Excerpt from "Avian Genetic Resources at Risk: An Assessment and Proposal for Conservation of Genetic Stocks in the USA and Canada". 1999. J.M. Pisenti, M.E. Delany, R.L. Taylor, Jr., U.K. Abbott, H. Abplanalp, J.A. Arthur, M.R. Bakst, C. Baxter-Jones, J.J. Bitgood, F.A. Bradley, K.M. Cheng, R.R. Dietert, J.B. Dodgson, A.M. Donoghue, A.B. Emsley, R.J. Etches, R.R. Frahm, R.J. Gerrits, P.F. Goetinck, A.A. Grunder, D.E. Harry, S.J. Lamont, G.R. Martin, P.E. McGuire, G.P. Moberg, L.J. Pierro, C.O. Qualset, M.A. Qureshi, F.T. Shultz, and B.W. Wilson. Report No. 20. University of California Division of Agriculture and Natural Resources, Genetic Resources Conservation Program, Davis CA USA. 120 p.

6

An Avian Genetic Resources System: Proposal

Task Force recommendation

IT HAS BECOME ABUNDANTLY CLEAR from the analysis of extant genetic stock collections and from the information obtained from task force members and others that many avian genetic stocks have been lost and many others are at serious risk of being lost. Further, the prognosis for maintaining new research stocks as they are being developed in current research programs is not good. In fact, when maintenance facilities for research stocks are not available, there will be no incentive for investment in lines of research that would produce such stocks. An avian genetic resources management system, with strong leadership, but shared responsibility, is proposed as the most efficient and secure way to conserve genetic stocks and address the concerns raised in this evaluation effort. The proposed Avian Genetic Resources System (AVGRS) would be comprehensive and would require the cooperation and collaboration of scientists, funding agencies, and research institutions. The System must be oriented toward research objectives, but it could also support the needs of breeders, breed hobbyists, and breed historians.

Rationale

Historic long-term collaboration between Canadian and US scientists provides a basis for collaboration in the formation and operation of an Avian Genetic Resources System. No comprehensive system exists in North America, nor anywhere else for that matter, for the conservation and distribution of avian genetic stocks (primarily chicken, turkey, and Japanese quail) of value for agricultural, biomedical, or biological research. The US National Plant Germplasm System and its counterpart in Canada serve as excellent models for the proposed Avian Genetic Resources System. A System on this binational level is necessary because no dependable regional or local solution exists.

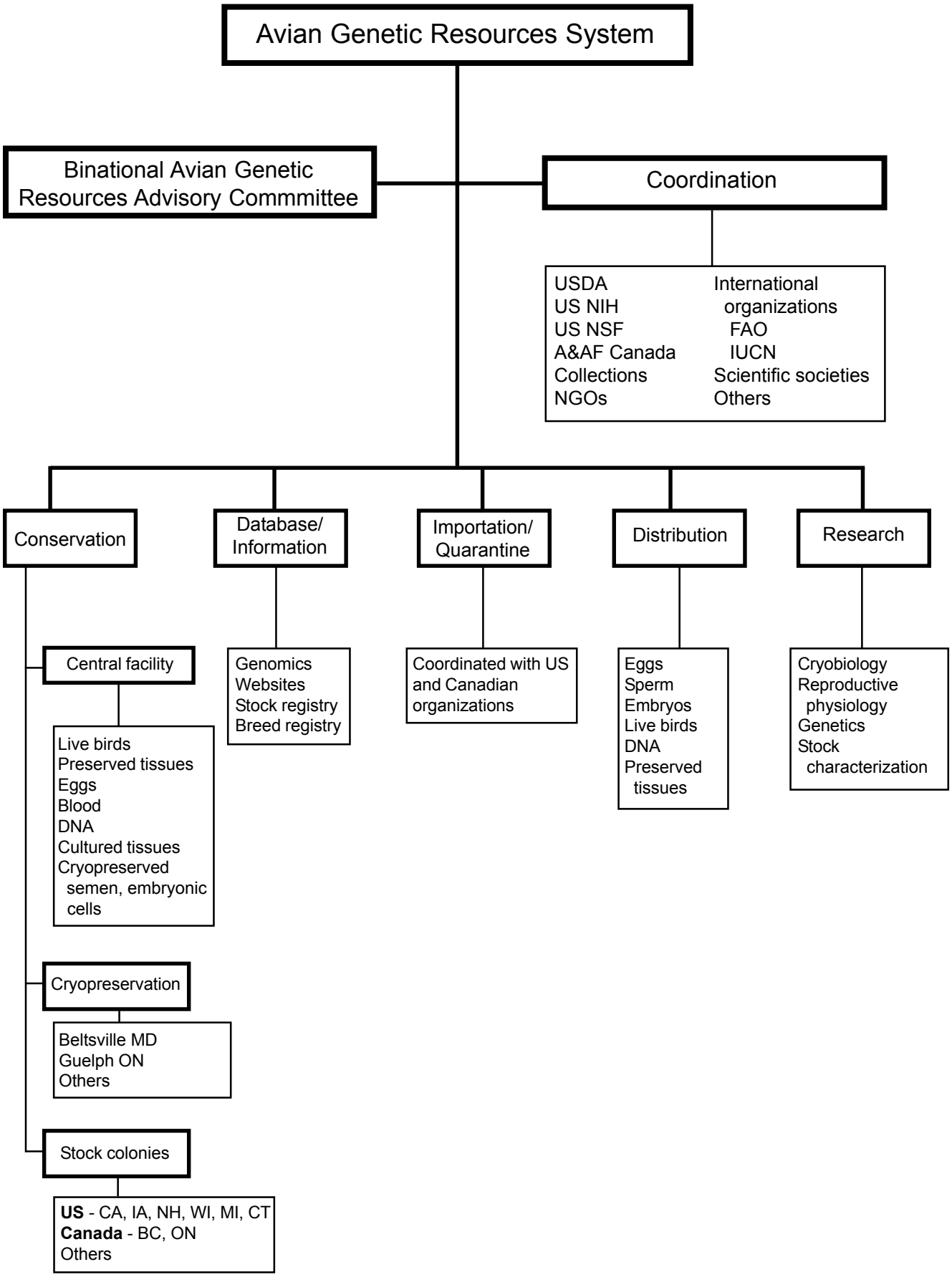
Components of an Avian Genetic Resources System

The Avian Genetic Resources System is envisioned as a multilocational organization that would serve the avian genetic resources needs for the US and Canada. The AVGRS would feature a central facility as a focal point for many of the activities of the System. The functional components are outlined in Figure 16 and are briefly discussed here.

Avian Genetic Resources Advisory Committee (AVGRAC)

The AVGRS would be advised by this binational committee comprised of representatives of national and state/provincial agencies, stock curators, and researchers. It would consist of 12 to 15 individuals who have worked with avian genetic resource issues, drawn from government, industry, and academic institutions in the US and Canada. Specifically, they should have worked in close association with national, international and private research-oriented organizations, and be familiar with avian genetic stock conservation issues. The members should meet at least once a year and be in regular communication during the year. The Committee would review reports and recommendations for conservation of stocks received from species-oriented committees. It would make recommendations to the management unit of the AVGRS.

Figure 16. Components of the Avian Genetic Resources System.



Coordination

The various government and research institutions involved in avian research and conservation would use the AVGRS for coordination of information about genetic resources and the AVGRS would in turn be responsible for maintaining and distributing this information. This function would also include strategic planning for conservation of particular stocks, based on advice from advisory groups established for each species. For example, imperiled stocks would be identified to the AVGRS and a plan for their conservation would be developed through coordinated analysis. International relationships would be coordinated through the AVGRS, including conservation of stocks in other countries, import and export of genetic stocks, data sharing, and development of conservation plans for landraces, wild species, and breeding populations.

Conservation

This is the cornerstone activity of the AVGRS and of critical importance. A central facility is needed for conservation and distribution of genetic materials. The central facility would house those living genetic stocks that could not be maintained elsewhere and would serve as a backup site for important stocks that are maintained elsewhere. This would include a secure backup repository for privately owned lines or populations, either as live birds or cryopreserved germplasm at the central or secondary centers on a fee basis. The central facility would also physically maintain the various types of preserved genetic resources and would coordinate those maintained elsewhere. The cryopreservation capabilities of the central facility would be supplemented by a specialized cryopreservation center, presently unused, at the USDA site in Beltsville, Maryland. No site for the central facility is identified at this time.

The central facility would support and be linked to secondary facilities located at active research centers which have the capability of maintaining genetic stocks for their own research needs. Several locations in the US and Canada would qualify as secondary sites.

Methods of conservation. Conservation methods employed in the AVGRS would be live-bird maintenance and cryopreservation.

Targets for conservation. Conservation emphasis of the AVGRS should be on live birds, embryonic cells, gametes, DNA, and tissues. The target species for the system will be those of interest in agriculture for food production and for basic biological and biomedical research. Thus, the focus will be on chicken, turkey, and Japanese quail genetic stocks. However, this system could also consider wild turkey, jungle fowl, and game birds, as well as other species commonly raised in captivity. The AVGRS will emphasize:

- Genetic stocks having traits and genetic characteristics useful in research, such as inbred lines, single-gene mutations, chromosome aneuploidy, and DNA marker sequences.

- Lines and populations developed by private and public breeders by hybridization and selection for important production-related traits.

- Domesticated mid-level production and fancy breeds held by small producers and hobbyists in North America and Europe.

- Domesticated, but primitive, landraces existing in Asia, Central and South America, and elsewhere, primarily as scavenger birds.

Archival preserved specimens of birds, organs, skeletons, eggs, feathers, and tissues that have been preserved as museum specimens are also a component of the genetic resources system, since these materials provide for baseline observations and time-course monitoring of factors such as environmental toxicants.

An informal *in situ* system of conservation of landraces and breeds is well established in North America. A monitoring and database system may be the most important need for those genetic resources. This could become an activity of this proposed system.

Databases

Detailed information about all genetic stocks in the US and Canada should be maintained and updated by the AVGRS in a genetic resources information system, similar to the Genetic Resources Information Network (GRIN) developed for the US National Plant Germplasm System and housed with the USDA National Agriculture Library. For example, all of the information included in Appendix 2 should become part of the AVGRS database. Additionally, database service would be offered to the various breed conservancies and hobbyists groups for inventory and location of conserved breeds, land-races, and spe-

cialty stocks. It would also be logical for the AVGRS database to include DNA sequence data as they are developed.

While GRIN currently focuses on plant information, its goal is to include information on all of the common and endangered breeds of farm animals, including the avian genetic stocks used primarily in research. Collaboration with the AVGRS database would facilitate this goal.

Outreach

Researchers can also be informed of the wide variety of available genetic stocks at the annual meetings of a variety of organizations, including the Poultry Science Association, the Pacific Egg and Poultry Association, the Poultry Breeders Roundtable, the Society for Developmental Biology, the American Association for the Advancement of Science, and the American Medical Association. Presentations at the commercially oriented meetings could be used to showcase the benefits the different companies could derive from supporting an avian genetic stocks conservation program, while the basic research or disease model aspect of genetic stocks could be emphasized for organizations promoting basic and biomedical research. Thus, the underlying goals of presenting genetic stocks information at such meetings is not only to attract the attention of researchers, but to engage the interest and promote funding from commercial sectors that can benefit directly from research using avian genetic stocks.

Another outreach option for the AVGRS would be an independent website that would promote the available avian genetic stocks to the scientific community by advertising what is available, and indicating those that are slated for elimination. The effectiveness of such a site could be multiplied by linking it with websites: the animal genetic map (Angen), the chicken map (ChickMap), various research organization sites (e.g., Poultry Science Association, Society for Developmental Biology, various commercial poultry sites, and sites for academic institutions).

The AVGRS website information could be further promoted by a series of clearly written review articles in several of the major biological science journals. In each case, a specific area of research would be targeted, such as animal models for human diseases, limb pattern defects, craniofacial defects, integumentary defects, or immunogenetic research.

The outreach activity would also involve international contacts through FAO or various countries with respect to avian genetic resources. For example, there are genetic stocks at risk in other countries that should be considered for rescue in the AVGRS because of their value for research.

Bird care and housing

The housing and care of the live birds at all centers will follow American Association for Laboratory Animal Care (AALAC) standards for a breeding colony. Essentially, the breeding stock should be kept in a facility that approximates that of a well-run commercial poultry breeding farm. The highest degree of automation for feeding, cleaning, watering and climate control is recommended. With most of the chicken genetic stocks, the adult birds will be housed in single-bird cages, and bred by artificial insemination. Other features of the facility may include: floor pens, with or without trap nests, to maintain stocks that do not perform well in cages; and separation of males and the females (in different rooms or cage rows), so that appropriate, sex-specific breeder diets, lighting, and feeding regimens can be provided for each group.

To minimize the disease problems in the genetic stocks and reduce the risk of spreading pathogens when stocks are shipped, all conservation centers should follow the National Poultry Improvement Plan guidelines (USDA-APHIS 1998). These procedures impact on the design of the facility, such as:

- All incoming stocks should be acquired only as fertile eggs, which are formaldehyde-fumigated, then incubated, hatched, and reared in a facility isolated from all other avian species, including those already shown to be free of the targeted disease agents. After the birds in isolation are at least six weeks old, they should be blood-tested for the presence of egg-transmitted pathogens (in chickens, this usually includes *Salmonella pullorum, S. typhimurium, Mycoplasma gallisepticum*, and *M. synoviae*; turkeys would also be tested for *M. gallinarium*), before being moved to the stock center.
- A random-sample of 10% of the adult birds should be tested each year for evidence of the important poultry diseases, including the disease pathogens listed above.
- Replacement birds should be raised in strict isolation for the first month after hatch.
- The stock center should be physically well-isolated from other poultry (commer-

cial or hobby flocks) and from facilities in which other captive bird species are housed.

- The bird houses should prevent entry of wild birds and vermin.

- Access to the facility should be restricted and closely monitored, complying with full necessary sanitary restrictions.

Importation and quarantine

Movement of animals introduces risks of spreading contagious diseases, obviously of great concern in long-term conservation of live birds. Movement of genetic resources as fertile eggs or semen reduces disease transmission risk and are preferred procedures. Importation of stocks to the central facility will be done through on-site isolation and through national facilities under the direction of USDA Animal and Plant Health Inspection Service. The central facility will have appropriate isolation and sanitation capabilities.

Distribution

A major function of the AVGRS will be to provide genetic materials to users in the research community, breeders, and others. The genetic stocks may be transferred as live birds, semen, or eggs. These will be distributed on a cost-recovery basis. Some users require a continuing supply of genetic stocks and these needs would be supplied by contractual stock reproduction programs. The distribution function would supply well-documented stocks to researchers, thus contributing to the integrity of research projects. This functional component of the AVGRS is analogous to services provided by the Jackson Laboratories for mouse genetic stocks.

Research

The AVGRS should have a research capability within the central facility, especially for developing cryopreservation technologies. Research would also be done on methods for documenting genetic integrity or diagnostics with DNA markers. Other research would be done as needed and appropriate. The research activities would be networked with research laboratories in the US and Canada for collaborative work.

Facilities and organizational aspects of AVGRS

The central facility

Ideally, the primary AVGRS facility would be constructed *de novo* near or part of a major agricultural institution (land-grant university) with a veterinary school that has a good avian medicine program, but reasonably isolated from commercial poultry stocks. The connection with a land-grant institution would give the center close ties to active research laboratories and faculty, who could benefit from such a resource and be drawn upon in support of the center. Access to state-of-the-art poultry disease diagnostics and veterinary care is critical, along with good, off-site quarantine facilities for newly acquired genetic stocks. Locating in a strong poultry producing state would also provide an existing poultry-oriented political and commercial infrastructure that could be mobilized to help support the conservation center.

This facility would include a hatchery, brooding and growing areas, adult bird housing, an isolation area, a cryopreservation laboratory and storage facility, a database center, staff and administrative offices, and a laboratory to support research and analytical services.

Bird housing should be designed to minimize disease and pest control problems, and maximize caretaker efficiency and bird well-being. Initially the facility should accommodate 1,000 adult birds, with options for expansion. Several design schemes will be evaluated to accommodate the genetic diversity of the stocks and their special requirements and for efficiency in management.

Network of secondary genetic stock centers

Secondary stock centers would be designated as part of the AVGRS at land-grant universities and other institutions across the US and Canada that fulfilled two criteria: (1) had adequate facilities and support for the genetic stocks used in its own research programs and (2) had a long-term interest in conserving genetic stocks. Such centers, approved as part of the AVGRS, would receive funding from AVGRS for maintenance of stocks. These secondary centers would maintain live birds and would provide backup for at-risk stocks held in the central facility. As with the central facility, the secondary stock colonies would also have a distribution function on a fee basis. Researchers could also, on a fee basis,

arrange to keep research flocks at the central facility or one of the secondary centers, since they may find it difficult or impossible to keep such stocks at their own institutions.

Secondary centers could specialize on one or a few classes of genetic stocks (e.g., inbred strains, congenic series, randombred stocks, selected stocks, single-gene mutant stocks, or chromosome translocation stocks). In fact, many of the existing poultry collections at both academic and government institutions are already quite specialized. The restricted number of classes and species of stocks at each secondary live bird center would simplify reproduction and maintenance for the curators, since each type of stock often has different needs in relation to population sizes, selection criteria, inbreeding considerations, and testing techniques.

Management

The central facility and the secondary centers would be administered by the research institutions with which they are located. The central facility would have, at a minimum, a director or manager (research scientist), curator, an administrative assistant, database manager, cryopreservation research scientist, and three or four laboratory and animal care technicians.

The AVGRS would be guided by the advisory committee on such matters as:

- Information system and website management
- Inventory control
- Conservation status determination (cryopreserved stocks only)
- Stock accessioning strategies
- Importation targets and necessary international cooperation agreements
- Appropriate stock-specific conservation protocols
- Management of grant funds for research and preservation efforts
- Curator training programs
- Program expansion decisions
- Budgets
- Fund raising
- Species coordinating committee organization
- Promotion of the use of these genetic stocks
- User fees and maintenance contract guidelines

Stock evaluation guidelines

One of the more important activities of the AVGRAC would be the evaluation of stocks for conservation, cryopreservation, or elimination. Guidelines for assessing the value of genetic stocks have been outlined in a report by the National Research Council Committee on Preservation of Laboratory Animal Resources (NRC 1990). The report suggests that value of a given stock should be established by considering:

1. Importance of the disease process or physiological function exemplified by the stock (especially when used as an animal model for a human disorder).
2. Validity of the model and continued genetic integrity of the stock.
3. Replaceability of the stocks (those developed after many years of selection or arising from a spontaneous mutation would be considered relatively irreplaceable).
4. Versatility of the stock (the variety of problems that can be addressed with a given stock).
5. Number of users.

The advisory committee would also formulate other criteria specifically relevant for the conservation of avian species.

Financing the Avian Genetic Resources System

Multiple sources of funding will be necessary to meet all of the needs of the AVGRS. Initial costs are those to construct the central facility and upgrade the secondary stock centers. Annual costs of the central facility would be for its personnel and operations. It would also be necessary to support the annual activity of the AVGRAC. The central facility could also direct

funds for specific needs to the secondary centers by means of annual grants.

From the US side, the biological resource programs of the National Science Foundation and the National Institutes of Health would be expected to provide operational funds through direct grants and through grants to investigators who use the avian genetic resources in their research. The USDA's National Genetic Resources System should participate in the AVGRS through the Agricultural Research Service and the Cooperative State Research, Extension, and Education Service. The various State Agricultural Experiment Stations and land-grant and other Universities should also participate. Canadian support and participation should be forthcoming to the extent that the AVGRS provides support to its research and development programs.

The AVGRS will be the major provider of genetic materials to researchers throughout the public and private sectors. For the most part, these researchers do not have capacity to maintain live bird colonies and depend upon stock colonies for their research. User-fees are an appropriate means to recoup costs of stock maintenance.

Donation funds can be expected to support the perpetual maintenance of particular genetic stocks. These funds may be provided as annual grants or through income derived from interest on endowment accounts.

Funding should be sought from the US government for construction of the central facility and for personnel support for operations as a part of the US National Animal Genetic Resources System.

Long-term funding would be the most secure from endowment funds. Contributors could be encouraged from the private sector, from large integrated commercial poultry companies to private individuals with interests in preserving poultry stocks or willing to promote the conservation of stocks that can be used to study human diseases.

Construction, personnel, and operational costs have not been established, pending further analysis of potential sites for the central facility and other considerations. For illustrative purposes, rough order-of-magnitude estimates are given in Table 4.

Table 4. Estimated costs of Avian Genetic Resources System.

Startup costs	
Constructing and equipping central facility	$15,000,000
Upgrading and renovating secondary centers	2,000,000
Total	**$17,000,000**
Annual costs	
Personnel at central facility	$400,000
Operating costs at central facility	100,000
Grants to secondary centers (8 x $25,000)	200,000
Advisory Committee	25,000
Total	**$725,000**