jacob, Hereford Pig).

Swine: Swine breeds can be subdivided into commercially viable breeds, minor breeds and rare breeds. Figure 8 shows that for the eight largest breeds in the U.S., seven have had a decline in annual litter registrations over the past 10 years. The one exception is the Berkshire which has had a resurgence associated with a high demand in the Japanese market, and is now starting to be reflected in the U.S. market, due to its meat color and intramuscular fat content.

The Choctaw, Gloucestershire Old Spots, Guinea Hog, Hereford, Large Black, Mulefoot, Ossabaw Island, Red Wattle, Saddleback and Tamworth are rare breeds in need of attention from a genetic diversity perspective (Annex 1). Although the Gloucestershire Old Spots and Hereford have increased in registration numbers, this progress is tenuous because swine populations can

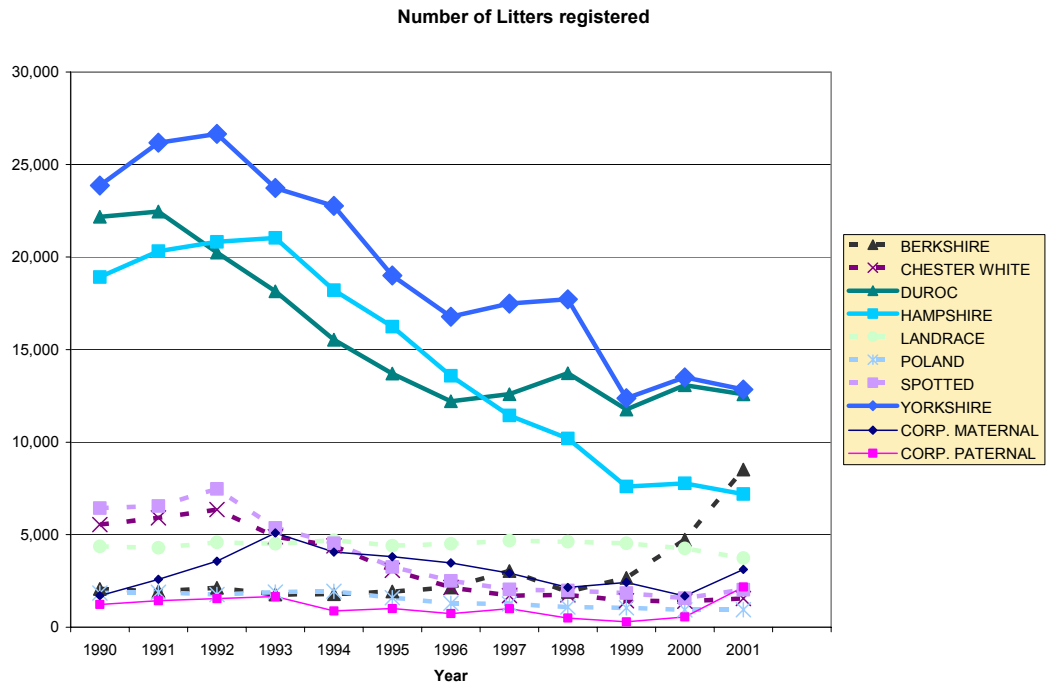
undergo wide fluctuations in population size in short periods of time as illustrated in with the Berkshire breed (Figure 5).

While population sizes have been decreasing for swine breeds in the U.S., several proprietary lines have been formed by private breeding companies. The population sizes of the proprietary lines are similar to those of the smaller traditional breeds (Figure 5).

In-situ conservation of rare swine breeds is maintained in small herds and breeders have established networks through respective breed associations to exchange animals. Ex-situ conservation has been initiated for some of the minor breeds; however, insufficient quantities of semen have been collected to regenerate any of these minor breeds at this point in time.

The largest eight breeds of swine have been characterized by industry and various public institutions (Annex 1). Characterization of the minor breeds is lacking at the phenotypic, genetic and molecular levels.

Figure 5. Trends in the number of litters registered for the 8 largest swine breeds.



Dairy: The nine dairy cattle breeds in the U.S. are experiencing genetic resource challenges. The utilization of artificial insemination and genetic evaluation programs have, in part, contributed to a reduction of the effective population size for dairy cattle breeds (Table 7). In-situ management for minor breeds revolves around small scale producers that have an interest in a particular breed and its conservation. During the late 1990s, the dairy industry became aware of increased inbreeding levels and the ramifications of inbreeding on production. As a result, some breed associations initiated efforts to make producers aware of inbreeding levels and in some instances made software available that enabled breeders to evaluate the genetic relationship and progeny inbreeding levels from potential matings. There are stores of germplasm that could be used for breed regeneration for 75% of the dairy breeds.

The major dairy breeds have been well characterized and documented for milk production and other performance and fertility measures. For the minor breeds, current (the past 10 to 15 yrs) characterization for production traits is lacking. Molecular markers have been used for several recessive defects, particularly among artificial insemination (AI) sires. To boost breed viability some dairy breed associations have opened their herd books and have developed upgrading programs.

Table 7. Dairy breed effective population sizes and annual registrations.

Breed	Effective Population Size	Annual Registrations	
		1990	2000
Ayrshire	59	8,020	6,046
Brown Swiss	47	10,031	10,648
Guernsey	43	13,991	6,151
Holstein	37	395,906	317,567
Jersey	27	54,213	63,776
Milking Shorthorn	56	2,596	2,811
Dutch Belted	-	50	147
Randall Lineback	-	30	30
Milking Devon	-	120	150

Beef: In the U.S. there are 49 beef cattle breeds (Annex 2). Beef cattle breeders have traditionally sought genetic resources from diverse sources that would increase profitability. During the 1970s a large number of continental European breeds were imported into the U.S. to incorporate increased growth rates and leaner carcass composition. At various points in time beef producers in the southern U.S. imported *Bos indicus* breeds to incorporate heat tolerance traits into the cow herd.

Major cattle breeds in the U.S. include Angus, Hereford, Simmental, Charolais, Limousin, and Gelbvieh. Evaluation of breed population status is based upon annual registration numbers. For many breeds there are significant numbers of full-blood cattle that are not registered. Across the major breeds there are significant quantities of cryopreserved germplasm.

Minor breeds are primarily maintained by small scale producers in either extensive or mixed farming systems. Pedigree information is limited for most of the minor or rare breeds. In addition to missing within breed pedigree information there are some breeds where the differentiation between the breeds is unclear (e.g., Pineywoods, Florida Cracker and Texas Longhorn). Cryopreserved stores of germplasm for minor and rare breeds exist in smaller quantities but are probably not sufficient for breed regeneration.

Chicken and Turkeys: Industrial populations consist of a limited number of breeds but a relatively large number of synthetic strains or lines. It is assumed that these populations are secure but, there has been a trend in the industry to maintain only the necessary populations as a cost saving measure.

The primary emphasis in this section shall be on breeds and strains that are not owned or widely used by the industrial sector. This assessment was accomplished through a survey. The two primary pieces of information that were derived from the survey were the number of breeding birds and the number of "primary breeders" (owners with flocks of more than 50 birds). Of the 70 breeds reported, 20 are considered Critical (Annex 5) with such small populations as to be threatened by extinction (Annex 3). Another four are classified as Rare (Annex 3). For these populations there is minimal infrastructure to support in-situ conservation. Ex-situ collections are

non-existent. In addition these populations have not been well characterized for production characteristics for a considerable period of time.

Sheep: There are approximately 50 breeds of sheep in the U.S. (Annex 4). Of these breeds, Rambouillet, Suffolk, Hampshire and Dorset would be considered major breeds generating the majority of revenue for the industry. Twenty-two of the breeds are categorized in one of five conservation priority levels while the remainder has sufficient population sizes as not to be classified as having genetic resource issues.

In general, management of purebred sheep production in the U.S. lacks critical mass and financial resources to implement genetic evaluation at the breed level. The National Sheep Improvement Program was developed to implement genetic evaluation technologies and service for all breed associations that wish to participate. Currently, six breeds utilize this resource (Suffolk, Targhee, Columbia, Hampshire, Dorset and Polypay). Suffolk, Targhee and Polypay have been involved in the program since 1986 and are able to demonstrate increased progress for selected traits as a result of their involvement. Several state universities sponsor ram performance tests which allow producers to obtain performance information. Typical information collected includes growth rates, fat measurements, wool characteristics, and birth type.

Breeds that are in critical need of in-situ and ex-situ conservation efforts include: Gulf Coast Native, Navajo-Churro, Barbados Blackbelly, Santa Cruz Island (feral), and Hog Island (feral). Most of these breeds have established breeder networks that exchange information and breeding stock. However, they lack the infrastructure to assess the population/genetic status and establish breed-wide selection strategies and breeding programs.

Goats: Compared to other ruminant species, the number of goat breeds utilized in the U.S. is small. Mohair production is dependent upon the Angora. Six breeds of dairy goats are recognized (Nubian, Alpine, Saanen, Toggenburg, LaMancha and Oberhasli). Specialized breeds for meat goat production are the: Spanish, Tennessee Stiff-legged (or Myotonic), and Boer. The Nubian has also been used for meat production due to its large body size. Small populations of domesticated or feral goats exist across the U.S. include: San Clemente (feral), Pygmy, Pygora, Kinder and the Nigerian Dwarf.

In the meat goat industry there has been a continuous conversion to the Boer goat due to the Boer's performance characteristics. This conversion is believed to be greatly impacting the viability of the Spanish breed as meat goat producers cross and then backcross Spanish flocks with Boer bucks. The Boer is also impacting the Angora and Tennessee Stiff-legged breeds as more producers are crossing their stock to Boer bucks.

Genetic evaluation has been initiated with Angora, dairy and meat goats (especially in Texas and Oklahoma). These evaluations give breeders information concerning the relative performance of their animals. For over twenty years Angora producers have participated in buck testing programs where mohair quantity and quality are evaluated as well as body weight and feed utilization. Several key lines of Angora have been developed in Texas. Periodically these producers have acquired additional genetic resources from South Africa.

Artificial insemination used across the goat industry is most prevalent with dairy goats. As with dairy cattle, the combination of AI and genetic evaluation is resulting in increasing rates of inbreeding in the dairy goat population as a whole. USDA data indicate, that for all dairy goat breeds, the average inbreeding level is 6.5%.

1.3 Assessing the State of Utilization of Farm Animal Genetic Resources

The livestock sector has responded in an economically rational manner to consumer demands. As the sector has become more industrialized there have been greater efforts to increase product uniformity and consistency. Part of this process is the identification of breeds, lines and stocks that meet a pre-specified set of product quality and biological performance standards, which enable industry to meet consumer demands and control production costs. This type of specialization has taken place most clearly in the poultry, swine and dairy industries. However, similar consolidation exists with sheep (the use of Suffolk and Rambouillet breeds) and beef cattle (Angus).

For all livestock sectors, with the exception of meat and milk goats, there are growing levels of integration between producers and retailers of animal products. Formation of "strategic alliances" is meant to produce livestock products that more closely match consumer demands. In addition it is a mechanism for the beef and sheep industries to create economies of scale. In addition to market quality issues, there is industry-wide emphasis upon reducing the cost of production. Major emphasis across species has been increasing rate of gain and a trend to set harvest end-points at higher weights. For example, average harvest end-points for swine, cattle and lambs are 118, 568 and 59kg, respectively.

Swine: Composite lines are playing a larger role as breeding animals in the commercial industry. The most prominent sire breeds are Duroc, Hampshire and Berkshire, while Yorkshire and Landrace are maternal breeds.

During the 20th century, market pig production moved from purebred systems, to rotational cross breeding programs, and now to terminal crossing programs utilizing specialized maternal and paternal lines or crosses associated with the trend to terminal crossing systems has been a shift in using crossbred multiplier herds as a source of replacement breeding stock. The driving force causing this shift is the 20% increase in market pigs produced per crossbred sow. Compounding the shift away from purebred animals has been the rapid adoption of AI in commercial pig production. From 1990 to 2000 the use of AI has grown from near zero to 60% of the national pig crop. AI sires can service 10 times as many sows as a natural service sire. Therefore, the number of breeding sires needed has decreased as the utilization of AI sires increased. The current inventory of approximately 280,000 breeding sires is about 50% of what was in use 10 years ago and could be reduced to 50,000 sires as AI mating approaches 100% adoption by the commercial industry. The combination of changes in mating systems and use of AI has contributed to a decline in the number of registered purebred swine.

Dairy: Selection for milk production has been extremely successful in increasing the amount of milk produced per lactation. As a result the U.S. Holstein has become a global breed. With the development of common management systems throughout the U.S. all of the current breeds have the potential to be produced in any geographic region. All major and some minor dairy cattle breeds have been characterized at the phenotypic, genetic and molecular level. Major efforts have been initiated to identify QTLs for milk production. Once such QTLs are found it is anticipated that such tools will be incorporated into selection strategies.

As previously stated there is some interest in importing breeds not commonly used in the U.S. Some dairy producers in the north and east are exploring grass-based, seasonal and organic production of milk. The market for this type of product is growing (but the depth of demand is

unclear) and as a result producers are interested in evaluating the potential of Dutch Belted, Red Poll, Native Shorthorn, Canadienne and Dexter cattle. Selection traits of interest include: foraging ability, longevity, fertility, milk nutritional content and milk flavor.

Beef : During the past decade branded meat products ensuring a consistent eating quality have been developed. The Angus breed has been successful in developing a branded product. This success has been translated into increased numbers of Angus or Angus cross cattle being raised in the U.S. similar programs in an effort to create a market identity have been initiated in other beef breeds. During the past decade there has been increased use of composite bulls that fit well into organized crossbreeding programs. Commercially, the major U.S. breeds tend to be used in crossbreeding programs or composite formation.

Crossbred cattle on cultivated pasture.

All major beef cattle breeds have genetic evaluation programs for growth, carcass and fertility traits (Annex 2). Through these programs breeders have been able to effectively tailor breeds to meet market niches and modify production characteristics (e.g., calving ease) which decrease production costs. As a result of genetic evaluation programs and public research efforts major beef cattle breeds have been phenotypically, genetically and molecularly evaluated. Most minor breeds are currently lacking characterization of performance. However, USDA/ARS has characterized Beef Devon, Red Poll and Highland cattle breeds. As with dairy cattle there is interest by some beef producers in switching to a totally grass-fed system. Under such management foraging ability, longevity and fertility are important as selection criteria.

Chickens and Turkeys: The poultry sector utilizes highly specific and proprietary lines. Within these lines intense selection pressure is applied to the pedigreed flocks to produce sire and dam lines which are crossed in various combinations to form composite populations for egg or meat production. There are instances where intense selection for one or two traits has resulted in the emergence of undesirable characteristics (e.g., ascites) when such problems occur industry has employed resources to address the issue. As to antibiotic use, breeding companies have eliminated or significantly reduced their use of antibiotics as a prophylactic in their pedigreed populations.

Consumer interest in range- and pasture-reared chickens, eggs and turkey has increased and in some situations production appears to be falling short of demand. However, the depth of the demand for poultry products raised in such a manner is unclear at this time. Interest in turkey breeds not found in commercial production is increasing and founded upon a belief (without any controlled studies) that they offer foraging potential, skeletal soundness, more robust immune systems and better flavor characteristics.

Sheep: Extensive range sheep production systems have traditionally used Suffolk and Hampshire rams crossed with Rambouillet type ewes for the production of slaughter lambs. Producers in these types of systems either raise their replacement ewe lambs or purchase them. For the maternal breeds selection has traditionally been applied for maternal ability, prolificacy, growth and wool traits. Selection intensity for maternal breeds has oscillated between meat and wool characteristics depending upon commodity price. During the past decade approximately 80 to 95% of income was generated from lamb production in extensive systems making it more

profitable to select for meat characteristics. Selection programs for sire breeds have focused upon growth rate and leanness.

In the mixed crop-livestock production system a wide variety of breeds is utilized including Suffolk, Hampshire, Rambouillet, Columbia and Dorset. This said, it is difficult to categorize how breeds are used in combination with each other in mixed crop-livestock systems, as there is a variety of small flocks raising purebred and/or crossbred lambs for market. The wool component of sheep production in this system has been de-emphasized over the past decade. Due to market forces there is growing interest in hair breeds of sheep such as Dorper, Katahdin, St. Croix and Barbados Blackbelly, which eliminate the need for shearing.

Goats: Breed selection within the goat industry is based upon functional need (meat, fiber, or milk), with several breeds utilized (with the exception of mohair where Angora is the only breed). Breeding values are estimated and used by dairy goat breeders. Angora breeders have consistently applied selection pressure for fiber, reproductive and growth characteristics. During the past decade there has been a shift to Boer goats among the traditional meat goat breeds and a shift from Angora to Boer in Texas. Selection criteria for meat goats are primarily growth rate and mature size.

1.4 Identifying Major Features and Critical Areas of Animal Genetic Resource Conservation and Utilization

Market forces are a primary feature impacting the utilization and conservation of animal genetic resources. In industry there is a continuing drive for product uniformity and production efficiency. To this end, and across sub-sectors, key breeds are emerging as predominant. Such a situation strengthens the need for effective in-situ and ex-situ conservation efforts.

For the economically most important species selection of mainstream breeds and lines will continue. Industry wide selection efforts that employ the most current and cost effective technologies. When implementing such technologies, full recognition of the impact they have or may have on genetic diversity needs to be determined and integrated into selection programs. Corporations, and to a lesser extent, individual breeders involved with these species will continue to explore and utilize new genetic resources within and outside the U.S. in an effort to increase profit margins.

Narragansett turkeys, the first U.S. domestic turkey breed.

Success of in-situ conservation efforts will depend upon sustained interest by the breeders of rare/minor breeds. Preliminary analysis indicates that the turnover rate of breeders raising minor and rare breeds can be as high as 30% per year. To increase economic viability of minor and rare breeds, niche markets have been and need to be developed with sufficient depth to stimulate production.

Providing an infrastructure for minor breed associations is needed. This infrastructure should primarily take the form of assistance in evaluating production characteristics, establishing genetic characterization, developing and maintaining databases for pedigree information and production characteristics, and in planning conservation strategies that will ensure the maintenance of genetic

diversity and possibly increase the marketability of the breed. Potential may also exist for interfacing animal genetic resource issues with land and water conservation efforts.

Given the lack of subsidy programs and the relatively rapid contraction of some genetic resources in the livestock sector, the development of cryopreserved collections needs to proceed immediately. Such an effort may be the most cost effective mechanism to protect and preserve genetic diversity.

Part 1. Summary – Genetic Resources and the Livestock Sector

Livestock and agriculture are important economic activities in the U.S. with farm gate cash receipts of $98 billion and $218 billion per year, respectively. Livestock production is executed in three primary production systems (grazing, mixed crop-livestock and industrial systems). Within each of these production systems the level of intensity of production can change dependent upon the economic circumstances. While each species grouping is confronted with its own specific issues (e.g., environmental regulations, increasing product uniformity, disease control), the beef cattle, dairy, swine and poultry industries are viable. Sheep and goat industries have experienced a significant downturn in animal and producer numbers in the past decade and their long term viability is less assured due to a decreasing critical mass.

Across livestock species there has been a consistent trend to increase production efficiency and strive for more uniform market products. There has also been a generalized trend for total animal numbers to remain constant (or in some instances decrease), a reduction in the number of producers raising livestock, and an increase the number of animals produced for market per producer.

State of Conservation: During the past decade there has been a substantial increase in efforts to conserve and manage animal genetic resources. These efforts have been in both the public and private sector. Across species in-situ conservation efforts are functioning at various levels of complexity. Cryopreserved conservation efforts have been initiated by the National Animal Germplasm Program on 42 breeds and to date one breed could be regenerated from cryopreserved germplasm. A system for categorizing breeds in critical need of conservation due to population size has been developed by the primary NGO involved with genetic conservation and is used throughout research and industry communities. Across species pedigree analyses are being performed to establish baseline levels of inbreeding, rates of inbreeding and effective population sizes.

While progress has been made during the past decade there are several issues limiting the full development of animal genetic resource management:

- public and industry awareness,
- human and financial resources, and
- industry's need to address critical non-genetic problems and not having resources to address genetic conservation issues.

State of Utilization: Major and minor breeds have had phenotypic and in most instances quantitative genetic characterization. Rare breeds by and large have not been so characterized. Within most species, industries tend to focus on utilizing a few selected breeds. In addition to focusing on a limited number of breeds several species groups develop and widely utilize composite lines than breeds. Within a breed or line reproductive technologies are serving to reduce the number of males used. This increases selection intensity but also reduces genetic diversity of the population.

Summary 1 - Continued

Breeders across species select for varying production or product characteristics. The tools utilized in this process are diverse and depend upon industry/breed infrastructure. Selection strategies vary from single trait, tandem, and index selection using varying levels of individual and relative phenotypic measures as well as pedigree information and heterosis. For many species molecular genetic tests are available and may be used to identify animals possessing alleles with positive or negative effects on production.

Critical Areas of Conservation and Utilization: Livestock industries have to position themselves to increase their competitive position in an effort to maximize profit. Development of genetic conservation efforts support such an industry goal by assuring industry has ample genetic resources to draw upon if and when market conditions or production settings change. In an effort to maintain profitability, industry will continue to select for characteristics that yield the greatest revenue. In addition, new genetic resources will be evaluated from time to time. Among major, minor and rare breeds an emerging issue is the duration of time that breeders raise a breed of livestock. For some rare breeds, breeder turnover rate is approximately 20 to 30 percent per year. Such a situation makes in-situ conservation efforts more problematic. Often many of the minor and rare breeds lack sufficient infrastructure to maintain and analyze animal pedigrees for inbreeding rates and levels. In addition, there is often a lack of consensus as to the relative importance of different selection criteria, which may help to maintain genetic diversity but does little to increase the marketability of the breed.

PART 2.0
Analyzing the changing demands on national livestock production and their implications for future national policies, strategies and programs related to animal genetic resources.

2.1 Reviewing past policies, strategies, programs and management practices related to AnGR.

The U.S. livestock sector operates in a market economy where producers make decisions concerning the breed and individuals within a breed that are used to produce future generations. As market signals are received, producers make decisions concerning what breeds to use and the alterations to make within a breed. The variation in producer response can be diverse given the number of producers (e.g., over 800,000 commercial cow-calf producers) engaged in producing a species, the ecological conditions they produce in, and the long term financial goals of the enterprise.

Coupled with this market economy has been a policy to provide consumers with cheaper and safer foods. Lower food costs benefit consumers and stimulate economic activity, which in turn stimulates other sectors of the national economy. Livestock research efforts have been so focused, and as a result, research results have impacted the entire livestock industry by improving management practices, nutrition levels, health and genetic selection. Advances in these areas have allowed the U.S. to produce more product per animal at a lower price.

An important element of the overarching policy for cheaper food, which has also impacted animal genetic resources, has been a national commitment to technology development through the Land Grant Universities and federal research agencies. This two-pronged research approach has resulted in development of very effective methods of genetic evaluation permitting more accurate selection within and between breeds and more rapid genetic improvement in selected traits, also as a result of these efforts considerable breed characterization has been performed and the effect of heterosis evaluated.

The result of these actions on animal genetic resources has been four-fold:

6. development of technologies for genetic evaluation;
7. a continual assessment of the performance of individuals within and across breeds;
8. a series of importations to evaluate new genetic resources for productive advantages; and
9. a narrowing of the genetic base of many species and breeds in an effort to have uniform product quality and/or lower costs of production.

In such a policy and economic climate, issues concerning conservation of genetic resources have to be weighted against more primary production issues that contribute immediately to the enterprise's revenue stream. In 1990 the U.S. Congress enacted legislation authorizing USDA's Agricultural Research Service to manage/maintain agricultural genetic resources. As a result, the National Animal Germplasm Program (NAGP) was initiated in 1999. The NAGP was the first U.S. nationally-formulated program to address the conservation and management of animal genetic resources.

There are several policies that have or are being implemented that impact the livestock sector. National and state environmental regulations concerning environmental quality, specifically air

and water, have been implemented. These policies have the greatest impact on the industrial production systems. It is not clear at this time if genetic modification of animals can be used to reduce emission levels or if these types of policies will alter the industrial production system and/or the genetic composition of the animal used.

In 1992, legislation was passed that removed the wool and mohair subsidy. This legislation has had a significant ramification on the small ruminant industries as a whole and the type of breeds utilized by those industries. As a result of the policy shift, there has been a precipitous decline in sheep and Angora goat numbers in the U.S. In addition to a reduction of numbers, there has been increased interest and shifts in breed choice, particularly toward hair sheep breeds and the South African Boer goat.

Nationally and across species there has been a continuing trend that reinforces the concept that breed development and the creation of new genetic lines within a species is a role best met by the private sector. This trend represents a change from several decades ago when federal and state institutions were more involved in breed and line development. By and large there have been no past policies specially formulated for in-situ conservation of animal genetic resources.

Past and current market and policy forces favor intensification of livestock production. As a result genetic resources were selected to perform in intensive industrial production systems. However, during the past decade there has been a growing consumer interest in products that have not been intensively produced. As a result, niche markets for these types of products have emerged for all livestock species. The livestock entering these niche markets tend to be minor breeds or major breeds produced at lower levels of intensification. The depth of demand for this type of product is unclear, at this time, and the magnitude of the market is relatively small, but some niche markets have grown at the rate of 20 to 30% annually in recent years.

The impact of past and present breeding methods, across species, has yielded increased productivity. As would be expected the magnitude of change has been dependent upon breeding programs, selection intensity and the production environment. In addition to selection pressure breeds that were not present in the U.S. have been imported and evaluated for potential production advantages. This type of importation has been very prevalent with beef cattle. More recent importations have been done with the South African Boer goat and Dorper sheep, and several dairy cattle breeds. The long term acceptance of imported breeds has been dependent upon the economic contribution the breed can make either as a purebred or in breeding systems designed to utilize heterosis.

2.2 - Analyzing Future Demands and Trends in the Livestock Sector

Analysis by Delgado et al. (1998) indicates that per capita demand for meat products in the U.S. will remain relatively constant to 2020 (Table 8). Annual U. S. growth rate of meat consumption was 1.8% per year from 1982 to 1993. Annual growth is expected to continue between 1993 and 2020 at an annual rate of 0.6%. The increase in the rate of consumption is due to increased human population. Per capita meat product consumption is projected to decrease from 118 kg per person to 114 kg per person. Although the per capita consumption is projected to decrease during this period total meat demand will increase by approximately 5 million tons (Council on Agriculture Science and Technology, 1999).

As global economic growth continues, there may be opportunities to increase exports of livestock, germplasm and livestock products. For example, Berkshire swine have been able to establish market share in Japan due to product quality factors that are desirable in that market. Domestically, opportunities for unique animal genetic resources to develop and fit into niche markets may exist.

Table 8. Past and projected consumption trends of meat to the year 2020.

	%/Year	1983	1993	2020
Annual growth 1982-1993	1.8			
Projected annual growth 1993-2020	0.6			
Total meat consumption, million mt		25	31	37
Per capita meat consumption, kg		107	118	114

While there is interest by some consumers in purchasing livestock products that are not produced in an industrial system, it is anticipated that industrial systems will remain prevalent for swine, poultry, dairy and the finishing phase of beef cattle production. Limits on levels of effluent discharge and odor control may encourage livestock production in non-industrial production systems. Animal welfare issues may also cause shifts in production practices, as evidenced by recent Florida regulations modifying the time sows spend in farrowing crates. As part of the movement to de-industrialize the livestock sector and de-intensify production practices there has been some interest in reducing or eliminating antibiotic use in livestock feeds. These factors could impact animal genetic resources by:

- creation of niche markets, and
- exposing livestock to a multitude of environmental changes that will require a more heterogeneous genetic composition to accommodate environmental differences.

Industry and academia have started to explore alternative genetic resources and selection criteria that would address these issues.

Future Directions for Genetic Resources and the Industry at Large

Swine: The swine industry will continue to depend upon existing and newly-formed composite lines. The major breeds will continue to play a role in swine production (especially if they can maintain sufficient population size for effective selection). The increased use of AI will reduce the number of boars needed and when coupled with evaluation of genetic merit will possibly cause a reduction in genetic diversity. There will be some exploration of different breeds and or lines within breeds to evaluate resistance to diseases of importance to the swine industry. The industry has found several genetic markers that are routinely used in selection programs and the trend for utilizing such approaches is expected to continue.

The industry at large will continue to utilize large production units to take advantage of economies of scale. In this type of industrial system, utilization of nutrient-dense feeds will be essential. Efforts will be made to better balance nutrient intake with nutrient needs so as to minimize nutrient waste. Uniformity of product at consistent harvest weights and ages will continue to be important. Therefore, it is anticipated that current trends towards fewer nucleus purebred herds will continue resulting in future reduction of genetic variation in commercial swine populations.

Dairy: Selection for increased milk production will continue to be a priority for the industry. There is a growing interest in employing multiple trait selection for disease or structural soundness. Structural soundness problems impact animal performance by lowering milk production and increasing replacement rates. Breed associations are becoming more aware of the impact that inbreeding can have on milk yield. Therefore, some associations have developed computer software to provide breeders with the inbreeding levels for potential matings. There is a growing interest in crossbreeding to alleviate inbreeding depression and to find genotypes that better match the production system that producers wish to employ. As a result there has and will be exploration of several European breeds not presently in the U.S. in large numbers, these breeds include Montbeliarde, Scandinavian Red and Normande. Preliminary observations would indicate that the Montbeliarde and Scandinavian Red could fit into industrial production systems while the Normande could have a role in low input dairy systems.

It is anticipated that the growth in dairy farms with more than 500 cows will continue in an effort to reduce production costs. Location of dairy production will continue to shift west in response to U. S. population movement and growth. Currently, and in the future, there will be major regions for milk production. The driving force for these regions is their proximity to urban population centers. The impact of animal welfare and environmental regulations on the dairy industry is not yet known. There have been some shifts in production to states with less prohibitive environmental regulations, but it is unclear how much more movement will occur due to regulatory issues.

Beef : U.S. beef producers will continue to select cattle for the greatest financial return. Utilization of genotypes that produce well within a given environment will continue to be of importance to cattle producers and serve to maintain genetic diversity within breeds. In addition producers will continue to explore genetic resources that either improve production efficiency for the specific environments or favorably alter product quality. Selection between breeds and between families within breeds will have the greatest impact on reducing genetic diversity. Due to market forces the number of beef breeds making substantial contributions to commercial beef production is anticipated to decrease over time. Currently artificial insemination accounts for about 5% of all beef matings, but it is not clear if the rate of AI use will increase or remain the same. If the level of AI remains stable inbreeding levels and the rate of change in inbreeding could remain relatively low. Selection for growth, carcass and fertility traits will remain important. There may be increased emphasis on cow longevity among major breeds. Some breed associations are utilizing multi-breed genetic evaluations. It will be difficult for rare or minor breeds to capture a greater market share unless they possess genes for improved production, product quality advantage, disease resistance or climatic adaptation.

The industry at large will continue to consolidate and value-based marketing of cattle will drive selection practices across breeds. As part of consolidation, product uniformity will continue to be an important issue driving biological decisions. To achieve greater product uniformity genetic evaluation will be used and as a result it will continue to be a primary driving variable in the reduction of genetic diversity. Alteration and/or attempts to change environmental policies will continue to be a priority for the industry. Regulations monitoring and controlling the rate of manure runoff may impact the feedlot segment of the industry. In the intermountain west, policies controlling the use of public grazing lands will continue to be debated.

Sheep: Due to depressed wool prices and costs involved in harvesting wool there is a growing interest in raising hair sheep or using them to develop a composite breed that would not require shearing. Currently Dorper (from South Africa) and Katahdin (a composite developed in the US) are undergoing evaluation by researchers and industry and appear to be generating producer

interest. The U.S. has not had a history of producing sheep milk for human consumption. However, over the past decade there has been an increased interest in milk production with selection in breeds known for heavy lactation (Shropshire, Cotswold and Lincoln, and importing East Friesian and Lacaune). Several importations from Canada and France have been made to increase the genetic base of these populations and exploration into this segment of sheep production.

Over the last decade there has been a downward trend in total sheep numbers and operations. It is unclear if the loss of sheep numbers and operations will stabilize or continue to decrease. The increasing demographic age of sheep producers, especially large scale commercial producers, perhaps indicates further losses will occur. Key indicators of the industry's health will continue to be importation of lamb and wool, ability to maintain infrastructure (e.g., packing plants) and federal and state lands policies. Opportunities exist for development of niche markets for lamb and fiber products. In addition the increasing interest in using sheep as a biological control mechanism for invasive weeds or controlling brush encroachment will provide avenues for increased revenue stabilization.

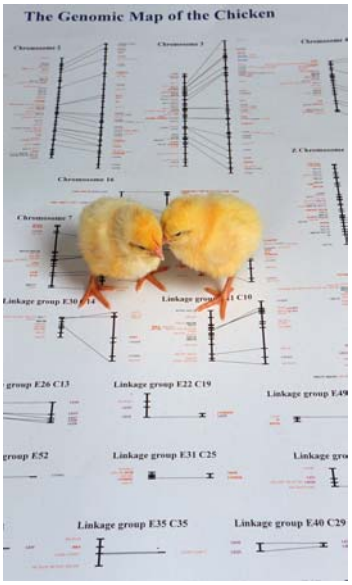
Industry contraction will affect animal genetic diversity. Contraction is expected particularly in the major sheep breeds. Both reduced number of operations and greater implementation of genetic evaluation will increase the need for careful management of genetic resources. Those remaining in the industry will most likely continue to explore the importation and/or development of existing genetic resources to increase biological efficiency and/or reduce production costs.

Goats: Across all three sub-sectors of the goat industry producers will continue to seek genetics that are believed to increase the profitability of their flocks. The decline in Angora numbers is of concern due to the time required to develop mohair with the quality characteristics necessary to compete in the global market. However, several factors (the value of the dollar and some increase in demand) would seem to indicate that the breeding doe population is stabilizing.

Several aspects of goat production suggest the existence of production/market niches which could have a positive impact on the industry and genetic diversity. These include:

- limited capital investment required,
- expanding markets for goat meat and dairy products,
- providing an income source from marginally productive lands, and
- controlling unwanted vegetation types.

Although opportunities exist for goat producers it is unlikely that goat milk and meat products will become mainstream products available for large numbers of consumers throughout the nation.



Poultry: For the immediate future, the poultry industry will continue to develop composite lines for market. The pedigreed populations, that are the foundation for composite lines will continue to be selected for growth, feed efficiency, fertility, structural soundness and carcass yield. In some if not all instances, companies have reduced or eliminated the prophylactic use of antibiotics which should in turn result in indirect selection being applied for disease resistance. Utilization of molecular genetic approaches will occur if the QTL's add value or efficiency to the selection process.

Breeding firms will continue to maintain multiple populations as a biosecurity measure. A large number of poultry breeding firms have undergone mergers and acquisitions during the past decade. It is unclear what impact these mergers have had on genetic diversity. Upon acquiring a breeding firm there tends to be a culling of lines that do not fit into the new owners' breeding program. Despite the consolidation of large breeding firms there are smaller and relatively younger companies that have entered the industry. As these companies develop product lines there is the opportunity to broaden the overall genetic diversity within the industry. The future role of non-industrial breeds and populations is unclear. Unless such breeds can demonstrate marketability their role and genetics will remain marginalized.

2.3 Strategies for conservation, use and development

Formulation and execution of strategies for conservation, use and development of animal genetic resources will occur at two levels: the public sector and the private sector. At the public sector level the National Animal Germplasm Program was formed to address conservation, use and development needs at the national level. In addition to the national effort, there are land grant universities that are engaged in maintaining unique research populations and addressing researchable voids in conserving genetic resources. Non-governmental organizations are also engaged in conserving rare breeds. Their contributions include monitoring live animal populations, assisting in the formation of breed associations and cryopreserving germplasm.

Cryopreservation is the principal public sector mechanism for ex-situ conservation of animal genetic resources as it allows genetic resources to be secured at nominal costs. Across species a strategy has been developed to acquire cryopreserved germplasm from numerically large and rare breeds simultaneously. As a result the germplasm collected to date represents a broad spectrum of breeds. With repeated sampling over time, changes in gene frequency can be captured, thereby preserving the value and utility of the collection for potential users. Table 9 provides a summary of the collection developed to date.

Table 9. Percent of breeds and germplasm present in cryopreserved collections and the number of breeds per species with known live animal conservation activities.

Species	Percent of breeds collected	Percent of required germplasm acquired*
Dairy cattle	75	30
Beef cattle	30	5
Swine	30	3
Sheep	43	4
Goats	20	3
Chickens	41 lines	1

* Given a target of 150% of breed regeneration.

The private sector is involved in conservation activities primarily through in-situ conservation. Numerous breeders are involved in raising rare and minor breeds. Across species and breeds within species there is not a uniform approach to in-situ conservation. Breeders raising a particular breed are linked together through a breed association or a loose network of interested breeders.

The public and private sector are interfaced by a number of different mechanisms. NAGP and universities work directly with producers and/or their organizations. In addition, extension

services have been engaged in the conservation effort by providing training to producers in the collection and preparation of germplasm for cryopreservation.

There is no legislation which provides producers with a subsidy for raising minor, rare or endangered breeds. Therefore, for unique genetic resources to remain stable or increase in usage they will have to compete in the marketplace. While, at this point in time, some breeds may have difficulty in competing, changes in consumer preferences may encourage the raising of diverse breeds.

As part of the in-situ conservation strategy (and the public-private linkage), studies have been initiated to evaluate baseline breed population dynamics using annual registrations as a proxy for population size, and evaluating inbreeding levels and the rate of change of inbreeding levels.

Use and Development: Choice and development of livestock breeds is a private sector activity. Breeders make independent decisions as to which breeds to employ and how a breed's genotype is modified to meet consumer demands. Key customer criteria will be increased efficiency of production and product uniformity.

Typical Berkshire boar.

Genetic gain will be a driving force in the selection and use of breeding stock. Some breeders across species have started to consider genetic plateaus, inbreeding levels and are making efforts to avoid inbreeding depression. Selection for disease resistance has and will increase in importance and some breeders are incorporating selection for disease resistance and immuno-competence into their selection strategies. The public sector will assist industry by developing technologies that contribute to selection accuracy and efficiency. Ultimately the sequencing of domestic livestock species' genome will lead to the development of tools that industry can use.

2.4 Future national policy, strategy and management plans for the conservation, use and development of Animal Genetic Resources

USDA/ARS is the lead agency charged with the conservation, improvement, utilization and development of animal genetic resources. ARS's formal conservation program, the National Animal Germplasm Program (NAGP), was initiated in 1999.

The NAGP is developing a comprehensive management strategy for animal genetic resource management. It is and will continue to cryopreserve germplasm from all livestock species that can be cryopreserved. In the cryopreserved collection all breeds will be repeatedly sampled over time to capture changes in allele frequency. In addition, the program will continue to monitor live animal populations at the breed level. The program will also evaluate the genetic diversity captured within and between breeds using pedigree and molecular marker information. The collection of germplasm, live animal census and tools to assist users in managing animal genetic resources will be integrated through an information system accessible through the internet.

A significant issue will be the assistance the program can provide to breeders of numerically limited breeds. Two primary issues to contend with are the economic viability of the small breeds and the rapid turnover of breeders raising rare breeds.

Cryopreserved samples offer the best conservation strategy, particularly when current market forces do not favor a particular breed or type. Such an approach also assists industry in increasing or maintaining its cost effectiveness and increasing the stability of food security.

Subsidies for rare or unique genetic resources are not viewed as an effective conservation strategy. Rather, market forces are the major driving variable controlling genetic resource utilization.

As previously pointed out, consumer demands across livestock species are transient in nature. As a result there is a need for public institutions to continue exploring and testing diverse genetic resources to meet changing market demands. The U.S. conservation effort supports this approach by assuring public institutions and industry access to a broad array of genetic resources.

International cooperation can be increased by allowing market forces to drive the exchange of germplasm. The current global structure permits public or private sector to purchase genetic resources for potential use in new environments and markets. In the current situation buyer and seller have the opportunity for price discovery.

Part 2.0 Summary – Changing Demand

Utilization of genetic resources in the U.S. is driven by market forces and a policy of providing consumers with cheaper food which in turn stimulates economic activity in other sectors of the national economy. As a result of market and policy actions animal genetic resources have been influenced in the following ways:

1. Development of technologies for genetic evaluation;
2. A continual assessment of animal performance within and across breeds;
3. Continued introductions followed by evaluations of new genetic resources for productive advantages; and
4. Increased uniformity and product quality and/or lower production costs with a consequent narrowing of the genetic base of many species and breeds.

Future domestic demand for livestock products has been projected to grow annually at 0.6%. While per capita consumption is expected to slightly decrease, the loss in consumption will be offset by population growth. Opportunities for organically produced livestock products will continue to develop and therefore offer some marketing options for minor and rare breeds. However, the depth of demand for such products is unknown at this time.

In response to future demand for livestock products and other market forces several trends will be prevalent across species. In general there will be an increase in the use of composite lines, an increase in the importance of specific families within a breed and an increase in market place dominance of a small number of breeds. Across species there will be continued emphasis on: exploring the potential of new genetic resources not currently in the country, selection for increased performance, and increased selection emphasis upon disease resistance and structural soundness. In some instances molecular markers will be found that can be used to increase selection intensity for specific traits.

Conservation Strategies: The primary national conservation strategy is to develop information on livestock population diversity and develop cryopreserved reserves of germplasm and other tissue types. There is broad consensus that such activities are essential for understanding and utilizing genetic resources. In developing the cryopreserved collection of germplasm all species committees (consisting of federal, state and industry representatives) involved with the national program have agreed that collections should be simultaneously developed for all breeds regardless of population size and therefore conservation of animal genetic resources is a uniquely federal activity. The developed collections will serve three roles:

1. A secure reserve of genetic resources for the industry and public at large, which can be used in times of need;
2. A source of germplasm for industry to use in the formation of new lines with production characteristics to meet changing consumer demand; and
3. A source of germplasm and/or DNA to be used by public and private researchers.

In-situ conservation will continue to be principally a private sector activity. However, due to the size and scale of minor and rare breed associations the public sector, in conjunction with non-governmental organizations, will develop tools and approaches that will assist such owners with the maintenance of their breed's genetic diversity and economic viability.

Part 3.0
Reviewing the State of National Capacities and Assessing Future Capacity Building Requirements

3.1 Assessment of National Capacities

In 1990, the U.S. Congress authorized the U. S. Department of Agriculture's Agricultural Research Service (ARS) to implement a national genetic resource program that includes plants, insects, microbes and livestock. ARS established the National Animal Germplasm Program (NAGP) in 1999. Formation of the NAGP gave the livestock sector a national focal point for addressing genetic diversity and conservation issues. The legislated functions for NAGP are:

- Provide for the collection, classification, preservation and dissemination of genetic material,
- Conduct research on genetic materials collected and on methods for storage and preservation,
- Coordinate program activities with similar domestic activities,
- Make available upon request, without charge, the genetic material which the program assembles, and
- Expand types of genetic resources included in the program to develop a comprehensive genetic resources program.

As no formalized national capacity existed before 1999 a national structure and laboratory infrastructure had to be developed. As part of the national structure six species committees were formed (beef cattle, dairy cattle, swine, small ruminants, poultry and aquaculture). Committee membership is comprised of scientists representing ARS and universities, breeders and industry. The NAGP looks to these committees for guidance in the planning and execution of collection development.

Human resources: As a relatively new program the NAGP needs address genetics, cryopreservation and information system issues. To do so will require additional resources for staff and the program. Within the university system there is technical capacity, but there is a need to increase awareness and the number of faculty that are involved in genetic diversity issues. There is a need at the university level to train a new cadre of professionals capable of working in this area.

Infrastructure: The development of the central repository has proceeded from the national program's inception in 1999. Laboratory space has been developed, as has the capability to cryopreserve relatively large quantities of semen. The national plan calls for the development of satellite repositories as resources become available.

Information Systems: Currently, a database/information system is under development. When completed it will be one component of the USDA's Genetic Resources Information Network (GRIN). As currently planned, the information system will allow users to inventory germplasm and its information. GRIN will present information at the breed level concerning the population status, phenotypic and genotypic parameters for the breed. Another component will contain a suite of tools available for a broad range of users to assist with the management of animal genetic resources.

Education and Research Facilities: Currently, at colleges of agriculture there are no formal courses in the conservation of farm animal genetic resources. Research efforts exist at a large number of universities in the areas of cryopreservation of germplasm or other tissues and characterization of breed types. There is additional scope for universities to explore other aspects of animal genetic diversity. With the exception of cryopreservation protocols, research activities concerning the genetic aspects of animal genetic resources are lacking at both the quantitative genetics and molecular genetics level. Across universities there is a critical situation emerging where animal resources are being significantly reduced and thereby limiting the ability of faculty to perform characterization or other long term breeding and genetic studies.

Legislation and regulations: As stated previously, in 1990 the U.S. Congress passed legislation authorizing the development of a national program to deal with the conservation of animal genetic resources. In the U.S. much of the development of unique genetic stocks is in the private sector. The absence of a benefit sharing plan enables the marketplace to exercise its ability to discover prices and reduce production costs that result in lower consumer food costs. Therefore, there has been no call for legislation or regulations to develop benefit sharing or otherwise impede the execution of commerce.

Increased environmental regulations for waste control may have a negative effect on the industrial system and stimulate interest in other genotypes. In addition, the need to control invasive weed species and decrease herbicide use may positively impact animal genetic resource diversity by providing a more secure niche for minor and rare breeds. Likewise the National Organic Standards for food production may also provide a niche for such breeds. There has been no call by industry for legislated subsidy for raising minor breeds of livestock.

International co-operation and trade: The US cooperates internationally on a number of animal genetic resource issues. Specific to the conservation of animal genetic resources there is interaction in North America, South America, Europe, Central Asia and Africa. Some of the European conservation programs are at a similar stage of development and there has been informal interaction with them. Across the US there are a number of federal and state scientists that interact with scientists of other nations on the use of animal genetic resources and mapping animal genomes.

U.S. animal genetic resources are traded globally and this trade has undoubtedly led to increased animal performance, economic returns and poverty reduction. The US Holstein is considered a global breed and has made substantial contributions to the global dairy industry. The U.S. also imports animal genetic resources as it searches for material that can contribute to its wide array of production environments. In some instances these imports have served to reduce the prominence or eliminate breeds that have been in place for considerable time (e.g., Spanish goats and Shorthorn beef cattle). While these breeds have been or are undergoing reductions in population size and industry importance, the consumer is ultimately benefiting.

Part 3.0 Summary – Building Capacity

Formation of the National Animal Germplasm Program (NAGP) by USDA/ARS in 1999 provided a basis to establish a national capacity to conserve animal genetic diversity. In addition to the national program, several state universities and non-governmental organizations are involved in the conservation effort.

On the national level the original design for the NAGP called for a central repository and three satellite repositories that would provide for redundancy of the collection and focus upon one or two species. Also part of the original design was staffing of the central repository and development of an information system that would assist in monitoring live animal populations as well as the inventory contained in the repository(s). At this time a central repository has been established, laboratories are under development and collection efforts underway. Staffing at the central repository is partially complete and awaiting additional funding to bring the scientific and technical complement up to full strength. Funding is needed to establish the satellite repositories.

An information system under development as part of the national program will be a component of the Genetic Resources Information Network. The system will allow a broad range of users to monitor live animal populations, the status of germplasm in the repository, and provide tools to assist users in managing animal genetic resources.

At the university level there are approximately 50 scientists working with the national program and in some instances maintaining unique research populations. There is a need for increased financial support for such efforts at the university level and there is a need for animal, dairy and poultry departments at universities to increase their teaching emphasis on animal genetic diversity in order to train a new cadre of professionals.

Part 4.0
Identifying national priorities for the conservation and utilization of animal genetic resources

The Food, Agriculture, Conservation, and Trade Act of 1990 established the conservation of animal genetic resources as a national priority. There are several actions needed for this legislation to be fully implemented. A primary action is the continued development of the National Animal Germplasm Program in three areas:

1. continued development of infrastructure and increased staffing;
2. continued development of cryotechnologoes and cryopreserved germplasm reserves and increased in-situ conservation and utilization activities; and
3. understanding between breed and within breed genetic diversity and the current and future economic valuation of genetic resources.

There is a significant need to improve information infrastructure through the continued development of the Genetic Resources Information Network. Information on breed population dynamics, state of inbreeding levels and the rate of change of inbreeding needs incorporation into the information system. Smaller breed associations need access to an information system that can assist them in recording pedigrees and planning matings within their small populations.

Many universities maintain unique animal populations that took several decades to develop. Many animal populations have already been lost while others are at risk of elimination, primarily due to budget constraints. Efforts need to be made to increase the awareness of the value of these genetic resources, increase their utilization in current research efforts, and make senior university administration officials aware of the utility and uniqueness of such lines.

Across production systems there are a number of land and vegetation conservation efforts implemented by government agencies where animal genetic resource efforts could be interfaced. Implementing agencies need to recognize that rare and minor breeds can be merged into their program efforts and can enhance their vegetation or landscape conservation goals.

Inter-agency planning should be done to develop plans for emergency collection of germplasm to capture genetic resources that are at risk of being lost during intentional eradication, epidemics and other natural disasters, and in planning how to utilize cryopreserved germplasm to reestablish animal populations that may have been significantly impacted by an epidemic and eradication actions.

Where appropriate and where industry has expressed a need for new or different genetic resources from outside the U.S., efforts should be made to acquire germplasm for evaluation in U.S. production systems.

Part 4. Summary - Priorities

Priorities are subdivided into biological issues and physical capacity issues. Biologically the priorities include:

1. Complete breed level collections of cryopreserved germplasm and tissue;
2. Increase levels of in-situ conservation by the private and public entities;
3. Create a more thorough understanding of within and between breed genetic diversity; and
4. Develop more efficient and reliable cryopreservation protocols for semen, embryos and oocytes.

Physical capacity priorities include:

1. Continue development of NAGP infrastructure and staffing;
2. Increase awareness and support of university conservation efforts;
3. Leverage the complementarity of different federal agency programs; and
4. Increase industry awareness and involvement with various aspects of managing animal genetic diversity.

Part 5.0
International co-operation in farm animal biodiversity

U.S. researchers and industry have a wide range of interactions and collaborative efforts abroad. Such interaction facilitates the exchange of knowledge, conservation and utilization of animal genetic resources. Furthermore such free exchange facilitates global improvement of livestock productivity.

Co-operation in development and utilization of information systems is a key area for international interaction. For example, linkage of the Genetic Resource Information Network with DAD-IS would be an important initiative.

It is anticipated that as development of cryopreserved collections of animal germplasm proceeds there will be more interaction between countries that are also developing gene banks. To date, these contacts and interactions have been informal, but they serve as a basis to develop into stronger bilateral and potentially multilateral interactions.

In the past, the U.S. plant conservation program has served as security backup for the seed collections for countries and international organizations. There is a willingness to continue this type of co-operation with animal germplasm.

Significant regulations are in place to facilitate principles, modalities, movement, fair exchange and trade of animal genetic resources via the World Trade Organization's linkage of monetary and health issues. Therefore, additional regulations and/or agreements are not necessary.

International exchange of animal germplasm

Importation and exportation of germplasm is relatively small, the value of which is less than 0.1% of the livestock sector's annual revenue. While the value may be small these exports and imports do provide producers on a global scale an opportunity to compare, test and improve livestock productivity.

During the last decade one interesting importation was the South African Boer goat. This breed appealed to U.S. producers due to the large mature size and growth rate. The original importations were from New Zealand, due to the phytosanitary issues involved with direct importations from South Africa and the high importation costs. As with previous beef cattle importations, there was price speculation for the imported Boers. As the population size grew the speculative bubble burst and today's prices are more in line with other goat breeds and production costs.

Positively, this importation created a number of opportunities for South African and U.S. breeders to exchange information on the production of the breed. For example, South African breeders traveled to the U.S. to consult on raising Boers through clinics sponsored by universities and serving as judges at livestock shows. In general, there was optimism expressed by breeders of both countries about collaboration and prospects for a two way exchange of Boer germplasm once U.S. populations grew to sufficient size and quality.

It is acknowledged that the Boer has made a significant impact on meat goat production, but it has created a genetic conservation issue by displacing other meat goat breeds, particularly the Spanish breed. In this case the positive economic impact of the importation may exceed breed displacement. The NAGP has initiated an ex-situ collection to secure the existing diversity of the Spanish breed While a genetic diversity issue arose from this importation, there have been no requests to alter policies on importation or to have a genetic impact assessment prior to importation.

Part 5.0 Summary of International Co-operation

The U.S. will continue to work with other countries in the development, use and exchange of genetic resources, in addition to information exchange concerning the performance of various genetic resources. The success of cooperative efforts will be greatly facilitated by open exchange of germplasm as would any market driven commodity.

Bilateral exchange of concepts and expertise is proceeding and expected to continue, particularly with countries that are establishing similar national programs.

In the past, the U.S. National Plant Germplasm Program has served as a security backup for various non-U.S. seed collections. There is a willingness to develop this type of collaboration for animal genetic resources.

ANNEX 1. Swine

Table A1. Annual registrations, characterization and conservation classification of swine breeds.

Breed	ALBC Classification	Registration Numbers		Phenotypic, Quantitative Genetic and Molecular Characterization for Growth, Fertility & Meat Quality							
		1990	2000-2001	G	BF	NBA	NW	ST	C	RN	HAL
Berkshire		16,568	37,912	+/+	+/+	+/+	+/+	+/	+/		
Chester White		44,352	12,783	+/	+/	+/	+/	+/	+/		
Duroc		177,432	100,680	+/+	+/+	+/+	+/+	+/	+/		+
Hampshire		151,400	57,579	+/+	+/+	+/+	+/+	+/	+/	+	+
Landrace		34,920	29,880	+/+	+/+	+/+	+/+	+/+	+/		+
Poland China		14,784	7,043	+/	+/	+/	+/	+/	+/		
Spotted Poland China		51,544	15,937	+/	+/	+/	+/	+/	+/		
Yorkshire		164,800	102,784	+/+	+/+	+/+	+/+	+/	+/		+
Choctaw	Study	No registry	No registry								
Gloucestershire Old Spots	Critical	36	225								
Guinea Hog	Critical	50	No registry								
Hereford	Rare	456	1,209								
Large Black	Critical	200	22								
Mulefoot	Critical	No registry	No registry								
Ossabaw Island (Feral)	Critical	35	No registry								
Red Wattle	Critical	200	58								
Tamworth	Rare	2,490	1,012								

+/+ Phenotypic and quantitative genetic characterization; +/ Phenotypic characterization; + molecular characterization.

G – Growth to Market Weight
BF – 10th rib Backfat Depth
NBA – Number Born Alive
NW – Number Weaned
ST – Body Structure and Soundness
C – Body Confirmation
RN – Rendenment Napole gene
HAL – Halothane gene

ANNEX 2 – Beef Cattle

Table A2.1. Beef cattle breed registrations, traits that are used in performance evaluation programs, and conservation status.

Breed	Registration Numbers		Weight Traits			Fertility & Behavior				Carcass & Ultrasound						ALBC Classification
	1990	2000-2001	BW	WW	YW	MI	TM	SC	ST	CE	YH	FT	MS	RE	CW	
American White Park	357															
Angus	159,036	271,222		+/+	+/+	+/+	+/+	+/+		+/+	+/+	+/+	+/+	+/+	+/+	
Ankole Watusi	125	27														Rare
Barzona	1,300															
Beefmaster	46,469	32,263	+/+	+/+	+/+	+/+		+/+								
Belgian Blue	200	30														
Belted Galloway	319	1,257														Watch
Blonde d'Aquitaine	756	452	+/+	+/+	+/+	+/+	+/+									
Braford	2,530	3,214	+/+	+/+	+/+	+/+	+/+									
Brahman	13,000	8,250	+/+	+/+	+/+	+/+										
Brangus	32,069		+/+	+/+	+/+	+/+	+/+	+/+				+/+	+/+	+/+		
Braunvieh	592	4,745	+/+	+/+	+/+	+/+	+/+									
British White	250															
Charolais	44,812	45,354	+/+	+/+	+/+	+/+	+/+	+/+				+/+	+/+	+/+	+/+	
Chianina	8,022	6,251														
Devon	177															Critical
Dexter	434	852														Rare
Florida Cracker Pineywoods	600															Critical
Galloway	102															Watch
Gelbvieh	36,964	55,276	+/+	+/+	+/+	+/+	+/+	+/+	+/+	+/+		+/+	+/+	+/+	+/+	
Hereford	186,382	98,444	+/+	+/+	+/+	+/+	+/+	+/+		+/+		+/+	+/+	+/+		
Herens	12															
Highland	766															Recovering
Kerry	20															Critical
Limousin	76,701	47,656	+/+	+/+	+/+	+/+		+/+	+/+	+/+		+/+	+/+	+/+	+/+	
Maine-Anjou	5,000	13,500	+/+	+/+	+/+	+/+	+/+									
Marchigiana	54	50														
Murray Grey			+/+	+/+	+/+	+/+		+/+		+/+						
Normande	350															
Piedmontese	783	732														
Pinzgauer	997															
Red Angus	22,530	51,423	+/+	+/+	+/+	+/+	+/+		+/+	+/+	+/+	+/+	+/+	+/+	+/+	
Red Brangus	5,205	2,647	+/+	+/+	+/+	+/+	+/+									
Red Poll	1,840		+/+	+/+	+/+	+/+	+/+									Rare

Table A2.1 (continued). Beef cattle breed registrations, traits that are used in performance evaluation programs, and conservation status.

Breed	Registration Numbers		Weight Traits			Fertility & Behavior				Carcass & Ultrasound						ALBC Classification
	1990	2000-2001	BW	WW	YW	MI	TM	SC	ST	CE	YH	FT	MS	RE	CW	
Romagnola	231	276	+/+	+/+	+/+	+/+	+/+									
Salers	30,467	14,330	+/+	+/+	+/+	+/+	+/+	+/+	+/+			+/+	+/+	+/+	+/+	
Santa Gertrudis	15,193	8,473	+/+	+/+	+/+	+/+	+/+									
Senepol	2,072	1,025	+/+	+/+	+/+	+/+	+/+					+/+	+/+	+/+		
Shorthorn	18,002	23,109	+/+	+/+	+/+	+/+	+/+					+/+	+/+	+/+	+/+	
Simbrah			+/+	+/+	+/+	+/+	+/+			+/+		+/+	+/+	+/+	+/+	
Simmental	78,456	43,073	+/+	+/+	+/+	+/+	+/+			+/+		+/+	+/+	+/+	+/+	
South Devon	800	2,177	+/+	+/+	+/+	+/+	+/+	+/+								
Sussex																
Tarentaise	3,506	1,632	+/+	+/+	+/+	+/+	+/+			+/+						
Texas Longhorn	11,919	6,519														
Tuli	150	150														
Wagyu			+/+	+/+								+/+	+/+	+/+		
Welsh Black	1000															
White Park	14															Critical

+/+ Phenotypic (first +) and genotypic (second +) measurements taken during the last 20 years.

LEGEND

BW	Birth Weight
WW	Weaning Weight
YW	Yearling Weight
MI	Milk
TM	Total Maternal
SC	Scrotal Circumference
ST	Stayability
CE	Calving Ease
YH	Yearling Height
FT	Fat Thickness
MS	Marbling Score
RE	Ribeye Area
CW	Carcass Weight

ANNEX 3 - Chickens

Table A3.1. *Critical* breeds of chickens

Breed Name (**Bold = American Breed**)	Number of Breeder Birds	Number of Primary Breeding Flocks	Comments
Andalusian	456	3	
Aseel	94	1	
Buckeye	72	0	
Buttercup	436	3	
Campine	390	3	
Catalana	38	0	
Chantecler	48	0	
Crevecoeur	191	2	
Delaware	601	2	While slightly over the numeric threshold, they are a US breed, & the only one developed as a broiler
Dorking	441	4	
Faverolle	456	3	
Holland	38	0	
Houdan	98	1	
Java	112	0	
La Fleche	69	0	
Malay	34	0	
Redcap	151	1	
Russian Orloff	35	0	
Spanish	143	1	
Sumatra	352	3	

Table A3.2. *Rare* breeds of chickens

Breed Name (**Bold = American Breed**)	Number of Breeder Birds	Number of Primary Breeding Flocks	Comments
Ancona	893	3	
Lakenvelder	567	3	
Langshan	514	4	
Sussex	860	4	

Table A3.3. *Watch* breeds of chickens

Breed Name (**Bold = American Breed)**	Number of Breeder Birds	Number of Primary Breeding Flocks	Comments
Brahma	3164	7	
Cochin	3195	6	
Cornish	1330	3	Listed as Cornish - Non-industrial. There are significant holdings by industry.
Dominique	1931	6	
Hamburg	1274	3	
Jersey Giant	2811	7	
Minorca	1328	3	
New Hampshire	3933	6	
Polish	2017	5	
Rhode Island White	2635	2	

Table A3.4 *Recovering* breeds of chickens

Breed Name (**Bold = American Breed)**	Number of Breeder Birds	Number of Primary Breeding Flocks	Comments
Australorp	5032	7	
Leghorn (non-industrial)	8180	10	Includes all purebred varieties. Does not include industrial strains of White Leghorns.
Orpington	9966	7	
Plymouth Rock	22,050	14	List as Plymouth Rock - Non-industrial
Rhode Island Red	20,780	11	
Wyandotte	8476	9	

Table A3.5. *Study* breeds of chickens

Breed Name (**Bold = American Breed)**	Number of Breeder Birds	Number of Primary Breeding Flocks	Comments
Araucana	4988	5	Araucanas & Ameraucanas are often confused with each other, and may be sold interchangeably and therefore these numbers may not be reliable.
Cubalaya	155	1	
Egyptian Fayoumis	300	2	
Hungarian Yellow	0	0	We know there are some in Canada. The North American population played an important role in the restoration of the breed to Hungary.
Iowa Blue	26	0	
Lamona	0	0	American Breed, developed by the USDA. None found.
Manx Rumpy, (aka Persian Rumpless)	11	0	Rumplessness is a single gene expression. However, two rumpless breeds – the Persian Rumpless and the Manx Rumpy – have breed histories as found in several older publications.
Modern Game	183	1	Concern about the reliability of the numbers due to lack of participation by breeders in the census.
Nankin	0	0	Bantam with no large counterpart.
Old English Game	213	2	Concern about the reliability of the numbers due to lack of participation by breeders in the census.
Phoenix	406	4	Imported in the early 1900s. Admitted to APA in 1965.
Sebright	55	1	Bantam with no large fowl counterpart.
Shamo	129	1	
Sultan	238	2	
Yokohama	101	1	

Table A3.6. Turkey census data by variety.

Variety Name	1997 Census (F only)	Total breeder birds (F/M), 2002	Number of Primary Breeding Flocks	Hatcheries Breeding	ALBC classification
Auburn	-	6 (3/3)	1	1	Study
Beltsville Small White	-	44 (34/10)	3	3	Critical
Black (Spanish)	62	460 (391/69)	8	9	Critical
Blue Palm	-	4 (2/2)	2	1	Study
Bourbon Red	664	1498 (1314/184)	11	11	Watch
Bronze - Standard		427 (362/65)	7	7	Critical
Bronze - Breasted	7038 (BB & Standard)	600	1	1	Watch
Buff	-	0	0	0	Critical
Calico	-	5 (4/1)	1	1	Study
Chocolate	-	5 (3/2)	1	1	Study
Jersey Buff	-	19 (14/5)	2	2	Critical
Lilac	-	13 (8/5)	2	2	Study
Narragansett	3	331 (288/43)	8	8	Critical
Royal Palm	381	810 (696/114)	10	10	Rare
Silver Auburn	-	6 (3/3)	1	1	Study
Slate (Blue)	60	421 (367/54)	7	7	Critical
Slate (Red)	-	11 (8/3)	1	1	Study
White - BB	4600	N/Av	N/Av		Study
White Holland	4	51 (39/12)	4	4	Critical
White Midget	-	24 (19/5)	1		Critical

ANNEX 4 - Sheep

Table A4.1 Annual registrations, characterization and conservation classification of breeds.

	1980	1990	2000	Phenotypic &/or Quantitative Genetic Characterization				ALBC Classification
				Growth	Wool	Repro.	Carcass	
Barbados Blackbelly								Watch
Black Welsh Mountain								Recovering
Blue Face Leicester		50	70					
Border Leicester		273	513					Rare
Cheviot	2518	2851	2136					
Clun Forest								Recovering
Columbia	10044	7828	4117	+/+	+/+	+/+	+/+	
Corriedale	6534	4332	2491	+/				
Cotswold		338	499					Rare
Delaine Merinos	196	732	497					
Dorper			2165	+/		+/	+/	
Dorset	15206	19531	11636	+/+		+/+	+/	
Dorset Horn								Watch
Finnsheep	1069	1034	264	+/+		+/+	+/	
Gulf Coast Native				+/		+/		Critical
Hampshire	21360	16460	10018	+/+	+/	+/+	+/+	
Hog Island								Critical
Jacob		625	172					Rare
Karakul		183	316					Rare
Katahdin Hair Sheep		825		+/				Recovering
Lincoln	275	716	915					Watch
Montadale	3139	3754	2806					
Natural Colored		1547	2425					
Navajo Churro		14	197	+/		+/		Rare
North Country Cheviot	705	685	544					
Oxford	1457	1914	1593					Watch
Polypay		11874	1935	+/+	+/+	+/+	+/	
Ramboullet	11872	17100	5062	+/+	+/+	+/+	+/	
Romney	1093	2806	1822					
St. Croix				+/				Rare
Santa Cruz								Critical
Scottish Blackface		250	219					
Shetland		385	1700					Recovering
Shopshire	4453	3114	2554					Recovering
Soay								Study
Southdown	4371	5899	5497					Recovering
Suffolk	83409	58928	18293	+/+	+/	+/+	+/+	
Targhee	1445	2538	1570	+/+	+/+	+/+	+/	
Texel			347					
Tunis	301	394	711					Rare
Wiltshire Horn								Rare

+/+ Current phenotypic (first +) and genotypic (second +) measurements taken during the last 20 years.

Annex 5 – American Livestock Breeds Conservancy Classifications

Table A5.1 Classifications for mammals.

Category	Definition
Critical	<200 annual N. American registrations and fewer than 2,000 global population.
Rare	<1000 annual N. American registrations and fewer than5,000 global population.
Watch	<2400 annual N. American registrations and fewer than 10,000 global population.
Recovering	Breeds once listed in one of the other categories and have exceeded Watch category numbers but are still in need of monitoring.

Table A5.2 Classifications for poultry.

Category	Definition
Critical	Fewer than 500 breeding birds in North America, with five or fewer primary breeding flocks.
Rare	Fewer than 1,000 breeding birds in North America, with seven or fewer primary breeding flocks.
Watch	Fewer than 5,000 breeding birds in North America, with ten or fewer primary breeding flocks.
Recovering	Breeds once listed in one of the other categories and have exceeded Watch category numbers but are still in need of monitoring.