Journal of Agriculture, Food Systems, and Community Development
ISSN: 2152-0801 online
https://foodsystemsjournal.org

Special Section:
Fostering Socially and Ecologically Resilient Food and Farm Systems Through Research Networks

SPECIAL SECTION SPONSORED BY:

Climate resilient food systems and community reconnection through radical seed diversity

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Submitted March 31, 2023 / Revised July 3 and November 21, 2023 /
Accepted November 21, 2023 / Published online March 12, 2024

Citation: Smith, C. (2024). Climate resilient food systems and community reconnection through radical seed diversity. *Journal of Agriculture, Food Systems, and Community Development*, *13*(2), 37–52. https://doi.org/10.5304/jafscd.2024.132.007

Abstract

Diversity is essential to climate resilience in food and farming. Traditionally, agrobiodiversity has been cultivated and sustained through communities' relationships with seeds. A fluid process of saving, preserving, and exchanging seeds allows for regional adaptation and transformation. This process results in seed diversity at the crop, variety, and genetic level. Over the last century, agrobiodiversity has declined at an alarming rate, and simultaneously there has been an erosion of community seed-keeping practices. A reaction to these interrelated crises has been an increased push to preserve biodiversity through institutional seed preservation efforts (also called ex situ preservation), which focus on genetic preservation of seeds in controlled environments. The seeds are genetic resources that are made available to plant breeders, who solve agronomic problems by creating improved cultivars for farmers. This is very different from community seed-keeping (also called in situ preservation), which values seed-people relationships and fosters natural agrobiodiversity and regional adaptation. Seeds are seen in direct connection to food, and saved for immediate and practical reasons like yield, flavor, and resistance to biotic stressors. In traditional communities, seeds are often perceived as kin, as ancestors or living beings with both histories and futures. For institutional seed preservation, collecting and maintaining seed diversity is an imperative insurance policy against future challenges. Ironically, this model erodes

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Development of the JAFSCD special section in which this article appears, "Fostering Socially and Ecologically Resilient Food and Farm Systems Through Research Networks," was sponsored by INFAS and eOrganic and supported in part by the U.S. Department of Agriculture, National Institute of Food and Agriculture, through the Organic Agriculture Research and Education Initiative, Grant # 2017-51300-27115.

community-based seed-keeping efforts and increases dependence on institutional seed preservation to maintain genetic diversity. In this paper, we explore declining agrobiodiversity and community seed-keeping and share our experiences working with a diverse range of varieties from The Heirloom Collard Project (HCP). We propose that radical seed diversity can jump-start autonomous, community-based seed-keeping efforts, increasing agrobiodiversity and, ultimately, the climate resilience of food systems.

Keywords
agrobiodiversity, climate resilience, relational seed-keeping, regional adaptation, seed preservation, collards, landrace, ultracross, plant breeding, community seed-saving, food systems, heirloom

Introduction

The Encyclopedia of Biodiversity defines agrobiodiversity as "variety and variability of living organisms that contribute to food and agriculture in the broadest sense, and that are associated with cultivating crops and rearing animals within ecological complexes. It is further expanded in some contexts to include all the organisms present in an agricultural landscape" (Jackson et al., 2013, p. 31). Increased agrobiodiversity has multiple documented benefits: farm resilience to extreme weather events and other system shocks (McFall et al., 2015), increased speed and capacity of a crop's climate adaptiveness (Ceccarelli & Grando, 2020), superior ecologically based pest and disease management (Altieri et al., 2014), and broader availability of nutritious and culturally appropriate foods (Fransiska et al., 2015). However, there is a clear lack of agrobiodiversity in food and farming.

The 2017 Census of Agriculture reported that 95% of U.S. farm producers are white (U.S. Department of Agriculture National Agricultural Statistics Service [USDA NASS], 2017), and farming is generally taught and understood through a colonial lens (Layman & Civita, 2022). Practices such as regenerative agriculture promote systems that can heal the land, but still often exclude Indigenous voices from which those practices are derived (Mangan, 2021); peasant[1] and Indigenous farming wisdom often promotes a more harmonious relationship with the land and its workers (Penniman, 2018). In terms of natural resource management, the white-dominant mindset still embraces an extractive relationship. Within white-dominated systems, the range of commercially grown crops is severely limited. According to a Food and Agriculture Organization of the United Nations (FAO) report on agricultural biodiversity, there are 20,000 edible plant species, only 6,000 of which have historically been used for food. In 2019, fewer than 200 made a major contribution to food production, and just nine crops are used for two-thirds of all food production (FAO, 2019).

Within the limited range of crops there has been significant erosion of genetic diversity over the last century, with 75% crop genetic loss (FAO, 2019). Much of this loss has occurred in loss of landrace varieties (domesticated but diverse, regionally adapted seed varieties), although modern cultivars and replacement landraces have created stable diversity in some areas; for example, diversity in pearl millet landraces in villages in Niger has remained stable despite the landraces themselves shifting significantly due to recurrent drought (Khoury et al., 2021). Genetic diversity of the varieties grown has also generally become limited, from homogeneity due to inbreeding multiple generations of heirlooms (Lofthouse, 2021) or from the dominance of commercial modern crop cultivars (Khoury et al., 2021). Just as heirlooms are precious objects passed from generation to generation, heirloom seed varieties have been around and inbred for a long time (strict definitions vary, but there is a general consensus that heirlooms are open-pollinated varieties that predate World War II).

Additional narrowing of agrobiodiversity can be seen in declining insect populations (Seibold et al., 2019), degraded soil biodiversity (Kraamwinkel et al., 2021), and homogenous farming landscapes and land management (Carmona et al., 2022). A recent collaborative project provides a succinct summary:

[1] I use the term "peasant" farmer to refer to a person of the land, who has a direct and special relationship with the land. For a fuller exploration of the term peasant, I recommend *Unpacking the Word Peasant* (A Growing Culture, 2023).

> The evidence is mounting that agricultural biodiversity ("agrobiodiversity") is vital for supporting human food sovereignty, food security, and nutrition. Biodiversity-rich agriculture has proven able to provide a stable, diversified, and nutrient-rich supply of food for farmers and their communities while supporting ecological functions important for resilient and sustainable food production and the sustenance of complex ecosystems. However, agrobiodiversity has declined dramatically in the last decades, with diverse impacts for human and more-than-human communities. Multiple studies point to the links between homogenization of the global food supply and the persistence of hunger and malnutrition among consumers, both rural and urban. (Limeberry et al., n.d., para. 1)

When the food system is reduced to a linear series of inputs and outputs—the industrialization of food and farming—costs such as societal health and environmental harm can be externalized and ignored. Reduction of agrobiodiversity can be justified as an improvement in efficiency because capitalism incentivizes profit-maximizing behavior by producers. In this paper, we prefer the term *relational foodways* as an alternative to *food systems* (Valeriote, 2021). Relational foodways speaks directly to the interconnected complexities of food system relationships, and opens the conversation to food as a way of life rather than a system of inputs and outputs. We propose the parallel term *relational seed-keeping* to depict the complexities of living alongside seeds in community. Much of our agricultural history has relied on our relationship with seed, and the coevolution of people and plants has allowed for tremendous human advancements. It is only in our very recent past that seeds have been separated from people and reduced to "genetic resources."

The Utopian Seed Project (TUSP) is a nonprofit based in Western North Carolina that encourages food and farming to embrace greater agrobiodiversity, encouraging relational seed-keeping by engaging a broad swath of stakeholders. These stakeholders are defined in the TUSP vision statement as "An engaged community of growers, gardeners, farmers, foodies, cooks and chefs (actually, everyone) who embrace diversity because they understand and believe in resilient, delicious and equitable food and farming" (TUSP, 2020, para. 3). Growers are considered to be not only food but seed growers as well, based on the core concept that a healthy and thriving seed system is a fundamental pillar of a healthy and thriving food system. TUSP is part of The Heirloom Collard Project (HCP), which defines itself as "a collaboration of collard-loving people and organizations—a crock pot of sorts, where the ingredients are each respected, but the true magic is in the pot likker" (HCP, 2021, para. 2). This collaboration is an example of high impact and effective change through community engagement. The HCP includes and empowers people and communities to interact with collards in a way that is deeply meaningful, often food and culture focused, and therefore long lasting. These relationships are critical because agrobiodiversity is not an object that can be stored and saved, but rather a process that needs to be embraced and applied. By working with diverse stakeholders, from farmers and gardeners to consumers, chefs and food businesses, TUSP aims to create deep connection with food and an appreciation of the important role of seeds in our foodways.

At least in part, TUSP asks the question, How do we re-infuse agrobiodiversity and seed connection into relational foodways? In 2020 TUSP planted 21 varieties of heirloom collard varieties as part of a national trial organized by The HCP and Seed Savers Exchange. The trial included a beautiful mix of diverse varieties, such as William Moore, Fulton Stroud, Tabitha Dykes, Fuzzy's Cabbage Collard, E.B. Paul, Jernigan Yellow Cabbage Collard, Yellow Cabbage Collard, Georgia, White Cabbage Collard, Willis Collard Greens, Ole Timey Blue, Georgia Blue Stem, North Carolina Yellow, McCormack's Green Glaze, White Mountain Cabbage Collard, Green Glaze, Miss Annie Pearl Counselman, Brickhouse Old Collard, Lottie Collard, Vates, and Georgia Southern (HCP, n.d.). At the TUSP experimental farm in Leicester, NC, we planted 10 plants of each variety in a randomized block design with a single replication (a total of 20 plants of each variety). The aims of the project

were fairly standard: to collect agronomic data on the plants as well as document the diversity of the varieties. We worked with chefs to do tastings and explore various food applications.

There was significant diversity within the varieties as well as between the varieties. The collards were allowed to grow into the winter season, during which we experienced a sudden low of 8°F, when some plants completely perished and others still thrived. Plants of the same variety performed differently, suggesting a strong genetic predisposition for cold tolerance. The cold snap caused about 30–40% plant loss, but the surviving population, which included plants from all varieties, continued to grow into spring when they flowered and produced a seed crop.

Given the use of randomized block design and the strong outcrossing habit of collards, the seed mix certainly contained a high level of intervarietal cross-pollination. The plants that produced seeds were simply the winter survivors, and initiated a seed mix that was beautifully diverse, delicious, and extremely cold-tolerant. An HCP collaborator, Melony Edwards, described this exciting new seed mix as Ultracross Collards, which we will explore in detail later. We will also compare institutional seed preservation (ex situ preservation) and community seed-keeping (in situ preservation), as well as the differences between commercial heirlooms and community-saved seeds. From that foundation, we will discuss reasons for declining seed diversity and the challenges of reintroducing it into communities. Our work with collard varieties from The HCP will serve as an example of both the loss and the importance of relational seed-keeping. We will then fully explore the potential of radical seed diversity (e.g., Ultracross) as a tool to create climate resilient foodways and community reconnection.

Institutional Seed Preservation vs. Community Seed-Keeping

Institutional seed preservation is a common response to declining biodiversity. It includes both the search for wild crop relatives as well as the collection and storage of peasant and Indigenous seeds, which are often described as landraces. The USDA has sponsored plant-collecting trips around the world for over a century and stores seed specimens in the National Plant Germplasm System. The seeds, and sometimes plant material, are made available as a public resource for research and education through the Germplasm Resources Information Network (GRIN), whose tagline is "Empowering and enabling crop diversity" (Germplasm Resources Information Network, n.d.). Globally coordinated efforts to preserve seed diversity were ramped up in the 1970s (Frankel & Bennett, 1970), with the International Board for Plant Genetic Resources (IBPGR) established in 1974. Perhaps the most famous institutional seed preservation effort is the Svalbard Global Seed Vault: over 1.2 million seed varieties and wild crops are stored in a vault designed to survive a range of global catastrophes (Angel, 2023). The prevailing narrative is of the threatened extinction of crop varieties, which establishes a moral imperative to preserve and protect them.

Sadly, access to the germplasm resource collections is often restricted to academic and corporate plant breeders for creating improved varieties (Gewin, 2017), which are often released as proprietary hybrids or patented genetics, further consolidating the seeds within the power of corporations and institutions (Greenaway, 2017). In a positive feedback loop, the work of preservation leads to the consolidation of seed genetics through the introduction of "improved cultivars," which further undermines in situ maintenance and availability of agrobiodiversity and therefore fuels the urgent (and morally justified) call for greater preservation efforts. In addition, it is the seeds, or genetic strains, that are often "saved," but the people and communities who have stewarded them are forgotten, ignored. and/or alienated.

This viewpoint has been explored by Helen Anne Curry, documenting efforts of the USDA and other organizations to save native corn varieties while the same government pursued policies of displacement and destruction of tribal communities who stewarded the corn (Curry, 2022). To save seeds by extracting them from communities deeply connected to them assumes that the communities are not capable of maintaining the varieties themselves, discounting the intergenerational labor, skill, and wisdom of those who developed the varieties into desirable "genetic resources." Loss of connec-

tion to community seeds and seed-keeping traditions is a tragedy, especially for communities where violence and displacement forced that loss upon them.

In addition, this storing and mining of specific genetic traits often ignores (or at least undermines) the plants' ability to change and adapt. Seeds grown and saved in relation to a specific environment by relational seed-keepers significantly contributes to community resilience and agrobiodiversity. A people-first approach to seed preservation would focus on protecting and promoting environments and systems in which communities are empowered to steward their seeds. Seed sovereignty is the right of a person or community to save their own seeds, but also requires access to regionally or culturally appropriate seeds and having the knowledge and skills to cultivate and save them. In many Indigenous and peasant farming communities, seeds are thought of as living beings, relatives, or kin, which connects strongly to the concept of relational seed-keeping. When seeds become family, a history and a future and a depth of relationship extends beyond a single growing season: "There is a maternal quality to seed stewardship that exists in the relationship between the seedkeeper and the seed" (Valeriote, 2021, para. 7). Seed rematriation is a movement led by Indigenous women to return seeds to their places and peoples of origin, a very different approach from the seeds-as-commodity relationship that industrial agriculture promotes, while the highly consolidated global seed industry continues to threaten peasant and Indigenous communities around the world (Peschard & Randeria, 2020).

Within smaller seed industry movements, there is increasing acknowledgment of the harm done, both past and ongoing, by seed commercialization, and a growing focus on rematriation projects and culturally meaningful seeds. The Ujamaa Cooperative Farming Alliance, for example, is a BIPOC-led organization doing important seed work. At nearly all of their workshops, they engage in deep healing and dialog, asking questions like, "What did your grandmother eat?" and "What ten crops can you not live without?" These are simple but powerful questions because they ask about relationships, family, food, and culture. In Black communities (but also more broadly across the American South), collards are almost always on the list of important cultural crops, and yet they have suffered the same fate of varietal loss. The HCP offers a clear example of the complexities of institutional seed preservation, and opportunities for reigniting community seed-keeping efforts.

Collards Part I: Saving the Collards

As early as 1992, Mark Farnham, a USDA research geneticist specializing in *Brassica*, the genus of cruciferous vegetables that includes collards, noticed a severe lack of genetic diversity in collards (*Brassica oleracea subsp. viridis*), and began collecting samples. In the early 2000s, he connected with cultural geographers Ed Davis and John Morgan, who were researching what made the South unique and had arrived at collards as a lens through which to answer the question. Farnham, Davis, and Morgan received USDA funding to travel across the Southeast in search of collard diversity. They collected 78 samples from backyard seed-savers, traveling over 12,000 miles across 12 states. None of these collards were in seed catalogs or had documented histories. Furthermore, many of the seed-keepers were elderly and reported that they had no one to pass the seeds to when they died, indicating that the varieties would likely die with them. The researchers reported that only one seed-keeper declined to share seeds, and most of the seeds were offered with great thanks. The collected varieties were added to the National Plant Germplasm System, through which they are publicly available for research and education work through GRIN.

We can easily imagine a scenario that had these collards not been collected and stored by the USDA, they would no longer exist. Because these varieties lacked documented histories, we would not even know that they had ever existed. Thus we should give great thanks to the efforts of Davis and Morgan, and acknowledge that many varieties—collards and otherwise—are surely already lost. Nevertheless, while it is undoubtedly true that we are in real danger of losing many seed varieties, the work of preserving biodiversity is not linear or simple: "Only by safeguarding crop diversity in perpetuity, and making it available for use by researchers, plant breeders, and farmers, can we adapt agricul-

ture to the climate crisis, reduce environmental degradation, improve livelihoods, and feed everyone adequately" (Crop Trust, n.d., para. 2).

Such statements trigger immediate questions. Who safeguards this diversity? Who decides to whom to make it available? And, who decides what it means to feed everyone adequately? Institutional seed preservation separates seeds from the communities that steward them, placing a high value on the genetics of seeds without considering the importance to both the people and the seeds of in situ preservation efforts. As the collards example shows, ex situ work is urgent. However, while the seeds are technically saved, when the community seed-keepers die the seeds will still be lost to the communities. The separation of seeds from people and land is a core problem. Seeds sitting in a seed bank and not freely exchanged and grown within a community will not be able to live and adapt to the needs of the community and a changing environment. Katharine Dow writes, "If seeds bring with them their worlds, then they are inherently malleable, so seed savers are concerned about how commercial seed breeding and ex-situ conservation denatures seeds' embodied relationships with their environments and, with that, their inherent intergenerational malleability" (2021, p. 496). While the collard collection trip demonstrates how institutional seed preservation can play an important role in agrobiodiversity conservation, especially in times of socio-political unrest (Andersen, 2016), there needs to be much greater effort for community seed-keeping if seeds (and therefore food) are to remain in relation with people (Graddy, 2014; van Dooren, 2009).

Called the "Godmother of Southern Seeds" by *The New York Times* (Roach, 2023), Ira Wallace is a seed-keeper and educator who lives at Acorn Community, an egalitarian intentional community in central Virginia that manages the heirloom-focused seed company, Southern Exposure Seed Exchange. In 2016 Wallace chanced upon a collard variety trial in Charleston, South Carolina, that Mark Farnham was running. The trial included around 60 of the varieties collected by Davis and Morgan. Wallace was astounded by the diversity on display and made a vow to get these varieties back to people who cared about collards (Smith, 2021). This was the beginning of an idea that developed into The HCP. Through a diverse network of community-based seed stewards, The HCP is working to regenerate and reintroduce collard diversity back into the food system. The aim is to develop relationships—including traditions of growing, cooking, and eating them—with these varieties beyond the standard seed catalog transaction. so that they can return to communities without the threat of extinction.[2] A friend of the project, Jon Jackson of Comfort Farms, describes the relationship of conservation by consumption: if people are not eating the collards, no one is going to care about growing them and saving the seeds.

The Limitations of "Catalog" Heirlooms

There are many organizations and seed companies that have been promoting heirloom seed preservation for a long time. Seed Savers Exchange was founded in 1975, and there are many heirloom-focused seed catalogs representing thousands of unique varieties. Through this lens, genetic diversity is alive and well. Modern seed-saving practices stress the need to control "open" cross-pollination with isolation by species, distance, and barrier, thus ensuring that the variety continues to grow "true to type," i.e., as it did last year and the year before ad infinitum. This preservation mentality is embedded in the concept of heirloom seeds and compels us to save seeds in a way that both preserves the purity of their story (also known as the seed description) and of their genetics. In Europe, seeds must conform to a rigid definition of distinctiveness, uniformity, and stability (DUS) to be sold (Animal and Plant Health Agency, 2022).[3] Even in the U.S., over the past century the expectations of "stability"

[2] This work and the work of The HCP have been widely reported, for example, in the book *Collards, A Southern Tradition from Seed to Table* (Davis & Morgan, 2015) and the National Public Radio story, "A community of seed savers has a recipe to revive rare varieties of collard greens" (Wood, 2022). Information about The HCP is available at https://www.heirloomcollards.org. I would also like to note that both Dr. Ed Davis and Dr. Mark Farnham have been highly supportive of this work.

[3] This is slowly changing in Europe. In 2022, a new European regulation of organic production was introduced, opening up the possi-

and "uniformity" have been codified in a model of regulation, control, and profit (Page-Mann, 2022). Basically, if you can name and describe it, you can own and sell it, making varietal purity a precursor to profit.

The timeline of most catalog heirlooms coincides with the formation of the American Seed Trade Association (ASTA) in 1883, which established business alliances with the seed industry (previously government-sponsored) and by 1924 had persuaded the federal government to stop its free seed distribution program.[4] Naming and describing an heirloom seed variety traps that seed at a single point in time, reinforcing the notion that the seed is a static thing. This arbitrary beginning (e.g., "This heirloom can be dated back to 1885") in actuality becomes the last page of the seed's story, which is rewritten every year as well-meaning seed savers strive to preserve the seed so it grows true to type. "What was that seed before 1885?" is a question generally unasked, further erasing peasant and Indigenous contributions to agrobiodiversity. With the static, objectified premise of catalog heirlooms, a core problem is that many varieties are highly inbred, but seeds are living organisms and are not meant to be held in stasis generation after generation. When the seeds are removed from their communities, cultures, and people, a relationship is broken. Seed savers may step in to steward those varieties, but they are merely caretakers of those seeds, guided by the name and description of the heirloom, but rarely empowered to be in relation with them.

In reality, a seed has a fascinating past and an immeasurable future. The story contained within a seed should be one without beginning or ending, a story in which the seed-keepers are active participants, and the seed-people relationship co-evolves every year. Katherine Dow, exploring community seed-saving of the London Freedom Seed Bank, writes of community seed activists, "Their focus on seeds and the worlds in which they grow and how these are transmitted across both species and generations suggests that, for them, seeds are not only embedded in their environments but also *embody* their environments" (2021, p. 495). As the seed continues to evolve with the changing environment and the seed-keepers themselves, then we should see the seed (and the people) as dynamic, rather than static.

A seed story is ongoing because the seeds remain in relation with the seed-keepers in the community. Peasant and Indigenous communities generally embrace dynamic, relational seed-keeping practices. Martín Prechtel describes an ancient practice of reintroducing wild genetics into stable corn populations in a 12-year cycle to reinvigorate the corn. This deep cultural ceremony has been recorded in corn-growing communities of people from Peru, Guatemala, and certain tribal districts of Mexico and New Mexico. With similar intent, Appalachian old-timers have described the community tradition of scooping a handful of bean seeds from a neighbor and dumping them in the seed stock of another neighbor, ensuring the genetic diversification of community seeds. Prechtel criticizes conventional notions of purity: "To keep seeds alive, clear, strong and open-pollinated, purity as the idea of a single pure race must be understood as the ironic insistence of imperial minds and should probably be boiled down into the tears of grief its insistence descends from and composted into something useful" (2012, p. 348). Seed-saver and farmer Michael Carter spent time farming in Ghana, where community seed-keeping is common. During an interview about seed heritage he commented on southern peas he'd seen growing in West Africa, and commented, "The thing with the cool ones is that they don't have no names, they're just beans" (Blackwood & Kadish, 2022, 19:12). There are millions of mothers out there, but they all share one name, mom (or version of). The reason we know our own mom's are special isn't because of their name, but because of our relationship with them. As with seeds, if everyone knows who the special (to them) seeds are, then specific names may not be necessary. This type of work requires a deep relationship with the seeds and

bility of marketing seeds of "organic heterogeneous material" (OHM) without the need to register in official catalogs (Lorimer, 2022).
[4] The free seed distribution was not without its problems; it was basically a tool to advance settler colonialism by supporting farmers to grow food on recently stolen land.

plants, and a deep knowledge of seed-saving. There is a substantial level of confidence and wisdom in mixing and sharing genetics without fearing loss of culturally important traits and varieties.

Collards Part II: Intravariety Diversity

Diversity is a component of a resilient system, and genetic diversity in a food system can form naturally when community seed-keeping is prominent. The varieties that The HCP works with have been called heirlooms because they are old enough to meet the definition, having been grown and saved in place for many generations. However, the seeds did not come with descriptions, and most of them did not have names before being collected by Davis and Morgan. They were just collards. Occasionally they would carry a name for a subtype or color, such as yellow cabbage collards. The original collard seed stewards were invited to name the collard seeds, and most varieties are now named for the people or places they came from (HCP, 2023). Brassicas can cross-pollinate over a long distance, and there are many crop types in the species *Brassica oleracea*, so the potential for intervariety cross-pollination is quite high. There is clearly large genetic variability within the heirloom collard varieties, which naturally leads to a high level of climate resilience (Ceccarelli & Grando, 2020). It has been observed that the size of populations from which seeds were saved was often quite low compared to the recommended population size to maintain genetic integrity, which is around 80 plants (Buttala & Siegel, 2015). Genetic diversity within each variety likely buffered the smaller population size and helped maintain genetic integrity; that is, population size for genetic integrity is inversely proportional to intravariety diversity. Due to observed diversity, seed-saving and selection for strict varietal purity did not seem to be a primary goal for the original seed-keepers.

This style of fluid, community-level seed-keeping is arguably what keeps agrobiodiversity alive and strong while also supporting community food resilience. It is how seeds were traditionally kept, with many peasant and Indigenous communities maintaining landrace populations rather than strict varieties. A landrace has been described as locally adapted, genetically variable, and promiscuously pollinating (Lofthouse, 2021). Some crops are more prone to promiscuous pollination than others. Perfect flowers contain both pollen producing and pollen-receiving anatomy (e.g., beans and tomatoes), monoecious plants have separate pollen-producing and pollen-receiving flowers (e.g., squash and corn), diecious plants have separate pollen-producing and pollen-receiving flowers (e.g., spinach and asparagus), and some perfect flowers are self-incompatible (e.g., collards and broccoli). The mechanism of pollination determines the level of promiscuity, with perfect flowers usually self-pollinating (not very promiscuous) and the other types usually outcrossing (more promiscuous). Regardless of the level of promiscuity, most modern cultivars and heirlooms are not genetically variable, and if the variety starts with limited genetic variance then the adaptive capacity of that variety will also be limited. Regional adaptation is widely considered to be an inherent advantage of seed-saving, but since most people are saving seeds from genetically limited heirlooms, the full advantages of seed-saving may not be realized (Lofthouse, 2021). The level of climate adaptiveness is improved with greater genetic diversity (Ceccarelli & Grando, 2020). Thus, the genetically diverse HCP varieties support more rapid regional adaptation because of the inherent variability of the varieties. We have seen evidence through our informal farmer network; one farmer seed-saver, Sandra Osterkatz, grew a variety named Tabitha Dykes and noticed some plants with more purple coloration, which her CSA customers liked. After just two years of selecting and saving the purple plants, she has a purple-dominant Tabitha Dykes seed line quite distinct from the original population (Osterkatz, 2023).

Ultracross: Reconnecting Forward

In 2020, TUSP allowed 21 varieties of heirloom collards to intercross. The plants that produced seeds were the plants that had survived extreme winter weather, yielding a diverse population of environmentally selected collards which we called Ultracross Collards. As a breeding method this would be described as a composite cross, but the concept of diverse seed populations is ancient. The model of hyper-uniform varieties, created in a cen-

tralized system, and sold through seed companies is the modern concept, distinct from the varieties held within communities and stewarded (and selected) in relation with those communities, like the heirloom collards. The Ultracross concept stands on the shoulders of traditional landrace cultures, although it is the author's belief that true landraces are intergenerational in nature. Many seed companies are beginning to offer breeders mixes and landraces for sale:

- Common Wealth Seed Growers is a plant breeding-focused seed collective that regularly releases varieties that are "in progress," offering genetics of F3, F4, F5, etc. breeding lines.[5]
- Fruition Seeds uses a model called Versions to describe "dynamic iterations of diversity we are growing-and-adapting with over the years" (Page-Mann, 2022, para. 1).
- Native Seeds/SEARCH sells heirloom and landrace seeds, offering varieties like the *Rarámuri Multicolor* corn, which they describe as "beautiful and diverse" (n.d., para. 1).
- Southern Exposure Seed Exchange, a traditional heirloom seed company, published a blog post on the advantages of promiscuous pollination in seed-saving, questioning the strict variety isolation model (Hollowell, 2020). It now sells the TUSP Collard Ultracross.
- The Experimental Farm Network increasingly sells seeds described as breeders mixes and landraces. In 2023, its seed store listed 152 products under the category Landraces and Breeding Stock (Experimental Farm Network, 2023).
- Two Seed in a Pod sells many highly diverse Turkish varieties from a tradition of domesticated regional landraces.
- Ujamaa Cooperative Farming Alliance has a seed company, Ujamaa Seeds, and it is a strong partner in developing and distributing the Ultracross model; we are working with the alliance to create a Sorghum and Southern Pea Ultracross to support its community.
- Wild Garden Seeds sells many of the early lines of Frank Morton's breeding projects as well as diverse mixes of multiple breeding populations, offering people the opportunity to grow and select their own varieties.

These projects and others embrace genetic diversity, in stark contrast with the institutional seed-saving practices that have come to prominence in the past few decades. By embracing radical genetic diversity, the Ultracross project offers (and encourages) climate-resilient varieties with high adaptive capacity and rapid regional adaptation. The broad genetic base of the population can be highly responsive to a wide range of stressors, creating opportunities for natural environmental selection in response to erratic weather and emergent pests and pathogens (Ceccarelli & Grando, 2020). An important distinction of Ultracross compared to highly diverse breeding populations is that its purpose *is* diversity, rather than diversity as a precursor to a "releasable" distinct, uniform, and stable variety.

The Ultracross seeds are more than just a genetic tool; they are an invitation to develop a relationship in an ongoing story. Growing catalog heirlooms compared to growing diverse seed mixes could be seen as the difference between reading a history book, where everything has already happened, and reading a sci-fi novel, where anything can happen. Or, to follow the analogy to a niche subgenre, in an episode of The Seed Growers Podcast, Rowen White, an Indigenous seed-keeper, described growing these diverse populations as "choose your own adventure" (Brisebois, 2022, 1:05:32).

If we are to encourage a mass mobilization of seed-people relationships, then it is important to shift the way we see seeds from static to active,

[5] The F# system denotes the filial generation after a specific intervariety cross has been made. In general it can be expected to take around 7 filial generations to create a stable, uniform, and distinct variety after a cross, so releasing earlier generations offers up seeds with lower varietal predictability but higher genetic diversity.

from histories to futures, from preservation to adaptive. SeedLinked is a digital resource for collaboration and networked varietal trialing that uses the term "breeding ecosystem" to express that plant genetics is a fluid concept, shifting and flowing based on community needs and environmental pressures: "Increased availability and use of diverse seed would create more diversity in agricultural landscapes, contributing to 'breeding ecosystems' that could evolve much quicker in face of climate change, boost local adaptation and performance, and bring climate resiliency and food sovereignty to local economies in an era of globalizing fragility" (Seedlinked, n.d., para. 5). SeedLinked is facilitating increased access to crop varieties, but the concept can be applied to radical seed diversity as well.

A regional Ultracross breeding ecosystem places the seed selection decisions back into the community, subverting the power imbalance of top-down centralized breeding strategies. The inherent genetic diversity of the Ultracross means that the seeds can be rapidly infused into food and farming communities, with all the associated benefits of regional adaptation and climate resilience. This kind of empowered, forward-thinking seed-keeping demands a relationship with the seed and appeals to our natural tendencies of curiosity and exploration. On a very visceral level, people are simply excited about Ultracross seeds and are willing to actively explore and engage with the plants. The excitement is further supported because many of the technical barriers to seed-saving, such as perceived complexity, lack of knowledge, strict requirements, minimum isolation distances, and population sizes, are removed. Strict adherence to varietal purity can be more or less abandoned.[6] And hybrid vigor and heirloom values can be combined without the issues of proprietary ownership and heirloom inbreeding.

Collards Part III: Community Seed Selection: from Whidby White Okra to Ultracross Collards

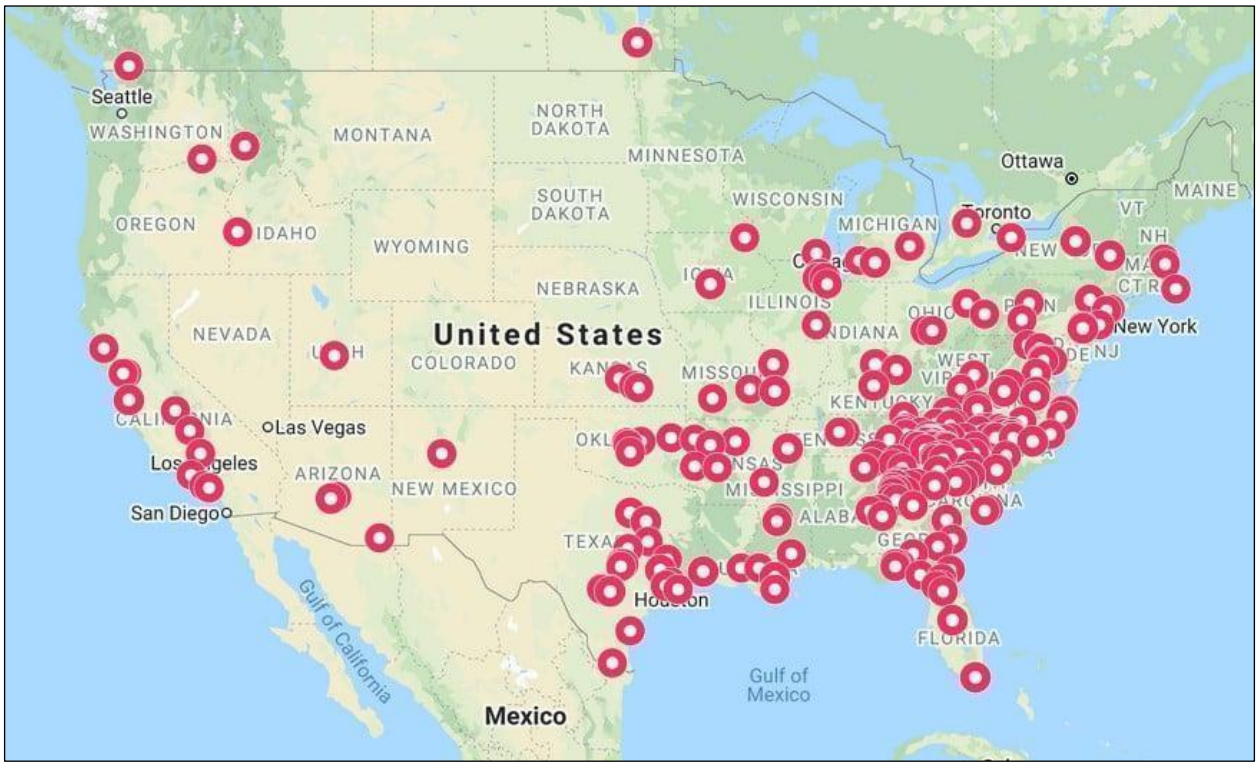
TUSP has been exploring varietal and crop diversity at our experimental farm, which grows large numbers of different varieties of traditional southern crops as well as new crops for the region. The project has always valued outreach and education as part of its work and has used the farm as a platform to showcase regional agrobiodiversity and expansive and exciting food systems.

In 2018, before our work with highly diverse seed populations really took off, TUSP assisted Seed Savers Exchange in selecting the heirloom okra variety Whidby White back to its original phenotype. The variety had experienced some accidental cross-pollination and was expressing a wide range of off-types. The basic method to recover phenotype was to grow out the seeds, wait until the plants had produced pods, visually assess the palest producing plants, cull the other plants and strip all the pods/flowers from the on-type plants, then save seeds from the subsequent pods. In 2020, TUSP produced a large number of seeds from this project and decided to attempt accelerated variety selection by outsourcing to other growers. In 2021, with financial sponsorship from Sow True Seed, TUSP launched the Whidby White Community Seed Selection (CSS) Project (TUSP, 2021b). The concept is based on a participatory plant breeding model, which invites farmers to grow breeding lines to help inform the plant breeding process and widen the scope of data collection. The CSS project sent Whidby White okra seeds to more than 250 growers who had volunteered to participate after we put out a call online (Figure 1). Our basic request was for growers to select the okra plant producing the palest pods and save and return seeds. TUSP provided educational support through monthly YouTube videos (TUSP, 2021c) and a Facebook group (TUSP, 2021a) to help growers through the selection, isolation, and seed-saving process. Over 50 packets of seeds were returned at the end of the season and a 2022 grow-out of those seeds produced a population of plants with a majority of pale pods.

A surprising and rewarding aspect of this pro-

[6] A creative writing teacher of mine once told me that you can break all the literary rules you want, as long as you know you're breaking them. To some extent, this might be true for Ultracross seed-saving, when there could be certain traits you do not want to accidentally cross into the population, such as Queen Anne's Lace into carrots; we had *Abelmoschus manihot subsp. tetraphyllus* cross into an Okra Ultracross, which was not desirable. We are not advocating complete seed-saving anarchy!

Figure 1. Distribution of Participants in the 2021 Whidby White Community Seed Selection Project, 2021

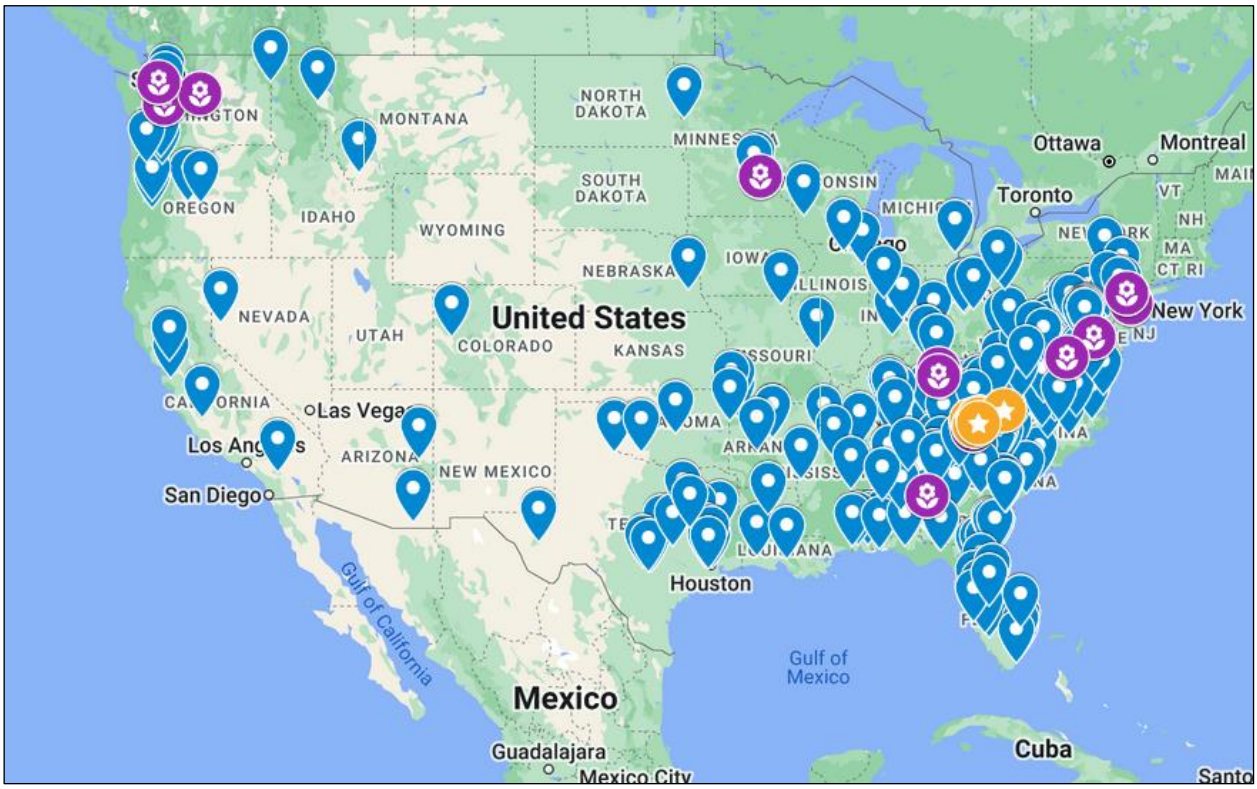


ject was the high level of community engagement. Participants, many of whom had never saved seeds before, were actively assessing their plants, sharing pictures on social media, asking questions in our Community Seed Selection Facebook group, and other members were supporting and answering those questions. As someone who had taught the standard form of seed-saving for almost a decade, it was extremely refreshing to experience the enthusiasm around this objective-based seed-saving process. The primary difference is that the end goal of standard seed-saving is to save seed (process driven, seed preservation), and for the CSS project seed-saving was merely a required tool to achieve the goal of a pale podded okra (objective driven, seed futures). It felt that we were succeeding in inviting people to be an active part of the seed's ongoing story and creating a deeper relationship that is missing with standard seed preservation efforts.

In July 2021 we harvested, processed, and saved the seeds from the winter survivors of the 2020 heirloom collard trial as discussed previously. We harvested around eight pounds of Ultracross Collard seeds, and we realized that we wanted to use them for the next CSS project. Southern Exposure Seed Exchange agreed to partner for seed distribution and we were able to get seeds out to growers in time for fall 2021 planting. Over 500 packets were distributed that first fall (Figure 2). This time we did not have a shared goal of creating something distinct, uniform, and stable, as with the Whidby White Okra; rather, we encouraged participants to pursue their own paths—in the words of Rowan White, to choose their own adventure—and create their own seed relationships.

One interesting barrier we ran into was the way that people were locked into the existing system. More than one farmer/gardener responded with the question, "But, what are we selecting for?" The honest answer was, "Whatever you want." However, we recognized that a project completely without parameters could be overwhelming to growers shaped by a seed-saving practice so heavily influenced by seed industry control. It felt like a kind of Stockholm Syndrome or form of code-

Figure 2. Distribution of Ultracross Collard Seeds Distributed in 2021 and 2022
Blue pins represent individuals who bought a packet of seeds. Purple flowers represent institutions growing larger populations of Ultracross Collards. Yellow stars represent a subgroup of growers working together to select for regional adaptation in Western North Carolina.



pendency. Our aim with the Ultracross is to encourage open-minded inspiration and community empowerment. Below are some examples of where people have (or could) take the Ultracross Collards:

- Cold tolerance: The initial environmental selection was a cold snap in winter 2020, and a primary goal is to maintain a population of collards that is beautifully diverse, delicious, and extremely cold-tolerant.
- Sweetness: TUSP works with a broad range of chefs, whom we often ask to taste plants in trials and then flag or mark their favorites. There is an opportunity to steer the Ultracross Collards toward an ultrasweet collard!
- Glazed: A diverse subset of the collards that have a glazed look (Green Glaze is a well-known variety).
- Purple: Many Ultracross growers have responded strongly to the purple coloration that is flourishing in the mix. Selecting a purple Ultracross population is a goal shared by many. An interesting side note is that the parent population had very little purple coloration, but it is a strong trait in the offspring.
- Perennial (high vernalization): Some of the original plants never went to seed, and there is a subset of collards often described as perennial or tree collards. It should be possible to select a collard population that rarely flowers and can survive multiple seasons.
- Low vernalization: Growers in the Deep South often can not save collard seeds because they do not experience enough cold days to satisfy the vernalization requirements. A selection goal could be reliable Deep South seed production.

- Pest and disease tolerance: A diverse population selected for pest and/or disease tolerance over time will lead to broad horizontal resistance (Robinson, 1995).

The Ultracross Community Seed Selection does not prescribe specific outcomes, but rather guides people with examples of what other folks are doing with the Ultracross Collards. It is important to maintain the open-book, never-ending-story concept of relational seed-keeping. Ultracross Collards are still a nascent CSS project, but they have been spread quickly and the concept has gained traction. They are helping seed-savers to understand the freedom that can be involved in seed-keeping, liberating community seed-keepers from the narrow vision of heirloom preservation. Already the concept of what Ultracross Collards actually are has become fragmented, diverse, and adapted to different regions and tastes, so much so that attempting to pin down a definition or description is futile. The seeds have found their people and the people have refound their seeds.

Conclusion

This paper has connected two problems:

1. We are experiencing declining agrobiodiversity, which has many associated problems, including food systems that are vulnerable to weather- and climate-related shocks. Institutional seed-preservation efforts exist to preserve biodiversity, but, somewhat ironically, the Western-led commodification of seeds and cultivar improvement undermines the availability of the agrobiodiversity on which it relies.
2. As people become disconnected from their seeds, community-based seed-keeping declines, which results in the loss of the traditional system for maintaining and advancing agrobiodiversity. As community seed-keepers age and pass away, their seeds often die with them. Heirloom seed-preservation efforts fall short because the focus is on preserving the seeds in stasis and not on reestablishing relational seed-keeping practices—that is, seeds and people existing in complex community-based relationships that change over time with both the needs of the people and the plants.

These problems exist as climate change is creating volatile environments that make growing food more and more challenging, which is unfortunate because agrobiodiversity and community seed relations offer tools for resilience, and therefore food security, in the face of climate chaos. Climate change is also shifting the seasons so as to impact what can and cannot be grown in regions; as crops, pests, and diseases shift geographically, regional agrobiodiversity will be essential for ongoing adaptation. Both seeds and people will need to grow and adapt together as they face climate-related challenges.

We have argued that these interrelated problems can be tackled by introducing radically diverse seed populations into communities that are invested in caring for them, which creates the opportunity for both rapid, adaptive diversity and community reconnection through relational seed-keeping. The HCP provides a model by which seeds can be withdrawn from institutional seed preservation facilities and used as a tool to re-engage community seed-keepers and generate radical seed diversity, like the Ultracross Collards. Following this model, TUSP has already developed an Okra Ultracross (2021), a Squash Ultracross using *C. maxima* and *C. moschata* (2022), and the beginnings of both a Southern Pea and a Sorghum Ultracross (2023). The Ultracross method produces radically diverse plant populations that support high adaptive capacity and climate resilience while inspiring community-based relational seed-keeping. People often ask, how many collard varieties are you growing? With the Ultracross, the answer is, As many plants as we have in the ground. And that is just at the TUSP farm; Ultracross creates and encourages limitless futures and never-ending stories.

Acknowledgments

I would like to thank Jay Bost, Dr. Tess Desmond, Yanna Fishman, Justin Sardo, and Eva Steinberg for their careful reading and insightful comments as I worked on this paper.

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