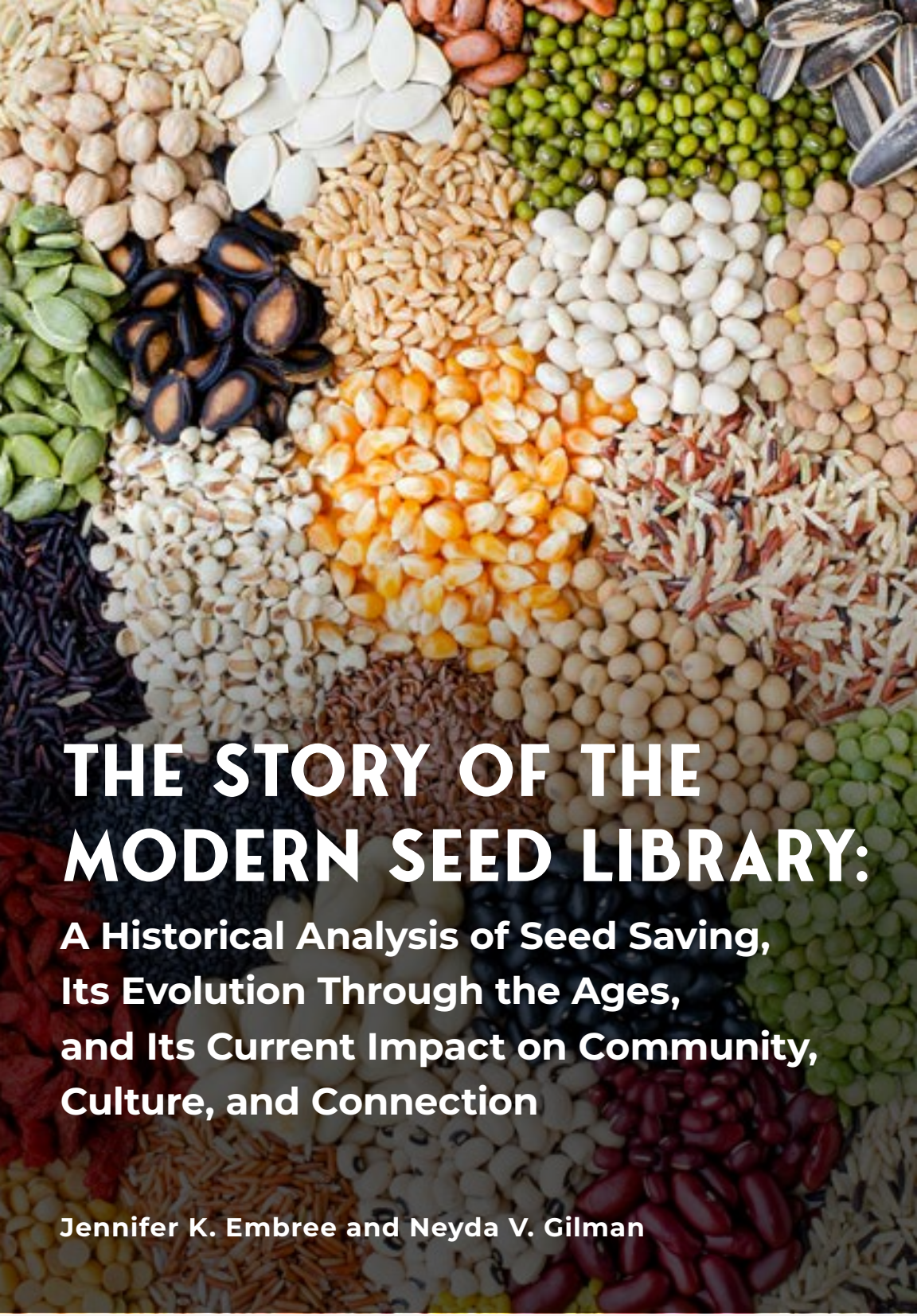

THE STORY OF THE MODERN SEED LIBRARY:

A Historical Analysis of Seed Saving, Its Evolution Through the Ages, and Its Current Impact on Community, Culture, and Connection

Jennifer K. Embree and Neyda V. Gilman

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CLIR Publication 191

Cover image:
Variety of natural cereal foods.
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Introduction

Seed saving has been a necessary part of human existence since humans began forming agrarian societies. Seeds from wild plants were collected and planted. Those plants grew, and seeds were saved again to continue the process. Individuals saved for themselves and traded with friends, family, and neighbors. When these individuals had enough seeds, they might sell them. Eventually, companies formed from these individuals and the practice of saving and trading seeds gave way to the convenience of buying seeds. As these companies grew from local individuals selling their seeds into large corporations, the practice of saving and sharing seeds dwindled. While convenient, the practice of relying on seed companies has led to a loss of diversity, adaptation, culture, and independence. Farmers and gardeners have become dependent on seed companies and thus only have access to the varieties the companies provide; they must pay whatever the company charges or go without. Seed companies also discontinue seeds that are not profitable or are otherwise inconvenient, further limiting growers' options. The commercialization of seed companies has further exacerbated the situation. A prime example of this is the Shaker Seed Company, which started with members of the Shaker community selling seeds to their local community in the late eighteenth century, growing into a large, but regional, official seed company in the early nineteenth century, and then failing as less community-minded seed companies became more competitive in the mid-1800s (Paine 1993). Figure 1 shows a Shaker Seed Company workstation.

Fig. 1: A Shaker Seed Company assembly station showing sifters, seed containers and labels, scoops, and scales. "Shaker seed assembling" by Doug Coldwell, CC BY-SA 4.0

Additionally, as scientific understanding of seed genomics grew, seeds were hybridized to produce plants that had specific qualities (e.g., earlier bloom, larger fruit, smaller footprint). However, the plants grown from these hybridized seeds do not reliably produce seeds with the same traits. The resulting seeds produce unknown results, often losing the desired trait. Thus, hybridized seeds are not able to be reliably saved, even by those with experience and knowledge, furthering reliance on the seed companies who produce the hybrids (Halaska 2019). Because of this growing reliance on hybrids, many traditional varieties of plants were lost because their seeds were not passed on (Conner 2015). Sixty percent of the current global seed market and seventy-five percent of the global pesticide market are controlled by just four companies, and the tie between agrochemicals and limited seed options is not coincidental (Lough 1999; Fakhri 2021).

In his 2022 report to the UN General Assembly Human Rights Council, UN Special Rapporteur Michael Fakhri identifies two seed systems. The first is the farmer's system, which is the more traditional method mentioned above and which Fakhri describes as "integral to the world's genetic and cultural diversity, and … foundational for all food systems." The second seed system is the more modern and conventional commodity system which is reliant on homogenous varieties, chemicals, and property and patent laws (Fakhri 2021). Modern seed saving and sharing in all its

forms has grown out of a desire, and need, to return to more of a farmer's system (Conner 2015, Montenegro De Wit 2016). As Genetic Resources Policy Specialist Ronnie Vernooy put it, community seed organizations "can enhance or revive traditional social seed networks that have existed for decades or centuries based on combinations of seed saving, seed exchanges, seed giving, seed bartering, and seed purchase" (Vernooy et al. 2017). While similar in focus, these systems come in a variety of forms and names, including seed/gene banks; seed libraries; seed collections; seed-saver/exchange clubs, alliances, and networks; seed production cooperatives; farmer committees and networks; and other varieties (Vernooy, Shrestha, and Sthapit 2015). Seed libraries and banks are probably the most commonly used terms, and the differences between them and all the others comes down to the primary motivation, goals, and methods of seed collection and distribution. Even with these differences, they are all part of the global seed sovereignty movement, itself a part of the larger food sovereignty movement, which aims to "reclaim seeds and biodiversity as public goods and as commons and defend the right of local communities to autonomously control how seeds are (re)produced, saved and circulated" (Peschard and Randeria 2019). We started creating our seed library at Binghamton University in upstate New York in 2020 to contribute to this movement and as a way to further connections with our community. This analysis will touch on our personal experiences while delving deeper into the history and impact of seeds and seed saving.

SEED BANKS

Perhaps one of the first things people think of when they hear "seed library" is the Svalbard Global Seed Vault (figure 2). Rather than a seed library, Svalbard is more of a seed bank and is considered "the world's largest and most important seed backup or duplication facility" (Angel 2022). They consider themselves a vault since they act as a backup to other seed banks, are underground, and ultimately serve to safekeep seeds. Seed banks are also considered gene banks as they "are locations where plant material is placed in short-and long-term storage and are intended to preserve the genetics of the species or variety" (Glasgow, Hughes, and Knezevic 2016). Broadly speaking, gene banks store various types of plant material in addition to seeds. The primary purpose of seed and gene banks is to store and preserve the genetic material of plants. This genetic material can then be used to reintroduce plants lost due to disasters, misuse, and climate change; provide genetic material necessary to breed new plant varieties; and overall act as a safeguard for the future (Angel 2022, Montenegro De Wit 2016).

Fig. 2: Svalbard Seed Vault Entrance by Einar Jørgen Haraldseid CC BY-SA 2.0

Since it is important that the seeds in banks are ready when needed, seed banks require viability testing and proper cleaning and storage (Fry 2016). Usually, they replenish their seeds on a regular basis by working with established, knowledgeable seed savers who can properly grow the plant and harvest fresh seed to return (Glasgow, Hughes, and Knezevic 2016). In addition to Svalbard, other examples of seed banks include, but are not limited to, the Atlantic Canada Regional Seed Bank (ACORN), the Comox Valley Seed Bank in British Columbia, the Navdanya seed banks across India, the Australian Seed Bank Partnership, and the Kew Millennium Seed Bank in London.

SEED LIBRARIES

Seed libraries, on the other hand, emphasize education, awareness, and empowerment over the safeguarding of genetic information. They act as traditional libraries and "lend" the information to anyone who is interested. Individuals can go to seed libraries and take seeds that they would like to grow. Ideally, seeds from the plants grown would then be returned to the library for growing the next year. However, since there is no guarantee that seeds will be returned, and since even returned seeds may be inaccurately labeled or the result of crossbreeding, seed libraries are not the best means for ensuring the preservation of specific plant varieties. The strength of seed libraries is in their ability to educate, build community, provide seeds to anyone who wants them, and spread joy and

awareness around seeds. As will be discussed later, these strengths are similar to those of traditional libraries, which is one of the reasons having seed libraries within libraries for printed matter often works so well.

Seed banks and seed libraries are frequently thought of as being the same thing, but they are separate concepts, each with important and specific roles to play. Seed librarian and horticulturist Zayaan Khan explains the difference between seed libraries and seed banks in that "[seed] libraries encourage the movement and use of seeds, as opposed to saving and storing them" (Fawzy 2022). Another way to differentiate between the two is explained by the author, gardener, and educator Cindy Connor: "Seed banks are repositories that hold seeds for the future. Seed libraries, on the other hand, are dedicated to getting seeds to as many gardeners as possible to be grown out each year—allowing the varieties to be preserved, while at the same time adapting as needed to the local climate and conditions. The libraries house the seeds, provide resources, and offer classes teaching patrons to save seeds'' (Conner 2015). As urban farmer and member of the Tlingit Nation Kirsten Kirby-Shoote puts it, "seed sharing is a verb" (Mitchell 2021).

According to Conner (2015), the first seed library in the United States was the Bay Area Seed Interchange Library (BASIL) which opened in 2000 in Berkeley, California. (It is probably more accurate to say BASIL is one of the first *modern* seed libraries in the USA, as some form of organized seed saving and sharing goes back generations.) BASIL grew out of the University of California, Berkeley, when the campus farm closed and became a community volunteer-run library. Since then, many other groups and communities have started seed libraries. Seed libraries have also been showing up in both public and academic libraries across the country, with the first public library seed library starting in 2004 in Gardiner, New York, when the Gardiner Public Library opened the Hudson Valley Seed Library (Ferro n.d.).

OTHER SEED COLLECTIONS

While seed/gene banks and seed libraries are the two primary categories of seed collections, there are many other types of organizing around seeds. Most of these have similar goals: preserving seeds and genetic material for the future and educating about seeds. Seed swaps are organized gatherings where individuals share seeds with one another. Seed libraries sometimes host seed swaps and invite people to bring their collections to share. Individuals sometimes find each other on the seed swap subreddit of Reddit. There are also large, organized, interstate swaps, the most notable of which is probably the Seed Savers Exchange. Seed swaps allow

individuals who enjoy seeds to focus on saving just a few varieties and then swapping their excess for seeds they did not save. The concept is popular enough that the United States has a dedicated National Seed Swap Day—the last Saturday in January.

There are also groups that refer to themselves as seed collections, coalitions, cooperatives, alliances, or networks. These groups often work toward preserving and conserving seed varieties by collaborating with local farmers and gardeners to collect seed. Rather than following the bank model of safeguarding seeds or the library model of lending seeds, these groups typically sell their seeds. They differ from traditional seed companies in that they are focused on community, seed diversity, conservation, and education, rather than on profit. Examples include the Rocky Mountain Seed Alliance, Snake River Seed Cooperative, Experimental Farm Network, Seed Savers Exchange (they have both a swap/exchange system and a traditional purchase model), Salt Spring Seed Sanctuary, and Hudson Valley Seed Company. Although these groups sell seeds to fund their efforts, they still maintain their initial missions and beliefs in the importance of seeds and self-reliance. One of the founders of Experimental Farm Network, Nathan Kleinman, states that the only competitors with seed companies like his are "giant agribusiness and the industrial food system." His fellow like-minded seed companies are colleagues who trade seeds and work together, despite each relying on seed sales to fund their efforts (Roach 2022).

Both seed banks and seed libraries are relatively recent phenomena in seed-saving history. Seed libraries have exploded in popularity in the last twenty years, and while there have been some recently published studies in the field of librarianship on how to start seed libraries and the many benefits they can offer, there are gaps in the literature when it comes to examining why seed libraries have come to exist, what is driving the rising momentum and interest in the seed library movement globally, and why it is so important that they continue to be seed stewards in their communities. To address these gaps and answer these questions, we decided to embark on a historical analysis of the practice of seed saving to understand how the practices of seed saving, collecting, and sharing have evolved over time and how they have continually impacted human connection, culture, and community. The questions that framed the scope of our historical analysis were as follows:

1. How have seed collecting, preserving, and sharing practices developed over time?
2. How did the concept of "seed libraries" first come to be and how has it evolved?

3. How did colonization and white, Eurocentric influence affect the collection, sharing, and accessibility of seeds from the Age of Exploration onward?
4. How and why are seed collecting and seed sharing practices so integral to human connection, culture, and community?
5. How and why are more public and academic libraries creating community-centered seed libraries in their institutions today?

We believe that this methodology yielded unique, engaging, and enlightening findings that shed light on why seed libraries are becoming more popular and why they are so important to continue to nurture into the future.

The History of Seed Saving

THE ORIGIN OF SEEDS

Seeds first evolved about 400 million years ago, after the first plant forms moved from the oceans into freshwater areas on land (Saladino 2021, Fry 2016). At this time, plants were still reproducing by releasing spores into their environments—a process that required access to water to be successful (Fry 2016). However, the wet and humid climate that allowed this process to easily occur was starting to become drier. Plants adapted to this change by developing female reproductive parts, called ovules, and male reproductive parts, called stamens, and these stamens began producing pollen (Saladino 2021, Fry 2016). The ovule would store eggs that, once fertilized by the pollen, would produce seeds (Fry 2016). This process allowed the plants to reproduce not only without the requirement of water, but with more protection for the plant's offspring (Fry 2016).

These first seeded plants are now referred to as gymnosperms (Fry 2016). Gymnosperms still exist today and include coniferous plants, such as pines and firs. The seeds of gymnosperms are often referred to as "naked seeds'' because the seeds form visibly outside of the plant without any enclosure surrounding them (Wu 1999, Hanson 2015). About 250 million years ago, new kinds of seeded plants, called angiosperms, evolved; these plants encase their seeds rather than leaving them exposed (Fry 2016, Saladino 2021). Once the angiosperms—also frequently referred to as the "flowering plants"—came into the mix, the diversity of plant life greatly increased, and new species of plants began evolving at an incredibly rapid rate. Darwin referred to this explosion of angiosperms as an "abominable mystery" due to its confoundingly quick spread and diversification throughout the planet, as compared to other evolutionary developments (Hanson 2015). Because angiosperms developed encapsulated seeds, the number of ways in which a seed could be safely dispersed considerably increased. Darwin describes several of these methods in *The Origin of Species,* when he writes: "Seeds are disseminated by their minuteness, by their capsule being converted into a light balloon-like envelope, by being embedded in pulp or flesh, formed of the most diverse parts, and rendered nutritious, as well as conspicuously colored, so as to attract and be devoured by birds, by having hooks and grapnels of many kinds and serrated awns, so as to adhere to the fur of quadrupeds, and by being furnished with wings and plumes, as different in shape as they are elegant in structure, so as to be wafted by every breeze" (1900, 157). Today, angiosperms make up the vast majority of plant species on the planet, with estimations of around 350,000 unique species (Fry 2016). In contrast, it is estimated that there are about 1,000 species of gymnosperms (Fry 2016).

SEEDS AND THE EVOLUTION OF HUMANS

Seeds continued to evolve, disperse, and diversify for millions of years alongside insects, animals, and eventually humans. Around two million years ago, the ancestors of modern-day humans developed the ability to walk upright, allowing them to walk across land and travel greater distances. This resulted in significant changes in their eating habits. Seeds from grasses, such as wheat, became larger parts of their diets, along with roots, tubers, and meat (Saladino 2021). These dietary improvements, along with the beginnings of cooking with fire (estimated to have developed around 790,000 years ago), allowed humans to be able to absorb more high-quality nutrients from their food and led to the development of bigger brains, smaller digestive systems, and complex cognitive abilities (Fry 2016, Saladino 2021). *Homo Sapiens* then began to migrate about the earth starting around 70,000 years ago, engaging in hunter-gatherer lifestyles that lasted hundreds of centuries.

While agricultural societies did not develop until about 12,000 years ago, there is still much evidence to suggest that hunter-gatherers collected and saved seeds and even engaged in loose management of wild plants before this time (Saladino 2021). For instance, Aboriginal hunter-gatherer societies that inhabited the Darling River basin in New South Wales, Australia, collected and harvested wild millet seeds. O'Dea states, "they developed an ingenious method of harvesting, and would gather the green grass before the seed was ripe, leave it in stacks for the seeds to ripen and dry, and then thresh it and collect the seeds" (1991, 75). There is also archaeological evidence that the Aboriginal hunter-gatherers from this area were grinding their seeds over 15,000 years ago, most likely for dietary or nutritional reasons. Elsewhere, collected seed stores have been found in prehistoric hunter-gatherer cave settlements, and great varieties of seeds have been found in the stomach contents of well-preserved bodies found in bogs (Behre 2008, Aura et al. 2005, Smith 1988, Fry 2016). There is also strong evidence that hunter-gatherer societies practiced controlled burning to encourage plant growth from seeds (Smith 1988, O'Dea 1991, Fowler and Mooney 1990).

The archaeological findings from studies of many hunter-gatherer societies throughout the world indicate that humans have long recognized the importance of seeds, both in terms of their nutritional and dietary value, and for their ability to grow desirable plants that were used in medicinal, cultural, and spiritual rituals (Fowler and Mooney 1990). Seeds are so frequently found in remains of ancient human campsites, settlements, and cave dwellings that it is clear they were purposefully collected and saved, maybe from the very beginnings of our species' existence. Our relationship with seeds would only deepen as humans began to dabble in plant domestication and to develop the first agricultural societies.

SOWING SEEDS: THE BEGINNINGS OF AGRICULTURE IN ANCIENT CIVILIZATIONS

The first signs of agricultural development emerged around 12,000 years ago in an area of the Middle East frequently referred to as the "fertile crescent" (Fry 2016). The fertile crescent encompasses areas along river basins in modern day Iraq, Turkey, Jordan, Israel, Syria, and Lebanon. It was here that wheat became one of the first domesticated crops, alongside lentils and chickpeas (Saladino 2021). Several crops were also domesticated independently in other parts of the world between 5,000-12,000 years ago, such as rice in China; corn, beans, and squash in Central America; sorghum and cowpeas in Africa; and quinoa and potatoes in the Andes (Saladino 2021).

For decades, anthropologists have speculated as to why some human societies moved away from hunter-gatherer lifestyles and began to practice agriculture. There have been several theories posed over time, including: (1) that population growth made it harder to sustain a hunter-gatherer lifestyle, (2) the "dump heap" theory, in which discarded seeds and plant bits may have been thrown into dump piles where they began growing, demonstrating that plants could be manipulated to fit human needs, and (3) that sedentary lifestyles arose because of social conflicts over hunting or fishing, or because the accumulation of too many tools and gear made it difficult to travel, so societies learned to grow food where they were based (Fowler and Mooney 1990). A more recent theory that has become more widely accepted among scholars is that the advent of agriculture was heavily influenced by changes in climate that occurred at the end of the ice age (Fry 2016, Gupta 2004). After the ice age ended around 12,000 years ago, the Earth's climate started to become warmer, wetter, and more temperate. This let wild grasses thrive (the precursors to domesticated crops such as millet, rice, corn, and wheat that became the foundation of most early agricultural societies) and it made the environment across the globe more conducive to successful agricultural practice (Saladino 2021, Fry 2016, Gupta 2004).

While there is no definitive answer as to why agriculture began when it did, and new archaeological discoveries are continuously being made that result in new theories, it is clearly evident that the domestication process was long and arduous, undertaken by hundreds of generations of dedicated planters to achieve the quality, size, and taste of the bountiful plants that sustain us today—and it all started by collecting and saving seeds. As Adam Alexander, avid international seed saver and author of *The Seed Detective*, summarizes, "Selecting the plants that expressed the traits the farmer wanted, saving their seeds, sharing them, and then sowing them the following year became the cornerstone of the development of

agriculture" (2022, 4). The first farmers began domesticating species by saving the seeds from plants that were desired for their taste, size, the time of year that they would ripen, or any number of other beneficial traits (Fowler and Mooney 1990, Hanson 2015). Perhaps one of the very first traits that the early agricultural practitioners sought out was the absence of seed "shattering." Fowler and Mooney (1990) describe the process of shattering seeds as follows:

> As hunters and gatherers walked through wild stands of wheat and barley, they could have harvested no more than half of the available seeds. Most would have fallen to the ground. The seeds that remained on the stalk to be harvested often did so because of minor physical differences—not very conducive to a wild plant's survival, but most helpful to someone trying to collect the seeds. The unavoidable collection of non-shattering types caused the first fields planted by the first farmers to be constituted primarily of grasses significantly different in one respect from those that grew wild. Repeated sowings of these seeds produced non-shattering plants–plants whose seed or grain would remain on the plant even if jostled by the emerging farmer with a flint-bladed sickle. Genetically, the change was simple. Often the difference between shattering and non-shattering types is caused by just one or two genes, the biological bearers of heredity. With non-shattering grains, people were able to harvest a greater percentage of all the seeds in the field. Harvested yield increased, giving those first farmers positive response for their efforts. (14)

As Fowler and Mooney highlight in this passage, collecting, saving, and sowing seeds had future effects on a harvest, sometimes good and sometimes bad, depending on the choices that were made in the selection process. Farmers continued to make consequential decisions when collecting seeds over centuries, based on preferences such as taste, size, uniformity, climate resilience, and more (Fowler and Mooney 1990, Fry 2016, Chaskey 2014). As every harvest came and went, the lives of farmers and their seeds became even more intertwined, and the relationships that humans built with their lands deepened. It is no surprise, then, that virtually all agricultural societies developed strong cultural, spiritual, and physical connections to seeds and plants, deriving meaning from the long hours of work and devotion they put into their lands (Fowler and Mooney 1990, Gilio-Whitaker 2019, Nazarea 2006). Not only did these ancient civilizations establish a variety of spiritual and cultural practices, rituals, and creation stories featuring seeds and plants, but they also established physical practices that resulted in the invention of many ingenious agricultural techniques and tools, often unique to their own

local landscapes; these tools optimized the sowing, growing, harvesting, and seed saving of their plants. Figure 4 depicts the results of these labors by showing the drastic differences between modern domesticated corn and its ancient wild ancestor, teosinte.

Fig. 4: An example of the domestication of maize from its wild ancestor, teosinte, to modern day. "Maize-teosinte" by John Doebley, CC BY 3.0

One example of this development of both physical and cultural agricultural practice in an ancient civilization can be seen within the Indigenous peoples that inhabited what is now the southwestern United States. Between 8,000 and 10,000 years ago, evidence of agricultural practices started to emerge in this area among the Pueblo peoples inhabiting the land. The food that the Pueblo peoples cultivated quickly became a part of their cultural and spiritual lives. As Dina Gilio-Whitaker writes, "Food traditions evolved to become inseparable from religious traditions, and sacred foods were perhaps unsurprisingly also their most nutritious foods, especially corn" (2019, 76). In addition to this, the Pueblo farmers saved and cultivated seed that exhibited high levels of drought tolerance and developed agricultural techniques, such as check dams and terrace farming, that were highly conducive to successful and abundant harvests within an arid climate (Gilio-Whitaker 2019; Schapiro 2023).

Cultivators in the Andes, in their domestication of potatoes and quinoa, also showcased ingenuity in developing vertical farming techniques that allowed them to foster exceptional diversity within their crops and produce a great variety of potatoes suited to many different climate conditions. First domesticated between 4,000 and 7,000 years ago in areas of modern-day Peru and Bolivia, the potato was grown in microclimates up and down

the Andes at many different elevations (Pearsall 2008, Brandes 1999). The vastness and steepness of the Andes created unique challenges for the farmers of the area because the differences in elevation could result in widely varying sun exposure, humidity, and temperature, all within relatively short distances (Pearsall 2008, Cañizares-Esguerra 2005). To ensure successful crop harvests despite these great differences in climate, the farmers engaged in a vertical farming process using techniques such as raised beds, terraces, and irrigation canals to keep their domesticated crops healthy. They also encouraged diversity within their crops and fostered the development of several varieties of potatoes and quinoa that would thrive in many different circumstances. As Michael Pollan stated plainly, "The Incas developed a different spud for every environment" (2001, 193). The Incans were also excellent seed and crop savers, creating advanced, climate-controlled storage houses built into the sides of their mountains to house surpluses of potatoes and other crops for times of hardship (Pearsall 2008). Figure 3 shows an example of terrace farming in the Andes today.

Fig. 3: A terrace farm in the Peruvian Andes. "Terrace Farming in the Andes Pisac Peru" by James Santangelo, CC0 1.0

These are just two examples of countless developments in plant domestication that occurred over centuries as societies turned to agriculture. Farmers made choices when selecting crops, saving seeds, and cultivating their fields that have affected us today. But this process of selection involved more than just farmers making detached decisions about which plants to breed and which seeds to save based solely on objective goals, such as higher yields. As Vandana Shiva states, "The seed, for the farmer, is not merely the source of future plants and food; it is the storage place of culture and history. Seed is the first link in the food chain. Seed is the ultimate symbol of food security" (2016, 8). Each farmer made decisions on which seeds were collected, saved, and shared within their communities to ensure plant harvests that would support the dietary, medicinal, cultural, and spiritual needs of their civilizations.

As agriculture continued to advance and humans developed more complex plant breeding techniques and farming tools, the human population boomed. Larger groups of people began to live together in increasingly complex societies. Throughout the development of these societies, seeds continued to be shared, saved, and cultivated among growers. Cultural and spiritual connections to seeds and plants within societies grew stronger as humans became even more reliant on successful cultivation for their livelihood, and they began to establish more formalized rituals, beliefs, and practices that became a part of everyday life. Dina Gilio-Whitaker highlights this when she recounts beliefs of the Indigenous peoples inhabiting North America thousands of years ago: "Corn [was] so important to the Pueblo people that their origin stories are constructed around it. Corns, beans, and squash were known affectionately by the Haudenosaunee people as the Three Sisters…[they] viewed their worlds as a network of intertwined relationships of which they were only a part, not the center. In this relationship, respect for their plant relatives and their environments ensured their health as well as the health of the people" (2019, 77).

Soon, trade routes were established, connecting different societies across regions and eventually continents, and new plant varieties and seeds exchanged hands. This led to new varieties being developed in different regions, and new plants taking on new cultural significance in other civilizations. Ancient civilizations also started to see the economic value in purposeful plant expeditions and in collecting seeds and plants from faraway regions. Queen Hatshepsut of Egypt is the first known example of a leader officially sending out an expedition of this sort around 1500 BCE to bring back the tree species (Boswellia and Commiphora) that produce the resins needed to make myrrh and frankincense from the northeast coast of Africa (Janick 2007, Fowler and Mooney 1990, IGPRI et al. 1995).

Collecting seeds and plants from other locales also rapidly became a sign of power and prestige as new societies advanced and began to regularly communicate, trade, and war with each other. Dating as far back as 800-900 BCE, kings of ancient civilizations, such as the Assyrians, were building beautiful gardens with advanced irrigation systems as testaments to the power of their kingdoms and to show off exotic plants that were acquired through conquest and adventuring. An engraved pillar created by Ashurnasirpal II, King of Assyria from 884-859 BCE, provides an account of the gardens that he created during his reign:

> I collected and planted in my garden, from the countries through which I marched and the mountains which I crossed, the trees and plants raised from seeds from wherever I discovered them, such as: cedars, cypresses, simmesallu-perfume trees, burasu-junipers, myrrh-producing trees…. In the gardens in Calah they vied with each other in fragrance; the paths in the gardens were well kept, the irrigation weirs distributed the water evenly; its pomegranates glow in the pleasure garden like the stars in the sky, they are interwoven like grapes on the vine…. (Pritchard 1975, 101)

Similarly, Alexander the Great is often credited with introducing several new plants from Asia into Europe after his conquests in lands spanning from Persia all the way to parts of Pakistan and India (Janick 2007). This led to the establishment of one of the most well-known trade routes in history, the Silk Road, through which seeds and plants from multiple continents were transported and traded for centuries. The Romans also were heavily engaged in seed collection and transfer and exported several of their crops to their conquered lands to bolster the production of foods that fit their preferences (Janick 2007). However, it was not until the beginning of the early modern period (around 1450-1800 CE), also commonly referred to as the "Age of Discovery," when European nations began to engage in the colonization of other civilizations around the world, that the acts of seed collecting, saving, and sharing would reach global proportions previously unknown.

SEEDS AND THE RISE OF MODERN COLONIALISM DURING THE "AGE OF EXPLORATION"

Colonialism, defined by Merriam-Webster Online as the practice of "domination of a people or area by a foreign state or nation," especially for the political, ideological, or economic benefit of the dominating power, has existed in human societies for thousands of years. However, the global scale on which colonialism was spread, practiced, and brutally

enforced by European nations starting in the 1400s and lasting through the 1800s and beyond was unprecedented up to that time (Fowler and Mooney 1990, Blakemore 2019). This period, often referred to as the Early Modern Period, the "Age of Discovery," or the "Age of Exploration" by Western historians, is defined by Europeans pursuing new territories, trade routes, commodities, and labor that they could rule, exploit, and abuse to achieve power, prestige, scientific advantages, and economic supremacy (Schiebinger and Swan 2005, Janick 2007). Much of this exploitation centered around collecting seeds and plants, which had significant economic and scientific value, and were also often used to support colonial interests. The term that best describes this new interaction between plants and humans is "colonial botany." Defined as "the study, naming, cultivation, and marketing of plants in colonial contexts," colonial botany was "born of and supported European voyages, conquests, global trade, and scientific exploration. The expanding science of plants depended on access to ever farther-flung regions of the globe; at the same time, colonial profits depended largely on natural history exploration and the precise identification and effective cultivation of profitable plants" (Schiebinger and Swan 2005, 2).

During the height of colonial botany, traditional practices of seed saving, seed sharing, and seed cultivation were severely disrupted, both within the home countries of the colonizers and within the societies that they colonized. Colonial powers began to prioritize the commodification of highly desirable goods and established massive monoculture farms. Cash crop plantations run by slave labor resulted in great economic and political gains at the terrible expense of colonized lands and peoples (Fowler and Mooney 1990, Schiebinger and Swan 2005). In addition, collecting seeds and plants for scientific study facilitated new medicinal discoveries that benefited colonial interests (Schiebinger 2005). This led to the creation of universal scientific classification systems that made these new, exotic plants fit into a Westernized world order (Cook 2005, Lafuente and Valverde 2005). Between the 1450s and 1800s, these changes in seed collecting, saving, and planting practices, driven by colonization, would significantly change the practice of agriculture across the entire world and leave lasting effects that are still being strongly felt today. Perhaps surprisingly, one of the contributing factors that aided these changes was the widespread establishment of botanical gardens (IGPRI et al. 1995, Mukerji 2005, Bourguet 2005).

Botanical gardens in Europe first emerged as medicinal, hospital, or physic gardens (gardens that were established as part of universities), with their primary purpose being to provide on-hand access to herbs and plants for medical purposes (IGPRI et al. 1995, Mukerji 2005). However, as the Age

of Exploration advanced and European nations continued to colonize more and more lands across the world, botanical gardens became places where newly discovered plants could be studied, cultivated, displayed, and ultimately commodified to further the colonial interests of the home nation (Fowler and Mooney 1990, Mukerji 2005). In France, botanical gardens during this time were often used as both economic and political tools to influence and impress their own populace. The Gardens of Versailles, for instance, often cultivated rare plants and this "spoke of the ambition and intelligence of the French naturalists and horticulturalists, and of the political aspirations of the monarchy to develop power over the natural world and deploy it to glorify France" (Mukerji 2005, 20). Louis XVI also used the very same gardens in the late 1700s to "trick" the lower classes in France to grow and eat potatoes. The potato was not a particularly popular food in Europe at this time (excluding Ireland), but it was nutrient-dense and easy to cultivate. To entice the reluctant populace to grow potatoes, Louis XVI planted them within the Gardens of Versailles and posted guards to protect the plant during the day. Once they would leave at night, people would steal the potatoes, now believing them to be highly desirable (Pollan 2001).

France, as well as several other countries, also used their botanical gardens to publicly display their rare and exotic collections to symbolize their overarching colonial and political prowess. France's prestigious Jardin du Roi, built in Paris, achieved this through its plant demonstrations that "were spectacles of natural knowledge that foregrounded exotics with amazing qualities—scents, colors, sizes, or uses. [They] were also displays of social difference, those at the Jardin du Roi spoke quietly but insistently of greatness—of France, its reach, its intelligence, and its administration" (Mukerji 2005, 26). Botanical gardens during the Age of Exploration were not all that different from the ancient gardens of the fertile crescent, in that they could serve as collections that showcased both the spoils of adventure and conquest.

Botanical gardens also served another crucial purpose during this time of colonization. They were used as transfer points for a variety of plants and seeds that would be taken from one colony and then eventually transplanted to another. Expeditions would bring back seeds and plants from one location to botanical gardens based in their home countries, where they would be studied and cultivated in controlled environments. They would then be transferred to new locations, both within the home country and to other colonies all over the world, to be (hopefully) transformed into successful cash crops and bring great profits (Fowler and Mooney 1990, Schiebinger and Swan 2005). One example of this is coffee and its journey to become a cash crop in the Caribbean and Latin America.

Coffee is native to Ethiopia and originally spread via ancient trade routes to various regions along the Arabian Peninsula, and eventually to India and Sri Lanka (Fowler and Mooney 1990). The Dutch, when they colonized Sri Lanka, took coffee and replanted it in Java. Once coffee became established in this region, they took a cutting from a coffee tree in Java in 1706 and sent it to the Amsterdam Botanical Garden for further cultivation (Fowler and Mooney 1990). Once this cutting was able to produce offspring in Amsterdam, the government gifted one of them to the King of France at the time, Louis XIV. Both the Dutch and the French then took cuttings from their coffee trees and sent them to their colonies in the Caribbean (Suriname and Martinique, respectively), to see if they could establish successful coffee plantations to further advance their trade and profits (Fowler and Mooney 1990).

The practice of using botanical gardens as a waystation to store, study, and then send plants and seeds for cultivation in new lands eventually led to the establishment of botanical gardens in the colonies themselves. Botanical gardens started appearing all over the world in places like Brazil, Cuba, South Africa, India, Vietnam, Uganda, Sri Lanka, and more (IGPRI et al. 1995, Fowler and Mooney 1990). Deepening horticultural expertise helped to streamline the seed and plant gathering process and ensure that specimens were being packaged more effectively, leading to a better chance of viability after traveling long distances (Fowler and Mooney 1990). It also made it easier for the colonies to acclimatize new, non-native crops to local growing conditions (IGRPI et al. 1995). This transplantation process completely transformed the global agricultural landscape, wreaked havoc on indigenous cultural and agricultural growing traditions, and destroyed native plant and seed diversity in colonized areas. There are still many regions today that are known for a particular crop that is grown in that area only because of colonization. For instance, sugar cane is often associated with the Caribbean. However, the plant originated from New Guinea and was first introduced to the Caribbean by Christopher Columbus (Fowler and Mooney 1990). By the 1600s, sugar cane plantations had spread across the Caribbean and South America, with Brazil being home to more than 120 sugar mills, and by 1666, Barbados being home to over 800 plantations run by 80,000 slaves (Fowler and Mooney 1990).

Mass production of cash crops through the exploitative plantation system resulted in huge economic gains for the colonizing countries. The potential gains were so large that seeds and plants started to be collected, and then hoarded, in attempts to prevent other European powers from accessing them. The Dutch East India Company (also known as the Verenigde Oostindische Compagnie, VOC) was particularly brutal in this practice, and often heavily policed their established spice plantations to prevent

rivals from stealing viable seeds or plants and breaking their monopoly on the spice trade (Spary 2005). The Dutch even "cut down three-quarters of the clove and nutmeg stands on the Moluccas in order to confine production to three defendable islands" (Fowler and Mooney 1990, 178). Spain, also recognizing how desirable seeds and plants from the Americas would be to their rivals, made it illegal for those outside of the Spanish empire to conduct any expeditions for new plants in their territories (Fowler and Mooney 1990).

However, economic advantage was not the sole reason that seeds and plants were collected during this period. Collecting seeds and plant specimens for scientific and medical research was also a high priority for colonial powers. During the height of colonialism, Europeans were being exposed to many new plants that they had not seen or experienced before, many of which they observed the local indigenous societies expertly use to sustain themselves, cure disease, and heal ailments. Understanding the scientific properties of these plants and knowing what they could be best used for became extremely valuable information, especially if they could use these plants to cure their own people of diseases developing in the colonies (Schiebinger 2005). Quinine, for instance, taken from Peruvian bark and an extremely effective treatment for malaria, was the most "valuable commodity by weight shipped out of America into Europe" in the eighteenth century (Schiebinger 2005).

Collecting seeds and plants also allowed European scientists to classify the plants in a logical system that fit their worldview, while stripping them of their local and cultural contexts, erasing the history and connectedness of these plants with the native populations in which they originated, and, ultimately, dehumanizing the peoples and cultures whose lives and lands they were abusing (Lafuente and Valverde 2005, Cook 2005). This is particularly noticeable in what botanists and horticulturalists chose to include, or perhaps more importantly exclude, in their publications discussing medicinal plants during this time. For instance, The Dutch East India Company murdered, enslaved, and forced countless Indigenous peoples into slavery to ensure exclusive access to spices such as nutmeg and mace (Hochstrasser 2005). This included annihilating an entire society of people known as the Bandanese in 1621 because they showed interest in trading with others besides the Dutch (Hochstrasser 2005). These acts of violence directly benefited Dutch scientists by providing easy access to novel plant specimens. Despite this, botanical authors, such as Dutch physician Johan Van Beverwyck (1594-1647), would completely strip contextual and cultural details from their writings, instead preferring to include only Westernized scientific information (Hochstrasser 2005).

In the words of Julie Berger Hochstrasser, "Van Beverwyck is coolly scientific in his descriptions of pepper, citing its distant origins and outlining the various types, likening leaves and growth patterns to those of more familiar plants" (2005, 176).

These careful omissions are perhaps most visible in how plants and seeds were collected and classified in European knowledge systems, such as the Linnaean classification system. Carl Linnaeus (1707-1778) is one of the most famous botanists in Western history because of his creation of a "universal" taxonomic classification system that is still widely used today (Lafuente and Valverde 2005). This system provides each species with "binomial nomenclature," or two Latin names that define and differentiate species from each other. This system, which helped satisfy a European desire to logically break down the natural world into a hierarchical order, is argued by Lafuente and Valverde (2005) to also greatly serve colonial interests. They state that "a species concept permitted the unification of knowledge concerning flora and fauna, minimizing distances between new and far, between Europe and America. Nature could be depicted as a continuous mantle of plant life made up by forms that would be described in Linnaeus' binomial terms. Nature, in short, became a structure of data whose objective was not to appreciate but to process local peculiarities into information using the botanical systems best able to homogenize diversity" (137).

Using a scientific order such as the Linnaean classification system allowed European powers to conveniently disregard their exploitations of Indigenous lands and peoples, while also removing the traditional cultural context from their newly collected plants and seeds (Lafuente and Valverde 2005, Müller-Wille 2005). LaFuente and Valverde refer to this as "imperial biopower," a process that "is devoted to turning diversity, local variation, and qualia into data" (2005, 141). This process erased the histories and contributions that Indigenous peoples made in both cultivating and collecting these plants, while also completely glossing over the aid they provided so that the colonizers could understand their potential uses. This lack of recorded history has led to the immense loss of indigenous knowledge related to seeds and plants that we can never recover (Gilio-Whitaker 2019, Schiebinger 2005).

The impact that the Age of Colonialism has had on the development of our agricultural systems, the diversity of the Earth's flora and fauna, and even the way that humans now tend to view and approach their relationships with the land cannot be overstated. As Fowler and Mooney succinctly put it, "the history of colonialism is the history of the struggle to capture and monopolize botanical treasures" (1990, 178). It was a time when "seeds,

bulbs, and roots were exchanged avidly, planted and transplanted, and studied fiercely for their potential properties—whether pharmaceutical in the case of foreign specimens or financial in the case of exotic, prized varieties (or both)" (Swan 2005, 228), and a time when the invaluable knowledge and cultural customs intertwined with these plants was systematically erased.

Among the devastating global consequences that colonialism inflicted on the Earth was the mass loss of genetic biodiversity among plants (Fowler and Mooney 1990, Chaskey 2014, Gilio-Whitaker 2019, Schiebinger and Swan 2005). Because colonial powers were so focused on establishing cash crops in their various colonies, they destroyed countless acres of native flora and fauna, enslaved millions of people, and created a lasting and cruel plantation system that often only grew single varieties of crops, contributing to a significant rise in monoculture agricultural practices that have continued into the modern day (Fowler and Mooney 1990). Indigenous farmers in French Equatorial Africa were forced into growing cotton; the French government went so far as to ban hunting among the local populations to ensure that their cotton plantations would have enough labor for maximum profit and production (Fowler and Mooney 1990). The US government, "having consolidated its power over tribal lands during the height of the industrial revolution in the late 1800s…compelled Native peoples to use land productively (that is, profit generation via farming, ranching, and so on) in keeping with European standards of land use" (Gilio-Whitaker 2019, 54). Indigenous peoples were often forced to grow the plants that would most benefit their colonizers, and this has resulted in several regions today being economically dependent on non-native crops that were introduced during this time. Sugarcane in the Caribbean, coffee in Brazil, and cacao in West Africa are just a few examples of this (Fowler and Mooney 1990). Several of those crops may be of only one seed or plant variety, making them extremely vulnerable to devastation caused by climate change, blights, and pests (Fowler and Mooney 1990). The scars from colonial botany are extremely visible in our current agricultural systems, and they still greatly affect the politics, policies, and cultures of seed collecting and seed saving today.

It is also important to note that surviving recorded history from the colonial period comes, overwhelmingly, from the perspective of colonized powers, making the information that we have unequivocally biased. Colonizers spent much of their time pillaging, destroying, and enslaving in some of the most biodiverse places on Earth, and this has resulted in the rewriting of histories and the erasure of indigenous cultures and narratives in colonized lands.

However, despite their best efforts to cast the people and cultures they colonized as less advanced, less "civilized," and less capable than their own, there are still many glimmers of the incredible cultural and scientific richness of Indigenous populations shining through in contemporary accounts that provide evidence to the contrary. For instance, there is documentation that the Aztecs had created incredible botanical gardens within their capital, filled with "exotic plants sown together from throughout the Aztec Empire and beyond—attached to an agricultural school with advanced methods reputed to have surpassed those of Europe'' (Fowler and Mooney 1990). Historian Kapil Raj notes that European botanists publishing books during this period were often just translating works already written by native authors, such as the case of French naturalist Nicolas L'Empereur, who translated works about plants in South Asia that were already in circulation in languages such as Tamil, Telugu, and Orivan (Raj 2005). There are also several accounts from this period stating that Indigenous and slave populations had much stronger knowledge systems and understanding of how to use plants in medicinal ways, and that Europeans would frequently spurn treatment by fellow white, European doctors in favor of local herbalists and healers (Schiebinger 2005).

Despite so much evidence that challenges Eurocentric and colonialist viewpoints, these narrow perspectives still shape our modern-day systems, structures, and worldviews. Scholars and laypeople alike still consciously and unconsciously "construe Europeans as the producers of knowledge and indigenous peoples as mere suppliers of material artifacts from which knowledge is born, and in so doing diminish the accomplishments of non-European peoples" (Schiebinger and Swan 2005, 11), which greatly harms our ability to truthfully examine the past and use it to understand and address our current circumstances. The Eurocentrism that fueled colonization and colored our narratives and interpretations of history would continue to have lasting, negative effects on the cultural and community practices of seed collecting and seed saving, as well as the biodiversity of seeds, throughout the industrial age and into the modern era. However, powerful challengers of this system would also emerge during this time, and the beginnings of seed banks, seed exchanges, seed libraries, and additional grassroots seed movements would take hold around the world.

FROM THE GREEN REVOLUTION TO GMOS: SEED SAVING AND GENETIC DIVERSITY IN THE MODERN WORLD

The meteoric rise of colonial botanical practices during the Age of Exploration led to the beginnings of massive monoculture and cash

crop farming in several parts of the world (Fowler and Mooney 1990; Schiebinger and Swan 2005). Plant diversity was significantly waning due to just a few non-native plants being transplanted and grown in large plantation systems (Fowler and Mooney 1990). Prior to the establishment of this colonial system, Indigenous farmers would generally grow a great diversity of plants, including multiple varieties of the same plant, in smaller plots that would ensure a higher chance of crop success (Shiva 2016). Making matters worse, many of these transplanted plants started as just a few seeds collected from one parent but were eventually used to propagate an entire nation's crops, making the supply genetically uniform and extremely vulnerable to all manner of threats. Unknowingly, colonial powers were putting their very food sources and commodities in danger of collapse because they did not recognize the importance of ensuring genetic diversity to prevent major crop loss to climate, blight, mold, and more.

The real-life ramifications of these choices came with devastating consequences in the summer of 1845 when Ireland was hit with a potato blight (Pollan 2001). In the two hundred years prior to 1845, potatoes had become the sole staple crop sustaining most of Ireland's population. The potato, so ubiquitous in cuisine around the world today, was not initially very popular in Europe because of its appearance (Pollan 2001). However, Ireland was the exception and adopted the potato quickly. It grew very well in their climate, and it was nutrient dense, vitamin rich, easy to grow, and did not take up a huge amount of farmland. However, all the potatoes that had been grown in Ireland for two hundred years were of one variety: the Lumper. So, when a fungal blight came to Ireland, it completely obliterated their entire supply of potatoes within three years, leading to a nationwide famine that resulted in over one million deaths (Fowler and Mooney 1990). Pollan explains cause and effect of the Irish potato blight and genetic diversity:

> Ireland's was surely the biggest experiment in monoculture ever attempted and surely the most convincing proof of its folly. Not only did the agriculture and diet of the Irish come to depend utterly on the potato, but they depended almost completely on one kind of potato: the Lumper. Potatoes, like apples, are clones, which means that every Lumper was genetically identical to every other Lumper, all of them descended from a single plant that just happened to have no resistance to *phytophtora infestans*. The Incas too built a civilization atop the potato, but they cultivated such a polyculture of potatoes that no one fungus could ever have toppled it. In fact, it was to South America that, in the aftermath of the famine, breeders went to look for potatoes that could resist the blight. And there, in a potato called the Garnet Chili, they found it. (Pollan 2001, 231)

Here, Pollan touches upon the consequences of having such reliance on a single variety of a crop while also pointing out the importance of preserving genetic diversity. When a single variety of a plant proves susceptible to a particular pest, blight, parasite, or climate, having access to a genetically diverse pool allows for a higher chance of success when searching for a variety that may have resistance to that threat. This is also why the practice of growing multiple varieties and multiple species of plants together in the same field was so common before colonization. Growing multiple varieties and multiple plants that all have genetic variations making them more resilient to certain climates, weather patterns, pests, and the like would result in more abundant harvests, no matter what unpredictable situations arose during the growing season. Monoculture provides no such contingency plans.

The devastating Irish Potato Famine should have served as a wake-up call to the world that genetic diversity needed to be incorporated into agricultural systems. However, monocultural growing practices continued to grow, as countries continued to value economic profits over food security. Crop failures due to monocropping continued to happen on grand scales. Famines occurred in Russia every three to five years for centuries as wheat crops regularly failed, fueling the bitterness that the peasant class felt towards the Czardom (Nabhan 2012). In the 1860s and 1870s, a blight known as coffee rust afflicted coffee plantations from Ceylon all the way to Africa, effectively destroying over 90% of the British Empire's coffee crops (McKenna 2020). They replaced their coffee crops with tea in Ceylon, which pushed the United Kingdom into becoming a nation of primarily tea drinkers–an association that still exists today (Fowler and Mooney 1990, McKenna 2020). These crop failures are still happening in the modern day, as the United States experienced a massive corn blight in the 1970s that led some regions of the country to lose more than fifty percent of their yields and the country to lose about fifteen percent of its yields overall (Fowler and Mooney 1990, Schapiro 2023).

Although the loss of genetic diversity was largely ignored globally in the 1800s and well into the 1900s, one notable botanist did recognize how crucial it was to bring attention to this issue. Nikolay Ivanovich Vavilov, a Russian scholar, scientist, and seed enthusiast, is often credited with establishing the official first seed bank in the world (Nabhan 2012). Vavilov was born in Moscow in 1887 to an economically advantaged merchant family. He went on to study plant pathology and genetics at Petrovsky Agricultural Institute in the 1910s and quickly became interested in conducting field research among local communities and observing firsthand the traditional methods of farming, particularly how farmers

chose seeds for growing and organizing their fields. He studied how to make crops more resistant to disease to help prevent the frequent crop losses Russia kept experiencing, and it was not long before he noticed that farmers growing a "polyculture" in their fields—meaning that they grew several varieties of plants rather than just one as in a monoculture—achieved much more successful harvests (Nabhan 2012). Unlike so many other European scientists, intellectuals, and colonizers before him, Vavilov realized that Indigenous farmers growing native plants held a wealth of advanced knowledge on how to optimize their growing practices using ancient techniques, and he was determined to learn from them.

Early on in his adventures, Vavilov also began collecting seeds from the many places that he would visit (Nabhan 2012, Shapiro 2023). Nabhan states, "because they were living, respiring, reproductively viable organisms that could be regenerated for posterity, seeds became the subjects of Vavilov's desire and the objects of his scientific inquiry" (2012, 38). Vavilov saw so much potential in the seed, both in terms of research, and in terms of its cultural and practical impacts, and because of this, "Vavilov collected, compared, and conserved far more than the plants themselves; he was just as intent on recording the native names, uses, and lore found among the various agrarian communities he visited" (2012, 39).

Because of his intuitive recognition that seeds were important in determining crop resiliency, Vavilov also began to notice connections between seed saving and plant diversity. An American scientist named Harry Harlan was also researching this phenomenon around the same time, and he and Vavilov started to "notice that traditional seed stocks were indeed blinking out; they recognized early on that agricultural modernization was driving into extinction some of the locally adapted varieties that they had collected on their earliest expeditions" (Nabhan 2009, 14). Through these observations, they were "among the first to articulate the concept of *loss of agricultural biodiversity* through the process now known as *genetic erosion*–the gradual and irrevocable diminishment of the gene pool from which new varieties would otherwise emerge" (Nabhan 2009, 15). Once Vavilov recognized this alarming phenomenon, his seed collecting only became more vigorous as he sought to prevent not only the loss of the plant varieties that were endangered, but also the cultural context and indigenous agricultural knowledge that were key to their survival (Nabhan 2009, Shapiro 2023, Fowler and Mooney 1990).

Over the next twenty years, from the early 1920s until the early 1940s, Vavilov visited sixty-four countries on five different continents over the course of 115 research expeditions (Nabhan 2009, Fowler and Mooney 1990). During this time, he amassed the largest seed collection known

to exist up to that time, with over 380,000 seeds from over 2,500 species of plants (Nabhan 2009). Vavilov's seed collection still survives today in the Vavilov Institute of Plant Industry, albeit not fully intact because of damage, war, and lack of funding (Nabhan 2009, Fry 2016). However, despite some hardships, his seed bank is still used to fulfill his mission of preserving plant genetic diversity around the world. The Vavilov Institute can, and has, used its saved seeds to "improve the disease and pest resistance of more vulnerable varieties whose susceptibility was leading to famines or food shortage; some deeply rooted varieties were useful for soil erosion control and for the restoration of damaged landscapes; still others were key to unlocking the stories of where our food originally came from, helping us elucidate the origins of agriculture and the earliest domestication of plants on several continents" (Nabhan 2009, 3). His seed bank, research, and advocacy to bring attention to genetic diversity loss around the world made him a trailblazer for this cause. He essentially advocated for a new purpose to collect, save, and even share seeds: to preserve genetic diversity to help ensure long-term food security on a global scale.

However, it would take many more years for global attention and policy to catch up to Vavilov's calls to action. While seed banks around the world now number in the hundreds, Vavilov's stood alone for many years as modernized agricultural systems and practices were adopted in westernized countries and then exported, often forcefully, to developing countries in favor of profit over plant genetic diversity preservation (Fowler and Mooney 1990). This phenomenon became known as "The Green Revolution," and its origins lie in the aftermath of World War II, when chemical companies that had been working to build bombs and other weapons during the war needed to pivot to a new market (McDorman and Thomas 2018, Fowler and Mooney 1990). These companies then began to produce fertilizers and pesticides using the same technologies they had used to create weapons. Simultaneously, plant breeders were selling the first commercially available hybrid maize seeds, or seeds that were created through "controlled pollination between distinct (inbred) parents" (McDorman and Thomas 2018, 191). Hybrid seeds became extremely popular because of their tendency to result in higher crop yields, and their use in the agricultural industry exploded, particularly in North America, after their first introduction in 1935 (Kloppenburg 2005).

Recognizing the potential not only for a great increase in food production but also for massive profits to be generated with these technologies, a powerful movement began to develop in the 1940s and 1950s among Western governments and industry leaders to bring these agricultural advances to the developing world. To help with this process, official facilities

were established to focus on plant breeding research for staple crops such as maize, wheat, and rice. Two of these institutes, the International Maize and Wheat Improvement Center (CIMMYT, established in Mexico) and the International Rice Research Institute (IRRI, established in the Philippines) were tasked by leaders of this movement to "produce a major transformation of Third World agriculture" by promising "not only to increase food production…but also to bring those regions in the fold as participating members of the market economy" (Fowler and Mooney 1990, 57).

The CIMMYT, the IRRI, and other similar institutes then hired scientists and plant geneticists to develop a single crop variety and accompanying fertilizer that promised increased yields for farmers (McDorman and Thomas 2018). These new single varieties of rice, wheat, and corn were then widely and aggressively advertised in developing countries and began to displace the many locally grown and genetically rich plants that farmers had grown in those regions for thousands of years (McDorman and Thomas 2018, Shiva 2016). It quickly became apparent that, while these new monoculture hybrid crops may have increased yields (although even this is disputed among experts), their drawbacks far outweighed their potential benefits. Not only was the genetic and local diversity of plants being significantly diminished, but these new seeds could not necessarily grow successfully on their own, as homegrown seeds bred to be resilient could. Instead, they heavily relied on external resources, such as specific fertilizers and chemicals, to produce the yields that companies were advertising (Shiva 2016). However, these materials were expensive and farmers with less money and smaller plots of land could not afford these additional costs. As Fowler and Mooney (1990) describe further, "Achieving high yields required fertilizer and irrigation. Fertilizer and irrigation nourished weeds as well as crops, creating the need for herbicides. And pests found the uniformity of new varieties appetizing, which necessitated the use of insecticides as well. Farmers lacking access to capital to buy these items were simply left in the dust" (58).

Overall, the Green Revolution may have led to an increase in crop production worldwide, but it did not solve world hunger, social inequities, or food insecurity. Instead, it created several new problems that make these major, global issues even more complex to eradicate. Local seed-saving and seed-sharing practices eroded, leading to the extinction of many traditional plant varieties that not only hurt regional food security and stability but also the local cultures that have long, rich histories tied to these plants (Shiva 2016, Fowler and Mooney 1990). As Fowler and Mooney heartbreakingly summarize: "The seeds came with the genetic code of the society that produced them. They produced not just crops, but replicas of the agricultural systems that produced them. They came as a package deal

and part of the package was a major change in traditional cultures, values, and power relationships both within villages and between them and the outside world. It is important to note that this process sometimes ripped apart and destroyed local cultures" (1990, 76).

In addition to this, countless local farmers could not keep up with the expenses necessary to make a profit from this monoculture farming system and lost their land to bigger farms (Fowler and Mooney 1990). The farms that survived lost their autonomy over their land, instead becoming reliant on chemicals, pesticides, and seed companies for survival (Shiva 2016, Mascarenhas and Busch 2006). Shiva gives a brief overview of just how much genetic diversity was lost during this period:

> Traditionally, 10,000 wheat varieties were grown in China. These had been reduced to only 1,000 by the 1970s. Only 20% of Mexico's maize diversity survives today. At one time, more than 7,000 varieties of apples were grown in the United States. More than 6,000 are now extinct. In the Philippines, where small peasants used to cultivate thousands of traditional rice varieties, just two Green Revolution varieties occupied 98 percent of the entire rice-growing area by the mid-1980s. (Shiva 2016, 80)

The loss of genetic diversity caused by the Green Revolution was devastating, but this was not the last, or even the greatest, threat to plant diversity. The agricultural sector launched a new development that purported to make crops better, stronger, and more resistant than ever: genetic modification.

Starting in the 1970s and 1980s, big oil and chemical companies such as Monsanto and DuPont started to show great interest in the seed industry. They were closely observing how the Green Revolution was sweeping across the world and taking note of the of newly bred plant varieties' increasing reliance on pesticides and herbicides (Fowler and Mooney 1990, Shiva 2016, Pollan 2001). They saw an opportunity to invest in seeds and, in particular, the genetic modification of seeds, to ensure the long-term market value of the chemicals that they were selling to the agricultural sector (Fowler and Mooney 1990). The idea was to create seeds through genetic modification that were dependent on the use of their own manufactured chemicals to be successful, all while advertising that their seeds would "feed the world" with their higher yields and pest resistance (Shiva 2016, Schapiro 2023). Schapiro explains this process more simply when he states, "Lock in the seed, and you can sell the chemical to go with it—two sides of the same coin. With a twist: the company sells its product on both sides of the same coin. Seeds can be bred and engineered to grow

in association with chemicals that the mother company also happens to produce" (46).

Over the next thirty years, Monsanto, DuPont, and other large chemical manufacturing companies began buying up hundreds of small, local seed companies to deny farmers easy access to seeds beyond their own. Schapiro reports that "between 1980 and 2000, more than a thousand seed companies were bought by petrochemical, pharmaceutical, and commodity grain companies, most of them snapped up in the wake of legal decisions strengthening their patent rights" (2023, 46). The patent rights that Schapiro mentions were based on a series of US patent laws that were approved through the 1980s and early 1990s that allowed corporations to patent the traits in seeds that they claimed they manipulated in "unique" ways. For example, by genetically modifying a seed through adding a single gene from a blowfish that may help a plant develop stronger resistance to a particular fungus, corporations can claim that seed as intellectual property and so prevent its use unless purchased directly from the company (Schapiro 2023, Pollan 2001, Shiva 2016).

These patent laws, coupled with the seed monopolies the same corporations established by buying so many independent seed companies, created a hostage-like situation for farmers, growers, and gardeners alike. Most horrifying of all is that these companies will not allow farmers to save seeds to replant in the next season. Instead, they are forced to buy new seeds and new chemicals every year (Schapiro 2023). In fact, seed companies have even created genetically modified plants which do not produce seeds at all (Shive 2016, Pollan 2001, Schapiro 2023). These companies will not hesitate to sue small-scale farmers if they do practice seed saving or seed sharing with their patented seeds, even if the patented seeds only cross into their lands by accident from neighboring fields (Schapiro 2023). It now feels as if "farmers are, legally speaking, no longer *purchasing* the seed that they plant but, rather, are *renting* the use of the traits that the seed contains. And their right to use those traits expire[s] at the end of the season" (Schapiro 2023, 47). Vandana Shiva communicates this idea more forcefully when she states, "As farmers are transformed from producers to consumers of corporate-patented agricultural products, as markets are destroyed locally and nationally but expanded globally, the myth of 'free trade' and the global economy becomes a means for the rich to rob the poor of their right to food and even their right to life" (2016, 7).

While farmers are at the mercy of seed and chemical corporations, the entire planet faces catastrophic losses in global biodiversity, cultural diversity, and food security because corporate agricultural systems threaten traditional seed collecting, saving, and sharing. However,

in the past 30 years, a small but mighty international contingent of grassroots movement organizers, scientists, scholars, and government policymakers has risen to counter the loss of genetic diversity and champion the preservation of cultural and indigenous knowledge of seeds. The preservation efforts that often get the most attention are the genetic seed banks scattered all over the world, including the Svalbard seed vault in Norway (Fowler 2016). These seed banks, much like Vavilov's initial collection in the early 1900s, store hundreds of thousands of seeds to preserve genetically diverse varieties of our plants so that we have access to them in case we need to solve a plant or food crisis in the future (Fowler 2016, Fry et al. 2011).

However, while seed banks are an important and necessary resource, they alone will not reverse the loss of genetic diversity or the loss of cultural traditions and relationships entwined with seeds. As Nabhan (2009) states, "Seed banks are not designed to maintain the ongoing processes of farmer-based…seed conservation and exchange. Their seeds are 'frozen in time'—that is, they are more or less adapted to conditions in the year of their last field grow out—and are not as dynamically changing in response to global climate change, disease, and pest introductions as are seed crops annually grown out in field settings" (196). Diane Ott Whealy, one of the founders of a well-known grassroots organization called Seed Savers Exchange, puts it more plainly: "The best way to preserve these seeds is to plant them" (Hanson 2015, 107). This planting is certainly happening, through growing establishments of community-oriented seed exchanges, seed libraries, and seed swaps at grassroots levels (Schapiro 2023).

As this historical analysis has shown, seed saving is an ancient practice, most likely as old as humanity itself, and it is intrinsically linked with our cultures, traditions, religions, and ways of life. How civilizations have approached, prioritized, and practiced seed saving over the centuries has shifted based on cultural and societal norms, and later because of Western colonization efforts that turned seed collecting and saving into an economic industry ripe for future exploitation. This approach to viewing seeds as commodities rather than as sources of cultural, spiritual, and social connection to the past has led modernized agricultural corporations to obliterate seed diversity, culture, and knowledge on a global scale. However, several passionate grassroots movements and community-oriented seed projects have arisen against these corporations, offering an alternative, sustainable, and democratic approach to seed access and seed sovereignty. One of these community-oriented projects is the seed library.

Much of the rise in community programs, such as seed libraries, is in response to a growing global interest and advocacy in favor of food

justice. Shiva (2016) refers to this concept as "food democracy," stating that "reclaiming democracy in food production implies reclaiming the rights of all species to their share of nutrition and, through this ecological step, reclaiming the rights of all people to food rights, including future generations" (118). Seed libraries contribute to this cause by providing free access to seeds while also encouraging communities to plant, grow, harvest, save, and then share saved seeds with others. Lenstra and D'Arpa (2019) found that seed libraries were one of the top three ways public libraries enable community-based agriculture. The other top two ways were with gardening classes and community gardens. During interviews for their research, Peekhaus (2018) emphasized the benefits of seed libraries and their strong connections with community gardens. Tying all these programs together further promotes food justice.

Why Seed Libraries?

Seed banks tend to focus on issues relating to conservation, genetic diversity, biodiversity, and native plants, while seed libraries focus more on community engagement, support, empowerment, and education. Of course, every seed library is different, but they are all guided by a recognition of the importance of seeds and the desire to share and educate about that importance. According to Conner (2015), seed library mission statements prioritize increasing community engagement, support, and empowerment; providing seed-saving education and developing skilled seed stewards; reclaiming seeds as a public resource and as safe alternatives to genetically modified seeds; conserving endangered varieties of seeds, supporting genetic diversity, and developing a reliable source of open-pollinated seeds for native plants; reflecting area cultural diversity; promoting healthy diets; and providing assistance with food insecurity.

BIODIVERSITY

The priorities mentioned by Conner are some of the many critical issues that all seed savers, from an individual gardener to the Svalbard seed vault, can help mitigate. These priorities are also interrelated, starting with genetic diversity: a drop in biodiversity is concerning for multiple reasons. As history has shown, not only does a lack of biodiversity cause ecological harm, it also impacts humans by increasing food insecurity and the risk of famine. Nabhan (2009) provides numerous examples spanning human history. Some of the most familiar include the Irish potato famine and the 1970s corn blight that affected China and the United States. Unfortunately, the lessons of those events were not widely learned. In *Seeds: A Natural History,* Fry outlines how the number of crop varieties has dropped drastically due to the commercialization of seeds and the growth of our modern conventional agriculture system (Table 1). A biodiversity report from the Food and Agriculture Organization of the United Nations estimates that 75 percent of crop diversity was lost between 1900 and 2000, and another study estimated that climate change will result in up to a 22 percent loss of the wild relatives of important food crops including peanuts, potatoes, and beans (United Nations 2010). A current example is the banana, a plant humans may have consumed as far back as 8000 BCE (Mancuso 2022, 137). There is an increasing risk of failing banana crops due to one single variety being grown in the more than 135 countries that propagate the fruit. Multiple diseases that affect the herbaceous plant are arising and the lack of genetic diversity means that the global supply of bananas is at risk; there are limited solutions to finding replacement varieties for this culturally, nutritionally, and historically important plant (Drenth and Kema 2021).

Crop	Varieties in 1903	Varieties in 1983
Beets	288	17
Cabbage	544	28
Maize	307	12
Lettuce	497	36
Muskmelon	338	27
Pea	408	25
Radish	463	27
Squash	341	40
Tomato	408	79
Cucumber	285	16

Table 1: Comparative numbers of US Crop varieties between 1903 and 1983 (Fry 2016, 162-63)

CULTURE

Cultural loss is tied closely to the loss of biodiversity. Culturally relevant and locally adapted foods are being lost due to conventional agriculture, colonialism, wars and hostilities, and climate change. Many individuals, especially those of older generations, take on the responsibility of saving their own seeds primarily to ensure that a plant they enjoy eating and that is important to their culture is not lost. One example can be seen in Figure 5, which shows the Chuvash people using seeds as part of their traditional fertility festival. Another example can be gleaned from the story of The Heirloom Collard Project. Starting in 2000, Emory & Henry College professors Edward Davis and John Morgan worked with Mark Farnham from the USDA and Clemson University professor Powell Smith to explore collards and their significance to cultural history in the American South. This research led them on a trip across the southern US, where they found individuals saving seeds for more than ninety varieties of collards. These seeds had stories, and the individuals who stewarded them did so because of strong cultural and personal ties to the seeds. When well-known seed-saver Ira Wallace learned of these seeds, she worked with the professors and seed-saving organizations to create The Heirloom Collard Project, which continues to collect, share, and research all things collards (Wood 2022, Culinary Breeding Network 2020).

Fig. 5: A member of the Chuvash community spreads seeds during the "Akatuj" festival in Saint Petersburg, Russia. "Seeds of Prosperity" by Zakharov Oleg CC BY-SA 4.0

COMMUNITY

As evidenced by the example of The Heirloom Collard Project, community is a critical part of the discussion, and the areas of culture and community allow seed libraries to play a more active role. The maintenance and success of a seed library is dependent on members of a community working together. Individuals borrow seeds, grow them, then harvest new seeds to return to the library to be further shared. This sharing builds a sense of shared purpose, self-reliance, and a resilient network. The benefits individuals get out of seed libraries—such as learning new skills and saving money, as well as the health benefits from being outside and with plants—strengthen those individuals and their surrounding communities. Alger, Jonkel, and Bray (2014) emphasize this point as they discuss their collaboration with a local food co-op to start a seed library at the Missoula Public Library. The organization decided to proceed with the seed library primarily because of its benefits to the community, and their story is just one example of many.

There are other inspiring examples of individuals and organizations creating seed libraries with community, culture, and biodiversity in mind. Junior Beauvais of the Haitian Heirloom Seed Bank is one example. Junior and his colleague Fang Wan have been working to restore native heirloom seeds to Haitian farmers who have lost productivity, as well as culturally relevant food, by using genetically modified and non-native seeds over

the past few decades (Mathieson, n.d.). Their work started in 2015, and in 2021 Junior presented on this work and the positive impact it has had on his local Haitian community in a panel discussion on seed saving and food sovereignty (VINES 2021).

While Junior was working to return to Haiti culturally significant, biodiverse, and natively adapted seeds lost primarily because of colonialism, Vivien Sansour was focused on doing the same in Bethlehem for seeds lost largely because of war. Sansour's Palestinian Heirloom Library strives to "find and preserve ancient seed varieties and traditional farming practices" (Ettachfini 2019). Nine thousand miles south of Sansour, another inspirational woman runs a seed library out of her home to create a more equitable food system in Cape Town, South Africa. Zayaan Khan opened her "Seed Biblioteek" when she felt drawn to do something to combat the immense damage caused by colonialism and genocide. Seeds and food education are her way of building community, providing individuals with a direct line to their culture and heritage, improving food security, and fighting against the extreme socioeconomic disparities and systemic racism she sees around her (Fawzy 2022).

These are just a few of the many individuals and small groups that have started seed libraries in their communities to help strengthen biodiversity and native ecosystems, cultural connection, and community in general. There are also larger groups focusing on larger geographical areas, a wider variety of plants, or both. Seeds of Diversity Canada is one such example. According to their website, Seeds of Diversity has more than 1,000 members across the country who grow and share seeds with the aim of protecting Canada's biodiversity. In addition to individual members acting as seed savers, they work together to run the Canadian Seed Library which has almost 3,000 seed varieties. In the United States, there are a variety of similar groups ranging from state, such as Hawai'i Public Seed Initiative, to regional, such as Southern Exposure Seed Exchange, to national, such as the Germplasm Resources Information Network (GRIN).

The Experimental Farm Network, a group that grows, saves, and sells seed, has the ambitious goal "to fight global climate change, preserve the natural environment, and ensure food security for humanity into the distant future" (Experimental Farm Network n.d.). One of the ways they work toward these goals is by obtaining GRIN seeds from areas devastated by wars and climate change, such as the Maldives, Kandahar, and South Sudan, and then growing them to share with others, particularly those from the seeds' native areas (Roach 2022). Another leader in widespread and impactful seed saving and education is Seed Savers Exchange, which started in 1975 with the goal of protecting the biodiversity of the planet

and our food system "by preserving rare, heirloom, and open-pollinated varieties of seeds… and encouraging gardeners and farmers worldwide to grow, harvest, and share heirloom seeds as well as recount the inspirational stories behind them" (Seed Savers Exchange 2023). These groups are having an impact. The number of seeds they steward and the number of people they impact increases every year. For the Experimental Farm Network, their 2022 catalog was the largest they have ever offered to date (almost 500 varieties), and their 2021 orders were more than twice as much as their 2020 orders (Roach 2022). Southern Exposure Seed Exchange has been credited with returning both the "Cherokee Purple" tomato and the worm-resistant "Charleston Belle" bell pepper to popular use (Barth 2017). In 2017, Seed Savers Exchange evaluated their collection and determined that they had seven varieties of tomatoes that were created in the mid-to-late nineteenth century by the "father of the modern tomato" A. W. Livingston. Many of Livingston's tomatoes were thought to be lost until the Victory Seed Company began working to locate and restore his tomatoes around the turn of the twenty-first century. Figure 6 shows a cover for A.W. Livingston's seed catalog featuring varieties of the tomatoes.

Fig. 6: A colorful seed catalog cover from 1895. "A. W. Livingston's Sons Seed Annual 1895 cover" by A. W. Livingston's Sons, Columbus, Ohio, Public Domain.

REMATRIATION

A discussion about seeds and their importance for biodiversity, culture, community, and their losses due to colonialism, cannot happen without talking about the rematriation of seeds to Indigenous peoples. A basic definition of rematriation is "returning the earth to mother nature to heal and regenerate" (Guntarik 2023, 63). Gray adds to this definition, identifying rematriation as "an Indigenous feminist paradigm, an embodied praxis of recovery and return, and a sociopolitical mode of resurgence and refusal" (2022). Regardless of the specific definition used, rematriation goes beyond colonial and patriarchal repatriation and focuses on undoing cultural assimilation by reuniting Indigenous people with their ancestral lands and culture. Seeds are a significant part of this process, and there are multiple groups working toward returning traditional seeds to Indigenous groups who were separated from them through the forced removal of people, lands, and customs. A few large and well-known examples of this work are being undertaken by Native Seeds / SEARCH, the Native American Food Sovereignty Alliance, the Indigenous Seed Keepers Network, and Dreams of Wild Health. There are also numerous tribes and nations working to reintroduce seeds in their own communities. Examples of this in upstate New York include various projects that the Haudenosaunee are working on, such as the White Corn Project, the Haudenosaunee Seed Keepers Society, Northeast Native Seeds, Revitalizing Our Sustenance Project, and multiple collaborations with regional universities to start Three-Sisters gardens, where the seeds are returned to the Haudenosaunee (Micale 2022). All of this is time-consuming and challenging work. Often there are not a lot of seeds to start with, and successful growing and drying periods are necessary to collect more seeds. It can take many years to gather enough seeds to save, and it is important that multiple people and groups are working on the problem (Mitchell 2021).

CLIMATE CHANGE

Climate change is another contributing factor to the loss of genetic diversity and biodiversity, introducing concerns around growing food in rapidly changing environments. While seed/gene banks and some of the large seed networks work toward adapting seeds for specific climate-related stressors (such as drought tolerance), seed libraries provide a way to maintain large varieties of seeds that can be grown in and adapted to local areas on an annual basis. This is one of the goals of the Hawai'i Seed Growers Network, which works to adapt seeds for the various microclimates across the state (The Kohala Center n.d.). Other examples of groups focusing on microclimate specificity are the University of California

at Santa Cruz Demeter Seed Saving Project and the Lopez Community Land Trust Seed Library. Both were started to preserve heirloom varieties adapted to specific local areas in order to increase community self-reliance (Conner 2015).

A recent report from the National Academies of Sciences, Engineering, and Medicine notes that climate disasters are causing ever-increasing economic and ecological damage that could in part be mitigated by ecological restoration (2023). Unfortunately, this restoration is hampered by the inadequate supply of native seeds (Fuller 2023). Native seeds are needed as they have coevolved with native insects, birds, and animals, making them essential to maintain the biodiversity of ecosystems. However, the report finds that "A relatively small segment of the nation's commercial seed industry produces seeds of native plant species for ecological restoration" and that there is a "severely insufficient" supply of native seed. To give an indication of the scale of need for this supply, the report's authors point out that in 2020 about a million pounds of seed were used just to reseed burnt lands. While collaboration with commercial seed providers, as well as state and regional organizations, is important and increasing, federal collaboration with seed banks across the country is another essential step to ensure supplies of native seeds for ecological restoration as climate change continues to cause unpredictable destruction. The 2023 National Academies report highlights numerous collaborations with seed banks and lists working with seeds in some way in both their recommendation 2.0 and recommendation 4.3. This type of work is not new to the Forest Service as it can be seen in the 1940 photograph in Figure 7. There is also work in seed/gene banks to not only save original varieties but also to selectively modify those varieties to create strains for new climates (Montenegro De Wit 2016). Smaller community banks and libraries add to this by focusing on the goal of "maintaining varieties of seeds for use by local farming communities" (Fry 2016, 165).

Fig. 7: A worker at the US Department of Agriculture Forest Service in Chippewa National Forest weighs and stores seeds. National Archives and Records Administration. "Photograph of Seed Stored in Airtight Metal Containers" by Department of Agriculture, Forest Service, Region 9 (Eastern Region). Public Domain

Seed Libraries in Libraries

Seed libraries have been started mostly by individuals seeking a way to share and connect with their communities. With this background, bringing seed collections into traditional public libraries makes logical sense. Conner (2015) discusses the history of public libraries back to the days of Andrew Carnegie and how the purpose of public libraries has been to share and provide resources to the communities they serve. Starting in 2010 the Richmond Grows Public Library in California has strongly promoted the idea of bringing seed libraries into public libraries and shared information on how to do so through its seed library and informative website. Seed collections are a way to further tie libraries to the local area while providing yet another reason for people to come into the library, which then exposes them to everything else the library has to offer (Alger 2014). Unfortunately, this view is not universally shared. Former Baltimore County Public Library director Charles Robinson, for example, expressed his opinion in 2015 that seed libraries were a trend that would die off as seeds did not fulfill the purpose of libraries to share books and information (Anonymous 2015). Robinson was not the only librarian to hold this opinion, but many others, and the communities they served, disagreed, and the trend of both public and academic libraries toward bringing seeds into circulation has not only continued, but has grown. Emily Hatcher, who works at the Daviess County Public Library in Kentucky, emphasizes that libraries are about community, stating that "We don't serve one individual; we serve the whole county, and with the addition of the seed library we can reach people throughout our community" (Bourne 2023). These days, while some libraries still struggle to get buy-in for seed libraries, Hatcher's line of thinking seems to be more common than Robinson's.

While there is not yet a good way to know how many seed libraries are housed in library organizations, it is becoming more popular to start one. Stories of seed libraries being started are becoming more regular in conference presentations, press releases, and news articles. In our area of Binghamton, NY, two of the five local public libraries have seed libraries and many more can be found online across the country and worldwide. An abbreviated list is provided in Appendix A. Regardless of the numbers, it seems evident that public libraries took the lead in the movement, and academic libraries are now joining. The "more unusual, community-oriented programs" that can readily be found in public libraries, such as makerspaces and tool libraries as well as seed libraries, have been slow to be embraced in academic libraries (Ingalls 2017). This is not too surprising as public libraries tend to be more tightly associated with the

public and their needs while academic libraries are tied to the academic missions of particular campuses. Anecdotally, this is changing, especially since the COVID-19 pandemic. Academic libraries are exploring more unconventional ways to engage with students, faculty, staff, and even the local community. Part of this stems from a growing understanding that learning and pedagogy take various forms; that students, and everyone else, are increasingly stressed and alternative activities can help educate in a less stressful way; and that current educational systems worldwide are systemically patriarchal and racist, and different ways of doing things should be explored. Binghamton University Libraries have joined numerous others in working to make the library more inclusive with an increased sense of belonging for everyone. Seed libraries are one way to do that, in addition to all the other benefits they provide.

ACADEMIC SEED LIBRARIES

Seed libraries in academic institutions provide an excellent opportunity to increase engagement with the campus community and beyond. While many of the academic seed libraries are run by the institution's library, others are run through organizations such as gardens and museums. From events about gardening to seed-saving workshops to lectures on why seed libraries are important, there are numerous opportunities to provide new educational avenues and broaden a library's ability to disseminate a wide range of knowledge (Ingalls 2017). Seed libraries can also help academic libraries move away from their colonial past by helping to improve student food security, bringing awareness to global and societal issues, strengthening the community through shared experiences, cultivating a sense of belonging, reducing environmental impact, and facilitating conversations about numerous social justice issues (Dean 2018).

Some individuals still react to the idea of seed libraries in the academic library with tilted heads and confusion as to the pedagogical and research value, particularly if they are at an institution that is classified in the Carnegie Classification of Institutions of Higher Education as an R1 institution (doctoral universities with very high research activity). What is often not understood is that seed libraries open the door to numerous possibilities, including research and pedagogical activities. In addition to programming and events that build community, seed libraries also allow faculty an outlet to further share research, opportunities for class assignments, additional hands-on ways to expand social-justice-related education, and new avenues for digging into the topics of inclusivity, environmental justice, colonialism, and more while connecting people from a wide range of ethnicities, cultures, genders, and socio-economic backgrounds (Dean 2018). Our experiences at Binghamton University have

borne out this potential. Between fall of 2022 and February 2024, almost six hundred individual packets of seeds have been taken from the seed library. In addition to the data showing the high use of the seed library, our seed library is part of a larger system that has resulted in course assignments, poster presentations, student-created digital and physical displays, and increased engagement with faculty, individual students, student groups, and campus-wide groups. The activities through our seed library have integrated us further into the community, brought more people into the library (who sometimes walk out with books they did not intend to), and allowed us to provide further educational opportunities to our campus's students.

SEED LIBRARY ORGANIZATION

No matter where they are, seed libraries share many of the same basic goals revolving around community, sustainability, biodiversity, and culture. Despite these similarities, all have different layouts, guidelines, successes, and complications. Some, particularly those in public libraries, actually catalog their seeds, and individuals "check out" the seed packets as they would any other library material (Alger 2014). Many others have a more informal method, or none at all. When we started our seed library, we initially had no check-out method and just expected people to take seeds (we asked people to take only what they would use but had no further guidelines). However, we found that not having a system in place left people feeling as if they were taking something they should not, so we now have a simple sheet where people can log their names and what seeds they took. They can also opt-in to our email list on this sheet. Every seed library will have a different system that works best for them and their community.

Another difference comes down to how the seeds are labeled and organized. It took us two or three tries to find an organization scheme that worked for us that included both common names and scientific names on our labels, as well as information about the year and source, and whether the seeds were open-pollinated and organic. We provide all this information because we know we are working with a wide range of individuals, from first-year college students to those with doctorates in all sorts of disciplines, including botany. We also wanted to use the seed library as a pedagogical tool as well as an outreach and engagement tool. Public and community-based libraries may choose to simplify their labels (Alger 2014). Figure 8 compares seed libraries at one public library and one academic library. As academic-based seed libraries promote the benefits of open-pollinated plants, they should remain aware of possible push back from campus researchers who may be focused on hybridization of plants and working with agribusiness. Seed libraries may need to find ways to

promote the value of increasing independence from seed corporations while also acknowledging the contributions of researchers who often rely on funding from the seed corporations (Ingalls 2017).

Fig. 8: Your Home Public Library in Johnson City, NY (left) organizes its seeds by family, and package labels include the seed common name, basic description, and growing information. Binghamton University (right), just three miles away, organizes its seeds alphabetically and includes on their labels the common and scientific name, as well as information about where the seeds came from and whether they are open-pollinated or hybrid.

Challenges

As with most new programs or projects, the primary challenges to building seed library collections and services often come down to time and money. While setting up a seed library can be done inexpensively by reusing old filing cabinets or card catalogs and getting seeds through seed donations from like-minded seed companies, there are always some initial start-up costs, as well as the ongoing costs of updating the inventory if donations are not sufficient. Day-to-day tasks include making sure things stay organized, that seeds are clean and divided into appropriate sizes, and fielding questions. Some seed libraries also face the larger challenge of a lack of understanding and support from leadership. It has only been eight years since Charles Robinson predicted that seed libraries would just be a trend, and there are still plenty of library administrators who do not see the value of adding seed libraries to their services. We have also faced skepticism from leadership in our academic setting. The evidence laid out in this report, and the use of our seed library in pedagogy and research, has allowed us to continue. We hope that others facing this challenge can also use this information to succeed.

POLITICS

Robinson was right about one point that often gets overlooked. The 2015 year-in-review article that highlights his opinion on seed libraries mentions one potential pitfall: some areas have laws and regulations in place that can be used against those who would like to start one, ranging from having restrictions on seed libraries to not allowing them at all (Anonymous 2015). Alger and coauthors (2014) give one such instance when they point out that the Cumberland County Library System (CCLS) in Pennsylvania had to shut down its seed library after it was deemed to be in violation of the Pennsylvania Seed Act of 2004 because it presented risks of "invasive or poisonous plant propagation, cross-pollination, misinformation, or 'agri-terrorism.'" This was not the first incident of its kind. As mentioned earlier, companies such as Monsanto are known to sue for any unauthorized use of their intellectual property. In 2011, Monsanto threatened that if any pollen from its genetically engineered plants spread (even by wind) to a farmer's non-genetically modified crops and the farmer saved the resulting seeds, the corporation would sue. Southern Exposure Seed Exchange was a plaintiff in the case, Organic Seed Growers and Trade Association v. Monsanto. In this instance, the case ended with Monsanto dropping these specific threats (Barth 2017). The CCLS incident received a lot of media attention, resulting in many seed library proponents speaking

out. Since then, as of 2018, several states have added exceptions for seed libraries to their seed laws (Carolan 2018).

Research has found that seed banks, libraries, and other entities can play a vital role in adapting to climate change, that they have been doing this work for decades, and that what is now needed is recognition of this work, especially recognition among policymakers that these systems "can be a very effective form of farmer organization toward more climate smart agriculture" (Vernooy et al. 2017). The Open Source Seed Initiative currently works toward promoting the open sharing of plant germplasm, including seed. Their work not only promotes seed libraries and exchanges, it also actively decreases the number of patented seeds used while increasing the availability of "free seed" (Open Source Seed Initiative n.d.). Recently, the UN's Special Rapporteur Fakhri recommended that UN States protect seed systems by recognizing farmers' rights as inalienable human rights, meaning that individuals have the right to "maintain, control, protect and develop their own seeds," and stop giving in to pressures to patent seeds or otherwise inhibit seed freedom (Fakhri 2021).

COVID-19

The COVID-19 pandemic had an impact on all things related to seeds. A 2021 report from the Organisation for Economic Cooperation and Development (OECD) Trade and Agriculture Directorate found many concerns during the pandemic around seed supply chains, particularly for countries relying on imported seed. They found that while overall the global seed sector was resilient, seed companies in the Asia Pacific region were more negatively affected (Deuss, Gaspar, and Bruins 2021). Pandemic lockdowns also changed the seed landscape in that suddenly more people were interested in gardening while at the same time it was more difficult to get access to plants and seeds. In 2020 nurseries and seed companies across the United States reported historic levels of demand. Some reports show sales increased over 60 percent in 2020 with additional increases in 2021 (Ball 2022). These demands often could not be met because of actual shortages of seeds for some varieties, and because the time and energy needed to fulfill orders could not be met by the human staff or sometimes even the packing machines (Cronin 2021, Brooks et al. 2022).

Early in the pandemic, the Experimental Farm Network created the Cooperative Gardens Commission, and they were able to get donated seeds (usually older seeds) and distribute them to over 300 seed-lending hubs (Roach 2022). They were not the only seed-sharing organization to see an increase in demand; many seed libraries did. It was also during this time that we were able to start our own seed library in part due to the sudden,

and confusing, free time found during the early COVID-19 lockdown. Our seed library did not open until well after we returned to campus (in April 2021), but the momentary pause in other work in early 2020 allowed us to explore the seed library idea and start planning. Already-established seed libraries were also affected by the confusion and sudden changes caused by the various COVID isolation regulations. Like seed companies, some seed libraries found that while interest in their seeds had grown, there were complications with keeping up with demand and in getting seeds to people. Some responded by mailing seeds to people, while others moved their seed libraries out of the library building so people could pick up their seeds without breaking lockdown guidelines (Seed Sovereignty 2021, Greater Long Island News 2020). In 2020 and 2021, The University of Vermont Center for Rural Studies surveyed farmers and gardeners about their seed interactions. Their findings supported these broad trends: respondents struggled to obtain seed, and some turned to seed-saving. This research and the 2022 summary report resulted in the preparation of a Vermont Seed Resilience Plan. The report also began the process of identifying seed varieties that are regionally important because of their cultural heritage, their ability to adapt to climate change, or their risk of being lost. These seeds will be housed in the University of Vermont's new Crop Genetic Heritage Lab. One of the ultimate goals of the lab is to be able to redistribute the seeds to growers and seed stewards (Brooks et al. 2022).

Current State and Impact of Seed Libraries

Overall, seed libraries are growing in numbers, visibility, and popularity. The Richmond Grows Seed Lending Library is a primary resource for those looking to start seed libraries as they have a robust collection of information, templates, and guidelines. They also encourage anyone starting a seed library to become a "sister seed library" simply by notifying them of the new library. In January 2024 they launched a new seed library census and map where people can see where other libraries are and register their own seed libraries. While this index of seed libraries from around the world is composed of self-reported data, so is not definitive, it is likely the most accurate count of the number of seed libraries we have. As of March 6, 2024, this resource documented over 2,000 open seed libraries in 15 countries and 48 states in the United States (Seed Library Network). The SHARECITY Database, an open access database that indexes various aspects of food sharing (Davies et al. 2016), identified 464 plant or seed-sharing entities across the 100 cities it currently tracks, as of August 16, 2023.

Seed libraries, seed banks, and other members of the seed sovereignty movement continue to become increasingly relevant. In the United States, the Sustainable Agriculture Research and Education (SARE) group provides grants and education around sustainable agriculture. Since 1988 there have been 123 grants awarded with a focus on seeds. 35 of those grants have been given between 2020 - 2023 (SARE n.d.). This increase in seed-related grants is just one example of the growing recognition and appreciation of seeds, likely due to the increased interest in sustainability, climate change, environmental and social justice, and rematriation. Seed libraries are getting more recognition globally as well. One example of this is the recently announced Green Library Award from the International Federation of Library Associations and Institutions (IFLA). A seed library in Italy is on the short list of winners for the Best Green Library Project because of its long-term effects and community engagement (ENSULIB 2023).

A large-scale example of the importance of these programs is that when a seed bank near Aleppo was destroyed in the war in Syria, the Svalbard Global Seed Vault was able to send wheat, barley, and other grasses to researchers in Lebanon. According to Stefan Schmitz, the executive director of Crop Trust, a nonprofit international organization dedicated to conserving crop diversity, "Seed banks are a kind of life insurance for

mankind. They provide the raw materials for breeding new plant varieties resistant to drought, new pests, new diseases, and higher temperatures" (Angel 2022). An even more recent example of the importance of seed saving is ongoing at the time of this writing. In May 2022, bombings during the Russian invasion of Ukraine destroyed some of the Ukraine National Seed Bank's collection; more of the collection was at risk of loss due to damaged infrastructure and ongoing violence. Ukraine has a long, important history in agriculture and many of the seeds in the collection are rare or essential in ensuring food security not only locally, but globally. Many groups, including the Food and Agriculture Organization of the United Nations and the European Union, worked together to move the seed collection in the hope of protecting it from further damage (Angel 2022; Mykhalchuk 2023).

On smaller scales, local seed libraries and groups also continue to make a difference. There are also organizations that follow the same principles as seed libraries but may not actually lend seeds. SeedBroadcast is a group that works to "uplift the Culture in agri-Culture through broadcasting Seed Stories and pollinating resource networks to cultivate bioregional food and seed resilience." They provide resources, tell stories, do art installations, and undertake various other timely and engaging projects ("SeedBroadcast" n.d.). The Utopian Seed Project is a nonprofit that runs an experimental farm that grows trial crops, promotes and works toward agro-biodiversity, and produces educational outreach resources. There has also been recent movement on the federal level. On February 24, 2023, the United States Department of Agriculture announced a bipartisan infrastructure law that will provide $5.3 million to "help increase native seed collection and native plant availability to restore and support resilient ecosystems on national forests and grasslands." The law also provides another $4.5 million for forest nurseries.

Conclusion

While the practices of collecting and saving seeds have existed since the beginning of human history, the establishment of seed libraries is a relatively recent phenomenon. Despite this recency, the popularity of seed libraries has exploded in the last twenty years, with an estimation of over 1,300 seed libraries now existing worldwide. To better understand why the seed library movement has grown so quickly and why seed libraries are already being viewed as essential in many library communities, we decided to conduct a historical analysis to gain more insight into how seeds have been collected, saved, and shared over time.

The goal of the historical analysis was to answer the following questions:

1. How have seed collecting, preserving, and sharing practices developed over time?
2. How did the concept of "seed libraries" first come to be and how has it evolved?
3. How did colonization and white, Eurocentric influence affect the collection, sharing, and accessibility of seeds from the Age of Exploration onward?
4. How and why are seed-collecting and seed-sharing practices so integral to human connection, culture, and community?
5. How and why are more public and academic libraries creating community-centered seed libraries in their institutions today?

Through this historical analysis, we were able to demonstrate how seeds, throughout time, have been integral to human culture, connection, and community. This relationship between human and seed has manifested in wildly varied ways based on region, era, and culture, but the practices of seed collecting, saving, and sharing have always existed. Our analysis showcased how these practices of seed collection, cultivation, and dissemination have changed over time, from the first hunter-gather societies and ancient civilizations to the age of global colonization from the 1450s to the 1800s, through the green revolution and monocropping of the 1950s and 60s, and finally to the modern age of genetic modification and calls for a return to sustainable food practices and food democracies. The context of these historical impacts on seed collecting and seed sharing was then used to shape our understanding of why the seed library movement began, why it is important, and why it continues to grow.

Ultimately, our analysis has determined that many historical occurrences led to a steady erosion in humanity's cultural and communal connection to

seeds over time. However, within the last few decades, several movements have arisen that push back against the industries and systems that helped lead to this erosion, and many are now seeking ways in which to reconnect with food, and ultimately with seeds. Seed libraries are one of the many responses to this movement. They provide their communities with free access to seeds, as well as educational resources, programming, and events that support seed growing, saving, and sharing. Seed libraries, therefore, are responding to and addressing important cultural and community needs by allowing their patrons to have unfettered access to seeds.

The future of seeds and the role that seed libraries play is hopeful while still providing many areas of research to explore. The impact of seed savers on local biodiversity and climate adaptability is still not well understood, nor is the question of how to go about bringing further attention to seed saving and its importance (Brooks et al. 2022). Another area of research worth exploring is exactly how many seed libraries there are and how they function. We hope that through this historical analysis, we have provided strong evidence for why the practices of seed collection, saving, and sharing are so important, and how library organizations are able to help support these practices through the adoption of seed library programs.

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Recommended Reading

For more on academic uses and benefits of seed libraries:

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For more about seed banks:

- Vernooy, Ronnie, Bhuwon Sthapit, Gloria Otieno, Pitambar Shrestha, and Arnab Gupta. 2017. The Roles of Community Seed Banks in Climate Change Adaption. *Development in Practice* 27(3): 316-327. https://doi.org/10.1080/09614524.2017.1294653.
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- Fowler, Cary. 2016. *Seeds on Ice: Svalbard and the Global Seed Vault.* Prospecta Press: Westport, CT.

For more about seeds and biodiversity loss:

- Fowler, Cary, and Pat Mooney. 1990. *Shattering: Food, Politics, and the Loss of Genetic Diversity.* The University of Arizona Press: Tucson, AZ.
- Shiva, Vandana. 2016. *Stolen Harvest: The Hijacking of the Global Food Supply.* University Press of Kentucky: Lexington, KY.

For more about the history of seeds and seed saving:

- Fry, Carolyn. 2016. *Seeds: A Natural History.* University of Chicago Press: Chicago, IL.
- Hanson, Thor. 2015. *The Triumph of Seeds: How Grains, Nuts, Kernels, Pulses, and Pips Conquered the Plant Kingdom and Shaped Human History.* Basic Books: New York, NY.
- Seeds of Hope. 2019. Hudson River Stories. New York: Oceans 8 Films. https://www.hudsonriverstories.com/seeds-of-hope/.

Appendix A: Examples of Seed Libraries

Community

- Bay Area Seed Interchange Library (BASIL) Project (https://ecologycenter.org/basil/)
- Reclaim Seed NYC (https://www.reclaimseednyc.com/)
- Canadian Seed Library Seeds of Diversity (https://seeds.ca/)
- Como Community Traveling Seed Library (https://www.comoseedlibrary.org/)
- San Juan Seed Savers & Community Seed Library (https://www.sanjuanswcd.com/seeds)
- Cebu Seed Savers (https://globalseedsavers.org/cebu-seed-savers-css/)

Public Library

- Pima County (https://www.library.pima.gov/seed-library/)
- Kansas City (https://www.kclibrary.org/library-locations/irene-h-ruiz-biblioteca-de-las-americas/seedlibrary)
- Springfield-Greene County (https://thelibrary.org/services/seedlibrary.cfm)
- The Cleveland Seed Library project (https://www.hummingbirdproject.org/seed-libraries)
- Everett Public Library (https://epls.org/496/Un-Bee-Leaf-Able-Seed-Library)
- Jefferson County Library District (https://jclibrary.info/use-the-library/bookmobile/seed-library/)
- Normal Illinois Public Library (https://www.normalpl.org/seeds)
- Vestal Public Library (https://www.vestalpubliclibrary.org/clubs)
- Lafayette Public Library (http://lafayettepubliclibrary.org/?page_id=65646)
- Hennepin County (https://www.hclib.org/about/locations/seed-libraries)
- Red Deer Public Library (https://rdpl.org/seedlibrary/)

Academic Library/Institution

- Binghamton University (https://libraryguides.binghamton.edu/sustainability/seeds)
- University of Massachusetts, Amherst (https://guides.library.umass.edu/seedlibrary)
- Eckerd College (https://seeds.eckerd.edu/home)
- University of North Carolina at Chapel Hill (https://library.unc.edu/science/makerspace/seed-library/)
- University of Arizona (https://lib.arizona.edu/seed-library)
- Milwaukee Area Technical College (https://guides.matc.edu/seedlibrary)
- The University of Tennessee, Knoxville (https://libguides.utk.edu/seedlibrary)
- University of Illinois Chicago (https://heritagegarden.uic.edu/seedlibrary)
- Indiana University Bloomington (https://libraries.indiana.edu/seed-library-program)
- Greenfield Community College (https://www.gcc.mass.edu/library/collections/seed-library/)
- James Madison University (https://www.lib.jmu.edu/community-seed-library/)

Acknowledgments

Thank you to Rebecca Newburn, founder of the Richmond Grows Seed Lending Library and SeedLibraries.net. Rebecca worked with us to get us an updated file of their sister library list so we could get more accurate numbers on the number of seed libraries. She, and the rest at SeedLibraries.net, also have our thanks for all they do to support seed libraries.

Thank you to Ben Lainhart, executive director of Your Home Public Library in Johnson City New York, and Jessica Gorman, who runs their seed library. Ben took pictures of their seed library for use in this report and Jessica was very helpful in explaining how she organized their library.

Lastly, a huge thank you to CLIR for giving us the opportunity to write a report on a topic that we are both so incredibly passionate about, and for being so delightful, flexible, and accommodating to work with during the entirety of our project.

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