

REINVIGORATING PUBLIC PLANT & ANIMAL BREEDING FOR A SUSTAINABLE FUTURE

A Position Paper of the Midwest Sustainable Agriculture Working Group & the Sustainable Agriculture Coalition

I. Introduction

The Midwest Sustainable Agriculture Working Group and the Sustainable Agriculture Coalition work for a system of sustainable agriculture that is profitable for small and medium-sized farmers, environmentally sound, family farm-based, and socially just. Agriculture production that is sustainable in the long-term relies on diverse crop rotations, increased use of perennial species, and the integration of livestock in pasture-based systems. Sustainable and organic agricultural systems require plant varieties and animal breeds that do not depend on high levels of external inputs and that are selected to perform under a wide array of local climate conditions, forage availability, and pest regimes. A diversity of plant and animal genetic resources are also needed to address the growing challenges of global climate change, increasing pest and pathogen pressure, food security, safety and resiliency concerns, and shifting consumer preferences including a rapidly growing market for organically produced food (Qualset & Shands 2005). These genetic resources are a public good that should be maintained both for our current needs and for future generations.

In the past, these agricultural plant and animal genetic resources were maintained through a national agricultural research agenda that included publicly funded breeding programs and research on numerous species, breeds, and varieties. In addition, both the Land Grant University system and commercial markets provided a wide array of plants and animals to farmers and ranchers, many of whom undertook further breeding and selection to meet the local conditions of their farms and ranches. Policy and legal developments over the last few decades have resulted both in an erosion of the public commitment to maintain our agricultural genetic resources and an increase in barriers to the ability of individual farmers and ranchers to contribute to plant and animal genetic diversity. The nation's agriculture is at a critical juncture, with our capacity to conserve and further develop crop and livestock varieties and breeds seriously limited.

This position paper affirms our support for a national agricultural research agenda that includes a strong commitment to sustainable and organic agriculture to meet the immediate and future needs of U.S. agriculture. The 29 policy recommendations in Section III of the paper constitute an agenda for the use of public resources to reinvigorate public domain plant and animal breeding programs. A number of these recommendations were developed through a Summit on Seeds & Breeds for 21st Century Agriculture held in September 2003 which brought together a group of scientists and participants from government and non-profit organizations, including many MSAWG and SAC member groups. We thank the Rural Advancement Foundation International – USA for sponsoring that Summit and for continuing the dialogue on this issue.

The MSAWG and SAC member organizations which have endorsed and signed-on to this position paper will continue to develop and support this renewed mandate to use public sector resources to serve the needs of our nation's farmers and ranchers and the public interest. Our food security is at stake and it will take a dynamic partnership among public education institutions, government agencies, and private, non-governmental farmer and consumer organizations to maintain our capacity to breed plants and animals for sustainable agricultural systems in the 21st century.

II. Decline of Public Agricultural Plant and Animal Genetic Resources

A. Erosion of Land Grant University Public Domain Breeding Programs

The Land Grant Universities and other public sector institutions have been the mainstays of public domain breeding programs. Historically, the crop varieties and animal breeds developed in these programs have been transferred to farms, ranches, and agricultural industries through the cooperative extension system as public goods to be used without restrictions. Public plant breeders are able to focus on the development of cultivars that are useful to farmers but may not result in high seed sales. These include perennials, pure-line or open-pollinated cultivars, and unique or original breeds. Public breeders can also focus on traits such as suitability for low-input and organic systems or marginal environments, high nutritional value, taste or other qualitative characteristics that are not as important to large-scale production systems (Jones 2004). Public breeding programs can also work on species that are not in the private-sector portfolio. There is not a substantial incentive for private sector development for varieties that are easily maintained or duplicated through seed saving. The public sector is still a major source of seeds for wheat, small grains such as oats and barley, "minor" field crops, fruits and vegetables, and to a lesser extent, cotton (Fernandez-Cornejo 2004). Pasture grasses and legumes are also primarily bred in the public sector. Minor crops are often a major part of diversified production systems, typically used on many small farms. However, these minor crops lack the market potential of a crop such as hybrid corn, which is often grown by large scale operations as a monoculture or part of a simple corn-soybean crop rotation.

Despite many advancements in genetic technologies, a complete understanding of the ways in which genes function that directly translates into crop and livestock improvement is a long way off (Heisey et al. 2001). Genetic engineering depends on classical breeding methods to bring viable varieties to the field. Major innovations may occasionally bring rapid improvements or lower production costs, but in many cases it is cumulative long-term research that results in impressive gains over time. There have been remarkable yield increases in all major crop species over the past 70 years. More than half of these gains are attributable to the genetic improvements brought about by classical plant breeders, many of them publicly funded (Fernandez-Cornejo 2004). Increases in yields were also due to a dramatic escalation in the use of fertilizer, irrigation and other inputs in production systems that have significant negative environmental impacts. These inputs also depend on fossil fuels, mining of groundwater resources, and other practices that are unsustainable in the long run.

The Land Grant University system's public breeding programs rely on a long-term commitment of public resources for an infrastructure to breed and preserve plant and animal genetic lines, as well as faculty with the expertise to oversee the breeding programs. The results of research conducted in these programs, plants and animals with desirable genetic traits, are valuable public resources. Annual returns on investment in public plant breeding exceed 30% according to most estimates, not counting the many positive externalities generated by the exchange of information among researchers (Fernandez-Cornejo 2004). However, the high rate of social and economic returns associated with public breeding programs depends on researchers having the "freedom to operate" and access to a large pool of germplasm adapted to the region, the ability to tap new genetic resources when needed, and the capacity to cross genetic material and evaluate the progeny in different environmental conditions (Heisey et al. 2001).

Several developments in intellectual property law have contributed to a shift away from a long term focus of public research programs towards short-term research results. In 1980, Congress passed the Bayh-Dole Act which allows universities to patent inventions developed with federal funds and encourages them to issue licenses for patents, including exclusive licenses, to private companies. The universities may use the revenue from the patent licenses to support research or education (Council on Government Relations 1999). Universities established technology transfer offices to oversee patenting and licensing of university inventions and encouraged partnerships with private companies. Although the Bayh-Dole Act requires that

small companies be given a preference in granting licenses, it also provides companies which have contributed funding for a research project the right of first refusal for a license. This right of first refusal has given larger companies the ability to control research results, even when the research is supported in large part with public funding (Leval 2004).

The Bayh-Dole Act was followed by the Federal Technology Transfer Act of 1986 and the National Technology Transfer & Advancement Act of 1995. The latter authorized Cooperative Research and Development Agreements (CRADAs) between federal laboratories and private industry. Under these CRADAs, the collaborating company gains access to technology, data and expertise funded in part by the public, as well as the option for future intellectual property rights including exclusive licensing over patented inventions of federal scientists. The Agricultural Research Service has entered into thousands of CRADAs with private firms.

Another development in intellectual property law affecting public plant breeding is the extension in the U.S. of intellectual property rights over genetic resources. In 1980, the U.S. Supreme Court decided, in the case *Diamond v. Chakrabarty*, 447 U.S. 303, that a bacterium genetically engineered to break down crude oil was a patentable discovery. The majority of justices found that the bacterium in question was an artificially made composition of matter and that it could not exist without human intervention and had capabilities not found in naturally occurring bacteria. The ruling allowed the bacterium to be the subject of a utility patent. In 2001, the U.S. Supreme Court extended general utility patents to cover plants and seeds in the case *J.E.M. Ag Supply, Inc. v. Pioneer Hi-Bred International, Inc.* 534 U.S. 124. The Court approved the general assertion that all life forms are patentable under current U.S. law.

The combination of the licensing provisions of the Bayh-Dole Act, CRADAs, and the extension of general utility patents to life forms has given the private sector powerful tools to sequester and limit the public use of plant and animal genetic resources. Government policy has profoundly changed the nature of public breeding programs and university research agendas by promoting patents and exclusive licensing of the results of publicly funded genetic research on living organisms (Leval 2004). In addition, implementation of the Bayh-Dole Act has provided some universities and researchers with an income stream from patent license royalties and from research contracts with private sector companies seeking to secure exclusive rights over the research results. University administrators encourage research projects that lead to immediate patents and products, rather than long-term projects and research that remains in the public domain. For example, a review of research agreements between the faculty of the University of Wisconsin College of Agriculture and Life Sciences and public and private funding agencies found that private industry support for biotechnology alters the "terms, structure, and objectives" of the research and that ". . . [b]y funding a specific research project, industry sponsors, with relatively small amounts of discretionary spending, are able to obtain public facilities and publicly funded researchers for their private research agenda . . . (Campbell 1993)." This privatization of research at public institutions combined with a profit motive has also given rise to increased secrecy about research methods and results. This includes private sector requests to researchers at public institutions for publication delays, censorship of results, and nondisclosure agreements. In addition, researchers have also grown more likely to withhold information and materials from one another, resulting in an erosion of cooperation among scientists (National Academy of Sciences, Government-University-Industry Research Roundtable 1997).

Even though one purpose of the Bayh-Dole Act was to create a source of revenue for research programs at universities, the actual net flow of money is questionable. Many technology transfer offices are not operating as profit-centers for the university due to transaction costs and the large numbers of patents that do not lead to significant royalties (Thusby & Thusby 2003). Private companies, however, are able to use public research to supplement or replace their in-house research and development programs, effectively using tax dollars to generate private profits. By targeting their support to specific research projects, private entities can steer public efforts towards work that supports their proprietary interests and results in private

benefits. Breeders are especially concerned because genetic lines developed over decades in the public sector may suddenly become proprietary and unavailable to other breeders (Leval 2004). This runs contrary to the ethos of the free exchange of germplasm that has long been prevalent in public breeding programs.

In addition, the "cutting-edge" of new lab-oriented genetic sciences pulls student and faculty interest and research dollars away from the trait and field-based science of breeding (Goldstein & Doetch 2004). As research dollars become increasingly scarce, faculty who continue public breeding research have fewer resources and many shift their research to other crops or more basic pursuits. Work on some species is entirely abandoned (Guner & Wehner 2003; Knight 2003). Research universities and experiment stations, not seeing a stable source of funding required for long-term plant and animal breeding research, are likely to fill open faculty positions with molecular biologists and genomicists.

With shortages in state funding for long-term research, breeders must seek grants from outside sources to support their breeding programs. These grants are often only a few years in duration and may come with strings attached, especially if they are from private corporations. This makes continuity in breeding efforts difficult. It also raises questions about the independence and 'public goods' focus of public researchers. There are criticisms that the public sector is being reduced to a research arm of private sector companies when public breeding lines are used as a base for patented, proprietary genetics. The reputation of public universities and support for funding research is being eroded by these partnerships with private entities that create conflicts of interest, that restrict the independence of researchers at public institutions, or that transfer the results of publicly funded research into private hands.

There is widespread consensus that the public sector should be the leader in training students to become plant and animal breeders. The ability of a breeder to intuitively select promising lines and predict future needs must be learned through experience and apprenticeship. Young people need to work closely with practicing breeders to gain working knowledge and understand the methodology of selection and evaluation. As universities look to research to generate profits, faculty involved with long-term public plant and animal breeding are not being replaced at retirement by new faculty with similar research interests. In addition, there are fewer opportunities for graduate students to gain hands-on experience or participate in functional public breeding programs. Only a few universities in each region still have breeding programs that can train new breeders, and only eight programs in the nation train more than six graduate students each year. Universities may soon have to eliminate courses for breeders due to limited enrollment and the retirement of faculty that have served as instructors (Guner & Wehner 2003). Ironically, a great concern among private breeding companies is the shortage of well-trained plant and animal breeders. Some companies have turned to training breeders in-house, but most do not have the resources to accomplish this task (Heisey et al., 2001).

The adverse effects of changes in intellectual property rights on public institutions and publicly funded research programs deserve increased public oversight. A pure public good has two characteristics: "non-rivalry," which means that more than one person can use it without reducing its availability to others, and "non-excludability," which means that users cannot prevent others from consuming it (Hulse 2003). A measure of whether public sector institutions are meeting their responsibilities for research in the public interest has been provided by the National Research Council's Committee on the Future of Land Grant Colleges of Agriculture. In a 1996 report, the Committee justified public support for research which ". . . addresses national needs and priorities, and . . . is aimed at generating public goods. Public goods are a class of goods of a 'common property nature', that is, they benefit societal groups but do not provide the means for economic returns to private individuals or firms." The Committee, in stating principles for the use of public funds, recommended that public research should include projects where the:

- Scale or length of research investment period is too large for private investment;
- Research outcome is too uncertain for stimulation of private investment;

- Markets are too small for adequate rates of return to private research investment;
 - Research addresses external (non-market) effects of food or agricultural activities; and
 - Research addresses issues of social equity
- (Committee on the Future of Land Grant Colleges of Agriculture, 1996).

The Bayh-Dole Act, with its emphasis on private competition and exclusivity, and the expansion of private sector intellectual property rights over common agricultural genetic resources have compromised the mission of the Land Grant University system to serve the public good through public breeding programs. Because breeding programs deal with constantly evolving life forms, it is difficult to restart a breeding program after a lapse of several years. Human capital and the wisdom of breeders is similar to genetic resources in this respect; once lost they are nearly impossible to recover. If public sector breeding programs are allowed to wither, it will take decades of work to build a new foundation.

B. Public and Non-profit Association Conservation of Plant and Animal Genetic Resources

Within the U.S. the public sector is the major player in germplasm conservation and enhancement and in the identification of key traits and characterization of genetic resources. The Agricultural Research Service's National Plant Germplasm System and the National Animal Germplasm Program are key federal institutions for retaining the ability to breed plants and animals for changing environmental conditions. A few of the largest private firms have their own significant genebank collections but their collections focus on three big commodities – corn, soybeans, and cotton - and are not publicly available. Researchers and private firms from around the world draw on the resources of USDA's germplasm repositories which are the largest in the world (Qualset & Shand 2005). It is critical, therefore, that a U.S. public germplasm preservation system be kept fully operational.

The National Animal Germplasm Program, though growing, is in its infancy. Congress authorized the program in 1990, but it did not receive its first animal germplasm until 2000. The need for animal germplasm preservation is critical. The United Nation's Food and Agriculture Organization estimates that about 1350 of the 6300 breeds registered with the Organization have become extinct or threatened with extinction during the last 100 years. Between 1985 and 2000 alone nearly 300 breeds disappeared. Among the 5330 mammal breeds, 17% are already extinct, and another 29% are endangered. For poultry, only 4% of breeds are thought to be extinct, but almost 61% are endangered. The loss of breeds continues with an estimated average of 2 domestic animal breeds being lost worldwide every week (FAO 2004). The National Plant Germplasm System has much larger collections with germplasm from 85 crops at 28 sites around the nation. But of the world's estimated two million plant species, the System stores only about 460,000 accessions, or distinct varieties of plants. The System lacks sufficient diversity to reduce crop vulnerability for almost half of the major crops. Moreover, there is a severe shortage of staff and resources to adequately maintain the U.S. germplasm repositories. Without adequate resources, seeds and other genetic material may sit in repositories without being replicated, losing viability and eventually deteriorating to the point past saving. There is a need for better information systems cataloging the content of genetic material held in the national system, but a lack of manpower prevents the development of a comprehensive database (Rubenstein et al. 2005).

Fortunately, there is growing interest and action among non-profit organizations, farmers, and ranchers in protecting heirloom varieties and native plant and animal species. Groups such as the Abundant Life Seed Foundation, Seed Savers Exchange, Native Seeds/SEARCH, Organic Seed Alliance, and the American Livestock Breeds Conservancy (ALBC) have formed as dynamic repositories of information and genetic material. People may grow out seed from these sources and return a package of saved seed with description of the growing characteristics of the plants. The ALBC maintains an extensive database of information on breeding populations and lineages.

Innovative partnerships have been developed among USDA, the Land Grant universities, and non-profit organizations with cooperating farmers and ranchers to undertake breeding programs to ensure that seeds and animal germplasm in public repositories are reproduced and that these resources are made available to farmers and ranchers. For example, the Northern Plains Sustainable Agriculture Society's On-Farm Breeding Program includes a Farm Breeding Club which brings together farmer cooperators, oat breeders and agronomists from the University of Minnesota and North Dakota State University to grow out public domain seed with a goal of finding varieties best suited for organic production on the High Plains. This project is part of a larger effort to develop a worldwide organic/heritage seed network available for public use. (Podoll 2004, Appendix I 2004).

The Farmer Cooperative Genome Project, organized by Oregon Tilth, was funded in 1998 for three years, through USDA's Fund for Rural America, to assemble a farmer owned seed cooperative. Participants in the effort worked with the National Plant Germplasm System and other seed resources, learning how to characterize or describe varieties, to grow true seeds, and to develop plant varieties for preservation and sale. The Project also included the long-term goal of having farmers provide the Agricultural Research Service with additional seed and information for the National Germplasm System (Stelljes 1999).

The Farmer Cooperative Genome Project had numerous offshoots. The Public Seed Initiative, a partnership including the Departments of Plant Breeding and Horticulture at Cornell University, Northeast Organic Farming Association of New York, USDA Plant Genetic Resources unit in Geneva, NY and the Farmer Cooperative Genome Project is one such program. The Initiative was funded by the Plant Genome Program of USDA's Initiative for Future Agriculture and Food Systems, with the goal to make publicly bred vegetable varieties available to more growers through small seed companies (Public Seed Initiative 2005). Building on the success of the New York Initiative, the Organic Seed Partnership was established in the Spring of 2005. This three-year nationwide project is dedicated to developing improved vegetable varieties for organic systems. The Partnership wants to expand farmer participation in breeding for varieties adapted to organic conditions. Another goal is to improve capacity for production of high-quality, organically certified seed. The Partnership is funded by an award from USDA's Organic Agriculture Research and Extension Initiative and its partners include NOFA-NY, Cornell University and the Plant Genetic Resources Unit (USDA-ARS) at Geneva, NY and New Mexico State University, Oregon State University, Alcorn State University (Mississippi), West Virginia State University, and the University of California at Davis (Organic Seed Partnership 2005).

There is also a need to recognize and give priority to seed saving and breed conservancy efforts in other USDA programs. For example, the Iowa Natural Heritage Foundation, Seed Savers Exchange and USDA's Natural Resource Conservation Service (NRCS) are working together to place a federal Farm & Ranch Land Protection Program easement on 715 acres near Decorah, Iowa. Seed Savers is purchasing the site, known as Twin Valleys, to expand its Heritage Farm which currently covers 170 acres (Iowa Natural Heritage Magazine 2003).

C. Concentration in the Private Market for Agricultural Plants and Animals

Private companies rely on public institutions for germplasm enhancement, the early stages of breeding, and the conservation of genetic resources. Small scale seed companies may use publicly bred lines to supplement their own limited supply. The availability of public lines means that companies can concentrate on work that leads quickly to marketable varieties. An estimated 80% of private breeding investment goes to cultivar development, compared with 12% in the Agricultural Research Service and 41% at State Experiment Stations (Frey 1996). Independent, local seed companies that carry regionally adapted lines may be the best vehicle for getting seed and breeding stock to farmers. Public breeding programs often release "rough" cultivars to smaller seed companies for final development, testing and marketing. This

relationship is threatened by the increased use of licensing fees and exclusive agreements with larger companies by Universities and other public institutions.

The gradual erosion of public capacity has shifted breeding work to the private sector and narrowed the research focus to crops and livestock breeds that currently have a large market share. The increasing privatization of breeding program research has contributed to the consolidation of seed and breed lines as companies focus on the "profit centers" and discard genetic lines and research for geographic regions that do not bring short-term high returns. A wave of seed company mergers and the vertical integration of the livestock industry eliminated many independent companies that provided products for small market segments. Nearly one-third of the livestock breeds found in the U.S. and globally is threatened with extinction as popular breeds become less distinct because of the narrow set of selection and production criteria applied to succeeding generations (Bixby 2004). The private seed companies now dedicate one-third of their research and development activities to corn, and a total of 80% to all field crops (Heisey et al. 2001). After completing several mergers, Seminis, the largest vegetable and fruit seed company, eliminated nearly one-half of its vegetable seed lines, particularly lines of open pollinated varieties (Navazio & Dillon 2004).

Moreover, larger seed companies are acquiring patents in a strategic attempt to block research at rival companies. These defensive patent portfolios also restrict work at public institutions and international organizations. This trend gives a few large companies effective control over breeding efforts in the private sector, leaving farmers few options when purchasing seeds. Five firms now dominate the genetics for most of the crops grown worldwide: Bayer (owns Aventis), Monsanto, DuPont (owns Pioneer), Dow, and Syngenta (a merger of Novartis and AstraZeneca seed divisions) (Hendrickson & Heffernan 2004). In 2005, Monsanto expanded its genetic holdings by purchasing both Seminis and Emergent Genetics Inc., a cotton seed company. This consolidation of seed companies, coupled with expansive control of genetic resources currently allowed under U.S. intellectual property law, restricts the flow of germplasm and narrows the diversity of genetic resources available to meet the needs of a wide array of geographic regions and markets.

D. Impacts on Farmers and Ranchers of the Loss of Public Domain Plants and Animals

A prominent historic role of the public sector was to ensure that the benefits of improved seed were spread equitably among farmers. This important role should continue, but it will not, unless the public sector actually produces varieties that farmers can use without restrictions on production and marketing or seed saving (Dechant 2003). As public breeding programs have reduced the development of plant varieties in favor of more basic research and genetic studies, public breeding of many crops has been drastically reduced or ceased altogether. The loss or restricted use of adaptable germplasm has also decreased the contributions of small seed companies. These companies commonly market so-called 'minor' crops but do not have in-house capacity for all stages of breeding. Small, regional companies and public breeding programs often served the needs of farmers in specific geographic locations or in market segments that do not have large sales volume.

Historically, there had been enough diversity among seed and livestock companies to adequately serve all market segments. This was to a large extent because of the initial work done at public research institutions and the issuance of non-exclusive licenses to public germplasm. But now, many farmers are experiencing difficulty finding seeds or breeds adapted to their region and agricultural systems, especially if they wish to diversify production and reduce external inputs. The decline of public breeding programs and acquisition of small companies by large firms leaves producers of other crops with very few options. Two classes of varieties are most vulnerable to elimination because of seed company consolidation: 1) specialty varieties that can serve very important niche markets and have specific quality traits, and 2) "workhorse" varieties that have durable adaptation and solid performance in the face of environmental stress, including many

open pollinated and older hybrid lines (Navazio & Dillon 2004). These are the genetic resources with the most potential value for sustainable and organic agriculture. Also, the loss of the genetic diversity in these varieties could have profound negative impacts on a conventional agricultural system which is balancing precariously on a narrowing base of genetic resources.

When purchasing seed from major corporations with investments in intellectual property rights and transgenic technologies, farmers are often required to pay royalty fees and sign technology use agreements that prohibit the saving of seed. For those farmers who do not wish to sign away this right, the alternatives provided by public breeding programs and smaller seed companies are quickly disappearing. While the private sector may serve some segments of the agricultural industry adequately, there is still a substantial role for public breeding programs. It is a role that complements the efforts of private industry to provide farmers with options that suit their needs

In addition to seeing a reduction in the number of available seed varieties, farmers interested in maintaining and experimenting with their own genetic lines or collaborating with researchers on long-term projects are subject to increased restrictions on access to genetic resources. The general utility patent has no exemptions which would allow farmers and ranchers to save seed for their own use or use and reproduce protected varieties for plant breeding or other bona fide research. The Plant Variety Protection Act, the primary tool in the U.S. for securing intellectual property rights in plant varieties, does have seed saving and research exemptions. The Plant Variety Protection Office within USDA's Agricultural Marketing Service, however, is severely under-funded and working under a large backlog of applications. Many companies, faced with delays in obtaining Plant Variety Protection certificates, are opting to secure general utility patents for agricultural genetic resources with no exemption for farmer breeding and research efforts. This troubling trend in the U.S. is in sharp contrast to the laws in other countries and international law which have almost universally adopted a system of intellectual property protection that allows for breeding research and farmer seed-saving. Breeders in the U.S. are at a disadvantage when compared to those in other countries which do not recognize patents on living material. Also, a recent USDA report recognized the important role in maintaining crop genetic diversity played by landraces. Landraces are varieties of crops improved by farmers to meet the needs of local conditions. Crop genetic diversity has declined as landraces have been replaced by scientifically developed varieties. This trend is exacerbated by the growing intellectual property right restrictions on the ability of farmers and ranchers to breed and develop local varieties of plants and animals (Rubenstein et al. 2005).

The loss of public domain breeding programs also diminishes the important link between Land Grant Universities and farmers and ranchers. Farmers and ranchers know the unique environmental and production characteristics of their regions and can contribute greatly to breeding programs. The exchange of information between these stakeholders and public breeders is critically important to maintaining the relevance of public research programs. These partnerships among farmers and breeders appear to be most successful when some of the selection is done by farmers and some of the evaluation is done on-farm. In these partnerships, most of the breeding and evaluation is done by professional breeders with advice from farmers as to which traits are necessary and desirable. Breeders have access to needed equipment, facilities, technical assistance, computer software and advanced germplasm for modern breeding efforts. They are also trained in methods of selection, experimental design, and statistical analysis. Farmers, with knowledge of their production systems and their own needs, can recognize good plants and animals traits when they see them (Falk 2003). Farmers and scientists observe from different perspectives. Combining the two approaches to breeding makes research more productive (Podoll 2004).

III. Recommendations for Reinvigorating Public Plant & Animal Breeding

Primary goals of U.S. agricultural research and policy programs should include: protecting genetic diversity; developing new plant and animal varieties that meet the needs of tomorrow's agriculture (particularly those of sustainable and organic production systems); and maintaining a diverse, independent farming sector. This paper has described the resource needs of public breeding programs. It has also provided examples of private-public partnerships that bring together breeders from universities, government agencies and the private sector with farmers, ranchers, consumers, and non-governmental organizations. These partnerships have outstanding results. What we seek now is a framework in which these partnerships can grow and multiply, so that the benefits of public plant and animal breeding are available to all farmers and consumers, both in this country and the wider global community. Therefore, we make the following recommendations to reinvigorate public plant & animal breeding in the United States.

A. Recommendations for Congress

1. Research Support for Public Domain Breeding Programs

- Increase financial and personnel support for the collection, preservation and evaluation of germplasm collections and encourage increased public use of the rich sources of genetic diversity in U.S. germplasm collections.
- Reestablish and implement the National Genetic Resource Program from the 1990 Farm Bill.
- Establish a program area within USDA's Agricultural Research Service for long-term research on plant and animal breeding, including the development of finished varieties.
- Ensure that dedicated funding streams are created for public plant and animal breeding research. Specifically include provisions for this type of research in the request for applications in the Cooperative State Research, Education and Extension Service's National Research Initiative and other USDA competitive grant research programs. These programs should emphasize plant and animal breeding focused on local and regional adaptations for increased environmental benefits, food quality, pest and pathogen resistance, etc.
- Link existing competitive research and extension grants and rural development programs to food and agricultural systems that promote environmental stewardship and small and mid-sized farm profitability, genetic resource preservation, and participatory animal and plant breeding initiatives.
- Adequately fund the Plant Variety Protection Office within the Agricultural Marketing Service to eliminate the backlog of applications for Plant Variety Protection certificates. This backlog discourages the use of certificates even though they are the international standard of protection for new plant varieties.

2. Education

- Increase public funding and other incentives for Land Grant Universities, including the 1890 and 1994 institutions, and for non-governmental organizations to maintain viable training and research programs for undergraduate and graduate students in the basics of classical plant and animal breeding. These programs should also be sensitive to the employment potential and needs of both the private and public sector job markets.
- Increase federal formula funds and competitive grants expressly for the purpose of educating and training public plant and animal breeders. New legislation should include incentives for publicly funded and

trained plant and animal breeders to remain in the public sector for 5 years through reduction of their school loan debts.

3. Farmer and Rancher Participation in Public Breeding Programs

- Establish incentive programs for farmers and farmer associations to participate in testing, selection, seed increase, and evaluation of plant varieties in germplasm repositories.
- Increase funding for public breeding projects that include partnerships with non-profit organizations and farmers and ranchers with a goal of increasing publicly available seeds and animal germplasm for sustainable and organic production systems. These projects should be based on the models developed by the Farmer Cooperative Genome Project, the Public Seed Initiative funded by USDA's Initiative for Future Agriculture and Food Systems, and the Organic Seed Partnership funded by USDA's Organic Agriculture Research and Extension Initiative.
- Increase Sustainable Agriculture Research & Education program funding to create a new national priority area for participatory plant and animal breeding for sustainable and organic agricultural systems. Include incentives for farmers to become active breeders and to form farmer/breeder clubs or teams.

4. Oversight of USDA Programs & Patent Law

- Conduct congressional hearings and other investigations, such as General Accountability Office reports, on the impacts of the Bayh-Dole Act, Cooperative Research and Development Agreements between USDA laboratories, and the use of utility patents for plants and animals. Hearings and investigations should address the linkages among the Act, subsequent Supreme Court decisions on patenting plants and animals and their germplasm, and the growing consolidation of seed companies and their intellectual property portfolios.
- Require USDA to perform a cost-benefit analysis on the Bayh-Dole Act for universities and public breeding programs. Evaluate the Act's effect on public access to germplasm and research results and on the scope of public breeding for "minor" crop and livestock species.
- Enact patent law reforms that would raise the standards for patenting, decrease the use of patents to bar research and breeding work, and encourage the use of plant variety protection certificates rather than utility patents for plant varieties.

B. Recommendations for the U.S. Department of Agriculture

1. Program Improvements & Coordination

- Gradually phase-in the enforcement of the provision in the National Organic Program which requires the use of organic seed. The current allowance for non-organic seed in the Program means that seed companies have no incentive to breed plant varieties suited to organic systems, which may have very different traits than those bred for conventional systems that use synthetic inputs. A viable organic seed production market is essential to the success of breeding programs focused on optimizing varieties for organic production systems. While the organic seed requirement is being phased in, tools which support organic production systems, for example an organic seed database and crop insurance programs which support organic production systems, should be provided or supported by USDA to assist the transition to all-organic seed.

- Coordinate regional efforts including those by federal agencies, educational institutions, and non-profit organizations such as the Natural Resource Conservation Service's (NRCS) Resource Conservation and Development Councils, the NRCS Plant Materials Program, the Agricultural Research Service Genetic Resources Units, Land Grant Universities, farmer organizations, and other non-governmental organizations to address regional agriculture and environmental needs for well adapted or native plant and animal varieties.

2. Increase Farmer & Rancher Participation in Public Breeding Efforts

- Establish an NRCS conservation goal regarding plant and animal germplasm conservation. NRCS should develop quality criteria for on-farm conservation of genetic resources and related conservation practice standards under the plant and animal sections of the Field Office Technical Guide.
- Provide a priority for participation in NRCS conservation programs, particularly the Conservation Security Program and the Environmental Quality Incentives Program, for farmers and ranchers who include plant and animal germplasm conservation as a primary goal of their program agreements.
- Provide incentives and conservation practice recognition through the Conservation Security Program for the on-farm practices of seed saving, preservation, regeneration, selection and breeding activities, which can contribute to increased biodiversity, more diverse cropping systems and richer wildlife habitats.

C. Recommendations for Land Grant Universities and Other Public Institutions

Overall, public breeding programs should be supported and designed to conduct valuable research and to develop improved germplasm. Breeding programs must be accountable for the financial, physical, and personnel resources that have been allocated to them. They must be transparent in the use of those resources and clearly articulate what has been accomplished and why it is important. Programs should focus on breeding for agricultural systems that are ecologically and economically sustainable in the long-term.

1. Research

- Direct public plant and animal research to produce seeds and breeds that perform well in diversified landscapes, that optimize the productivity inherent in multi-species synergies, and that perform well in localized eco-systems within particular soil types, climates, crop and livestock mixtures, and landscape designs. Public programs should work on breeding improved cultivars and breeds of both minor and regionally adapted major crops and livestock breeds as keys to a more diversified and secure food system.
- Target breeding programs and research to meet the needs of sustainable growing conditions and emerging markets, especially the market for organic food. This research should involve such things as breeding for better quality, disease or pest resistance, plant competitiveness with weeds, efficient management of inputs or cycling of nutrients, and for cropping and livestock systems that perform well under lower-nitrogen supplementation. It would also involve breeding for improved taste and nutritional characteristics and work on unique varieties suited to regional and local food systems.
- Support interdisciplinary teams of researchers, including breeders, entomologists, plant pathologists, soil scientists, agronomists, ecologists and farmers, to conduct long-term studies and develop agricultural systems that are environmentally benign and economically profitable for small and mid-sized farmers and ranchers.

- Do not allow public breeding programs to result in proprietary germplasm that is unavailable to other breeders in the public and private sectors, or to farmers and ranchers. Improved varieties of crops and livestock can be protected, but must be available through non-exclusive licenses and material transfer agreements that allow their use in breeding or seed-saving activities.

2. Education

- Reward faculty members who devote substantial time to teaching and outreach activities. Encourage researchers to develop mentoring relationships with students. Educating the next generation of public plant and animal breeders is crucial to maintaining the functionality of these disciplines and meeting demand for breeders in the private sector.
- Develop and actively promote programs at the undergraduate, masters and doctoral level to train future plant and animal breeders. Encourage students to get involved in breeding programs, research farms and agricultural organizations on campus. Make students aware that public breeders are essential to food security and sustainability.
- Include real field experience, plus strong emphasis on biology, mathematics, chemistry, computer programming and communication skills in university and NGO public breeding training programs. The programs should also include work with farmers and other stakeholders.

3. Increase Farmer and Rancher Participation

- Encourage research programs that build meaningful farmer/breeder collaboration and emphasize the exchange of knowledge and skills in breeding for sustainable agricultural systems.
- Foster partnerships among public breeding programs, farmers and ranchers, and small and medium sized seed or livestock companies to provide affordable and marketable germplasm, to effectively use publicly developed breeds, and to increase farmer choice.
- Conduct outreach programs such as workshops, listening sessions, field days, on-farm research and demonstration projects, and community events such as harvest festivals that bring farmers, researchers and consumers together for discussion about breeding objectives and celebrate the achievements of public breeding programs.

We all need to strive toward a more balanced research agenda developed democratically with key constituencies for a more sustainable future. It is a crucial time to bring public and private plant and animal breeders, farmers, ranchers, consumers, business representatives, policy makers and other stakeholders into a dialogue to ensure that we can continue to have a strong national public plant and animal breeding system for the 21st Century. (Closing Statement of Summit - SUMMIT ON SEEDS AND BREEDS FOR 21ST CENTURY AGRICULTURE. WASHINGTON, DC. SEPTEMBER 6-8, 2003.)

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Endorsing *Reinvigorating Public Plant & Animal Breeding For A Sustainable Future* (12-12-2005).**

Center for Rural Affairs, Lyons NE (www.cfra.org)

F.A.R.M. Alliance of Rural Missouri, Marionville MO

Iowa Environmental Council, Des Moines IA (www.iaenvironment.org/)

Kansas Rural Center, Whiting KS (www.kansaruralcenter.org)

Land Stewardship Project, White Bear Lake MN (www.landstewardshipproject.org/)

Michael Fields Agricultural Institute East Troy WI (www.michaelfieldsagainst.org/)

Midwest Organic and Sustainable Education Service (MOSES), Spring Valley WI
(www.mosesorganic.org/)

Minnesota Project, St. Paul MN (www.mnproject.org/)

Nebraska Wildlife Federation, Lincoln NE (www.nebraskawildlife.org/)

Ohio Ecological Food & Farm Association, Columbus OH (www.oeffa.com/)

Organic Farming Research Foundation, Santa Cruz CA (www.ofrf.org)

Rural Action, Trimble OH (www.ruralaction.org/)

Women, Food, and Agriculture Network, Atlantic IA (www.wfan.org)