From Commodification to Conservation: Restoring Agrobiodiversity Through Seed Breeding – Part I:

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Editor's Note: This post is the first in a two-part series about seed breeding. This series will explore the history of seed breeding in the US, the impacts of consolidation and concentration of seed breeding on farmers and our food systems, and what a more democratic seed breeding system might look like. This series was created in collaboration with the Ujamaa Cooperative Farming Alliance and Dr. Cathy Day of Cathy Day Consulting.

Seeds are an integral underpinning of our food system. Over the past decades we have seen a hyper consolidation of seed systems that has led to a dominant culture of seed commodification. Over time, the consolidation and commodification of seeds has eroded the resilience of our food systems, diminishing the agrobiodiversity of crops cultivated in the US at an alarming rate. Support for resilient and diversified seed systems is critical in the upcoming Farm Bill and can also be a direct pathway to support BIPOC (Black, Indigenous, People of Color) communities and climate change strategies.

The History of US Seed Breeding

For most of the history of domesticated crops, those who grew crops saved seeds from one growing season to the next. They were able to identify the best of what they had grown in one season and set aside enough seeds to plant the following season. That meant farmers could maintain and improve the traits that mattered most to them and that best fit local growing conditions. Seed saving was also an important element of maintaining food traditions. From the high value placed on the flavor and texture of Carolina Gold rice by generations in the South to growing the right tepary beans for a favorite Southwestern dish, the particularities of foods matter for more than just their appropriateness for a climate or soil. They underpin what it is to feel at home; what it means to sense one's lineage through food in a single place or across oceans.

In short, being able to save seed in prior centuries was central to adapting to an environment and to carrying on the most-valued rhythms of one's ancestors by preserving culturally appropriate foods.

However, during the nineteenth century, these patterns of seed growing and saving began to change.

Before 1862, the US Patent Office was mailing millions of free seed packages to farmers across the country. One of the core functions of the USDA, upon its foundation in 1862, was the collection and public distribution of germplasm, or seeds. By the end of the 19th century, a third of USDA's budget was devoted to germplasm collection and distribution. USDA distributed seeds to farmers for free, encouraging growers to save and share seed and to experiment with any crop that could become economically important to US agriculture. With the passage of the Morrill Act in 1862, land grant universities began to establish regional seed breeding programs. While these breeding programs furthered the base of scientific knowledge around plant breeding and led to significant increases in yields, farmers were slowly pushed out of their historical role as the primary stakeholders in seed saving and development.

Although free seed distribution programs were immensely popular among farmers, emerging private seed breeders and horticulturalists lobbied the federal government to end the program in 1924. The shift toward commercialization of seed began in earnest.

Among the most pivotal changes to growing crops was the development of corn hybrids in the first decades of the 20th century and the subsequent commercialization of hybrid corn in the 1930s. For the first time, seed-saving for a staple crop began to be infeasible, and private breeding became paramount. This marked another distinct point of transition to the professionalization of seed breeding. The resulting 20th century trend was toward decreasing control of seedstock by growers and more and more breeding by land-grant university researchers and–especially toward the end of the 20th century–by large transnational corporations. Such changes reduced the overall resilience of the agroecological system.

Seed Breeding Commercialization and Food System Resilience

As corporations increasingly became the main seed breeders and therefore the arbiters of available seed, the diversity of seed options steadily declined, with substantial impacts on overall crop diversity.

Robust, diverse food systems rely on varied seed to respond to challenges like pests and disease, but also to respond to the increasingly challenging conditions created by climate change. The responses to challenges of climate change, including pests and disease, will be most effective if they include perennial crops. Perennial crops, many of which have deeper roots, offer resilience to drought, flood, and disease more so than annual crops. Moreover, they have more potential to contribute to greenhouse gas mitigation via carbon sequestration. By expanding the diversity of our seed system, seed and planting stock for perennial systems will also be an important element of building resilience.

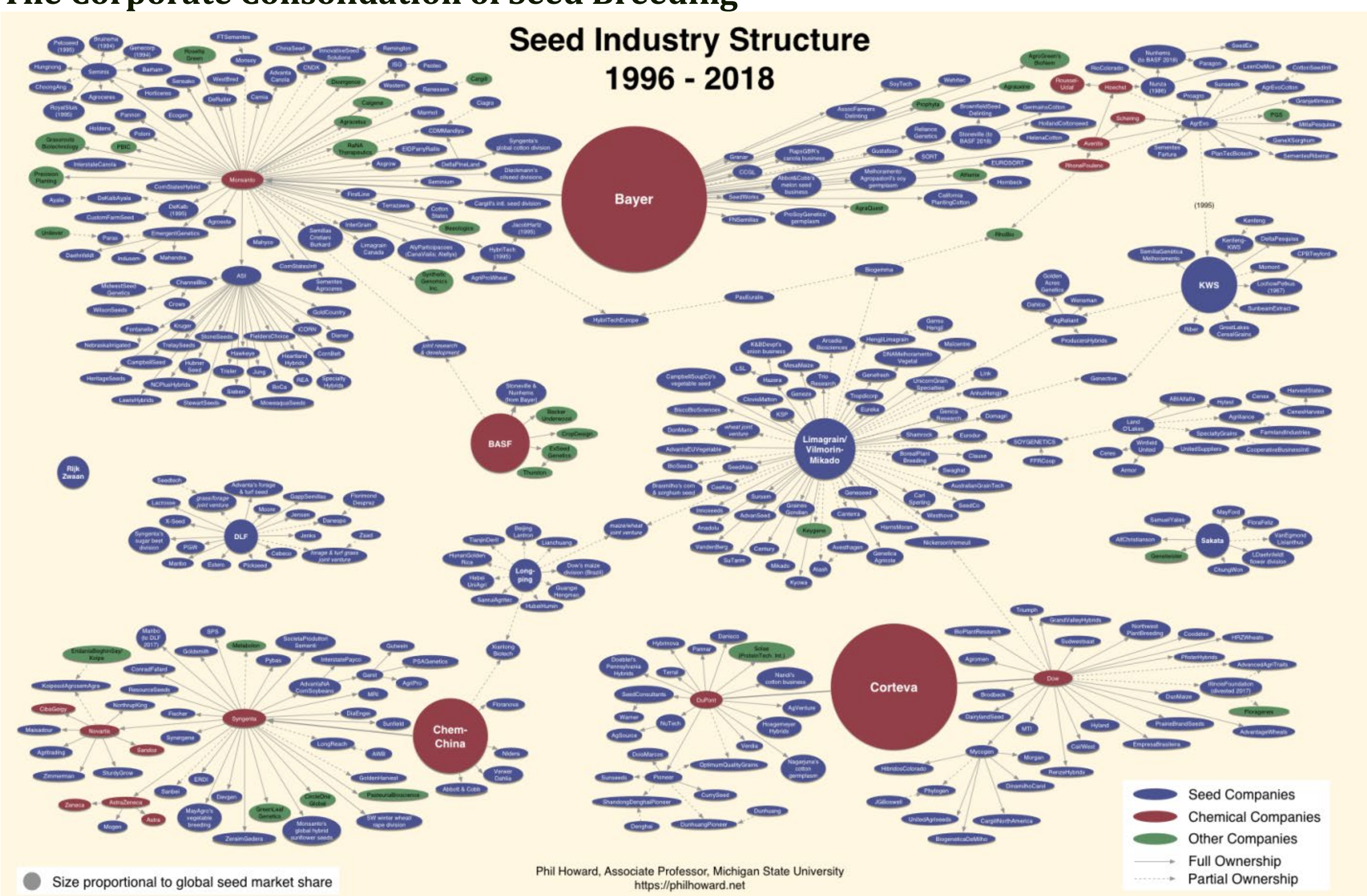
However, given the substantial shift away from public seed research and toward a corporate-driven research agenda, along with the consequently common focus on production of genetically modified organisms, the approach to climate mitigation and adaptation in seed breeding has been narrowly focused. For example, identifying drought tolerance characteristics offers some opportunity to decrease the stress on certain crops. However, given the wide range of new stressors on crops, from shifting pest pressures, smoke stress, and increasingly high temperatures, to more stochastic spring and fall freeze events, a much more holistic and comprehensive approach to seed breeding is needed.

A better system would allow farmers to diversify the range of species they produce. This would further enable farmers to drastically cut pesticide use and increase habitat availability for a wide range of species. This diversity helps build more resilient farms as compared to farms where only a single trait of a single species is altered.

In other words, effectively responding to present and future climate challenges means thinking ahead about the seeds we will use in a much broader light than is possible under the dominance of corporate breeders. Identifying the traits that work with weather impacts like heat, drought, floods, and smoke is important. But part of that adaptability comes from having multiple different species of both plants and animals in the same space. For example, farmers in highly variable climates like Niger succeed best by having a range of species and varieties mixed across the landscape so that every year something will thrive. Moreover, the needed shift away from industrial farming means identifying effective mixes of crops that produce nutrients in place. Reducing greenhouse gas emissions means moving away from the use of high-energy and polluting nitrogenous fertilizers. Diverse plants and manure must take their place. We can look to the many species that represented the exclusive sources of nitrogen and other nutrients for farming in use before 1950 and especially in prior centuries.

However, the move away from a focus on corporate breeding, to one that incorporates more climate-adaptive and culturally relevant crops, requires understanding the system that brought us to this point.

The Corporate Consolidation of Seed Breeding



Over the past decades, we have seen a hyper consolidation of the seed market with over 50% of seed sales coming from companies that are owned by four large biotechnology corporations. Source: Philip H. Howard

Above, we discussed the transitions in seed breeding that occurred during the nineteenth and early twentieth centuries, including the shift from farmer-led seed saving to private breeding companies. Yet, the early private seed industry bears little resemblance to the commodified industry we see dominating farming today. Small and regionally-based private seed companies acted mainly as breeders of regional seed and distributors of publicly developed seed varieties. In contrast, today's dominant players genetically engineer and mass produce seed alongside complementary inputs including fertilizers and pesticides. This is seen repeatedly with major field crop seed corporations selling corn, soybeans, cotton, canola, sugar beets, and alfalfa.
In the 1930's, as the market shifted toward hybrid varieties with desirable traits, companies developed exclusive cultivars. The increased demand for agricultural exports generated by World War II, and with continued research breakthroughs, led to the mass acceptance of hybridized seed. Moreover, in the wake of the war, the Marshall Plan converted bomb factories to fertilizer factories, rapidly creating an entire system of hybrid seeds and manufactured inputs upon which farmers rapidly became reliant.

Though plants and seed were historically interpreted to be products of nature and thus, not patentable per existing patent law, the American Association of Nurserymen successfully lobbied the federal government to pass the Plant Patent Act of 1930. This became the first statute allowing biological materials to be patented, though this applied only to unique asexually reproducing plants. You can see the difference between the two patent types in their definitions:

Utility Patent: The right to exclude others from making, using, offering for sale, selling, or importing the invention. May be granted to anyone who invents or discovers any new and useful process, machine, article of manufacture, or composition of matter, or any new and useful improvement thereof.

Plant Patent: May be granted to anyone who invents or discovers and asexually reproduces any distinct and new variety of plant.
For decades, USDA and Congress remained hesitant to extend patents to sexually reproducing plants, fearing that patents on seeds would lead to market concentration and less innovation. However in 1970, in the face of mounting pressure from burgeoning seed companies, Congress passed the Plant Variety Protection Act (PVPA). Under the PVPA, breeders could obtain a Plant Variety Protection Certificate (PVPC) for new varieties. Farmers, land grant universities, and other seed companies were still allowed to save seed protected with PVPCs, but they could no longer sell the seed to other farmers except under license from the PVPC owner. Seed companies and breeders could still freely use protected varieties as parent material in their own breeding programs. Evidence suggests that in its first decade, the PVPA actually increased the number of distinct plant varieties available to farmers, but this arrangement did not last.

The 1980 Supreme Court decision, *Diamond v. Chakrabarty* allowed newly engineered oil-eating bacteria to be patented, effectively signaling that inventors of any human-made microorganism could be granted utility patents – including plants. The US Patent and Trademark Office was soon approving thousands of utility patent applications for plants that reproduce sexually. **Importantly, where PVPA protections were explicitly designed to reinforce the rights of researchers and farmers to save protected seed, utility patent holders can now forbid this.** The expansion of intellectual property protections in the 1980s occurred in tandem with the evisceration of antitrust policies and merger guidelines under the Reagan administration. These policy shifts laid the foundations for a "merger mania" in the 1980s and late 1990s, giving agribusiness corporations the ability to buy-out potential competitors or otherwise expand their services and markets unchallenged.

Today's dominant agriculture corporations genetically engineer and mass produce seed alongside complementary inputs including fertilizers and pesticides, as is seen with major field crop seed corporations selling corn, soybeans, cotton, canola, sugar beets, and alfalfa. Private investment in food and agriculture systems are designed to maximize a narrow concept of economic efficiency which fails to prioritize the well-being of small family farmers, rural communities, or the land.

"In 2019, US farmers spent $118 billion to purchase seed and plants, fertilizers, animal feed, and agricultural chemicals. The cost of total farm input expenditures has increased almost $80 billion since 2009, a classic symptom of an industry that has become too concentrated. Bayer, Corteva, Limagrain, Chem-China, and BASF exclude competitors with control of at least 50 percent of the seed and agrochemicals markets by raising the price of inputs for farmers (including with a novel "technology fee") without risking their own market dominance.

To strictly analyze the cost of seed, consider that corn farmers who paid $26.65 per planted acre of seed in 1990 paid $93.48 in 2019. This represents a dramatic increase of roughly 350 percent, beyond the rate of inflation, following the biotechnology merger-mania and the co-opting of the seed industry." ***-Billy Hacket, NSAC***

The rise of private seed breeding and the decrease in public investment in seed breeding has led to the loss of national control over food systems. This has resulted in the growth of monopoly power in input markets that could drive up input prices; technology determinism, where farmers choices may be limited to technologies favored by private developers, such as hybrid seed and GM crops; and a preference to serve the needs of large commercial farms at the expense of small-medium size farmers, farmworkers, rural communities, and the environment.

The Value and Institutions of Public Plant Breeding

By contrast, over the last several decades, publicly funded agricultural research has led to the advancement of countless innovative techniques and practices that have helped farmers across the country increase their profitability and sustainability. This public research and development (R&D) investment is the primary driver of long-term productivity growth in US agriculture. In addition to increasing farm productivity, public agricultural R&D investment also supports improvements in natural resources and forestry management, helps advance rural development, and enhances food safety and quality. All farmers need access to high-quality research; and investing in research at the intersection of agriculture and climate change is critical to both short-term and long-term efforts to protect the viability of the agricultural industry.

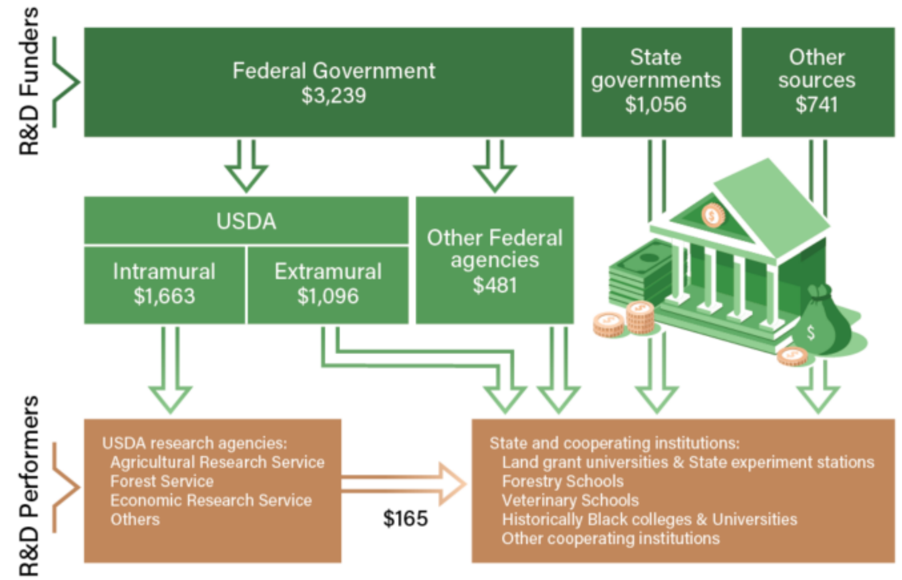
Publicly funded research institutions include not just work at land-grant universities, but at USDA itself. Research, education and extension at USDA is carried out by four main agencies;

- **Agricultural Research Service (ARS)** is USDA's "chief scientific in-house research agency" and plays an important role in long-term agricultural research. This research is used to help farmers meet and adapt to challenges while increasing overall productivity. The agency has over 660 research projects within 15 National Programs at 90+ research sites.
- **USDA's Economic Research Service (ERS)** provides critical, objective, data-driven research and analysis that identifies economic trends and challenges for producers across a range of topics. This research is essential to ensure agricultural businesses, service providers, and policymakers are making sound decisions.
- **National Agricultural Statistics Service (NASS)** conducts hundreds of surveys, including the Census of Agriculture, every year and prepares reports covering virtually every aspect of US agriculture. Production and supplies of food and fiber, prices paid and received by farmers, farm labor and wages, farm finances, chemical use, and changes in the demographics of US producers are a few examples.
- **The National Institute of Food and Agriculture (NIFA)** was created under the 2008 Farm Bill to elevate federally funded competitive agricultural research within USDA. NIFA administers all competitive agricultural research grant programs authorized in the farm bill, such as the Agriculture and Food Research Initiative (AFRI) that funds projects in public plant and animal breeding, sustainable agriculture systems, small and mid-sized farms, rural economies, and many other topics.

Land-grant universities and other "non-Federal institutions" perform about 70 percent of US public agricultural research. USDA agencies, such as ARS perform the remainder. USDA's National Institute of Food and Agriculture (NIFA) administers most of the funds for extramural research funded by USDA. Extramural research programs like the Sustainable Agriculture Research and Extension Program (SARE), Agriculture and Food Research Initiative (AFRI), Organic Research and Education Initiative (OREI), and Organic Transitions Program (ORG) are available to land-grant institutions, farmers, non-profits, private entities, and individuals.

Funders and performers of U.S. public agricultural research in 2019

U.S. dollars, millions



Notes: Total funds allocated to agricultural research and development (R&D) in 2019 were $5.04 billion, while total reported expenditures by R&D performing institutions that year was $5.16 billion because of differences in budget procedures and timing of expenditures.

Source: USDA, Economic Research Service based on data from USDA, National Institute of Food and Agriculture and National Science Foundation.

Source: USDA ERS

Despite its strong record of serving public needs, according to a 2022 report by the Economic Research Service (ERS), US public agricultural R&D investment has fallen by about one-third since its peak in 2002. Underscoring the important role of public research, the study found that every dollar invested in publicly funded agricultural research generates $20 in economic activity.
In its key public role, USDA-funded research can seek to optimize the balance among production, nutrition security, environmental services, and socio-economic sustainability.

Filed Under: Carousel, Research, Education & Extension