

Freelance Plant Breeding

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ABSTRACT

A vibrant community of freelance plant breeders is breeding crops for better flavor, local adaptation, performance in organic and sustainable systems, and other virtues. Most varieties bred for organics in recent decades have been bred by freelance plant breeders. Freelancers are strongly committed to agricultural biodiversity and work on myriad rare crops and wild species in addition to common crops. Freelance breeders have succeeded in extending the practical growing ranges for a number of crops. They sometimes breed for resistance to specific diseases that matter in their regions. They have bred varieties for special purposes, such as squash for drying in the summer squash stage for use as a dried vegetable, flint corns for whole-grain polenta, special varieties of flour corns for parching to make a tasty snack food, quinoa for use as greens, and lettuce and spinach varieties for harvest at the baby-leaf stage.

Freelance plant breeders have rediscovered and modernized the concept of breeding and using landraces. They often create deliberately variable varieties that can be superior to more uniform varieties for particular purposes—such as lettuce varieties that give a desirable mix of colors and shapes from a single intercrossing and segregating population. Freelancers sometimes engage in elaborate collaborations; one such collaboration involves more than 200 participants in four countries and has released more than a hundred dwarf tomato varieties.

Freelance plant breeders actively support and encourage seed saving and focus on breeding open-pollinated varieties. They eschew all forms of proprietary control over seed, from the legal means of intellectual property to the biological means of F_1 hybrids. They release their work as public domain or open source varieties. They support their breeding work in various ways, most often by combining it with running small retail seed companies, acting as wholesale seed growers, or collaborating with local farmers. In addition,

a number of seed companies now offer voluntary royalties to freelance plant breeders to encourage and support their work. This chapter introduces freelance plant breeders and describes their motivations, goals, methods, economics, and accomplishments.

KEYWORDS: amateur plant breeding, independent plant breeding, farmer plant breeding, breeding for local adaptation, breeding modern landraces, breeding for organic systems, Open Source Seed Initiative, seed sovereignty

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ABBREVIATIONS:

CSA	community-supported-agriculture
IP	intellectual property
GMO	genetically modified organism
MAS	marker assisted selection
MTA	material transfer agreement
OSA	Organic Seed Alliance
OSSI	Open Source Seed Initiative
PVP	Plant Variety Protection or a variety so protected
SSE	Seed Savers Exchange
SOSP	Society of Organic Seed Professionals
STEM	science, technology, engineering, and/or math

I. INTRODUCTION

Wheat, corn, beans, squash, and nearly all of the other food crops upon which humanity depends were originally bred by freelance plant breeders. With the exception of the last century or two, all plant breeders were freelance plant breeders. We work for no universities, corporations, or other institutions that provide salaries, benefits, or support for our plant breeding work. The main rewards are the satisfaction of curiosity, the fun of the work itself, and, if successful, the superiority of the new cultivars.

Most of us who breed plants outside of institutional settings in America these days prefer to call ourselves *freelance* plant breeders rather than *amateurs*. One problem is that *amateur* is often used to imply that someone is not an expert or is inferior. We do not consider our cultivars inferior to anyone's. Nor do our customers, who eagerly buy them. Nor does *amateur* quite fit for those of us who have STEM degrees or even advanced degrees in related fields such as biology, botany, genetics, chemistry, or biochemistry. In addition, the term generally implies that no money is earned by the activity. Many freelance plant breeders do earn part to all of their incomes from their plant breeding work. Many start small retail seed companies to distribute and help support their plant breeding work. Most of these are small, specialized one-person or one-family operations that exist for this purpose exclusively. They are commonly sole proprietorships, not entities that pay salaries or involve any security. Some freelance plant breeders grow and sell wholesale seed, and/or combine plant breeding with farming.

Farmer-breeders are freelance plant breeders but are only one class of freelance plant breeder. Many freelance plant breeders do not identify

as farmers or farmer-breeders. They sell no produce other than seeds. (Or sell only the produce that represents culls or byproducts of their breeding and seed production activities.) They instead identify primarily as retail seed companies or wholesale seed growers.

Freelance plant breeders, in a business sense, are most similar to freelance artists or writers—at least those who work completely independently of corporations or institutions until they have a finished product to sell. Freelance plant breeders are unlike most freelancers in the tech world, whose employment usually involves a series of jobs or subcontracting arrangements with one or more corporate or government employers. I know of no freelance plant breeder who has ever subcontracted with anyone for any plant breeding work. Freelance plant breeders work independently of the corporate world. They either approach seed companies only once they have a finished variety to sell or not at all, instead starting their own seed companies to sell their varieties.

Freelance plant breeding is also usually distinct from participatory plant breeding. Participatory plant breeding usually involves university or institutional breeders doing plant breeding with variable degrees of input or involvement from farmers, chefs, or others who are not plant breeders. The farmers or others may make suggestions as to needed crop traits or provide land and labor. However, the goal is more or better varieties developed by the university or institutional breeders, not the training of the farmers or others to become plant breeders themselves. There are exceptions, however, and participatory plant breeding programs may have many levels of involvement from farmers, and thus some overlap with freelance plant breeding (Westengen and Winge 2019). In addition, some recent participatory plant breeding features a freelance plant breeder, who then collaborates with chefs or other interested partners who are not plant breeders.

Most university and corporate breeders are unaware of the existence of freelance plant breeders. In this chapter I introduce and describe the world of freelance plant breeders in USA, Canada, Australia, and New Zealand—our motivations, methods, economics, and accomplishments. I hope to present us as worthy colleagues and potential collaborators.

II. EVOLUTION OF A FREELANCE PLANT BREEDER

In this section I must justify the unusually personal nature of parts of this chapter and the extent to which I serve as my own source. I believe the latter is legitimate because of my role in the field of freelance plant breeding.

I went to undergraduate school at University of Florida, which had no tuition for in-state students in those days. I needed to work my way through college, a blessing in disguise. It got me into labs early. I majored in zoology and took genetics as a freshman. The following term I started working for my genetics professor, Henry M. Wallbrunn, himself a protégé of Sewell Wright. Wallbrunn became my first important science mentor. He was “officially” a *Drosophila* geneticist, but he had two huge greenhouses at home and spent all his spare time breeding orchids. My introduction to plant breeding was long conversations with Wallbrunn about all aspects of biology—but especially plant breeding—in the *Drosophila* lab in the Zoology department at University of Florida. My second important mentor was University of Florida biochemist Arthur L. Koch. I worked in Koch’s *E. coli* lab and curated the *Drosophila* stocks and taught the genetics course labs in Zoology department from sophomore age on. I also went over to the botany department in the ag school and took plant physiology and senior research in botany. I took senior research five times in four different labs and four different departments, starting as a freshman.

For graduate school I decided to work on genetic regulatory mechanisms in lower eukaryotes. I won an NIH Predoctoral Fellowship, and earned a PhD with fungal geneticist John R. Raper at Harvard. Afterward, I took a somewhat abortive assistant professorship in the Genetics department at University of Minnesota. I was the first woman faculty member there. The experience left me still determined to spend my life learning about, doing, and teaching science, but equally determined to never work for a university again. Or anyone else, if at all possible. Fortunately, by this time I had started gardening as well as reading widely about agricultural issues.

I became convinced that American agriculture had taken some wrong turns. I felt that “conventional” American agriculture was overly dependent on herbicides, fungicides, pesticides, and soluble fertilizers, and was not as ecologically healthy as it could be. I was attracted to organic gardening and farming. I didn’t agree with all the tenets of organics, but felt that it came closer to an ecologically healthy and sustainable way of farming than did the conventional pattern. In the 1970s, however, university faculty in agriculture schools were usually downright contemptuous of organic gardening and farming. Plant breeding at universities was all being done in the context of conventional agriculture, as was corporate breeding. I decided I could use my background and interests and make a contribution by breeding vegetables for organic systems and teaching others to do likewise. I couldn’t do molecular genetics on my own without institutional or grant support. But to do plant breeding, all I would need is a garden.

I left Minnesota in 1979, moved to Corvallis, Oregon, began gardening, and started transforming myself into a plant breeder. Corvallis is home of Oregon State University. I might have lost all desire to work for a university, but I had to be near one. I needed a first-rate graduate-level agriculture library. I began my plant breeding career in the plant breeding section of the library at Oregon State, reading everything academic plant breeders had to say about their craft.

I also early became concerned about the issue of seed sovereignty. When I started gardening, I fully owned the seed I used. Increasingly, seed companies were dropping open-pollinated varieties and substituting proprietary hybrids. In addition, increasingly new varieties were encumbered with intellectual property in various forms—PVPs, patents, licenses, and bag-tag agreements—that prevented seed saving and in some cases also prevented breeding with the seed. I felt that the resilience of farmers and gardeners, their communities, and humanity depends upon being able to save, stockpile, store, exchange, sell, and breed with food-crop seed. When universities began to release varieties of their breeders with the same sorts of IP as used by corporate breeders, I was especially deeply disturbed. The entire plant breeding enterprise was going in a direction I considered harmful to humanity. Breeding only for conventional agriculture meant strengthening conventional agriculture at the expense of alternatives. Breeding new varieties encumbered with IP was, in my view, both a public good and public harm. It represented the public good of creating new varieties, but also the public harm of contributing to the privatization of plant germplasm. Increasingly, I became aware of the fact that plant breeders breed their values right into their varieties.

I decided to write a book to create and train an army of plant breeders outside of academia and the corporate world—plant breeders with a different set of values. The first edition of *Breed Your Own Vegetable Varieties* was published by Little, Brown and Company in 1993. The second expanded edition, *Breed Your Own Vegetable Varieties: The Gardener's and Farmer's Guide to Plant Breeding and Seed Saving*, was published by Chelsea Green in 2000. *Breed Your Own* is often credited with beginning a resurgence in freelance plant breeding in America. There were, of course, many other factors, most especially the influence of freelance plant breeder Alan Kapuler (Peace Seeds), and, a bit later, Organic Seed Alliance, which was founded in 2003. Many of those now active in freelance plant breeding, however, got their start or early encouragement from my book, and subsequently contacted or visited me to discuss their projects. I also wrote two more general gardening books that project plant breeding as a normal thing all farmers and

gardeners should do, have considerable plant breeding in them, and drew a following (Deppe 2010, 2015). As a result, I personally know many of the freelance plant breeders operating in USA, Canada, Australia, and New Zealand today. The information in this chapter is based primarily on my knowing about 80 freelance plant breeders personally, including most of those whose varieties appear widely in today's seed company catalogs.

In 2015, my evolution and that of the Open Source Seed Initiative became irrevocably intertwined. OSSI was founded to establish an alternative to the proprietary/IP model of plant breeding and variety release. It creates an ever-expanding protected commons of germplasm by means of a Pledge that is disseminated with the seed of 'OSSI-Pledged' varieties: *"You have the freedom to use these OSSI-Pledged seeds in any way you choose In return, you pledge not to restrict others' use of these seeds or their derivatives by patents or other means, and to include this Pledge with any transfer of these seeds or their derivatives"* (Luby et al. 2016).

I joined OSSI, OSSI-Pledged all my varieties, and joined the OSSI board of directors. After I joined, many of the freelance breeders who had been influenced by me joined too, as did many of the seed companies where I had close contacts. I also became chair of OSSI's Variety Review Committee, allowing me to work closely with and nurture OSSI-associated freelance plant breeders. This chapter is also based on data on the 471 varieties developed by the 35 OSSI-associated freelance plant breeders, for which OSSI serves as the registrar.

There is little written information on freelance plant breeders and freelance plant breeding *per se*. But some does exist in Luby et al. 2016 and Montenegro de Wit 2017. However, there is a lot of information in the form of articles, interviews, podcasts, and videos in the popular and gardening/farming media about some of the better-known freelance plant breeders. (See those listed in Table 5.1.)

III. WHO AND WHERE

The practice of most—perhaps all—scientific endeavors is some combination of science and art. In most science, the art is practiced in order to accomplish the science. In plant breeding—at least where the focus is on flavor, aroma, or visual delight—the science may be practiced in order to achieve the art. Plant breeders, freelancers or otherwise, differ widely in the extent to which they are motivated by the desire to do science and the desire to do art.

Table 5.1. Accomplishments of 28 freelance plant breeders¹ and their best-known varieties.

Name	Location and organization or company	Varieties, descriptions, biographical information
David Catzel	British Columbia, Canada, Glorious Organics Co-op	'White Winter Kale Sprouts,' developed from a cross of kale and Brussels sprouts, and features baby leafy clusters of kale leaves instead of baby cabbage heads along the length of the stem.
Dave Christensen	Montana, USA	Spent more than 40 years breeding a single variety, 'Painted Mountain' flour corn. This variety contains germplasm from more than 80 Native American corns, and has been selected to survive, thrive, and produce good crops in the mountains in Montana. Each year Christensen finds and crosses new varieties into his material, tests the results, and incorporates the result into Painted Mountain if warranted. So Painted Mountain is fixed in basic type, but ever-evolving genetically. Painted Mountain is designed primarily to produce food in northern latitudes under harsh, marginal conditions, but in USA is also grown and sold widely as a very early ornamental corn.
Carol Deppe	Oregon, USA, Fertile Valley Seeds	Released 23 varieties. Author of <i>Breed Your Own Vegetable Varieties, The Resilient Gardener, and The Tao of Vegetable Gardening</i> . Best known varieties: 'Cascade Ruby-Gold Flint' corn, 'Fast Lady Northern Southern Pea,' the winter squash 'Sweet Meat—Oregon Homestead,' and (with Nate France) 'Candystick Delicata.' OSSI board member.
Glenn Drowns	Iowa, USA, Sandhill Preservation Center	Put in a career as a high school biology teacher while growing and distributing heirloom and rare vegetables and poultry. Released 16 varieties. Prominent in Seed Savers Exchange. The only freelance breeder I know who was motivated to breed plants by a high school biology course. He lived in the mountains of Idaho at the time and was already an avid gardener. But he couldn't grow mature watermelons. When he heard about hybridization in high school biology, he tried a cross. After stabilization, the result became 'Blacktail Mountain' watermelon, still his best-known variety.
Ewald Eliason	Minnesota, USA	Retired dairy farmer, now deceased. Bred only potatoes. Best-known varieties: 'Blossom,' a pink-fleshed potato, and 'Mesabi Gold.'

Ianto Evans	Washington, USA	Released 'Aprovecho Select' fava bean. When he migrated to Oregon from Wales, UK, he immediately said, "Where are the fava beans?" He made extensive collecting trips to South America and brought back and distributed favas and information about growing them throughout Oregon and Washington via a collaboration he co-founded, the Fava Project.
Edmund Frost	Virginia, USA	Released two varieties. Combines growing seed wholesale with plant breeding and some wholesale squash sales. Specializes in breeding for downy mildew resistance in cucurbits. Best known variety: 'South Anna' butternut.
Brad Gates	California, USA, Wild Boar Farms	Breeds tomatoes exclusively—about 70 released varieties. Helping a friend sell tomatoes in a farmer's market introduced him to heirloom tomatoes. Soon he was growing, selling, and breeding them. Famous for varieties with beautiful colors and spectacular flavors. Among his best known are 'Pink Berkeley Tie-Die,' 'Pork Chop,' and 'Black Beauty.'
Chris Homanics	Oregon, USA	Breeds perennial kale, potatoes, squash, apple, pear, figs, mulberries, quince, hawthorn, peaches, plums, paw paw, apricots, hazelnut, walnut, chestnut, hawthorn, and others. Best known for perennial kale. He's in the process of OSSSI-Pledging his 'Homesteader's Kleidoscopic Perennial Kale Grex' and 'Fruit Punch' apple.
Alan Kapuler	Oregon, USA, Peace Seeds	Over 50 varieties covering nearly all vegetable crops as well as some flowers. Co-founder of Oregon Tilth and Seeds of Change. Among his best-known varieties are: 'Three-Root-Grex' beet, 'Peacevine Cherry' tomato, 'Orange Centiflor Hypertruss' tomato, 'Nutribud' broccoli, 'Green Beauty' snow pea, 'Sugar Magnolia' purple-podded snap pea, 'Magentaspreen' greens (<i>Chenopodium gigante</i>), and sweet corns 'True Gold' (with D. Kapuler and M. DiBenedetto) and 'Double-Red,' a red pericarp variety.
Dylana Kapuler and Mario DiBenedetto	Oregon, USA, Peace Seedlings	Alan Kapuler's daughter and her partner. More than 20 varieties of many vegetables and flowers. Best known for 'Dreamin' Mix' zinnia and (with A. Kapuler) 'Double Red' sweet corn.
Hank Keogh	Oregon, USA, Avoca Seed Farm	Released 'Dazzling Blue Lacinato' kale. Works for Wild Garden Seed as well as has his own wholesale seed growing operation.
Robert Lobitz	Minnesota, USA	Lived from 1941–2006. Bred more than 90 varieties of beans. Best known are 'Red Swan' and 'Purple Dove' bush snap beans.

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Table 5.1. (Continued)

Name	Location and organization or company	Varieties, descriptions, biographical information
Craig LeHoullier	South Carolina, USA	Released four standard tomato varieties plus many dwarf varieties. Author of <i>Epic Tomatoes and Growing Vegetables in Straw Bales</i> . Prominent in and advisor to Seed Savers Exchange. Co-director of Dwarf Tomato Project. Best known varieties: the standard tomato varieties 'Cherokee Green' and 'Cherokee Chocolate' and, with Patrina Nuske-Small and Dwarf Tomato Project, 110 dwarf tomato varieties. Started breeding tomatoes while working as a chemist and plant manager in "Big Pharma."
Joseph Lofthouse	Utah, USA	Put in a career as a chemist before breeding plants. Released 11 OSSI-Pledged varieties, with dozens of other germplasm pools also being distributed. Best known for 'Lofthouse-Oliverson Landrace Muskmelon' and 'Lofthouse Landrace Moschata.' Single-handedly made his mountain village of Paradise able to grow most vegetable crops through developing locally adapted landraces. Speaks widely on landrace plant breeding, interacts and teaches on plant breeding forums, and has inspired dozens, perhaps hundreds of farmers and gardeners to get interested in plant breeding in general and landrace breeding specifically. Founder and moderator of the OSSI-sponsored Open Source Plant Breeding Forum.
Frank Morton	Oregon, USA, Wild Garden Seed	Released 189 varieties. Started as a farmer selling baby-leaf salad greens mixtures by mail-order. Lettuce and greens specialist but now breeds most vegetables. Former executive director of OSA. Best known for 'Wrinkled Crinkled Crumpled Cress,' 'Stocky Red Roaster' pepper, 'Zeppelin' delicata squash, 'Aurora' orach, 'Flashback Mix' calendula, 'Scarlet Ohno Revival' turnip, 'Mizspoona' mustard, and lettuces 'Outredgeous,' 'Hyper Red Rumpeld Waved,' 'Joker,' and 'Jester.' First freelance plant breeder to join OSSI and Pledge all his varieties, which became the core of the OSSI seed list.
Greg Muller	Australia, Useful Seeds	Released 'Joni's Taxi' a yellow-podded snow pea, and 'Jupiter,' a purple-podded snow pea.

<i>Patrina Nuske-Small</i>	<i>Australia, Dwarf Tomato Project</i>	<i>Co-director of the Dwarf Tomato Project. Best known for (with Craig LeHoullier and Dwarf Tomato Project) 110 dwarf tomato varieties. Raised children, then went to and graduated from Flinders University as a Speech Pathologist, a career she then pursued. Science and biology had been her favorites in high school, however. When Craig LeHoullier suggested the idea of breeding dwarf tomatoes with all the colors and flavors and qualities of heirlooms, she joined as co-director, learned to cross tomatoes, and made the initial crosses that began the project, as well as did many of the growouts and selections. Her website is dwarftomatoproject.net.</i>
Tim Peters	Oregon, USA, Peters Seeds and Research	Started breeding while a high school student. (Seed company folded, and Tim moved out of the region some years ago; no one seems to know what became of him.) Over 50 varieties covering nearly all vegetables as well as perennial grains. Many Peters varieties appear to have been lost. Adaptive Seeds carries 17 of his varieties. Best known variety: 'Umpqua' broccoli.
<i>David Podoll</i>	<i>North Dakota, USA, Prairie Road Organic Seed</i>	<i>Released eight varieties. In collaboration with Theresa and Dan Podoll, combines plant breeding, seed growing, and wholesale and retail seed selling with grain farming. Best known varieties: 'Dakota Black Pop' popcorn, 'Dakota Tears' onion, and 'Sweet Dakota Rose' watermelon.</i>
<i>Beth Rasgorshek</i>	<i>Idaho, USA, Canyon Bounty Farm</i>	<i>Wholesale seed grower. Has released one variety 'King Sieg' leek.</i>
<i>Jonathan Spero</i>	<i>Oregon, USA, Lupine Hill Farm</i>	<i>Wholesale seed grower. Released eight varieties. Sweet corn specialist. Best known varieties: 'Solstice' broccoli, and the sugary enhanced sweet corns 'Tuxedo,' 'Tuxana,' and 'Festivity.' OSSSI board member emeritus.</i>
<i>Andrew Still</i>	<i>Oregon, USA, Adaptive Seeds</i>	<i>Released 16 varieties. Cofounder of Seed Ambassadors. With partner Sarah Kleeger, made extensive germplasm collecting trips to Europe. Started farming intending to grow and sell grains and beans locally and run a CSA. Dropped those activities after producing and selling seeds turned out to work better. Best known for 'Butternut Early Remix' and tomatoes 'Perfect Rogue' and 'Santiam Sunrise.' OSSSI board member.</i>

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Table 5.1. (Continued)

Name	Location and organization or company	Varieties, descriptions, biographical information
Elmer Swenson	Wisconsin and Minnesota, USA	Lived from 1913–2004. Bred only grapes. Released 30 named varieties and many more numbered varieties. His two most famous are ‘Edelweiss’ and ‘Swenson Red.’ His work aimed at combining the genetics of wild native American species with standard European material to develop good-tasting table grapes capable of surviving in the upper Midwest. His germplasm became the basis for the commercial production of both table and wine grapes in the upper Midwest and throughout colder areas worldwide. A chapter about Swenson and his work appears in <i>Plant Breeding Reviews</i> (Clark 2019).
<i>Mel Sylvestre</i>	<i>British Columbia, Canada, Eco Seed Co-Op</i>	<i>Released ‘Melaton’ leek and ‘Purple Stripe’ tomatillo</i>
<i>Don Tipping</i>	<i>Oregon, USA, Siskiyou Seeds</i>	<i>Released 11 varieties. Prominent permaculture farmer, speaker, and activist. Best known for ‘Cassiopeia’ popcorn and ‘Popeye’ spinach.</i>
Tom Wagner	Washington, USA, Tater-Mater Seed	Breeds tomatoes and potatoes only. Grew up on a Kansas wheat farm and started breeding vegetables, poultry, and hogs as a grade-school kid. Has been breeding plants for 67 years, and has bred over 150 varieties. Best known tomatoes: ‘Green Zebra,’ ‘Green Grape’ and ‘Skykomish.’ Among the best-known potatoes are ‘Skagit Valley Gold’ and ‘Azul Toro.’ Most Wagner potato varieties are no longer available as clonal lines but are instead distributed as populations of derived true potato seed. Wagner started a movement of people planting potatoes from true potato seed, accepting and using the variable populations, and making potato breeding an ordinary part of growing potatoes. This is in lieu of trying to maintain and grow vegetatively propagated material that is not available as certified seed, and that presents major problems with viruses and disease.
<i>Bill Whitson</i>	<i>Washington, USA, Cultivariable</i>	<i>Released 16 varieties. Specializes in perennial root crops, Andean root crops, and potatoes. Best known for: ‘Loowit’ potato and ‘Sockeye’ oca. Put in a career as a computer programmer before retiring and starting to breed vegetables. Major teacher of breeding of potatoes and Andean root crops via very scholarly but accessible articles on his website. See for example, ‘Potato: Color Genetics’ (https://www.cultivariable.com/potato-color-genetics/). OSSSI board member.</i>

¹ All breeders were active at least into the 1990s or beyond. Open Source Seed Initiative (OSSSI)-associated breeders are listed in italics; descriptions and photos of their varieties may be found at <https://osseeds.org/seeds/>. Most breeders and varieties are included largely on the basis of presence and distribution in seed catalogs other than just their own. Others are included because of the nature or influence of their varieties.

Many freelance plant breeders are strongly motivated by the science aspects. A substantial number have formal scientific training. None I know have PhDs in plant breeding. Mike Hessel has an MS in plant breeding, however. And Alan Kapuler, Craig LeHoullier, and I have PhDs in biochemistry, chemistry, and genetics, respectively. It is common for freelance plant breeders to have undergraduate degrees in some STEM area. Many put in entire careers in a STEM field while or before becoming freelance plant breeders. Joseph Lofthouse was a chemist before starting his freelance plant breeding work. Bill Whitson was a computer programmer. Glenn Drowns has an MS in biology and was a high school biology teacher. Tom Wagner has three degrees—in botany, geography, and anthropology.

Some freelance plant breeders discover an interest in science only as adults with careers established in something else, when they stumble across the idea of freelance plant breeding, or an off-type plant appears in their gardens. Most had not a single course in their entire public school educations that suggested that science or plants could be the slightest bit interesting. Others have a serious interest in science and read popular science widely, often starting in early childhood, but have no formal education in it. Some were interested in science but prevented from pursuing a career in it by lack of opportunity for college or other aspects of the social situation. A Mennonite farmer recently contacted me about his corn breeding work. His schooling ended at tenth grade. However, he was always interested in science, read widely in it as a child, and still reads widely in it as an adult. When he came upon my plant breeding book, it was a perfect fit. Freelance plant breeding is a way he can experience the joy of doing science himself in the context of his vocation and his community. Women in my own era were largely not hired for science jobs no matter how interested or qualified they were. So the woman who was always interested in science did something else as a career or became a full-time homemaker. Then one day she notices a reference to a book, or an off-type plant appears in her garden, and her thwarted scientific curiosity comes roaring back. And this time it is a love that will not be denied.

Plant breeding is one of the few areas of science where one can participate with only the resources of a farm or garden. Those with no scientific interest or curiosity aren't interested in reading books about any aspect of science, however. And if an off-type plant shows up in their gardens, they may just cull it out. Those who instead respond to that off-type plant by saving and planting the seed, by becoming freelance plant breeders, come from and exist in all walks of life, and have educational backgrounds ranging from high school or home schooling

only to PhDs, and they may have loved science their entire lives, or have discovered the capacity for that love only as an adult, in the context of plant breeding. But their interest in science and scientific curiosity make them more likely to self-select into becoming plant breeding.

For some, however, the appeal of freelance plant breeding is primarily as a creative art or craft in which they can express their own desires, personalities, and aesthetic preferences. The relationship to science may be incidental. There is often also a philosophical, almost mystical component. Freelancers sometimes speak of “freeing nature” to unleash its “natural” creativity, or acting as part of the evolutionary process. There seems to be a certain wildness and unruliness in the nature of most freelance plant breeders. We tend to delight in the wildness and unruliness of our plants, and relish finding ways to make good use of wildness and unruliness—that in both our plants and ourselves.

A few freelance plant breeders grew up on farms. But it’s more common for the freelance breeder to start as an urbanite and become interested in organic farming as part of the philosophical rebellion of “going back to the land.” Most, though not all, have undergraduate degrees, but usually in something other than agriculture. Their first challenge is to gain control over a farm or somehow arrange access to one. Sometimes parents can be convinced that some farm land would be a good family investment. More often what is required is working for some years at some other career in order to earn enough money for the farm. Many read widely to develop ideas for their farm-of-the-future while still doing the other career. Virtually all recognize that surviving by farming is difficult, and that it will take hard work and originality to make it. Market gardens or CSAs focusing on sales to local markets are the most common choices. Usually growing crops using organic methods is part of the initial rebellion and vision, and the idea of plant breeding comes later.

Organic farmers-to-be usually start by working or volunteering on local organic farms to learn the basics. When access to a farm is finally obtained, what then happens, especially in the maritime Northwest, is the new farmers try growing some seed crops. And many discover that growing and selling seed crops is easier or more lucrative than selling produce. So they then tend to grow more seed and less of everything else. Some continue selling produce as they expand into seed growing and plant breeding. But many drop the produce and stop calling themselves farmers and start calling themselves seed growers or seed companies. This means that if you look for freelance breeders in America under the name “farmer-breeder” or farmer, you miss many or even most. They are calling themselves seed companies or seed growers, not

farmers. Farms that are the base of operation for freelance breeders, whether they call themselves farms or seed companies, are usually small by agribusiness standards, as is true of most one-family organic farms in general.

Freelance breeders tend to be invisible for another reason. Up until the last decade or so, they were almost never credited for their work. Seed company catalogs usually credit university breeders in the descriptions of their cultivars. Most major seed companies, until recently, gave no such credit to freelance breeders whose cultivars they carry.

In this chapter, I consider just freelance plant breeders in USA, Canada, Australia, and New Zealand. This is only partly because these are the freelance plant breeders I'm most familiar with, and with whom I have no language barrier. I believe the presence and visibility of freelance plant breeders in these countries also reflect a difference in seed laws between these countries and others. In most countries, freelance plant breeders cannot just breed a variety and start selling it. In Europe there are lists or laws that prevent cultivars from being sold unless they are on a national list. This prevents new cultivars from being introduced without receiving formal permission from some regulatory entity. The permission is costly to obtain, and essentially precludes introduction of freelance-bred varieties (Bocci 2009, Winge 2012). Most countries also have phytosanitary and seed quality laws that serve as a barrier to those who want to start a seed company or sell and distribute seed (Luby et al. 2016, Wattnem 2016). With no means to distribute or sell varieties they develop, freelance plant breeders have little incentive to operate. USA, Canada, Australia, and New Zealand have no laws or lists that prevent freelance plant breeders from selling their varieties, and only minor barriers of entry to starting small seed companies to do so. Of the 35 OSSI-associated freelance breeders (Table 5.2; Figures 5.1 and 5.2), one is in UK. All the rest are in USA, Canada, or Australia. Twenty-nine are in USA, two in Canada, and three in Australia. The resurgence in freelance breeding seems to have first started in USA, and then in Canada, Australia, and New Zealand only much more recently. There are additional freelancers located in Canada, Australia, and New Zealand who are interacting on freelance plant breeding forums or already in contact with OSSI, however, who will likely soon be finishing and releasing their first varieties.

As shown in Table 5.2, in USA, 12 of the 35 OSSI-associated plant breeders are in maritime Oregon. This is undoubtedly partly because it is one of the world's best seed production areas, and growing and selling seed crops and plant breeding go so well together. In addition, most freelance plant breeders are organic growers. The maritime

Table 5.2. Thirty-five open source seed initiative-associated freelance plant breeders, the crops they breed, and their number of releases.

Breeder	Gender, location, and livelihood	Crops released (total number of varieties)
Ken Asmus	M, USA/Mchigan	Watermelon seed (1)
Roberta Bailey	F, USA/Minnesota, ws	Pepper (2)
Anne Berblinger	F, USA/Oregon, f	Bean, pepper (8)
Chuck Burr	M, USA/Oregon, rs	Asparagus, kale, lettuce, tomato (8)
Brian Campbell	M, USA/Washington, rs	Spinach (1)
Mary Campbell ¹	F, USA/New Mexico	Pepper (1)
David Catzel	M, CA/British Columbia	Kale sprouts (1)
Carol Deppe	F, USA/Oregon, rs, ws	Bean, chickpea, cowpea, flint corn, flour corn, kale, melon, quinoa, summer squash, winter squash (23)
Glenn Drowns	M, USA/Iowa, rs	Flint corn, popcorn, sweet corn, melon, pepper, winter squash, tomato, watermelon (16)
Avram Drucker	M, USA/Oregon, rs	Garlic (5)
Dwarf Tomato Project ³	Australia	Dwarf tomato (110)
Nicholas Fevelo	M, USA/New York	Flint corn (1)
Heike-Marie Eubanks	F, USA/Oregon	Brussels sprouts (1)
Edmund Frost	M, USA/Virginia, rs, ws , f	Winter squash (2)
Owen Glyn-Smith	M, UK	Oca (8)
Mathew Goldfarb ²	M, USA/New York, rs , ws	Carrot (1)
Mike Hessel	M, USA/Oregon, f	Squash (1)
Hank Keogh	M, USA/Oregon, ws	Kale (1)
Nate Kleinman	M, USA/New Jersey, rs	Turnip greens (1)
Craig LeHoullier ³	M, USA/North Carolina	Dwarf tomato, standard tomato (114)
Joseph Lofthouse	M, USA/Utah, f	Bean, mixed-type corn, sweet corn, cucumber, Jerusalem artichoke, melon, okra, winter squash, tomato (11)
Frank Morton	M, USA/Oregon, rs, ws	Amaranth, basil, broccoli, calendula, celery, chicory, cress, epazote, fennel, kale, leek, lettuce, mustard, orach, pepper, poppy, quinoa, winter squash, strawberry spinach, Swiss chard, tomato, turnip (189)
Gregg Müller	M, AUS, rs	Pea (snow/snap) (2)
Patrina Nuske-Small ³	F, AUS/New South Wales	Dwarf tomato (with Dwarf Tomato Project) (110)

Table 5.2. (Continued)

Breeder	Gender, location, and livelihood	Crops released (total number of varieties)
Petra Page-Mann ²	F, USA/NY, rs , ws	Carrot (1)
David Podoll	M, USA/ND, rs , ws, f	Bean, beet, popcorn, melon, onion, winter squash, tomato, watermelon (8)
Beth Rasgorshok	F, USA/Idaho, ws	Leek (1)
Relentless	M, USA/Pennsylvania, ws	Parsnip, pepper, winter squash, tomato (4)
Tevis Robertson-Goldberg	M, USA/Massachusetts, ws	Tomato (3)
Rowan	F, AUS, f	Garlic, summer squash (2)
Loretta Sandoval ¹	F, USA/New Mexico	Pepper (1)
Jonathan Spero	M, USA/Oregon, ws	Broccoli, sweet corn, kale, lettuce (8)
Andrew Still	M, USA/Oregon, rs , ws	Dent corn, sweet corn, 3 kale, lettuce, melon, mustard, pepper, winter squash, tomatillo, tomato, turnip (15)
Mel Sylvestre	F, CA/British Columbia, ws	Leek, tomatillo (2)
Don Tipping	M, USA/Oregon, rs , ws	Flour corn, popcorn, kale, lettuce, mustard, radish, spinach, winter squash, sunflower, Swiss chard (11)
Bill Whitson	M, USA/Washington, rs	Jerusalem artichoke, mashua, oca, potato, ulluco, yacon (16)

rs = Owns a retail seed company

ws = wholesale seed grower

f = farmer; also sells produce other than seeds

Bold indicates the primary activity where the breeder engages in more than one.

Crops listed without a number mean that the breeder bred just one variety of that crop.

¹ Sandoval and Campbell were co-breeders on their pepper.

² Petra Page-Mann and Mathew Goldfarb were co-breeders on their carrot.

³ Patrina Nuske-Small and Craig LeHoullier are co-directors of the Dwarf Tomato Project that involves more than 200 gardeners in Canada, USA, Australia, and New Zealand.

Northwest with its irregular landscape has a high proportion of small farms in general, as well as one-family organic farms—exactly the sorts of operations most associated with freelance plant breeding. Corvallis and nearby areas of Linn and Benton counties, in Oregon, are an especial hotbed of freelance plant breeding. There are five OSSSI-associated freelance breeders here, myself included, and two more non-OSSSI-associated breeders. This is partly because it's prime agricultural land and ideal land for seed production, but also because of the presence of Oregon State University. The other freelance plant



Fig. 5.1. Carol Deppe harvesting an Eat-All patch of leaf radish greens. She harvests by clear-cutting 15 cm above ground with a serrated bread knife. She keeps the greens oriented while harvesting to save prep time later. In the kitchen, she runs a knife over bunches of greens perpendicular to the stem at 2.5 cm intervals, then drops the greens into boiling water and cooks for about two minutes. She removes the greens by pouring the water through a strainer into another pot to catch greens, reserving the water. Then she eats some and spreads the rest out on a baking sheet so they cool quickly and don't continue cooking and overcook. The cutting in the field and kitchen could be done by machine on a commercial scale. Carol doesn't wash the greens; they come out of the field clean. After the greens and cooking water have cooled, the greens are packed into plastic freezer containers, covered with cooking water, and frozen for use in winter. Photo credit: Carol Deppe/Fertile Valley Seeds.

breeders are sprinkled throughout the United States, with no large concentrations in any one area.

IV. HOW FREELANCERS LEARN THE PLANT BREEDING TRADE

In 1990, when I first started writing about and for freelance plant breeders, there was little available for freelancers to learn from other than the textbooks used in university plant breeding courses. These books usually focus on theory, and seem to have played little or no role in attracting or training freelance plant breeders except for myself. Occasional freelancers drew practical guidance from the journals of Luther Burbank (Burbank 1914). And some remembered from high school biology that there was a guy called Mendel, and he did something



Fig. 5.2. Freelance plant breeders Andrew Still, Joseph Lofthouse, Frank Morton, Patrina Nuske-Small, David Podoll, and Jonathan Spero.

Andrew Still. Photo credit: Adaptive Seeds.

Joseph Lofthouse. Photo credit: Joseph Lofthouse.

Frank Morton. Photo credit: Karen Morton/Wild Garden Seed.

Patrina Nuske-Small. Photo credit: Patrina Nuske-Small.

David Podoll. Photo credit: Prairie Road Organic Seed.

Jonathan Spero. Photo credit: Jonathan Spero.

with tall and short peas. But that was about all. Many freelance plant breeders in that era got inspired because an accidental cross or off-type showed up in their garden. And most seem to have got the beginnings of their plant breeding education from the plants themselves.

This role of the plants themselves as teachers is particularly facilitated when the plant breeder is working with a largely inbreeding crop that outcrosses just often enough to create the occasional inspiring cross. This is how Frank Morton (Wild Garden Seed, Philomath, Oregon) got his start as a freelance plant breeder (Morton 2014) (See Figure 5.2). He was earning his living growing and selling baby-leaf salad greens mixes at the time. And he started saving seeds, since he needed a lot of seed of many species, shapes, textures, flavors, and colors. One day, a reddish lettuce seedling turned up when he planted seed from a patch of green plants. It was clear what had happened. The patch of green lettuce had been adjacent to a patch of red lettuce the year before. The off-type red seedling was obviously a hybrid. Morton saved the seed. And he was on his way.

Each hybrid segregated out into multiple types. Morton would choose his favorites and save seed from them. So propagated, each hybrid of a mostly inbreeding crop sorts itself out, ultimately, into new pure-breeding lines, with nothing needed beyond choosing your favorites each year and saving their seed—and rogueing out the occasional outcross, or starting a separate project with it. Soon Morton was making deliberate hybrids by planting the desired parent plants side by side. The ultimate result, after a number of years, was the baby-leaf salad greens business got dropped, and Morton was a full-time plant breeder, seed-grower, and seed company.

These days, I'd guess roughly 75% of the freelancers active now got their start or at least some education along the way from my book *Breed Your Own Vegetable Varieties*, first published in 1993, with a second edition in 2000 (Deppe 2000). The other book of that era most often mentioned as inspiring freelance plant breeders is *Return to Resistance*, by Raoul A. Robinson, a Canadian plant pathologist and plant breeder (Robinson 1996). A more recent book that is also especially useful is *Breeding Organic Vegetables* by Rowan White and Bryan Connolly (White and Connolly 2011). In addition, *Breeding Ornamental Plants*, by Dorothy J. Callaway and M. Brett Callaway (Callaway and Callaway 2000), and *Plant Breeding for the Home Gardener*, by J. Tychonievich (Tychonievich 2013) have joined the ranks of books designed specifically for and useful to freelance plant breeders. In addition, I also published *The Resilient Gardener* (2010) and *The Tao of Vegetable Gardening* (2015), which are more general gardening books that also contain considerable plant breeding.

Some freelancers operate at a relatively casual level of information with respect to genetics in general and familiarity with what university and major seed company breeders are doing with their crops. Others learn serious amounts of genetics and read academic papers and review

articles on breeding the crops of their choice. Some freelance plant breeders know the major university breeders of the crops they are most interested in and don't hesitate to go to them with specific questions or attend their field days.

Certain seed catalogs, most especially those of Frank Morton (Wild Garden Seed), Andrew Still (Adaptive Seeds, Sweet Home, Oregon), Bill Whitson (Cultivariable, Moclips, Washington), and my own Fertile Valley Seeds (Corvallis, Oregon) have and are playing major roles in enticing people into freelance plant breeding and aiding and abetting their efforts by including information about the parents of cultivars they sell as well as providing mixtures of germplasm segregating from named crosses. These materials allow a would-be breeder to jump into a project that already has a goal, with the parents of the cross chosen, the cross made, and the first few years of selection done. Such catalogs also encourage freelance plant breeding by spreading the "idea of plant breeding" and making it seem a normal thing that every adventurous gardener or farmer should do. In addition, some freelance plant breeders include essays in their seed catalogs about issues related to seed rights or plant breeding.

Alan Kapuler played an especially large role in inspiring many farmers and gardeners in the Northwest and beyond to rejoice in agricultural biodiversity and to do some of their own plant breeding. Many freelance plant breeders today, myself included, studied his seed catalogs, visited his gardens, and received useful advice about everything from growing particular crops to starting a small seed company.

The Open Source Seed Initiative sponsors a series of podcasts by OSSI-associated plant breeders, each giving a detailed account of how the breeder bred some particular variety—everything from the design of the project, how to make the crosses, methods of selection, etc. This series, which just completed its third season and twelfth podcast, is hosted by Rachel Hultengren, who herself has an MS in plant breeding from Cornell (<https://osseeds.org/category/free-the-seed-podcast/>).

Most freelance plant breeders are organic farmers or gardeners, and the Organic Seed Alliance (OSA) is playing an increasingly important role in encouraging and educating both seed growers and freelance plant breeders. John Navazio and Mathew Dillon, co-founders of OSA, are often mentioned as OSA people whose workshops and advice have been helpful to freelance plant breeders. (Navazio is now a plant breeder for Johnny's Selected Seeds, Albion, Maine; Dillon is now with Clif Bar, Emeryville, California.)

The OSA-sponsored Organic Seed Growers Conference, held every two or three years in Corvallis, Oregon, attracts seed growers, freelance

plant breeders, university breeders interested in organics, and seed company breeders and representatives from across the nation and world. In addition to workshops aimed at teaching seed production and plant breeding, there are seminars where university as well as freelance plant breeders present their work. These conferences allow university and freelance breeders to meet and get to know each other personally, resulting in greater interaction between the two groups and genuine collaborations.

These days, internet forums for freelance plant breeding play a major role in introducing gardeners and farmers to the idea that they can breed plants. So do Facebook groups dedicated to plant breeding. Such forums and groups give the new would-be freelance plant breeder sources of ideas and allow them to interact with others more advanced and willing to help by answering questions and providing feedback. Freelancers use such forums and groups not just to teach and help each other but to collaborate in various ways. A limitation of such forums is that they are usually controlled by people or organizations not primarily interested in plant breeding. The result is that the plant breeding forums have a tendency to operate for a few years, then disappear without notice, taking tremendous amounts of useful information with them. This is such a problem that Open Source Seed Initiative has started a plant breeder's forum specifically for freelance plant breeders and providing a permanent home for their interactions. (See <http://opensourceplantbreeding.org/forum/>.) All plant breeders, freelancers or not, are welcome. Nor is there a requirement that participants release their varieties in any particular way. A university plant breeder interested in freelance collaborators should drop by this forum, tell the members a little about the project, and issue an invitation to collaborate.

Homegrown Goodness (<http://alanbishop.proboards.com>) had very active plant breeding forums for a number of years. These seemed to wind down a few years ago, and most of their members have moved to the OSSI plant-breeding forum. Homegrown Goodness still has lots of useful archives, however. For permaculture-interested freelance plant breeders, there is <https://permies.com/f/234/seed>. Facebook groups are typically dedicated to the breeding of a particular crop. Just look up the crop you are interested in. Examples are the Kenosha Potato Project (www.facebook.com/groups/KenoshaPotatoProject/) and True Garlic Seed Growers of New Zealand (www.facebook.com/groups/1495484050715162/).

Cornell University has been explicitly involved in training freelance plant breeders. Cornell involvement with freelancers began when the

late Larry Robertson, then geneticist and vegetable curator at the USDA-ARS Plant Genetic Resources Unit (PGRU) in Geneva, New York, contacted Molly Jahn, then vegetable breeder at Cornell, about organic vegetable growers whose preferred hybrids were being lost as the seed industry consolidated. Jahn then started the Public Seed Initiative, succeeded by the Organic Seed Partnership, to train farmers to be freelance plant breeders. Michael Mazourek, current vegetable breeder at Cornell, tells me his primary reason for being at Cornell is to continue Jahn's legacy (Mazourek 2019).

Mazourek has indeed built on and expanded Jahn's legacy. He now effectively runs an apprenticeship program for freelance plant breeders as part of his university plant breeding program. This started when he began working with Annie Richard, a farmer in Canada. She met Mazourek at an ecological farming conference in Canada, and asked him about breeding peppers. She wanted red peppers better adapted to Ontario. Mazourek began advising via email, then suggested she come work for him for a season and learn the plant breeding trade. He normally hired seasonal help locally. That season he hired Richard instead. He soon realized Richard was his first freelance plant breeding apprentice, and was herself a teacher of others. Richard went on to found Kitchen Table Seed House, and to start breeding peppers with germplasm from a cross from Mazourek's operation that was suitable for the purpose (Richard 2019). Mazourek has trained two other freelance breeders subsequently, in each case by hiring them for a "year-long deep dive into experiencing a year of breeding projects at the university with access to courses."

Mazourek also works less formally with a number of established freelance plant breeders. He has been a major source of advice for Edmund Frost, for example, on his work on downy mildew resistance in cucurbits for the South (Frost 2019).

Mazourek points out that it is critical to know the freelancer's goals in setting up the collaboration. It's important to establish the intellectual property parameters at the beginning. Some freelancers want to end up with varieties free of any claims from Cornell. Others don't mind a claim from Cornell. Which situation applies shapes exactly what Mazourek can do. If the freelancer wants varieties independent from Cornell, Mazourek can suggest crosses and strategies, and even make initial crosses for the freelancer and provide segregating populations of seed. If the project is to be shared with Cornell, Mazourek can go farther, and do or host subsequent selections. With one apprentice in this latter situation, Mazourek and the apprentice will soon be releasing varieties together as co-breeders.

It's quite possible that Mazourek's pattern of training freelance breeders through apprenticeships funded by ordinary seasonal labor budgets could be adopted by other university plant breeders. Richard pointed out that the fact that her apprenticeship was a paid job was critical. Few would-be freelance plant breeders can afford to volunteer without pay for a season.

V. WHY—MOTIVATIONS AND VALUES

A. Breeding for Organic Systems

Nearly all freelance plant breeders are organic farmers or gardeners and do all their breeding in the context of organic systems. A few are biodynamic farmers or biodynamic and organic. When I began writing about and doing freelance plant breeding, there were not, to my knowledge, any university or corporate plant breeders breeding for organics. Now there are a number of university breeders with at least part of their programs based on breeding for organic systems. There is also some corporate breeding for organics. But by far the largest number of open-pollinated organic-adapted varieties have been bred by freelance plant breeders. This is partly because freelancers normally do all their breeding, not just part of it, in the context of organic systems. In addition, we have been breeding for organics 20 years or more longer. The OSSI database on OSSI-Pledged varieties (<https://osseeds.org/seeds/>) shows that 420 of the 487 OSSI-Pledged varieties were bred in the context of organic systems.

B. Local Adaptation

Local adaptation is high on the list of values for freelance plant breeders. Local adaptation to specific regions is one of those niches that usually doesn't work for university breeders, big seed companies, or any entity that is going to try to profit from plant breeding by using IP. Only if the crop is a major commercial crop in the area is the market for locally adapted cultivars likely to be large enough to cover the cost of the breeding and IP and still make a profit. Small seed companies run by freelance plant breeders are usually operating at a small enough scale so that they can do very well with locally adapted varieties. Many gardeners and farmers are eager to trial cultivars bred by freelance plant breeders in their region and discover ones that perform unusually well. Such people are strong supporters of the freelance breeders' seed companies and offerings. In addition, there is a movement of "locavore"

orientation in food that goes together with local pride and support of local products, farmers markets, and local cuisine. Supporting local plant breeders and buying and using and taking pride in their varieties is part of that larger local-first movement.

Most large seed company and university breeders have their prospective cultivars evaluated in multiple regions, in multiple areas of their state, or on multiple types of soils. Few freelance plant breeders do this. One reason is because it is unnecessary, since our small-scale direct-sale operations can do well breeding and releasing locally adapted cultivars. In addition, we usually produce just one line of a new cultivar, which we then release, not several lines, which we must evaluate to decide which to release. If my new cultivar produces well and tastes great grown on my own soil in my own region, that is all I require. I'll release the variety. After release, customers from across the country try the cultivar. Some give feedback about it. In other cases, the cultivar proves that it is adapted to other areas as well as my own by the fact that people in those regions continue buying it. In addition, seed companies in other regions, especially OSS-partner seed companies, are likely to trial my cultivars, and if they work in their regions, contact me about buying wholesale, or asking for references to wholesale growers for the cultivar. I'm always pleased when a variety of mine turns out to be widely adapted. But some are and some aren't. I breed for *local* adaptation. Anything more is a pleasant surprise. That is the norm for freelance breeders.

The small seed companies that are the mainstay of survival for so many freelance plant breeders tend to have customers who are highly adventurous gardeners and farmers. Many will be within their local regions. But many are from throughout the country or the world, and represent explorers searching to find new varieties for their own regions.

C. Agricultural Biodiversity

Most freelance breeders care passionately about agricultural biodiversity. So we are likely to work not just on the major crops but on all sorts of minor crops grown in our regions. Bill Whitson (Cultivariable, Moclips, Washington), for example, has an extensive breeding program focused on potatoes and perennial vegetables such as Jerusalem artichoke and the Andean root crops oca, mashua, ulluco, and yacon.

Freelancers often also work with wild edible fruits and vegetables in their regions. Joseph Lofthouse, on his Utah mountain farm, is working on domesticating four species of cactus for better edible fruits. Alan Kapuler is working on domesticating camas, wapato, and all the wild vegetables of the maritime Northwest.

Freelancers also often “redomesticate” escaped domesticates that have been feral for a while, and gained vigor but lost food value or controllability thereby. Nate Kleinman (Experimental Farm Network) and his co-breeders, for example, reselected a common weed on their New Jersey farm into ‘Dietrich’s Wild Broccoli Raab’ for better use as turnip greens. Alan Kapuler redomesticated a feral *Chenopodium giganteum* into the variety ‘Magentaspreen’, which is now widely used as a salad plant as well as sprouting seed for microgreens.

D. Freelance Plant Breeders and Intellectual Property

Most freelance plant breeders draw part of their motivation for plant breeding from a deeply held belief that the rights of farmers, gardeners, and others to grow seeds, sell them, and breed from them should not be infringed. I’m one of them. I believe that the resilience of farms, farmers, agricultural regions, and all humanity is best served when farmers and gardeners are free to save seed for replanting, stockpile seed, exchange seed, sell seed, breed from seed, and adapt it to their local regions. Most practicing freelance plant breeders believe likewise. Some take the even stronger stand that “patenting life” is immoral. Freelancers frequently write on seed sovereignty in their seed company catalogs and elsewhere, and speak on the issue in interviews (Morton 2013a, Morton 2013b, Dunton 2016, Still 2018, Still 2018, Frost 2019). Particular resentment is inspired by the fact that corporations are now patenting preexisting traits—that is “inventions” that they did not invent at all or that are trivial or obvious to any practitioner in the field. “Holy Crap! You can patent that!?” is the subtitle in one of Morton’s essays (Morton 2013a). Nearly all freelance breeders release their varieties as public domain or as OSSI-Pledged varieties.

The gardeners and farmers who are buying seed from small seed companies run by freelance breeders *do so specifically in part to obtain open pollinated varieties that are free of patents or PVPs*. This is so much the case that I know of no seed company run by a freelance plant breeder that sells any hybrids of seed-propagated crops *at all*, or any PVP or patented cultivars. Our customers are willing to pay the considerably higher prices charged as well as suffer the inconvenience of dealing with small specialist seed companies that can fill only part of their seed needs. Some of the customers do save seeds, so they buy a cultivar from us only once. More often, they mix seed saving with occasional reordering. And some buy all their seed. They simply want cultivars to which they have full rights and which they could save if they wanted to. But seed production is hard work, so usually they don’t.

They want seed that is theoretically savable—open-pollinated and legal to save—even though they usually don't save it. So the fact that we sell all our cultivars without using hybrids or IP is less of a disadvantage than one would think, and is essential to appealing to our market.

While many large seed companies do a lot of breeding for the purpose of creating proprietary positions for themselves through hybrids, we freelance breeders frequently do the opposite. Most hybrids show no advantages over the best equivalent open-pollinated variety. Where any hybrid actually does show serious advantages over the best equivalent open pollinated variety, we may undertake to dehybridize it. It is, of course, not always possible to develop an open pollinated variety very similar to the original hybrid. But usually it is. And where it isn't, we often end up with something we like just as well or better than the original hybrid, though it might be quite different. Dehybridizing commercial hybrids is a common freelance plant breeding project. So is using a suitable commercial hybrid in a cross with a beloved open pollinated cultivar so as to upgrade its resistance to modern diseases or acquire other useful modern traits while maintaining the traditional cultivar's superior flavor, vigor in organic systems, or other advantages.

VI. CROPS

There is no official record of freelance-bred crop varieties, but in recent years the Open Source Seed Initiative has been the de facto registry for a number of freelance-bred varieties. Table 5.3 lists the number of varieties of various crops that have been developed by the 35 OSSI-associated freelance breeders (see Figure 5.3 for photos of a number of OSSI-Pledged varieties.). Table 5.1 fills this picture out with additional information on 28 freelance breeders, 17 OSSI-associated and 11 not, and their best-known varieties. The numbers of breeders who have released varieties of given crops (Table 5.3) is a much better indication of interest among freelancers than total number of varieties of each crop released (Table 5.2). The total number of varieties released of various crops is much more affected by individual breeders with large specializations in certain crops and the small sample size.

The most obvious conclusion is that freelance plant breeders love tomatoes. Eleven of the 35 OSSI-associated freelancers breed tomatoes. In addition, in most cases where a breeder focuses entirely on a single crop, it is tomatoes. Squash is a close second with 10 breeders, 9 of whom breed winter squash only. Peppers, corn, and kale are next with 8, 8, and 7 breeders, respectively. Melons and lettuce are next,

Table 5.3. Crops bred by 35 OSSI-associated freelance plant breeders.

Crop	Number of varieties	Number of breeders	Name of breeder(s)
Amaranth	1	1	Morton
Asparagus ¹	1	1	Burr
Basil	1	1	Morton
Beans, all	10	4	Berblinger, Deppe, Lofthouse, Podoll
Chickpea ²	1	1	Deppe
Common bean	7	3	Berblinger, Deppe, Lofthouse
Cowpea	1	1	Deppe
Phaseolus	1	1	Podoll
Interspecific cross ³			
Beet	1	1	Podoll
Broccoli	2	2	Morton, Spero
Brussels sprouts	1	1	Eubanks
Calendula	10	1	Morton
Carrot	1	1	Page-Mann and Goldfarb
Celery	2	2	Morton
Chicory	2	1	Morton
Corn, all	29	8	Deppe, Drowns, Fevelo, Lofthouse, Podoll, Spero, Still, Tipping
Corn, dent	1	1	Still
Corn, flint	6	3	Deppe, Drowns, Fevelo
Corn, flour	7	2	Deppe, Tipping
Corn, mixed	1	1	Lofthouse
Corn, pop	6	3	Drowns, Podoll, Tipping
Corn, sweet	8	5	Drowns, Lofthouse, Spero, Still, Tipping
Cress	1	1	Morton
Cucumber	1	1	Lofthouse
Epazote	1	1	Morton
Fennel	1	1	Morton
Garlic	6	2	Drucker, Rowan
Jerusalem Artichoke	2	2	Lofthouse, Whitson
Kale, all	17	7	Burr, Deppe, Keogh, Morton, Spero, Still, Tipping
<i>Brassica napus</i>	12	5	Burr, Deppe, Morton, Spero, Still
<i>Brassica oleracea</i>	5	4	Keogh, Morton, Still, Tipping
Kale Sprouts ⁴	1	1	Catzel
Leek	5	3	Morton, Rasgorshek, Sylvestre
Lettuce ⁵	104	4	Burr, Morton, Spero, Still
Mashua	3	1	Whitson
Melon	5	5	Deppe, Drowns, Podoll, Lofthouse, Still
Mustard, all	22	3	Morton, Still, Tipping
<i>Brassica juncea</i>	10	1	Morton
<i>Brassica rapa</i>	12	3	Morton, Still, Tipping
Oca	12	2	Glyn-Smith, Whitson
Okra	1	1	Lofthouse
Onion	1	1	Podoll
Orach	4	1	Morton
Parsnip	1	1	Relentless

Table 5.3. (Continued)

Crop	Number of varieties	Number of breeders	Name of breeder(s)
Pepper	29	8	Bailey, Berlinger, Drowns, Morton, Relentless, Sandoval & M. Campbell, Still
Poppy	3	1	Morton
Potato	2	1	Whitson
Quinoa	14	2	Deppe, Morton
Radish	1	1	Tipping
Pea, Snow/Snap	2	1	Muller
Spinach	2	2	Campbell, Tipping
Squash, summer	2	2	Deppe, Rowan
Squash, winter, all	16	9	Deppe, Drowns, Hessel, Morton, Podoll, Lofthouse, Relentless, Still, Tipping
<i>Cucurbita pepo</i>	3	3	Deppe, Hessel, Morton
<i>Cucurbita maxima</i>	9	6	Deppe, Drowns, Podoll, Lofthouse, Relentless, Tipping
<i>Cucurbita moschata</i>	4	4	Deppe, Frost, Lofthouse, Still
Strawberry spinach ⁶	1	1	Morton
Sunflower	1	1	Tipping
Swiss chard	2	2	Morton, Tipping
Tomatillo	2	2	Still, Sylvestre
Tomato, dwarf ⁷	110	1	Dwarf Tomato Project ⁸ (Co-directors: Nuske-Small & LeHoullier)
Tomato, non-dwarf	21	10	Burr, Drowns, Lehoullier, Lofthouse, Morton, Podoll, Relentless, Robertson-Goldberg, Still, Tipping
Turnip	2	2	Morton, Still
Turnip greens	1	1	Kleinman
Ulluco	5	1	Whitson
Watermelon	2	2	Drowns, Podoll
Watermelon seed	1	1	Asmus
Yacon	1	1	Whitson

¹ seed propagated² chickpea version of popbean³ Derived from spontaneous cross of *P. vulgaris* X *P. coccineus*.⁴ *B. oleracea*; developed from a cross of Brussels sprouts and kale; green and white sprouting baby heads in place of the small buds typical of Brussels sprouts.⁵ 99 of the 104 lettuce varieties were bred by Frank Morton, for whom leafy greens, especially lettuce, is his major focus.⁶ *Chenopodium capitatum*⁷ Tomato varieties homozygous for *dwarf*, *dd*.⁸ The Dwarf Tomato Project is a collaboration of more than 200 gardeners in Australia, Canada, USA, and New Zealand dedicated to developing and expanding a new class of compact tomatoes with heirloom colors and flavors based on the *dwarf* gene *d* rather than standard genes causing determinate form. Dwarf tomatoes are indeterminate; they are compact via shorter internodes. They have distinctive rugose foliage. It is thought that dwarf tomato varieties can develop full heirloom quality flavor on compact plants. The Dwarf Tomato Project is led by two co-directors, Australian gardener Patrina Nuske-House, and USA gardener Craig LeHoullier.



Fig. 5.3. Twenty-seven cultivars developed and released by freelance plant breeders.

'Hannan Popbean' chickpea. Breeder: Carol Deppe; photo credit: Carol Deppe/Fertile Valley Seeds.

'Magic Manna' flour corn. Breeder: Carol Deppe; photo credit: Carol Deppe/Fertile Valley Seeds.

'Cascade Ruby-Gold Flint' corn. Breeder: Carol Deppe; photo credit: Carol Deppe/Fertile Valley Seeds.

'Goldini' squash. Breeder: Carol Deppe; photo credit: Carol Deppe/Fertile Valley Seeds.

'Candystick Delicata' squash. Breeder: Carol Deppe; photo credit: Carol Deppe/Fertile Valley Seeds.



Fig. 5.3. (Continued)

'Melaton' leek. Breeder: Mel Sylvestre; photo credit: Hannah Lewis.

'Hyper Red Ruffled Waved' lettuce. Breeder: Frank Morton; photo credit: Karen Morton/Wild Garden Seed.

'Joker' lettuce. Breeder: Frank Morton; photo credit: Karen Morton/Wild Garden Seed.

'Oro del Valle' quinoa. Breeder: Frank Morton; photo credit: Karen Morton/Wild Garden Seed.

'Sticky Red Roaster' pepper. Breeder: Frank Morton; photo credit: Karen Morton/Wild Garden Seed.

'Red Ursa' kale. Breeder: Frank Morton; photo credit: Karen Morton/Wild Garden Seed.

'Jupiter' snow pea. Breeder: Gregg Muller; photo credit: Gregg Muller/Useful Seeds.

'Dulcinea' carrot. Breeders: Petra Page-Mann and Matthew Goldfarb; photo credit: Lisa Barker/Fruition Seeds.

'Sweet Dakota Bliss' beet. Breeder: David Podoll; photo credit: Prairie Road Organic Seed.

'Uncle David's Dakota Dessert' squash. Breeder: David Podoll; photo credit: Prairie Road Organic Seed.

'Solstice Broccoli.' Breeder: Jonathan Spero; photo credit: Jonathan Spero/Lupine Hill Farm.

'Festivity' sugary-enhanced sweet corn. Breeder: Jonathan Spero; photo credit: Jonathan Spero/Lupine Hill Farm.

'Tuxana' sugary-enhanced sweet corn. Breeder: Jonathan Spero; photo credit: Jonathan Spero/Lupine Hill Farm.

'Early Butternut Remix' squash. Breeder: Andrew Still; photo credit: Adaptive Seeds.

Fig. 5.3. (Continued)

'Farthest North Galia' melon. Breeder: Andrew Still; photo credit: Adaptive Seeds.

'Santiam Sunrise' tomato. Breeder: Andrew Still; photo credit: Adaptive Seeds.

'Purple Striped' tomatillo. Breeder: Mel Sylvestre; photo credit: Hannah Lewis.

'Mocrocks' oca. Breeder: Bill Whitson; photo credit: Cultivariable.

'Copalis' mashua. Breeder: Bill Whitson; photo credit: Cultivariable.

'Loowit' potato. Breeder: Bill Whitson; photo credit: Cultivariable.

'Oyehut' Jerusalem artichoke. Breeder: Bill Whitson; photo credit: Cultivariable.

'Queets' ulluco. Breeder: Bill Whitson; photo credit: Cultivariable.

with 5 and 4 breeders, respectively. All other crops are being bred by 3 breeders or less.

I make no arguments as to the statistical significance of the differences among the more popular crops. In a different sample of freelancers, one might get a different order of interests. But I think you would still see more interest in tomatoes, peppers, corn, and winter squash than most other crops. This group of breeders do breed grains, but more often corn, grain legumes, and quinoa than wheat, oats, or rye. Some breed a few flowers along with their vegetables. In this group of freelancers, none have released any fruits, nuts, or berry varieties. But Chris Homanic is in the process of OSSI-Pledging an apple variety, and Lofthouse is close to releasing some walnuts and apricots.

It's interesting to compare this list of relative interests in various crops with the relative interests of seed savers. Seed Savers Exchange is by far the largest organization of seed savers in North America. It publishes an annual yearbook listing varieties available through its membership network. The listings are almost exclusively varieties not available commercially and exclusively material being grown and distributed by the members. (The SSE Store is a separate operation.) The number of pages of listings of different classes of crops can be taken as a proxy for level of interest in the crop among those who want more or different varieties than are available commercially. In the most recent edition, *The Exchange 2019*, there are 130 pages of listings for tomatoes, 57 for common bean, 39 for potatoes, 24 for peppers, 23 for fruits, nuts, and berries, 13 for flowers, 12 for lettuce, 11 for winter squash, 11 for corn, 5 for melons, 3 for kale, and 2 or less for everything else. Seed savers, like the OSSI-breeders, are highly interested in tomatoes and peppers. Seed savers appear to be more interested in common beans, potatoes, and fruit/nut/berries than OSSI freelance breeders.

OSSI freelancers appear to be more interested in winter squash, corn, and kale than seed savers are. The OSSI freelancers also show more interest in less popular or rare crops than the seed savers. At a guess, I think the OSSI breeders' choices of breeding projects are being influenced partly by what they like to eat, but also by the difficulty of breeding the particular crops, the perceived possibility of making a significant contribution, and an apparent extra interest in staple crops such as corn and

winter squash. Trees take more land and years per generation. There are many good varieties of common bean, both dry beans and snap beans, available. Potatoes are problematic because it's almost impossible to keep the clonally propagated material adequately free of viruses and disease in most regions. That means even if you breed one, you probably won't be able to sell it for long; and you certainly can't sell it mail-order without phytosanitary certificates, which aren't needed for selling seed.

I think there is actually a lot of freelance potato breeding happening, however, with most of the material exchanged as true seed (from seedballs and meiosis) rather than as clones. In addition, I think there is more freelance breeding of fruits, nuts, and berries than the OSSI list suggests, with the freelance breeding in those areas not fitting ordinary commercial patterns as well, thus being less visible. (There are two freelance breeders of tree crops included among the non-OSSI-associated breeders in Table 5.1.)

The number of kale breeders among the OSSI freelance breeders is higher than one would expect from the amount of seed saving that is going on with kale. I believe the level of interest in kale among OSSI breeders reflects the fact that so many of the freelance breeders are located in the maritime Northwest. Kale is very popular in the maritime Northwest. Kale of the right varieties overwinters in our region and produces abundant harvests of prime greens that taste excellent from fall through spring. There is a need for locally adapted varieties, because overwintering the kale is essential, and can be improved with simple survival-of-the-fittest style selection in most varieties. All seven of the OSSI-associated freelance plant breeders breeding kale are located in the maritime Northwest. When we freelancers from the maritime Northwest visit other regions and eat their kale, we are usually surprised at how bad it is by our standards, even when it's the same varieties. If kale grown in the maritime Northwest tasted like that, we probably wouldn't be breeding it, either.

Many freelance plant breeders specialize. Some start with a strong specialization and add other crops as they go. Some remain focused on one or two crops. Or on particular types of crops. Patrina Nuske-Small breeds only tomatoes. Tom Wagner breeds only tomatoes and potatoes. Robert Lobitz bred only beans. Bill Whitson's specialty is perennial vegetables, especially Andean root crops and potatoes. Frank Morton started primarily breeding lettuces and other greens for his baby-leaf salad greens business, and added other crops from there after the salad business was replaced by a seed company business. My own specialty is staples—corn, grain legumes, and winter squash. I needed really delicious staples because I have celiac disease, and can't eat most of the staples in the stores. I needed staples that were so delicious that I didn't care that I couldn't eat wheat. Once I had bred enough staples to satisfy my own needs, I started expanding to additional crops.

Freelance breeders of dry corn usually breed cultivars intended for use in making richly flavorful whole-grain polenta, cornbread, corn

cakes, and gravy for gourmet people-food, not dent corns bred for the highest possible yield for animal feed or use in processed food. Flavor and excellence for specific uses are the major breeding objectives rather than yield. Poppcorns and sweet corns are also popular, including sugary-enhanced and super-sweet varieties. Among the dry corns, red-pericarp types are very popular. Those of us who grow dry corn to eat ourselves or sell to others who also plan to eat the stuff themselves generally want red-pericarp flint and flour corns or white-endosperm corns, not yellow dents.

Freelance plant breeders of cross-pollinating species who sell seed have a tendency to be forced to diversify with time because of isolation problems. By the time I have one or two varieties of each of the three major species of squash, for example, it's increasingly difficult to add more breeding projects involving those species without interfering with my ability to grow, sell seed of, and eat the varieties I've already bred. In addition, if you are earning your income in part by selling seed, too many varieties of one sort are a two-edged sword. For example, the fact that I have five unique flour corns draws potential customers who are interested in flour corns. But they don't usually buy more than one or two varieties, however many I have. The varieties compete with each other. So breeding more at this point would not add to my sales at all.

VII. GOALS

Flavor is a high priority for freelance plant breeders. For most commercial vegetable breeders, yield, shipping ability, storing ability, shelf life, and appearance are usually higher priorities than flavor. This is reasonable, as it doesn't matter what a commercial cultivar would have tasted like in its prime if it arrives in the supermarket as rotten mush. When freelance plant breeders try to improve commercial cultivars, we have to meet these same hard standards. But freelance plant breeders often aim first and foremost for better flavor. If this means the cultivar is only suitable for local markets, so be it. In fact, cultivars need not be suitable even for local markets if the breeder and a reasonable number of home gardeners love the flavor. Gardeners may need no more handling ability from a cultivar than what it takes to get the produce from the garden to the kitchen. A freelance breeder operating a small seed company can do well with a variety that is just for home gardeners. Many home gardeners as well as freelance plant breeders got their start partly as a rebellion against generic vegetables with suboptimal flavor.

Disease resistance is often a priority for freelance plant breeders. Plant diseases frequently limit the use of particular crops in certain areas, or destroy yield or quality toward the end of the season. Wherever a crop's yield or quality is limited by diseases and there is genetic variability for resistance available within the cultivar, freelancer breeders as well as seed savers are likely to be breeding for resistance simply by saving seed from the less affected plants. Freelance plant breeders often also screen germplasm extensively for suitable sources of resistance, make crosses from among the most resistant varieties, or transfer resistance from wild relatives of crop species.

Some freelancers focus explicitly on particular diseases. Frank Morton (Wild Garden Seed) has major projects going involving selecting lettuce for downy mildew resistance in maritime Oregon and has released a number of cultivars with good downy mildew resistance. Edmund Frost (Commonwealth Seed Growers, Buchanan, Virginia) specializes in breeding cucurbits for downy mildew resistance in Virginia, and has released 'South Anna Butternut,' a downy mildew-resistant butternut. I've developed powdery mildew resistance in 'Goldini Zucchini II' that doesn't involve any known commercial sources of powdery mildew resistance in the parentage.

Freelance plant breeders often breed for earliness, cool/cold tolerance, or winter-hardiness, especially in areas with low summer heat or short seasons. Elmer Swenson bred table grapes for cold-hardiness combined with good flavor; his germplasm became the basis of the commercial table and wine grape industries in the upper Midwest and other areas that had been too frigid to grow grapes before his work. My cowpea variety 'Fast Lady Northern Southern Pea' was developed simply by selecting from a single individual plant that was a bit more determinate and about two weeks earlier than the rest. Fortuitously, the extra early plant presented itself in the earliest variety in some trials I did of all the earliest cultivars I could find. As far as I know, Fast Lady is the earliest cowpea, and it is this earliness in addition to its cool-weather tolerance that extends its adaptation beyond the South to the maritime Northwest and Northeast. Fast Lady will even produce good crops in British Columbia, Canada.

Glenn Drowns, a high school student in Idaho at the time, bred 'Blacktail Mountain' watermelon because he loved watermelons, and no cultivars would ripen in his home garden. To my knowledge, Blacktail Mountain is still the earliest of icebox-size watermelons. And it is still very popular among those in extremely short-season or colder areas. 'Butternut Early Remix,' bred in Oregon by Andrew Still (Adaptive Seeds), is a highly selected gene pool population of small very early

good-flavored butternuts. The size, shape, and appearance are a bit variable, but they are all early, maritime-Northwest- and organic-adapted, and all taste good.

Likewise, Joseph Lofthouse bred landrace versions of dozens of crop species that will ripen crops in his Utah mountain village, where they could grow almost no local vegetables before. My 'Cascade Ruby-Gold' flint corn can produce well on the coasts of Oregon, Washington, and British Columbia, Canada, as well as other areas in Canada where no corn with large enough ears to be practical could grow before. Dave Christensen's flour corn variety 'Painted Mountain' extended the range for growing flour corns to places colder or with shorter seasons than was otherwise possible.

In the maritime Northwest and other mild-winter areas, crops that overwinter well are especially valuable. Specific varieties of kale, rutabagas, beets, tatsoys, carrots, and other crops can overwinter in my Willamette Valley gardens in Corvallis and Albany, Oregon, for example (latitude 44.6°N). However, overwintering ability appears to be very variety specific. And what will overwinter in areas much colder than our climate may not overwinter here. Other factors include details of whether plants are usually protected from freezing weather by snow, whether there are freezing rains, whether plants are subjected to repeated cycles of freezing and thawing, and diseases and disease resistance. Many freelance breeders select for overwintering ability of vegetable crops in the relevant areas.

Freelance plant breeders often breed crops for special or unusual uses. Many freelance plant breeders breed dry corn—but not usually the high-yielding yellow dent corns typical of agribusiness plant breeding. We breed flint corns for spectacular flavor as whole-grain polenta, flour corns of many colors and flavors for use in fine-textured all-corn corn cakes and gravies, parching corn for tasty snacks and trail food, and red-pericarp types for spectacularly flavorful cornbread. (Cornbread is a traditional American bread made with a batter of ground corn, water or milk, eggs, butter or fat of some sort, and baking powder, and baked in an oven.) Our red-pericarp cultivars have flavors so unusual that people by and large don't even know what grain was used to make the cornbread unless they're told. And premiere flour corn varieties can be used to make angel-food cakes that are indistinguishable from those made with wheat flour. Corn can be amazingly delicious whole-grain people food—if it's bred primarily to be delicious whole-grain people food instead of for highest possible yield (Deppe 2010).

I've bred flour corns for parching, a traditional Native American use for certain flour corns whose kernels puff a little, cook completely, and

change to magnificent unique flavors in response to dry heat. I think parching corn has considerable potential for use as a snack food or for grinding into flour after parching to make distinctively flavored crackers, chips, and baked products. Popped corn is relative bland; the flavor of parched parching corns is intense, and nothing like that of popped corn or corn products prepared by boiling or baking. In addition, there are three very distinctive classes of flavors in parching corns that co-segregate with the genes for pericarp and aleurone colors. (For my research on and breeding of parching corns, see Deppe 2010, pp. 269–279.)

Drying slices of squash harvested in the summer-squash stage was a traditional Native American use (Wilson 1987). But I knew of no information on the varieties used. So I tried dozens of varieties. Most varieties of summer squash taste bland when dried. But a few varieties develop powerful, distinctive flavors quite different from that of the squash either raw or cooked. In certain squash varieties—a tiny minority—that flavor dried or dried and reconstituted in soups or stews, is spectacular. My ‘Goldini Zucchini II’ is bred for dual use as a summer squash and a drying squash—that is, a squash bred in part to be dried in the summer squash stage for producing chips for dipping and dried slices and dried powders for use as ingredients or bases for soups and stews. Goldini not only has great flavor dried as well as fresh, but it is designed to be prime at larger than usual sizes—at about 400 g to 1 kg. Home gardeners can grow Goldini and eat the 400 g fruits as summer squash and dry the escapees to make a tasty long-storing food for winter. I’m of course biased, but I think Goldini could be the basis for a new dried squash industry. Goldini should also be better for processing for frozen, canned sliced squash, purees or baby food, I think, than any other squash available because the cooked squash has a rich, delicious, slightly sweetish flavor and firm texture, and the larger size when prime should make for higher yields and less labor in picking and processing on a commercial scale. Goldini might also be better for making pickle slices and pickle relish than cucumbers. And it’s certainly easier to grow. (For my research on drying squash, see Deppe 2010, pp. 207–213.)

My ‘Hannan Popbean’ is a chickpea bred for parching in dry heat rather than boiling. It is a chickpea version of *nuñas* (Deppe 2010). Many of Frank Morton’s leaf lettuce cultivars were bred for picking baby leaves for salad mixes. Brian Campbell (Uprising Seeds, Bellingham, Washington) bred ‘Beaujolais,’ a spinach with dramatic day-glow magenta-red stems and veins, for use in the baby-leaf stage.

My quinoa variety ‘Eat-All red-Leaf’ is bred not only for leaves instead of grain, but also for leaves produced under what I call the

Eat-All Greens Garden method. This method involves growing certain varieties of certain crops in broadcasted beds, letting them grow without any weeding or labor except watering for eight weeks or less, then clear-cut harvesting the entire bed by cutting everything at far enough above ground level to avoid any dirt or mud, giving totally edible succulent greens that require no washing or sorting in the kitchen. The method produces huge yields of greens compared with the more common methods for producing greens used in America. It depends on specific varieties that germinate and grow very fast, faster than and suppressing weeds, that are erect, and that have all succulent leaves and central stalks except right near the ground.

The Eat-All Greens Garden method differs from the Cut-and-Come-Again method in that with the latter, the plants are much more tightly spaced, and small yields of very tender greens are harvested for salads. For Eat-All crops, the spacing is wider (usually about 7.5 cm in all directions), the growing time is a bit longer (usually five to eight weeks), and the object is huge yields of greens for cooking, drying, pickling, or freezing with minimal time, land, and labor both in the field and in processing or in the kitchen. I discovered the method by accident with “Green Wave” mustard, and spent more than a decade searching for other varieties and crops that would work with the method. However, the method has long been used with certain varieties of certain crops elsewhere, especially in China, Japan, and Korea.

I’ve started a number of breeding projects aimed at selecting various greens crops specifically for optimal performance as Eat-All greens. My first release in this series is ‘Eat-All Red-Leaf’ quinoa. It’s selected for rapid germination and growth and good biomass production in Eat-All plots, for slow bolting, and for the red leaf color. The parent, ‘Kaslala Multicolored,’ has multicolored grain but mostly green leaves. For broadcast plots, I wanted the red color so I could easily distinguish quinoa seedlings and plants (*Chenopodium quinoa*) from the common weed lambsquarters (*Chenopodium alba*), with which it can cross. In addition, greens from the red-leaved plants have a more delicious and distinctive flavor than those from green-leaved plants.

I’m also breeding radishes for their greens, as grown using the Eat-All method. Figure 5.1 shows me harvesting a small trial plot of the Eat-All leaf radish ‘Sai Sai’ hybrid. This small 1.5 square meter patch was broadcast-sowed and covered lightly by bouncing a rake over the bed on July 4 and clear-cut harvested 41 days later. It yielded a measured 6 kg of all-edible greens for a yield of 4 kg per square meter. Since I can get three crops per season, that’s 12 kg per square meter of 100% edible greens that require no washing or sorting in the kitchen. I think

this way of growing greens could be of great use for those with limited garden space, those living in urban food deserts, and for those wanting to grow vegetables in containers or on rooftops. I think it also has considerable potential for commercial harvests of a much wider range of greens for fresh use, freezing, fermenting, or drying, and with much less land and labor. (The leaf radishes that appear to have been bred for Eat-All style growing are all hybrids—at the moment. They all germinate and grow very rapidly and produce lots of hairless greens.) *The Tao of Vegetable Gardening* has a whole chapter on my explorations with the Eat-All Greens Garden method (Deppe 2015).

VIII. METHODS

A. Standard Methods

Freelance plant breeders use all the basic methods of traditional plant breeding. We use selection to develop uniform populations from more variable ones. We make crosses for myriad purposes. We inbreed to reduce genetic variability and fix specific traits. We use backcrosses, recurrent backcrossing, F_2 s, F_3 s, etc. We make use of wide crosses. We sometimes cross food crop cultivars to wild relatives and introgress desired traits into new cultivars. We use mass selection, familial selection, and progeny testing. Some freelancers use disease-laden plots to select for resistance to specific diseases. We do a lot of taste testing. Some of us screen hundreds of cultivars to identify sources for traits we want. We take opportunistic advantage of accidental crosses and spontaneous mutations. Basically, we use all the major methods that university and corporate plant breeders use except genetic engineering and gene editing.

Genetic engineering is beyond the abilities of freelancer breeders because of patents on the technology itself as well as lack of laboratories. Gene editing technology, CrispR in particular, might be within our capabilities, aside from IP issues, especially given the possibility of subcontracting for lab work. The opinions of the freelance plant breeding community on both GMOs and CrispR are divided. Some are strongly anti-GMO. Others have nothing against GMOs. Some are against GMOs for reasons having to do with seed system consolidation or IP issues, lack of labeling, questions about the safety or environmental impact of glyphosate, or concerns about the safety of particular modifications for particular human populations rather than blanket concerns over safety of all GMOs *per se*. In general, while some freelance breeders are very anti-GMO, many seem to have opinions that

are more neutral or nuanced than is typical of most organic farmers and gardeners. However, both genetic engineering and gene editing such as with CrispR are excluded for varieties to be used in production of USDA-certified-organic crops (www.ams.usda.gov/sites/default/files/media/NOSBProposalsAllApril2019.pdf). Since most freelance breeders sell primarily to organic farmers and gardeners, this makes even use of CrispR-derived varieties problematic.

As yet, no freelance plant breeder has developed any cultivar using marker-assisted selection (MAS). However, now that marker identification in samples can in many cases be subcontracted to commercial companies, this is likely to change soon. Michael Mazourek gave a talk on MAS to a very eager audience of freelancer plant breeders at the 2016 Organic Seed Growers Conference. Afterward, about eight of us virtually kidnapped Mazourek, sat down with him at a table in the hall, and asked myriad details in the context of specific crops about specific companies, specific numbers of markers, and prices per sample. I am clearly not the only freelance plant breeder who has a project in mind that would benefit from MAS.

B. Developing Modern Landraces

Freelance plant breeders use some approaches not common among university or corporate breeders. One of these is the development of modern landraces. Landraces are frequently assumed by professional breeders to be inferior material. I think there is a tendency for university and corporate plant breeders to call everything they do “elite” and everything others do “landraces,” even when the supposed landraces are highly uniform and superbly productive.

In many cases, somewhat variable landraces can actually serve the needs of organic gardeners and farmers better than uniform varieties, especially if they have been selected for uniformity for flavor and use, and left variable for characteristics where variability either doesn't matter or is actually advantageous. Landraces have the advantage that they are easy to develop and give results fast. And in some cases, only landraces will do.

When Joseph Lofthouse started farming near his mountain village of Paradise, Utah, the farmers markets had very little that was locally grown. They were full of *imported* vegetables. The conditions were so harsh that even *Cucurbita pepo* winter squash could not be grown to maturity. Lofthouse began developing very vigorous landraces for his area. Initially he needed to recruit friends in other regions to do crosses for him in order to be able to get seed grown to maturity. Now, after his

decades of developing locally adapted landraces, he and his neighbors can grow winter squash of all three major species, tomatoes, melons, and even okra using his landrace varieties. And the local farmers market is full of locally grown produce of these crops raised by Loft-house and his neighbors. Customers don't mind the fact that the vegetables are variable. The choice is between variable local vegetables and no local vegetables. Lofthouse is the originator, leader, and inspiration of a movement toward renewed interest in breeding and using landrace varieties.

C. Developing Varieties with Deliberate Crafted Variability

We freelance breeders frequently incorporate certain kinds of desirable variability into our finished varieties. By this, I mean variability that is necessary to create a variety that best fills its objectives, not variability that we dislike but have not yet managed to eliminate. This is variability we have bred into the variety on purpose, and we deliberately maintain the variety so as to continue maintaining the variability.

We frequently develop red-pericarp corn varieties, for example, which have a spectacular and unique flavor as cornbread. But we do not fix the red-pericarp characteristic. It carries a genetic load. Plants homozygous for it are smaller and the ears are *much* smaller than plants and ears that are heterozygous. Invariably, whenever anyone fixes the red-pericarp trait so that the variety gives nothing but deep red ears, they end up with a variety that yields so poorly it's impractical to grow except as a novelty. So we let the variety vary for pericarp color so most of the red-pericarp-carrying plants are heterozygous. This also has the advantage of giving us solid red and solid yellow ears in a yellow-endosperm corn, making the variety better for secondary use as an ornamental.

Many freelancer-developed varieties of greens intended for use in salads are what we freelancers call *grexes*. "Grex" is a term from the world of orchid breeding that was picked up and spread by Alan Kapuler (Kapuler 2015). His use varied over the years, however, and so does that of freelancers. I use the word to mean the populations segregating from a cross of two parents, which can be, for example, F_4 s, F_5 s, and F_6 es, plus all possible intercrosses. Or it may be much later generations. Sometimes grexes include the parental types; sometimes not. Some people still call it a grex when there are multiple parents involved, though most of us at that point call it a *gene pool*. Normally these grexes and gene pools are highly selected for specific characteristics. They are left as populations segregating for some characteristics because they are superior that way.

For mixed salad greens, for example, home gardeners as well as commercial growers usually want to end up with greens of many colors, textures, and shapes. One approach is to grow many varieties separately and add them together after harvest. But it's usually much easier to grow a grex, gene pool, or landrace that produces many different colors, shapes, and textures from one variety. However, the variety is heavily selected to produce colors, shapes, and textures desirable in salads, and plants that all grow at the same rate.

D. Designing Ease of Seed Saving into Varieties

The grexes and various segregating populations so many freelancers develop for salad greens are also designed with ease of seed saving in mind. It is a pain for a seed saver to maintain six different lettuce varieties in order to end up with lettuces of different colors and textures in the salad. It's much easier to maintain one variety that segregates all the desired colors, shapes, and textures.

I've been trying to establish the idea of "sister varieties" as an additional way to build ease of seed saving right into varieties. For those who practice seed saving in the home garden, isolating different varieties appropriately can be a major issue. Most dry beans cross readily on organic land in the maritime Northwest, for example. Gardeners with limited space who want to keep their varieties pure may be limited to growing just one variety per year. However, in some cases, a single gene difference changes a variety into an entirely different one in a culinary sense, but in such a way that, planted and defined appropriately, isolation between the two varieties becomes a non-issue. This allows growing the two sister varieties with essentially no isolation.

For example, my favorite heirloom dry bean variety is an Argentine heirloom, 'Gaucho,' a very early yellow bush bean that yields well and has a rich full flavor. One season, about one plant's worth of something different showed up in about 10 kilograms of Gaucho—seeds the same size and shape as Gaucho but that were white with a candle-and-flame pattern on the hilum. I named the resulting cultivar 'White Candle Gaucho.' It presumably differs from Gaucho by just a single recessive gene. However White Candle Gaucho tastes completely different from Gaucho. It has a mild flavor instead of the powerful flavor of Gaucho. I prefer powerful-flavored beans. But mild-flavored beans are needed, too. Powerfully flavored beans overwhelm a vegetable, chicken, or turkey soup, for example. So I grow and sell both varieties. The plants and beans look and act identical except for bean color. So I call the two varieties sister varieties. I advise customers that they can plant the two

varieties in the same row, and just eat the beans where the two varieties come together and save seed from the rest. Occasionally, crosses between the two varieties don't matter. The few off-color beans can be removed before planting.

I've also developed several flour corn varieties where the only difference between them is pericarp color. All have a clear aleurone and white endosperm. 'Magic Manna' contains clear, red, and brown pericarp colors. Since the pericarp is synthesized by the mother plant rather than the seed, the result is the variety gives solid ears of white, red/pink, and brown colors. The ears of different colors have very different flavors *and uses*. Only kernels from the red/pink ears are good parching corns, as the rest taste awful and/or burn. Corn from the white ears, when baked in recipes with sugar, have a very pancake-like flavor. They are my favorite for pancakes. Without sugar they are a little sweet themselves so taste a little weird. Kernels from the brown ears bake into products that taste great without sugar; they also make great gravy. So I developed sister varieties, each with a higher portion of one of the three types. But all contain some of all colors in order to avoid genetic load issues associated with homozygosity for genes for pericarp colors. So 'Magic Manna,' 'Parching Red Manna,' 'Pancake White Manna,' and 'Brown Gravy Manna' are all sister lines that can be grown in one field, with seed saving from the middle of each patch, with occasional crosses not mattering. Magic Manna itself is designed to facilitate seed saving. It gives four different colors of ears, each with different uses and flavors, all from one variety. In addition, 'Parching Starburst Manna,' is a sister variety to the others that has a red starburst pattern on the pericarps. It's a parching corn with an entirely different flavor from the red-pericarp manna ears (Deppe 2010).

E. Developing and Distributing Breeding Material

Many freelance breeders distribute varieties that are intended primarily to be used as breeding material. University plant breeders sometimes call this *prebreeding* material. We freelancers don't like that name. Designing a great cross or combining the right choice of two or multiple parents and doing the first few years of breeding to develop material with the best potential for further breeding into many great varieties is "breeding," we say, often the most important breeding there is.

Sometimes breeding-material varieties represent materials bred specifically for that purpose. In other cases they represent early stages in our own breeding projects. If we share such material, others might be inspired to develop their own varieties adapted to their own regions,

thus greatly leveraging the usefulness of our starting material. Descriptions of the materials and the possibilities in our seed catalogs is a great way to seduce others into freelance plant breeding and give them a two to many years head start on their own first projects. In cases that involve an F_6 or later generation after a cross in a highly inbreeding crop, the new breeder may need to do nothing more than select a desirable plant from the mix and save its seed. In many cases, the seed will already be pure breeding. In the freelance plant breeding world, it's conventional for breeders who start with such materials to have the full rights to name the resulting variety and credit themselves as the breeder. But it is expected that in the description of their new variety, they will acknowledge the breeder of the breeding material from which they selected.

There is also a simple economic reason for selling breeding material. Usually, the initial stages of a breeding project—making initial crosses and going to an F_2 or backcross—cost little land or labor. But after that, the costs in land, labor, and time evaluating get more serious. It's easy to start breeding projects with small amounts of land and limited resources. It's hard to finish them. Most freelancers are not affluent enough to devote enough time or land to finish breeding many varieties without an input of funding. Selling breeding material for the early stages of a project helps the project pay for itself while we finish the breeding.

It's also fairly common for freelancers to leave a little variability for certain characteristics in varieties even if they could remove it easily, thinking in terms of the breeding possibilities for future generations. For example, I left a little of the pencil-cob characteristic in my flint corns. I don't like pencil-cob ears because they give a much smaller weight of grain per ear and per picking gesture when ears are hand-picked. In addition, cobs of pencil-cob ears have a tendency to break up in a hand corn sheller, leaving chunks of cob in the grain that have to be removed by hand. However, pencil-cob ears dry much faster than ears with thicker cobs. If someone needed to be able to dry ears much more easily, they might prefer pencil-cob ears. So I leave a little of that trait in my varieties so they could easily be selected into pencil-cob varieties. That's a common attitude among freelancers.

F. Preference for Mass Selection

Many freelance breeders strongly prefer mass selection rather than inbreeding to fix desired traits. A common experience many of us have had is that when we develop a squash for use in low-input organic systems, for example, and use the common method of inbreeding from a

cross for a number of generations, we initially start with a cross that is vigorous. But the more we inbreed, the less vigorous *all* the segregants get. Mass selection from a good-sized population tends to result in more vigorous organic-adapted varieties than inbreeding. However, it's much harder to eliminate undesirable recessives using mass-selection. Freelance breeders and our customers normally have to live with a few percent of off-types in exchange for the greater vigor and organic-adaptation.

One might think, at this point, that we freelancers should be using hybrids instead of open-pollinated varieties. However, most commercial hybrids don't actually perform very well in organic systems—especially under field rather than garden conditions. Many also don't give segregants that do so. Many commercial hybrids are apparently the result of crosses of closely related lines, as suggested by their showing segregation for only a few traits. Or they simply are not very well-adapted to organic systems or to our region. Developing our own hybrids would work, but it's not obvious our seed customers would accept them, even if they knew and had access to the parental varieties. Straight seed saving is something many of our customers are willing to do—making hybrids, probably not.

Where eliminating off types matters enough, I've actually taken to starting with mass selection, then doing one round of self-pollination to identify families carrying undesirable recessives, then recombining a number of the "clean" families to restore the vigor-promoting genetic heterogeneity in everything that doesn't matter. Goldini Zucchini II, for example, was bred that way. It is uniform for fruit flavor, color, shape, and maturity. And plants all are bush type. But the variety has every possible leaf shape and color. And I help maintain the genetic heterogeneity by deliberately maintaining all those leaf shapes and colors in the variety. The variety germinates and grows far faster than every other squash, in my experience, including hybrids. But, as I warn my customers, "If you want uniformity for things that don't matter, buy something else."

G. Premature Release of Varieties

Many freelancers, myself included, release varieties when they are seriously short of being "finished." This is largely a matter of straight economics. After four or five years of breeding a variety, we need the variety to start paying its way through seed sales. So we release it. It often takes another four or five years of breeding to bring the variety to optimal. The convention in the freelance plant breeding world is to feel free to release varieties prematurely, but to be blunt about the flaws.

If a variety is more than a percent or so of off-types, we include in the variety description what the off-types are and their approximate frequency. Customers can wait until the variety is perfected or buy it then and replace their seed when we have further improved it, as they wish. If we freelancers were trying to obtain patents or PVPs on our varieties, our practice of releasing varieties when they are a bit less distinct, uniform, and/or stable than we aim for ultimately would be a problem; but we aren't trying to obtain patents or PVPs.

H. Elaborate Collaborations

Freelance breeders, especially in the era of internet and plant breeding forums, sometimes engage in projects that dozens or even hundreds of people have participated in. The Dwarf Tomato Project is a notable example. It was started by Craig LeHoullier (USA) and Patrina Nuske-Small (Australia), who serve as co-directors. The basic observation was that most determinate tomato varieties don't have optimal flavors; this may be associated with a lower ratio of leaf surface area to fruits than for indeterminate tomatoes. However, dwarf tomato varieties, which usually have small fruits, are capable of having large fruits with all the colors and flavors of heirlooms. Dwarf tomatoes, like determinates, are also compact plants. They are homozygous for *d*, and have full-sized leaves and indeterminate habit, but short internodes. They also have a characteristic rugose foliage. They are easily fully supported by commercial tomato cages. Like determinates, they have many advantages for those with small gardens. They seem to have a better ratio of leaf surface to fruit volume than determinates, and to be more capable of having fruits with heirloom quality flavor. But dwarfs were mostly available only with small fruits. So the object was to cross varieties with the *dwarf* gene to heirlooms and develop dozens of new varieties with full-size tomatoes with heirloom colors and flavors and quality but on compact small-garden-adapted plants.

More than 200 volunteers in USA, Canada, Australia, and New Zealand recruited from a tomato lover's forum, participated in the project. Nuske-Small made many of the original crosses. Then the germplasm from each cross was passed back and forth between North America and Australia so as to get two generations per year, at least until Australia passed laws that added tomatoes to the quarantine list. Volunteers grew out various crosses and derived lines for six generations or more, selecting their favorites along the way. The project has resulted in 110 stable new dwarf tomato varieties, all of them OSSIPledged. (See the OSSIP Seed page, <https://osseeds.org/seeds/> under "Dwarf

Tomato Project as the breeder for varieties for descriptions, photos, and sources. See <http://osseeds.org/the-dwarf-tomato-project/> for a description of the project and contact information.) Varieties were released by simply putting seed into the hands of cooperating seed companies, who increase and sell the varieties.

I. Converting Clonally Propagated Vegetables into Seed Propagated Ones; Perennials

Many freelance plant breeders appear to be becoming increasingly irritated by and intolerant of clonally propagated vegetables such as potatoes, garlic, and sweet potatoes that in many cases are incapable of producing true seed, that is, seed resulting from meiosis. Potatoes, for example, are problematic for freelancers because most clonally propagated varieties don't produce seed balls well or at all under most conditions. It's hard to breed with no seed. In addition, if you rejoice in potato diversity and want to be able to grow and maintain dozens (or hundreds) of heirlooms and other varieties, including those you've bred yourself, you usually have to grow them all every year. A single unfortunate season, broken leg, or family emergency can result in loss of your entire collection, including everything you've bred. Heirlooms and rare varieties are also not normally available as certified seed. Buying even the best maintained lines usually means importing viruses and diseases. Specialists in rare potatoes sometimes clean up some lines of some heirlooms by apical meristem culture. But with time, it's become obvious that even a year or two of field growing "clean" clones reinfests everything. The "normal" pattern of growing potatoes by buying certified tubers every year is only possible if you grow varieties that are commercially important. And even certified seed tubers are not necessarily free of viruses or disease.

Freelance breeder Tom Wagner (Tater-Mater Seed, Everett, Washington) has started a movement to distribute and encourage use of true potato seed rather than the parent clonal material as a routine way of growing as well as breeding potatoes. Freelance breeder Bill Whitson (Cultivariable, Moclips, Washington) has expanded on this idea by beginning the work of breeding genetically heterogeneous true-seed-propagated populations that share certain characteristics and are more likely to give offspring of particular types. (See <https://www.cultivariable.com/catalog/potato/true-potato-seeds/>.)

The homesteader or gardener who is interested learns to start and grow potatoes routinely from true seed instead of maintaining them clonally. Accepting and evaluating variability and choosing parents

from which to save seed balls is considered part of the ordinary potato growing process. Unlike the situation with commercial potato breeding, the ability of a potato plant to flower and produce seed is a required characteristic. Gardeners and farmers have to deal with the as yet highly variable populations that true potato seed populations as yet produce. However, they don't have to import or fight disease, or pay for clonally propagated rare-variety germplasm, which has always been expensive. And the variability of the results from the current generations of true potato seed is projected as being part of the fun.

Freelance breeder Avram Drucker (Garlicana, Tiller, Oregon) and others are doing much the same thing with garlic—that is, developing varieties that are capable of producing true garlic seed, selecting noteworthy progeny from true seed developed from various crosses, and requiring any candidates for naming and propagating as clones, in addition to excelling in flavor, storage, and other relevant criteria, to also meet the criterion of being able to produce viable true seed. Garlic diseases are not as problematic for most of us as potato diseases. But they are still an issue. And as with potatoes, rare clonally propagated material is very vulnerable to being lost entirely.

Another freelance plant breeder, who has not yet formally released his material, found a sweet potato plant that produces viable seed much more easily than is normal for sweet potatoes, greatly facilitating sweet potato breeding. A number of freelancers who communicate on the Open Source Plant Breeding Forum (<http://opensourceplantbreeding.org/forum/>) are working with the material. As for the potatoes and garlic, part of the object is just to develop new varieties. But part of the object is to develop sweet potato varieties that are more cooperative participants in their further breeding.

There is also a lot of interest in perennial herbaceous vegetables. Perennial vegetables are an essential part of the philosophy of permaculture, as is using understories of perennial vegetables beneath tree crops. It's not necessarily easy to do in practice. We don't actually have very many perennial vegetables, and those we do have don't necessarily perform well in partial shade or when competing with tree roots. There's much to be done to domesticate the wildlings whose natural niche is woodland understory plants, and/or breed existing perennials and other vegetables to be more shade tolerant.

Along with this interest in perennials goes an interest in perennializing some of the crops normally grown as annuals. Chris Homanics, for example, is working with and developing perennial kales—kales that taste great and grow for years, but also flower and set seed enough to permit further breeding. They don't quit growing and die after flowering.

IX. SOURCES OF GERMPLASM

A. USDA-ARS National Plant Germplasm System

The USDA-ARS National Plant Germplasm System is *beloved* by freelance plant breeders. Nearly all freelancers make use of the USDA collections. Some have requested hundreds or, over their lifetimes, thousands of accessions. In addition, the USDA curators often go far beyond merely sending freelancers the requested accessions. Many often help with ideas, tips, and suggestions. Rich Hannan, then curator of the legumes at Pullman, Washington, suggested the entire idea for one of my projects.

I had just read *Lost Crops of the Incas* (National Research Council 1989), and was excited about nuñas—popping varieties of *Phaseolus vulgaris*. Hannan was willing to send me all the accessions of nuñas. But he was pretty tired of getting requests for them. “After that book came out, everyone wants nuñas,” Hannan said. “Why does everyone want nuñas, that don’t grow here, and nobody wants chickpeas, which also pop, and do?” “Because I didn’t know that. They weren’t in the book,” I responded. “Which ones pop?” “I don’t know,” Hannan replied. “I’ve got 6,000 accessions.” Five hundred chickpea accessions and 10 years of breeding later, I released a chickpea I named “Hannan Popbean,” in Rich Hannan’s honor.

On another occasion, Mark Millard, then curator of the USDA corn collection, aided and abetted me in my efforts to figure out which corns parched. I had learned about the fact that Native Americans had some varieties just for parching from *Buffalo Bird Woman’s Garden*, a book on the agriculture of the Hidatsa Indians (Gilbert 1987). Kernels of parching corns, in response to dry heat, crack open and expand a little, cook completely, and have very delicious unique flavors; they make a great snack or trail food. In addition, a friend of mine who had visited the mountains in Guatemala described how men always carried a little bag of parched corn tied to their belts when they went off to the fields to work. They had varieties just for parching, too. But there was no information in the GRIN database on parching. So it was a matter of much exploration with the help of a cooperative curator to find varieties that parched. I couldn’t start breeding better parching corns until I knew what made a good parching corn. About 200 corn accessions later, I knew exactly what made a good parching corn and started developing some of my own (Deppe 2010).

Larry Robertson, geneticist and vegetable curator at the USDA-ARS Plant Genetic Unit from 1998 to 2016, was an inspiration and founding

partner in several initiatives that created collaborative relationships between farmers and university breeders in the Northeast. His death was lamented by the entire organic farming community (Colley 2016).

If only the rest of the government worked as well as the USDA-ARS National Plant Germplasm System!

B. Seed Savers Exchange

The Seed Savers Exchange is also an invaluable source of germplasm for freelance plant breeders. The annual *The Exchange* winter yearbooks list thousands of open-pollinated public domain varieties, almost all not commercially available. The yearbooks include the locations and contact information of those listing varieties. This means you can choose seed savers in your region to request seed from so that you know you are getting material that at least grows in your region. Many of these seed savers have screened hundreds or thousands of varieties of particular crops from the USDA collections, other collections throughout the world, and from other private seed savers for ability to grow in their regions. Using the SSE yearbooks, members obtain starting samples of seed directly from each other.

SSE also has its own germplasm bank and preservation department that documents information about varieties. It serves as a major conduit for material from other world germplasm banks coming into the country. In addition, SSE grows out and documents varieties and has a seed company arm that sells a selection of available varieties each year. SSE also publishes the garden seed inventories. The most recent is *Garden Seed Inventory, 6th ed.: Inventory of Seed Catalogs Listing All Non-Hybrid Vegetable Seeds Available in the United States and Canada* (Whealy and Thuente 2005). It lists variety descriptions and all sources for the more than 8,000 open-pollinated vegetable varieties that are available commercially in North America. Of particular interest is the fact that even the smallest and most specialized seed companies are included in the listing. The most recent *Garden Seed Inventory* was a good starting point in searching for germplasm back when these were updated about every five years. The sixth edition is still useful, though it doesn't include varieties or seed companies added in the last 15 years. I'm told that SSE is in the process of publishing new editions, one in print, the other online and free, and to be updated regularly. There is also an equivalent inventory for fruits, nuts, and berries.

In the days before the internet, when it was much harder to found a seed company or find a customer base for it, many small seed companies got their start by simply listing all their available varieties in the

SSE annual yearbooks. This still happens to some extent. And many small seed companies with their own catalogs, including those founded by freelance breeders, still list a number of their varieties with SSE so as to maintain a presence there and attract customers from among SSE members. Freelance breeders without seed companies often first list and release their varieties through SSE annual yearbooks, too.

The presence of varieties in the SSE yearbooks constitutes a kind of evolutionary process. Some SSE members will list varieties just because they exist, and focus on obtaining the varieties and making them available rather than on evaluating them. If the variety is really good, with time one tends to see more and more SSE members offering it. After the numbers of people listing the variety swell to a certain point, usually one or more seed companies offer the variety commercially, whereupon its listing in the SSE yearbook usually vanishes, since the SSE yearbooks are for listing and exchanging varieties that are not available commercially. SSE and its members and publications thus serve as a mechanism for screening and evaluating germplasm from throughout the world.

C. Other Sources of Germplasm

A number of small seed companies have played major roles in collecting, preserving, and distributing rare germplasm. Seeds Blüm was one of the first of these. Peace Seeds and Abundant Life Seed Foundation were others. Adaptive Seeds, Baker Creek Seeds, Peace Seeds, and Victory Seeds are among those that play this role today. In addition, some seed savers maintain and distribute considerable collections of germplasm—Will Bonsall, with his Scatterseed Project, and William Woys Weaver with his Roughwood Seed Collection, for example. In addition, some university breeders maintain their own collections of relevant material not covered by IP, and may provide such material to freelancers interested in it.

Freelancers, of course, also use standard commercial open-pollinated varieties and hybrids as sources of germplasm. In addition, increasing these days, many freelancers build varieties based on those of other freelance-bred varieties. My flour corn varieties are all selections from freelance plant breeder Dave Christensen's variety 'Painted Mountain,' for example.

Some freelance breeders do their own germplasm collecting. Andrew Still and Sarah Kleeger, now co-owners of Adaptive Seeds, expanded their seed saving interests by traveling around Europe and collecting germplasm. This gave them a lot of unique material not available in USA otherwise, which formed the foundation for their seed company.

Finally, one advantage of owning and running a small seed company focused on your interests is your customers. They know your interests. And many just send you germplasm they think you might be interested in.

X. ECONOMICS OF FREELANCE PLANT BREEDING

Once freelance breeders have developed a number of varieties, they have the basis for earning an income from their plant breeding. However, it's usually not possible to earn an income from breeding plants *directly*. Usually, the plant breeding pays for itself indirectly. Table 5.2 gives the major plant-breeding-related sources of income for the 35 freelance plant breeders associated with OSSI. (The retail seed companies are all small mail-order companies. Wholesale seed growers sell to retail seed companies or distributors, often growing seed on contract. Farmers, for my purposes, refers to those who regularly sell produce other than seeds.)

Of the 35 OSSI-associated freelancers, 15 own and run small mail-order retail seed companies, sometimes alone, sometimes in combination with wholesale seed growing and/or farming; for 11, their retail seed company is their primary plant-breeding related income. These 15 breeders include at least some wholesale seed growing as part of their repertoire; for 9 it is their primary plant-breeding-related income. Six are farmers. Only four are exclusively farmers, that is, don't also or primarily sell seed. Nine engage in none of these plant-related economic activities, earning their livings entirely by other means, or are retired and have retirement income. Even those who have plant-breeding-related income often have other income, too—such as retirement income, or, in my case, garden book royalties.

A. Combining Plant Breeding with Running a Small Retail Seed Company

Running a small retail seed company has many advantages for a freelance plant breeder. It means you can introduce a variety whenever you want, at whatever stage of perfection or lack thereof. You simply include information about off-types and imperfections in your variety descriptions so customers can avoid or buy accordingly.

With a small seed company, it doesn't take much seed to introduce a new variety. It rarely costs more than a year of seed increase between when you finish a new variety and when you release it, if that. Usually, the same year I decide a variety is finished, I'm selling the seed.

You also have much greater freedom to breed whatever you want when you know at least one seed company—your own—will offer it. I've started most of my projects by aiming at something I really wanted for myself, even if it was the opposite of what most people supposedly want. I bred 'Sweet Meat—Oregon Homestead,' a squash that runs up to 10 kilograms—as large as it can be and still fit in a home oven—while the conventional wisdom was that everyone wants only little squash. 'Sweet Meat—Oregon Homestead' has been the best-selling squash for my own and two other Oregon seed companies for years. Last year I started working on less-sweet sweet corns. Does everyone want sweet corn so sweet it tastes more like candy than corn? I don't. Maybe there will be others who don't, either. It won't matter if most people prefer the candy-like corns, as long as there are some whose tastes are more like mine, and they can find me. Operating on a small scale means being able to be successful with varieties that buck the trends or satisfy minority preferences or create entirely new uses or market categories.

When you have your own retail seed company, you control your variety descriptions, your presentation of your varieties to the public. You can make your variety descriptions as long as you want. You can use them for purposes other than just selling the seeds. I use mine to encourage others to get involved in plant breeding, for example.

If you breed a cultivar for a new use, your cultivar isn't going to fit into standard market categories. It's a hard sell to get such varieties listed by seed companies you don't control. The more original your varieties, the more you need your own retail seed company so your varieties need not fit into standard categories. In addition, you will need to educate your customers about the variety and how to use it. This means you need to be able to have lengthy variety descriptions that include preparation or cooking tips. You can usually only have variety descriptions long enough if you have your own retail seed company.

If you have bred cultivars of crops for which big seed companies don't even have a listing, in order to sell them you are probably going to need your own seed company. Bill Whitson specializes in perennial vegetables, including Andean root crops such as Oca, mashua, ulluco, and yacon. He sells them through his own company, Cultivariable.

If you run a small seed company, you can often sell breeding material or release varieties a little early and make them help pay their way for the last part of their breeding. You can do this with your own company, because you will have attracted customers who are unusually adventurous as gardeners or farmers, and unusually interested in trying new things.

Finally, a small retail seed company makes the freelance breeder visible in a way that can attract donations. Freelance breeders always

have a donation line as part of their seed catalog order form. Our customers know that breeding, growing, and distributing seed of open-pollinated, locally adapted, IP-free varieties is not one of the more lucrative of possible activities. Many want to help. Most of my donations are \$5–20. Some are considerably larger, several hundred dollars sometimes. One donor to a freelance plant breeder I know paid off his entire mortgage of more than \$30,000 one year.

Those of us who own retail seed companies cannot, unfortunately, sell only our own varieties. The individual order size would be too small to be workable. So we add enough other varieties to our lists to make the order size workable. Sometimes these other varieties are heirlooms or other valuable open-pollinated varieties we are already saving seed of, and expect our customers would like also. Some of the varieties can be standard commercial varieties bought from wholesale suppliers, and repackaged. Wherever possible, we fill out our lists, however, with the varieties bred by other freelancers, especially those in our region, and whose seed can be bought wholesale directly from the breeder—varieties we like that we think our customers will like, too.

Ideally, the seed company of the freelance plant breeder carries his or her own varieties plus at least one variety of nearly every other crop. People will often remember they need, for example, green beans when they see them listed. I sell a lot of “Provider” in spite of the fact that everyone else sells it, too. People come to my company to buy my unique varieties. But once there, they buy other varieties too, if I have them.

Most freelancers with small seed companies have specializations. It’s hard to offer as many total varieties as a large seed company. But it is very easy to offer more or better varieties in your specialization than other companies. People who share your interests learn to come to you for seed in your specialization.

The biggest disadvantage of running a small mail-order seed company is that it’s a lot of work. You need to grow larger amounts of seed than necessary for just your own use. And you’ll spend a lot of time packing seed packets and filling orders.

An additional problem is that your seed company has to get noticed somehow. If you are writing books or magazine articles, giving gardening talks or workshops, or blogging anyway, this may take care of itself. Otherwise you might have to engage in unpaid work in order to bring people to your paying business. However, this tends to be true for all freelancers in all fields, and is part of the cost of freedom.

Finally, combining running a small retail seed company with plant breeding puts you in an ambiguous situation with respect to promoting your varieties. Ironically, semi-obscurity can be advantageous for the

freelance plant breeder whose varieties are not protected by IP, and who survives in part by selling them directly to the customer via a small retail seed company. As long as your new variety is relatively obscure, especially when your seed company is the only source, those interested must come to you, often buying a hundred dollars or more of other stuff they happen to notice when they come. If instead your new variety is available from larger seed companies who are growing it themselves or subcontracting with their own growers, you can lose most of those potential customers and sales. When the variety is carried by many larger seed companies, it no longer has much value in drawing customers to your own company. It's much more convenient for people to buy it from the big seed company where they get most of their other seeds.

However, if your variety is never carried by other seed companies, it never really succeeds as a variety. It will probably die with you. When other seed companies pick up our varieties, it's a kind of validation of their worth. And these varieties are much more likely to survive beyond us. It's satisfying to see our varieties in other seed catalogs, especially these days, when they may even be attributed to us, and we may even be paid a royalty for them.

Where I've ended up is that I am uneager for other seed companies to carry a new variety of mine in the first three years after its release. After that, I get increasingly eager to see my variety offered by other companies and going forth to make its mark and contribute to the agriculture of the world, even if this costs me sales. At this point, I have other new releases coming along.

One particular element of vulnerability is when a larger seed company, especially one in the same region, offers most or all of your varieties. That can put you out of business. I always hope that other seed companies who like my varieties offer a few of them only—not offer every one of my most popular varieties.

One approach that helps mitigate this problem is if you are in a position to sell your varieties wholesale as well as retail. Then if a larger seed company likes them, there is a good chance they will buy the seed from you. You may or may not be in a position to grow and sell the seed wholesale, however. And you still lose the value the variety has of attracting customers to your own company when you are the only source.

B. Combining Plant Breeding with Wholesale Seed Growing

The other most common economic approach to surviving at freelance plant breeding is to combine it with growing seed wholesale. This is much more viable for more growers now that organic crops have to be

grown with certified organic seed if it is available. This approach has the advantage that you can contract with retail seed companies for your grow-outs before you do them, thus making the sale before growing the crop, and avoiding growing a crop nobody wants.

An additional advantage to being a wholesale grower is that you are in an unambiguous position with respect to promoting your new variety. You want it to be carried by as many seed companies as possible, as long as they buy the wholesale seed from you.

Wholesale seed growers need not have a 10-year lag at the beginning, either. They can start by growing heirlooms and other public domain or OSSI-Pledged varieties for which there are no wholesale sources, and add or replace them with their own varieties as they breed them.

An advantage to being the major or only wholesale grower for a crop you've bred is that you do the quality control. Where others are the wholesale grower, they can screw up and ruin the reputation of the variety you spent so much time developing. Since there is no IP on your crop, others can grow and sell wholesale even if you do sell wholesale. But usually others do not move in and compete directly for wholesale sales with the breeder who developed the crop and is making it available wholesale at a reasonable price. Within our community, such direct undermining of the livelihood of the breeder of the crop is frowned on. In fact, nearly everyone who sells my own varieties has approached me as to whether I could sell to them wholesale, and if not, whom I would recommend as a grower.

The major disadvantage to wholesale growing as a strategy to support your plant breeding habit is that you are dependent on retail seed companies liking and deciding to list your variety. And there is no guarantee that you will be able to get retail seed companies interested in all your varieties, especially those that are the most original, that most break the normal categories and definitions. University breeders, who normally don't have their own retail seed companies, have this same problem.

C. Combining Plant Breeding with Farming or Collaborating with Farmers

Some freelance plant breeders are market gardeners or farmers. This can work well when it's an already-established and successful market gardener or farmer adding a plant breeding enterprise as one component of the mix. It tends to not work well when it's primarily a plant breeder trying to add a farming or market-gardening component to support the plant breeding. These days, even established farmers often have

trouble supporting themselves with farming. In addition, both growing and selling produce—especially selling produce retail—are time consuming; doing both can leave no time for the plant breeding. What is a lot more common and more successful is for a freelance breeder to *collaborate with* a farmer or market gardener, especially in the case where the freelancer owns little or no good agricultural land.

Brad Gates, for example—of ‘Pink Berkeley Tie-Die’ tomato fame—went through a phase when he was growing tomatoes on other people’s land and selling huge numbers of tomatoes in local markets and to high-end restaurants to support his breeding work. But growing tomatoes and selling them as produce was very time consuming, even without the three hours per day he was spending commuting. In addition, he couldn’t get prices for his tomatoes that were much higher than for standard tomatoes when he sold his unique varieties as produce. Selling his unique varieties as produce didn’t make enough money over selling standard tomatoes to pay for the breeding work.

Brad now has an arrangement with a wholesale tomato grower who grows 80,000 plants a year. Brad can plant a few hundred tomatoes here and there at the ends of rows, and grow and breed with a couple thousand plants a year without having to tend the plants himself. The tomato grower gets early access to Brad’s new varieties as well as the excess from Brad’s plants. Brad doesn’t have to harvest any tomatoes except those he wants to harvest for seed. In addition, Brad can grow enough tomatoes to allow him to harvest and process each variety he wants for seed by picking and processing just once, instead of having to make multiple pickings and do several fermentation processings per variety.

Brad now supports his tomato breeding by selling seed of his varieties to national seed companies and transplants of his varieties to local nurseries. Seed companies ordinarily pay substantially higher for seed of Brad’s varieties than they would for standard varieties. The local nurseries also pay Brad substantially more for and can charge substantially more for transplants of his varieties than for standard tomato varieties. So selling his plant breeding in the form of seeds or transplants *does* work to support his plant breeding.

Grape breeder Elmer Swenson owned a farm. But the ordinary single-family farm doesn’t provide much land by the standards of the enthusiastic breeder of fruit or nut trees or berries. Swenson made various arrangements and planted grapes on farms of multiple neighbors and others (Clark 2019).

Chris Homanics, Oregon freelance breeder of fruit, nuts, berries, and other crops—who also owns no land—has multiple arrangements whereby he has planted tree-breeding projects on land belonging to

others. The key, he says, is “multigeneration” breeding projects. By this he means multiple generations *of humans* cooperating on the breeding projects. Homanics laments the disconnect between human generations these days. He wants to see more people of all ages crossing generational barriers and working together to achieve breeding projects that may take multiple generations of trees *and humans* to achieve.

Like Brad, I own no agriculturally useful land of mine own. I do most of my plant breeding on the land of a local collaborating organic farmer. I sometimes, in addition, subcontract with other farmers for particular tasks, or get help from gardening friends, especially for the initial stages in projects. With cross-pollinating species, I often can’t afford to “spend” an isolation niche on the main farm for a handful of plants used to do an initial cross, for example when it would ruin my ability to grow a major seed crop or a later-stage project of the same species. My collaborating farmer grows grains and vegetables for local and farmer’s markets and the Corvallis school system. The summer season vegetables he grows at this point are almost entirely varieties I’ve bred myself. He has access to unique and especially good vegetables to sell in market. I get to select for seed to breed or sell from tenfold to twentyfold more plants than I would be able to grow otherwise. And, while I plan the arrangements in the breeding field, and do the crossing and most of the evaluating labor, I have to do none of the ordinary labor of weeding or watering. I participate in and direct the planting and harvesting of “my” crops and projects, but with considerable help from my collaborating farmer as well as a team of volunteers.

D. Volunteers

One of the most delightful aspects of being a freelance plant breeder is that many people consider developing and distributing new locally adapted, open-pollinated and IP-free varieties a tremendous public service. So they volunteer to help with the field work. Some in addition volunteer because they would like to learn about growing these crops at a bit larger scale than they can in their home gardens. Others like the camaraderie of working hard together with others very interested in gardening. And most also appreciate a share of the produce that often comes with the deal.

I plant most of my seed crops on the land of a local organic farmer. I design the breeding projects and the layout of plantings in the field. Then the farmer and I and a team of volunteers plant the major crops, the corn, beans, and squash. The farmer tends, weeds, and waters the crops. I do the crosses and taste testing and most of the evaluation.

Then he and I, with my team of volunteers, do the harvesting. The planting and harvesting of the corn, beans, and squash are labor bottlenecks. My farmer and I can deal with about 10 times as much crops as he could otherwise if we have volunteer help with the planting and harvesting. In addition, my farmer is helped in an on-going basis by a volunteer who works one or two half-days a week on his farm. She is planning on becoming an organic farmer herself. This is the way many learn the basics.

Most freelance plant breeders are in a good position to attract volunteers. Announcements on their websites, recruitment through their seed catalogs, giving local talks and workshops, writing books, or even just posting a note on local bulletin boards can all work.

E. Royalties for IP-Free Freelance-Bred Varieties

A great boon for freelance plant breeders has been the introduction of voluntary royalties or benefit sharing of some kind for their varieties. This practice was apparently started independently by Fedco Seeds and Johnnys Selected Seeds. It's intended as a means of supporting and encouraging freelance plant breeding. Says Petra Page-Mann, co-owner of Fruition Seeds, "When we know the breeder and did not purchase seed from them, we joyfully invest 10% of sales to increase the capacity of their future work. I've been hearing folks call these reciprocal investments 'liberties' rather than 'royalties' which I love, speaking to the new models and paradigms we're cultivating along the way" (Page-Mann 2019). May the practice spread!

Johnnys Selected Seed and Fedco each pay 10% of the full retail price of seeds minus quantity discounts. A number of smaller companies also pay a voluntary benefit share on freelance-bred varieties. Southern Exposure Seed Company and my own Fertile Valley Seeds pay 5% of retail. This smaller amount for a small seed company can actually represent paying more per seed than 10% for a large seed company, as most of the price of a packet of seeds for the smaller company is the packing labor, mailing, and website maintenance, not the seed. In some cases, the royalty is in the absence of any formal contract, and is done routinely for all freelance breeders. I suddenly received several hundred dollars in royalties last year from a company I had never heard of for one of my corns, for example, a corn that was released many years ago.

In some cases the royalties are paid only by arrangement or advanced contract, or only for varieties that are just being introduced, and perhaps only for the first few years after introduction. In other cases, they are paid routinely to all living freelance breeders whose varieties the

seed company is carrying where they are not buying the seed from the breeder. In some cases it matters whether the seed company folks know the breeder personally, or the breeder needs to contact the seed company and mention that the variety is theirs. Contracts may not be needed, and aren't with Fedco and Southern Exposure. For example, in 2018 Fedco Seeds added my cowpea 'Fast Lady Northern Southern Pea' to its list. Fedco Seeds first approached me to see if I wanted to grow and sell it wholesale myself, and if not, whether I could suggest a grower. I didn't want to grow the variety wholesale, as our bean threshing capacity is already maxed out by my bean breeding projects, my collaborating farmer's sales in the farmers markets where people await and ask about the beans every year, and the fact that our beans are staple crops for myself, my farmer collaborator, and some of our volunteers. I suggested a local grower I had worked with who I knew could do a good job with the variety. After the first season, I received a check from Fedco representing a voluntary royalty for the beans they sold. Had they bought the beans from me, they would not have paid a royalty, assuming the cost of the breeding was included in the wholesale price, which they would expect to be a bit higher than even other hand-produced seed of the crop to help cover breeding.

The seed companies that pay such voluntary royalties or a compensation or premium of some sort to freelance plant breeders include A. P. Whaley Seed (Mt. Horeb, Wisconsin), Adaptive Seeds (Sweet Home, Oregon), Baker Creek Seeds (Mansfield, Missouri), Fedco Seeds (Waterville, Maine), Fertile Valley Seeds (Corvallis, Oregon), Fruition Seeds (Canandaigua, New York), High Mowing Organic Seeds (Wolcott, Vermont), Johnny's Selected Seeds (Albion, Maine), Southern Exposure Seed Exchange (Mineral, Virginia), and Wild Garden Seed (Philomath, Oregon).

High Mowing Organic Seeds makes arrangements through advance contracts only. Adaptive Seeds has no direct amount associated with particular varieties or sales figures, but simply sends a check occasionally as an appreciation to some freelancer whose varieties they carry. Baker Creek Seeds makes special arrangements with particular freelance plant breeders as well as, in some cases, certain seed savers who are preserving large amounts of unique material. In general, their arrangement is for a three-year exclusive on a variety as it is introduced. (That is, the freelancer does not sell the variety elsewhere in that time.)

Baker Creek produces the seed and gives about 30% the retail price to the breeder/source for those particular varieties for the three years (only). It also features the varieties and give them major promotion so that they are widely distributed after the first year, and pretty much everywhere by the end of the third year. Baker Creek may or may not

make a profit on those particular varieties; the point is to support the breeder or curator. Baker Creek also sometimes supports particular freelance projects or supplies funds informally in various ways. Baker Creek does not usually make any royalty/premium arrangements for varieties that are widely available through other seed companies. However, in all cases, it supports freelance breeders by buying the seed wholesale from them where it is available, even though there may be other sources that are cheaper.

Many seed companies don't pay voluntary royalties because they don't do or contract for their own grow-outs. They instead support the work of freelance breeders by buying the seed from them wholesale, even though it usually costs more than from other sources that aren't doing breeding. The practice of buying preferentially from the breeder is widespread, and many consider it an ethical issue. It's also becoming increasingly common for seed companies to explicitly mention their paying royalties to or sourcing seed directly from the freelance breeder right in the variety descriptions.

My varieties are all OSSI-Pledged, that is, they are released under a pledge that forbids their ever carrying any patents, PVPs, or other IP. This doesn't preclude anyone paying a voluntary benefit share to support my work, however. In addition, however, OSSI allows contracts of all sorts, including those involving obligatory royalties between parties participating in growing and selling seed, as long as no restrictions on the variety extend to third parties. So, for example, Organic Seed Alliance negotiated a contract with High Mowing Organic Seeds requiring a royalty when High Mowing grew, introduced, and sold seed of its OSSI-Pledged variety "Abundant Bloomsdale" spinach. This was an OSSI-compatible situation, since no restrictions or royalty requirements were passed along to the High Mowing customers who bought the seed.

F. Other Funding for Freelance Plant Breeding

It is sometimes possible for freelancers to get small grants for specific plant breeding projects, especially after the first few years on the project are done, and scaling up for a couple of years is necessary to finish it. The two sources I know of that occasionally fund freelance plant breeding projects are the Organic Farming Research Foundation and SARE, Sustainable Agricultural Research and Education Program. Clif Bar (Emeryville, California) has been funding one freelance breeder for a number of projects. One freelance breeder raised a significant round of funding through a crowd-source campaign.

Sometimes family help a would-be freelance plant breeder or farmer with a down-payment on a farm. Or just buy the farm as an investment and let the freelance plant breeder use it. One Oregon freelance plant breeder has been backed by a farmland investor who wanted the land for an investment but wanted to support someone trying to improve the agricultural system too. Freelance plant breeders with farms may have spouses with outside jobs. Someone with an outside income is often an essential component in the survival of small family farms of many sorts, especially those with mortgages. Even farming operations that are financially successful can have bad years, and small diversified organic farms cannot ordinarily get crop insurance. In addition, one employed spouse may be essential to provide health insurance for the family. And of course many freelancers start their plant breeding essentially as a hobby while holding full-time jobs, and only graduate to full-time plant breeding after they have retired and have retirement income as well as a number of released varieties with a steady stream of new releases on the way.

XI. FREELANCE PLANT BREEDING THAT DOESN'T FIT COMMERCIAL MODELS

To what extent does the freelance plant breeding described in this chapter include all the freelance plant breeding happening in its target areas of USA, Canada, Australia, and New Zealand? I believe that it misses more than it covers. What I have described is the kind of freelance plant breeding that results in varieties that can be sold by seed companies. When you peruse freelance plant breeding forums, however, you see a lot of plant breeding happening where no effort is being made to develop stable varieties or anything that can be sold by seed companies. The germplasm is bred, distributed and exchanged, though, often for free. Unless and until the material is stabilized enough to fit into the patterns of sales through seed catalogs, the plant breeding isn't visible.

Why would a lot of material be unsuitable to distribute through seed companies? One issue is stability. Another is characterization. Those plant breeders who run small seed companies may have more flexibility in what they offer as varieties than is typical for most seed companies. But there are still limits. Most customers want a variety that is at least stable for the characteristics that matter. Or if it is variable, it is variable in only certain ways that are advantageous. Customers don't want complete unpredictability. Nor do they want to buy varieties that vary dramatically from year to year. The latter is common, because freelancers who don't care about developing varieties that can be sold

through seed companies often keep adding new germplasm into the breeding project every year. Seed company customers also don't want material that is not characterized. And while some customers might buy breeding material to play with themselves, even among customers of small seed companies, breeding material does not usually sell nearly as well as finished stable or mostly stable varieties.

Joseph Lofthouse normally breeds landraces. His landraces are generally too variable to fit into normal seed company's offerings. But they are heavily selected for earliness and ability to produce under very harsh conditions, so are very valuable to those who live in places where they have trouble producing the relevant crops at all. We OSSI-Pledged some of his landraces, ones that he basically maintains in a consistent form from year to year. But most of his breeding work is even more variable than these landraces, and changes from year to year as he adds more germplasm. He maintains all the *Phaseolus vulgaris* in his dry bean collection as a single population, for example. And likewise for all the other bean species. He works with dozens of species in addition to those for which he has OSSI-Pledged some varieties. He distributes seed of many of the species to whoever is interested. But he is ever changing and breeding the material. Lofthouse doesn't run a seed company nor sell seed to seed companies. He grows and sells produce. Those who don't run seed companies don't necessarily feel any need to develop material that can be sold through seed companies.

An additional problem is that freelancers often make incremental changes to material. In that case, very often only the last of a series of breeders, the one who names something as a new variety that can be sold by seed companies, shows up as a breeder and is actually credited for doing any plant breeding. There may be dozens of breeders involved sequentially.

Much freelance breeding of fruit and nut trees takes the form that a freelancer simply collects fruits or nuts from a tree they like and starts sharing or selling the seed. They may or may not own the tree. Chris Homanics has traveled widely throughout California, Oregon, and Washington and has examined thousands of walnut trees and identified exactly five that appear to be walnut blight resistant. When he saves and plants and distributes nuts from those trees, it's selection, the core of plant breeding. But it doesn't involve named varieties or variety release. This sort of plant breeding tends to be invisible.

Undoubtedly, a lot of plant breeding happens when people are just trying to save seeds. If they are somewhat familiar with plant breeding, and they develop something new from an off-type plant, sport, or accidental cross, they may give it a new name. But if they aren't very aware

of plant breeding, they may select and develop a new variety and continue calling it by exactly the same name as what they started with. In that case they've done plant breeding that is invisible. In cases where seed savers select, deliberately or accidentally, for characteristics that aren't physically obvious, they may do significant plant breeding and have no idea they did, even if they are experienced plant breeders. So their variety will not get a new name or a formal release and the plant breeding will be invisible. I can normally find new varieties by simply talking with anyone very active in SSE who maintains many varieties and asking them what varieties they have been maintaining that are quite different from what they started with. Most will be able to remember at least one or two varieties that were very crossed up when they got them, and stabilized only after they selected consistently for years. Undoubtedly, most of the time they don't remember. And undoubtedly, much of what seed savers might select for accidentally is invisible.

In some cases it's obvious that someone did a lot of plant breeding, but it's not at all obvious who. Glenn Teves, who is an extension agent at University of Hawaii, works with a lot of Native Hawaiian farmers. Teves tells me these farmers are growing many vegetable varieties that have clearly been developed from modern hybrids, but are now open-pollinated varieties. Nobody seems to know who was responsible for doing the breeding (Teves 2014).

New varieties frequently are not named but instead just given a number by a prolific breeder. And some breeders provide a full characterization of a new variety. But others just hand it, unnamed and uncharacterized, to others, or list it under a number with little or no information in the *SSE Yearbook*. Such material is much less likely to get tried and picked up by others, or to survive the life of the breeder.

The freelance plant breeding I've been discussing in this chapter is, I'm convinced, only a minority of the freelance plant breeding happening. It's more visible because most of it is more deliberate, and it comes closest to fitting into our commercial patterns for naming, identifying, and distributing varieties.

XII. OPEN SOURCE SEED INITIATIVE AND FREELANCE PLANT BREEDING

The consolidation of control over food crop seeds and loss of freedom to operate of plant breeders by increasing use of plant IP has been discussed extensively (Kloppenborg 2004, 2010, 2014, Tracy et al. 2016,

Lawn 2016, 2019, Halpert and Chapell 2017). The creation of the Open Source Seed Initiative is a positive reaction to these problems, an effort aimed at assuring that there will be an expanding pool of plant germplasm that remains free from IP.

The Open Source Seed Initiative grew out of a collaboration of Jack Kloppenburg with Irwin Goldman, Tom Michaels, Claire Luby, Frank Morton, Tom Stearns, and other university and freelance plant breeders, seed companies, and seed rights activists. OSSI has been reviewed by Luby, Kloppenburg, and Goldman (2016) as well as discussed in other academic journals ranging from agriculture to sociology (Kloppenburg 2010, 2014, Luby, Kloppenburg, Michaels, and Goldman 2015, 2016, Luby and Goldman 2016a, 2016b, 2016c, 2017, Montenegro de Wit 2017). OSSI has also received considerable attention in popular media (Morton 2013a, 2013b, 2016, Hamilton 2014, Cernan-sky 2016, Deppe 2016, 2017a, 2017b, Dunton 2016, Lawn 2016, 2019, Roach 2016, Greenaway 2017, Still 2018, Frost 2019, Luby, Endres, Wander, and Ugarte 2019.)

Once a variety is OSSI-Pledged, the breeder sells or transfers seed of that variety and all its derivatives, in perpetuity, only with the OSSI Pledge:

“You have the freedom to use these OSSI-Pledged seeds in any way you choose. In return, you pledge not to restrict others’ use of these seeds or their derivatives by patents or other means, and to include this Pledge with any transfer of these seeds or their derivatives.”

There are currently 487 OSSI-Pledged varieties, 43 OSSI-associated breeders, and 64 OSSI-Partner Seed Companies selling the varieties.

Six of the 43 OSSI-associated breeders are university breeders; one is a major seed company; another is OSA. All the rest—35 of the 43—are freelance plant breeders. *Of the 487 OSSI-Pledged varieties, 471, that is, 96.6% were contributed by freelance breeders.* The difference in numbers of varieties contributed is only partly because there are more freelance than university breeders. An even bigger factor is that university breeders who are interested in OSSI can usually get permission from their institutions to OSSI-Pledge only the occasional variety. Freelance breeders, in most cases, pledge *all* their varieties. At this point it is obvious that the fate of OSSI and the freelance plant breeding movement are intimately intertwined.

OSSI offers important advantages for freelance plant breeders. OSSI serves as a registry for OSSI-Pledged varieties. The OSSI website maintains a searchable database (<https://osseeds.org/seeds/>) of all OSSI-Pledged varieties that gives photos, descriptions, date OSSI-Pledged,

date released, whether bred for organics or not, whether a finished variety or breeding material, commercial sources, and live links to the OSSI-Partner Seed Companies that sell the varieties. OSSI actively promotes the varieties through outreach of various kinds, draws attention to the varieties, and channels that attention directly to the seed companies that sell the seeds. In addition, OSSI requires partner seed companies to acknowledge the breeder in catalog descriptions of OSSI-Pledged varieties.

Before OSSI, freelance plant breeders had a hard time even getting their new varieties trialed by seed companies. It was common for freelance plant breeders to be completely unable to interest seed companies in their work until a decade or more after their varieties were released through Seed Savers Exchange or their own small seed companies and had begun to catch on through such small beginnings. Now there are 64 OSSI partner seed companies ranging in size from one person operations to some with substantial sales such as Fedco Seeds, Harris Organics, High Mowing Organic Seeds, and Nichols Garden Nursery. These retail seed companies are eager to trial OSSI-Pledged varieties to find additional ones suitable for adding to their lists. Many catalogs of OSSI partner seed companies list OSSI-Pledged varieties in their ordinary sequence, but also double-list them at the front of their catalogs in a separate section for OSSI-Pledged varieties. They are proud of their OSSI-Pledged varieties, and want to carry as many as possible. Some seed companies even have special collections of OSSI-Pledged varieties. Established freelance breeders of *OSSI-Pledged varieties* can now easily get their varieties trialed by appropriate seed companies essentially as soon as enough seed is available.

New freelance breeders with their first OSSI-Pledged variety can also now much more readily get their variety trialed and introduced by major seed companies if they wish. Their variety is listed right where seed partners looking for new OSSI-Pledged varieties can easily find them. In addition, new freelance breeders can often get informal advice about commercial issues as part of the Pledging process. All five members of the OSSI Variety Review Committee, myself included, are OSSI board members as well as plant breeders. Three of us are freelance breeders with our own seed companies. We have extensive contacts with retail seed companies and wholesale seed growers. We can usually advise new freelance plant breeders as to which seed companies might be interested in their varieties, as well as alert appropriate seed companies about new varieties that they might like.

In addition, OSSI sponsors the Open Source Plant Breeding Forum (opensourceplantbreeding.org/forum/), a permanent home where

freelancers can interact with and learn from each other. OSSI also sponsors the podcast series *Free the Seed!*, which is specifically aimed at encouraging freelance plant breeders and teaching plant breeding. OSSI in addition runs free meet-and-greet sessions after the OSA Seed Growers Conferences that allow all involved with OSSI to talk with each other and make useful contacts.

OSSI has also been a boon to new seed companies, too, those started by freelance plant breeders or others. For a small, new one-family seed company, the problem is that no one knows about you unless you are already well known for something else. Most newcomers, especially younger newcomers, aren't. So for most, there was a huge barrier to entry to starting even a small, one-family seed company. Most freelance plant breeders, in fact, used to distribute their varieties through the Seed Savers Exchange for years or decades before they could usefully start even a small one-family retail seed company. The barriers for entry are hugely reduced for new seed companies who become OSSI partners. The OSSI support for OSSI-Pledged varieties translates into support and promo for its seed partners, including the newest.

All partner seed companies and their logos and live links appear on the Seed Partner page on the OSSI website (osseeds.org/seed-company-partners/). The page features a world map that locates partner seed companies geographically. That way, seed customers can easily find the OSSI partner seed companies in their own region or country. And people who run OSSI-partner seed companies can find OSSI-associated freelance breeders in their regions. Best of all, a new seed company gets live links from the OSSI Seed page for any given OSSI-Pledged variety they carry right to the page on their own website where the customer can see their listing and buy the variety, and with a little luck, be impressed with the rest of their listings, buy considerably more than one variety, and become a regular customer.

Of the freelance plant breeders who were established before the era of OSSI, most went with OSSI; a few didn't. Some stayed with their familiar pattern, the public domain release model and its lack of paperwork. For most of the younger freelance breeders coming along now, OSSI is the obvious choice. They begin interacting with and getting help from OSSI or OSSI-associated freelance breeders before they ever release their first variety. The OSSI-Pledging of their first variety represents a coming of age and a moment of pride and accomplishment. OSSI serves as a spiritual home for freelance plant breeders and engenders a sense of community, and camaraderie. It's an exciting time to be a freelance plant breeder—especially an *OSSI-associated* freelance plant breeder.

XIII. FUTURE PROSPECTS

The future prospects for freelance plant breeding in USA, Canada, Australia, and New Zealand are integrally linked with three movements—those associated with organic farming and food, local seed and food, and seed sovereignty. All three of these movements are strong and appear to be growing. I expect freelance plant breeding to expand and thrive accordingly.

Twenty-eight years ago, when I started writing about and for freelance plant breeders, most freelancers were happy to get a variety listed by a major seed company, with the seed company growing the seed itself and paying the freelancers nothing beyond an acknowledgement. And often they didn't get even that. OSSI-associated seed companies are explicitly interested in varieties bred by freelancers. In addition, OSSI-associated seed companies are required to acknowledge the breeder in variety descriptions for OSSI-Pledged varieties. And growing numbers of seed companies willingly pay freelance plant breeders a voluntary benefit share when they grow and sell their varieties. Many retail seed companies also follow a voluntary ethical principle of always buying wholesale seed of freelance-bred varieties from the breeder when the breeder is able to supply it, even though such seed is usually more expensive than could be had from a grower who is not supporting a serious plant breeding habit.

The advent of the internet has been a boon to freelance plant breeders. Many support themselves and their work in part by starting and running small seed companies. It used to take several thousand dollars per year just to print and mail out a few thousand catalogs. It was a major barrier to entry. Now, smaller or starting companies can use online-only catalogs. In addition, it used to take most freelancers a decade or more to build up their mailing lists to a workable size. Now, freelancers can much more readily attract a customer base via blogging, YouTube videos about gardening, participation in various online gardening groups and forums, and other social media. I expect increasing numbers of small seed companies started primarily to support freelance plant breeding or engaging in freelance plant breeding as part of their mix of activities.

There is still a dearth of organically certified seed, which is increasingly required for growing certified organic crops. This gap between demand and supply is a ready niche for new dedicated organic retail seed companies as well as organic seed growers. These niches are the hotbed for freelance plant breeders.

Freelance plant breeders are now much more able to communicate with each other as well as with university breeders as a result of the

internet, internet forums on gardening and plant breeding, and conferences such as the OSA-sponsored Organic Seed Growers Conferences and those run by OSSI and SOSF. I am predicting that in the future there will be many more large complex collaborations among freelance breeders for specific projects, such as was done with the Dwarf Tomato Project. In addition, I anticipate many more collaborations between freelance plant breeders and university breeders.

One impediment to freelance plant breeding in the future will likely be the increasing use of MTAs with ongoing restrictions for public domain seed from other countries, and the use of restrictive MTAs for much of the material in the USDA collection. Any MTA or restriction that requires a percent of benefit sharing is problematic if the intent is to use the germplasm to develop either public domain or OSSI-Pledged varieties. In the future, freelance plant breeders may be cut off from access to much of the germplasm that has in the past been available. In that event, the Seed Savers Exchange and its network of seed savers, which already has much of this germplasm in its seed bank and member network, may be more important than ever. The situation may also require freelance plant breeders to do more of their own germplasm collecting, or to engage in more informal exchanges with noninstitutionally allied people in other countries.

An additional threat to the freedom to operate of freelance and other plant breeders is the increasing tendency of the major retail seed companies to sign or accept contracts, licenses, bag-tag agreements, and language on invoices from their major wholesale suppliers that put serious restrictions on seed. Those who buy the seed from the retail seed companies are almost universally not being informed of the restrictions except for the patents and PVPs. CR Lawn, founder of Fedco Seeds and an OSSI board member, compiled data on all varieties carried in the 2013 Fedco catalog that carried these invisible forms of IP, who the suppliers were, and what restrictions were put on the seed (Lawn 2019). Fedco, as a matter of policy, does not carry any patented seed. However, it does carry hybrid seed, seed with PVPs, and seed with these invisible restrictions. Lawn presents information about the exact nature and form of all the restrictions on all its seed used by its eight major relevant wholesale suppliers or seed licensors (Bejo, Cornell University, Crookham, Floranova, Sakata, Syngenta, Syngenta Flower, HM Clause/Tezier, and Genesis). He presents the exact nature of the restrictions for each supplier and licensor. In addition, he then contacted these suppliers and licensors for further information as to whether Fedco and other retail seed companies were supposed to inform their buyers of the restrictions and whether the restrictions extended to third parties, such

as the gardeners and farmers who buy Fedco seed. In many cases, the wholesale suppliers claim that neither Fedco nor its customers have any rights to the seed they are buying at all beyond the right to produce a vegetable crop in one year only. Lawn further presented a list by crop and supplier of every one of the restricted varieties—126 of the approximately 1,050 varieties in the Fedco catalog. Because suppliers are using the same bag tags, licenses, and invoices on all varieties, even heirloom varieties are being encumbered with such restrictions. Seven of the varieties carrying such restrictions in the Fedco catalog are well-known heirloom varieties.

These invisible threats to seed saving and plant breeding rights need to be addressed and fought explicitly. Seed savers and plant breeders of all kinds need to band together and demand that retail seed catalogs tell them explicitly about any patents, PVPs, or restrictions of any kind in the variety description for each variety, and let buyers act accordingly. Only if retail seed companies are required to be explicit about seed rights—and face the potential wrath and boycott of their customers—will they have the incentive to refuse to accept such additional inroads on seed sovereignty.

Aside from the issue of access to germplasm, I think the main problem in the freelance plant breeding world is that many freelance-bred varieties get lost before the varieties are distributed widely enough to survive. This can especially happen when the plant breeder dies, or as a result of illness or age or moving, must cut back on or cease gardening or farming activities. But loss of varieties tends to be a problem for freelance breeders of all ages who are gardeners rather than seed company owners. They do not have a mechanism in place for distributing their seeds themselves. Nor do they have the platform for promotion that a small seed company provides. OSSI might be able to provide a solution for this problem. There are discussions underway about the possibility of creating a frozen-storage seed bank and hiring people to mail out packets of seeds for OSSI-Pledged varieties for which there are no commercial sources, and for which the breeder requests this service.

I think a large fraction of the plant breeding that has been done in the last two decades has been aimed more at creating proprietary positions than anything new or superior with respect to the varieties. That is, the major aim has been to replace open-pollinated public domain varieties with hybrids or IP-entailed varieties. I expect to see ever-increasing amounts of plant breeding among freelancers aimed at doing the opposite—breeding to create nonproprietary positions rather than necessarily anything new in the varieties. In many cases, the freelancer is happy with a particular hybrid's general characteristics and

performance—except for the fact that it is a hybrid. In other cases, a more vigorous, more organic-adapted open pollinated variety can be developed by combining germplasm from two or more hybrids or combinations of hybrids and open-pollinated varieties and selecting from there. But just the mere creation of an open-pollinated variety to replace a hybrid or a variety encumbered by IP is increasingly a major objective.

I expect many more genuinely dramatically different varieties from freelancers in the future, too, however. Varieties dramatically more vigorous and higher yielding than any hybrids in the crops, and with dramatically superior flavor. Entire new classes, such as the 110 dwarf tomatoes. Heirloom-quality tomatoes with full resistance to late blight. A lot more varieties that involve introgressing traits from wild relatives into domesticated varieties. A lot of new sweet potato varieties bred from true seed. A lot of new garlic varieties bred from true seed. A lot of varieties with regional adaptation beyond the norms of anything today. And a lot of new, delicious flavors.

A few of my generation of freelance plant breeders began by learning from books by and for academic plant breeders because we had relevant academic backgrounds and could do so. But most freelancers of our era had to learn largely by trial and error. Those learning now have a number of books written specifically for them as well as organizations such as OSA, OSSI, and SOSP to support them. And there are myriad forums for freelance plant breeders so they can learn from each other. The number of freelance plant breeders is increasing. We are being recognized and given credit for our work. A growing number of people are interested in locally adapted, organic-adapted seed, and are willing to pay a premium price for it, creating niches we can use to help support our work. The excitement when we get together at conferences is electric. It's a great day to be a freelance plant breeder.

ACKNOWLEDGMENTS

The author thanks Jack Kloppenburg, Michael Mazourek, and Irwin Goldman for reading the manuscript and making many useful suggestions.

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