INTRODUCTION
This paper will address the development and implementation of the National Animal Germplasm Program (NAGP), which has responsibility for executing the collection and preservation of animal genetic resources. The program has been designed to advance a concerted and comprehensive effort in managing U.S. genetic resources. Development of this program follows considerable discussion, within the U.S. and internationally (Barker, 1986). In the U.S. several key policy documents urged the development of a national program (CAST, 1984; OTA, 1987). These efforts contributed to a U.S. Congressional response and the formation of NAGP. In the U.S., as with other countries, the animal genetic conservation program is relatively new and still in a formative stage. Recently, several insightful papers (Oldenbroek, 1999) have been put forward describing how genetic conservation programs should be formed; however, they lack (due to the phase of development) an operational perspective. Therefore, this paper will address several operational approaches and issues that the U.S. program has confronted.

MATERIALS AND METHODS
The NAGP mission is comprised of three major activities: cryopreserving germplasm and DNA; assisting breed associations in assessing the status and genetic structure of live populations; and the accumulation, synthesis and distribution of information by breed on live populations and germplasm in the repository. Assisting in program development and execution are beef, dairy, small ruminants, swine, poultry and aquaculture committees. Committee membership is composed of public and private sector representation. The committees assist in determining the priority for breed collections, and in interacting with breed organizations and private companies.

Collection Development. There are three underlying concepts for building the cryopreserved germplasm reserves; these are: 1) all breeds, regardless of population size, should be acquired; 2) the collection should be an active collection, where samples are available for immediate research and/or industry use and emergency use; and 3) collections, particularly of popular breeds, should be made repeatedly over time, so as to have a snapshot of a breed’s genetic complement as it changes.

The snapshot concept implies acquiring germplasm across a span of time (Meuwissen, 1999). Using this approach will allow the NAGP to: 1) keep the collection vibrant and useful for industry and researchers, 2) explore changes in gene frequency, and 3) provide industry with relatively current generations of germplasm, to address genetic anomalies and/or genetic bottleneck issues.

A breed’s collection will consist of three separate components termed Original, Evaluation and Base Collections. The Original Collection will be accessed when there is a national emergency.
or need by the breed, as determined by the industry/breed association and appropriate species committee. The Original collection will have quantities of semen and/or embryos that are approximately equal to the levels recommended by FAO (1998). The Evaluation collection will consist of a relatively small number of samples that will be used to evaluate the post-thaw motility of incoming samples and for DNA studies. The Base Collection represents material above that needed to regenerate a breed during emergency situations. The Base collection is intended to be an active portion of the collection where industry and researchers can come and freely access germplasm. Population status will determine the rate at which the Original, Evaluation and Working collections will be developed.

**Sampling Breed Populations.** Key in sampling a breed is the need to insure that the animals selected for the repository represent the full breadth of genetic diversity of a breed. Because NAGP is dealing with a broad range of breeds with various organizational structures and information, there are several factors that must be considered in a selection strategy. These include: pedigree information, sampling known subpopulations (especially those isolated for more than 10 or 15 years), sampling animals in diverse environments/ecosystems, and the utilization of molecular DNA information.

In addition to pedigree and relationship considerations, there is the issue of successfully capturing rare alleles. The probability of capturing an allele in 10 or more units of semen equals $1 - (1 - P)^N$, where $P$ is the allelic frequency and $N$ is the number of males sampled (Smith, 1984). Where possible, NAGP breed collections will have at least 50 males cryopreserved. By collecting 50 males there will be a probability of greater than 0.6 that an allele at the one percent level will be captured.

Utilization of pedigree information from breed associations provides a basis by which individuals can be quantitatively assessed and selected. We are currently exploring two approaches of how to best use pedigree information (MacNeil *et al.*, 2001). One approach involves starting with a pre-selected individual or group of individuals and sequentially selecting the animal with the lowest cumulative relationship ($R$) to the previously selected animals. An alternative approach is to take the reciprocal of the relationship coefficient ($1 - R$) and use it as a measure of distance, then perform a cluster analysis and identify a set of animals for cryopreservation. To date using simulated data with the first procedure, it has been determined that the procedure can select animals with a lower relationship than if they were randomly selected from the population (a correlation of 0.102 for random selection and 0.067 for the first procedure). These approaches for selecting individuals for cryopreservation appear promising and need further evaluation.

**Live Animal Populations.** Activities with live populations include performing population surveys to determine population trends, and assisting breed associations in determining inbreeding levels, effective population size and recommendations in maintaining genetic diversity.

**Information Systems.** A vital element for NAGP is the development of a relational database capable of assisting a broad array of users in understanding the genetic diversity of the collection and the amount of material stored in the collection. In addition to a relational database, we are developing decision support tools that will assist users in understanding the status of a breed’s genetic diversity and if necessary, assist a breeder or association in developing options to minimize the loss of genetic diversity. To facilitate knowing where livestock breeds are located and where germplasm has been collected, we have been exploring
the use of GIS. A preliminary study using GIS (Geographic Information System) has been performed with the Navajo Churro breed of sheep. In that effort, we mapped location, flock size and flock inbreeding levels.

RESULTS AND DISCUSSION
Since initiation, NAGP has proceeded in collecting germplasm or executing in situ activities for all the species of interest. Table 1 provides an overview of collection and live animal activities initiated by NAGP. Germplasm has been acquired through the efforts of species committees and has been submitted to the repository either frozen or fresh (i.e. swine). Collection efforts range from being performed at a public institution, a commercial stud or on farm.

Two in situ activities that NAGP has undertaken provide an example of current and future efforts. The first was a national census on non-commercial turkey breeds where it was determined that 45 % of the breeds were in critical condition (< 200 registrations per year).

### Table 1. Status of collection and live animal activities by the National Animal Germplasm Program

<table>
<thead>
<tr>
<th>Species</th>
<th>Collection activities</th>
<th>Planned collection activities</th>
<th>In-situ activities</th>
<th>Germplasm Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy</td>
<td>Holstein, Jersey, Brown Swiss</td>
<td>Historic germplasm, Guernsey, Aryshire, Milking Shorthorn</td>
<td>3,500 units of semen</td>
<td></td>
</tr>
<tr>
<td>Sheep</td>
<td>Targhee, Western Whiteface, Gulf Coast Native</td>
<td>Suffolk, Dorset, Rambouillet, Dorper, Romanov, Texel, Finnsheep, Katahdin</td>
<td>Navajo-Churro</td>
<td>1,300 units semen, 500 embryos, 250 DNA samples</td>
</tr>
<tr>
<td>Swine</td>
<td>Yorkshire, Hereford, Industry lines</td>
<td>Research lines</td>
<td>3,500 units of semen</td>
<td></td>
</tr>
<tr>
<td>Beef</td>
<td>Hereford, Florida Cracker</td>
<td>Historic germplasm</td>
<td>Inbreeding of Hereford and Angus</td>
<td>500 units of semen</td>
</tr>
<tr>
<td>Poultry (chickens and turkey)</td>
<td>Industry lines</td>
<td>Research lines</td>
<td>Maintenance of chicken lines and census on non-commercial turkey breeds</td>
<td>300 units of semen</td>
</tr>
<tr>
<td>Goats</td>
<td>Angora, Spanish</td>
<td>Tennessee Stiff-legged</td>
<td>1,400 units of semen</td>
<td></td>
</tr>
<tr>
<td>Aquaculture</td>
<td></td>
<td>Salmon and Catfish</td>
<td></td>
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</tbody>
</table>

A second in situ activity has been a pedigree assessment of the Navajo Churro sheep. This breed represents one of the oldest breeds imported into North America and one that has been identified as a priority breed for assessment and cryopreservation. Since the inception of a breed registration in 1988, inbreeding levels have increased from 0.2 to 3.8 % and effective population size has decreased from 193 to 85 head. To further assess the population, GIS was used to map flock location, flock size and flock inbreeding level. This analysis demonstrated
that the breed’s problem of decreasing genetic diversity was national and not geographically isolated nor was it dependent upon flock size.

Conservation Issues. Perhaps one of the largest differences in developing a conservation program in the U.S. vs. other countries is the level of public and private sector interaction that has to occur before collection and conservation of germplasm occurs. Issues of property rights must be addressed for the protection of the owner and NAGP while maintaining long-term genetic security. In some instances the repository has to enter into long-term agreements with owners to obtain selected germplasm. Three technical areas also affect the collection and storage of germplasm. Across species there are a number of breeds with no pedigrees, limited pedigrees and/or breed associations with limited infrastructure and capabilities to assist in collection development. For small ruminants, some beef breeds, swine and chickens there are infrastructure issues revolving around the collection and cryopreservation of germplasm. We have addressed this issue by either sending out teams of specialists to collect selected populations or by shipping fresh extended semen to the repository for cryopreservation (for swine). The ability to freeze a wide range of germplasm either within species or breed is not clearly defined. For example, preliminary results from one NAGP study indicate that over 70% of the variance for post-thaw characteristics of bull sperm is between bulls while between line effects are non-significant. At this time it is unclear how robust cryopreservation procedures will be for individual animals with cells that do not cryopreserve well. Considerable improvement in cryopreserving swine, chickens and turkeys is needed. These issues can be overcome with time and increased funding but for the present, they represent areas that impede the collection and placement of germplasm in a national repository.

CONCLUSION
The NAGP has taken a broad and comprehensive approach in conserving and assisting in the management of U.S. genetic resources. A consensus exists that such an approach is necessary for effective resource management. The evolving philosophy of the program is that cryoreserves are collected and stored for a number of potential uses. Primary among these uses are to safeguard livestock genetic diversity in the U.S. Secondarily, genome mapping, creation of experimental lines and industry utilization are also potential uses of such a resource.

REFERENCES