5280



Photograph by Benjamin Rasmussen

# The Investment Bank

A small facility in Fort Collins is home to one of the world's largest curated seed collections. The lab could save our food supply in the case of a disaster—but only if the federal government continues to fund it.

BY NATASHA GARDNER | 5280 MAY 2017

12 1

5280 > Feature

Emergency rooms have a sharp, antiseptic scent, but this space smells like rich, loamy, soil.

The air is slightly humid, and the overhead lights are bright, glinting off the metal trays and instruments arranged technicians dressed in white lab coats sit at desks, hunched over their work on a frigid day in November. Both are singularly focused on their patient: a pile of small twigs.

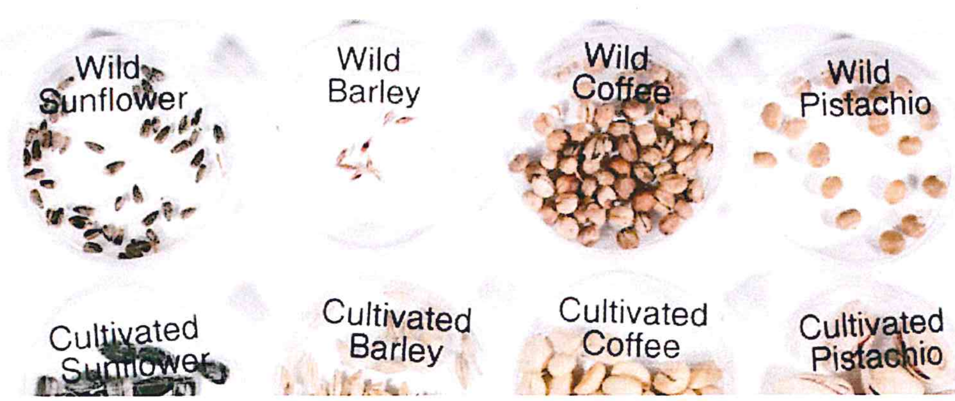
The two women work at a furious pace—because they must. One grabs a small branch that has been cut from a citrus tree and uses a microscope to scan the bark for one of the earliest signs of life: a leaf bud. She expertly slices off a tender bud, deposits it into a petri dish, and immediately picks up another stick. The two techs are part of a five-person project team at the National Laboratory for Genetic Resources Preservation (NLGRP) that's been working overtime since July to cryogenically preserve the genetic code of an entire grove of citrus plants from Riverside, California, before it's infected with the lethal and incurable "huanglongbing," otherwise known as citrus greening disease.

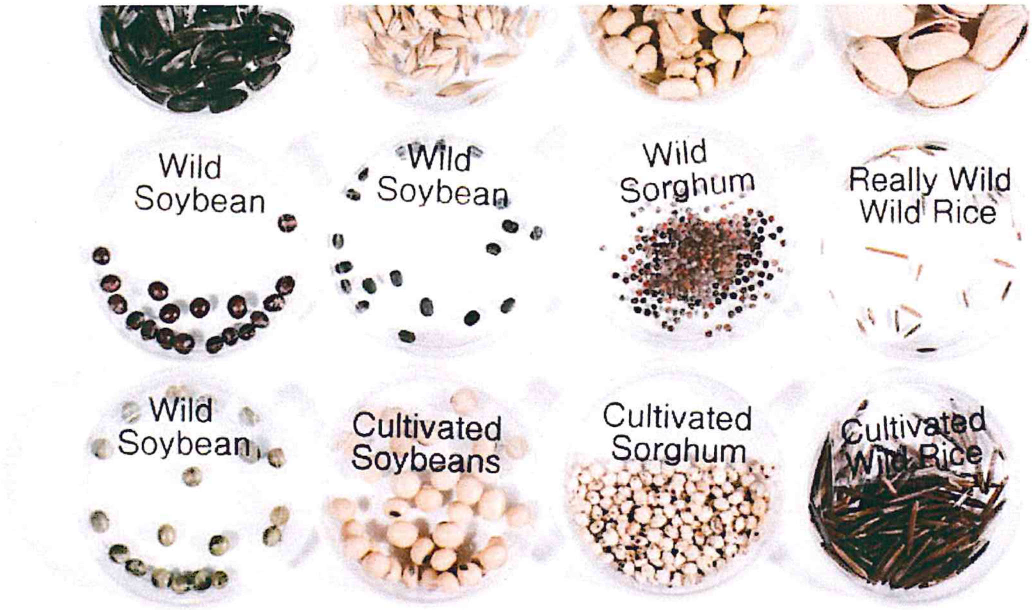
Citrus greening is spread by the Asian citrus psyllid, a small bug that likes to munch on citrus trees—which wouldn't be much of a problem except that it sometimes carries a pathogen in its saliva that infects the bitten tree and causes a slow death. The disease can go undetected until farmers notice unripe fruit, skins with a greenish tint, and mottled leaves. By then, an entire grove can be infected.

Like many plant diseases, this one isn't new; reports of citrus greening in China date to 1919. It only became a significant problem in the United States, particularly in Florida, in 2005. Now, eight of every 10 Sunshine State citrus trees—oranges, key limes, grapefruit—are infected, and production has dropped by as much as 75 percent. The disease is also moving; affected trees have been spotted in Texas, California, and seven other states.

The U.S. Department of Agriculture (USDA) and its Agriculture Research Service arm are working to find a solution, including funding an additional $13.6 million in grants in January for research on a cure. Pesticides don't work. Antibiotic sprays are ineffective. Isolation—growing trees in protected greenhouses—has had some success, especially at the Agriculture Research Service's citrus collection in Riverside. That grove is still in danger, though, so the NLGRP got involved.

Instead of trying to find a cure, the NLGRP asked if there might be a way to reconstitute the trees in the event the entire population were to be wiped out. It's a common question at the lab, which focuses on the preservation of genetic agricultural resources. The easiest route would be to dry and store seeds from each tree, but regrowing citrus is a fickle business. As with apple trees, the seeds of other delicious fruits don't necessarily grow up to produce the same types of offspring. Taking a living portion of the tree, preserving it, and grafting it to rootstock to regrow offers more predictable results. So instead of saving seeds, the lab snips off tiny buds to cryogenically preserve them at minus 321 degrees Fahrenheit to promote longevity until growers need them.






Researchers at the NLGRP store and run experiments on millions of different kinds of seeds. One floor of the Fort Collins facility can hold up to 600,000 samples, or accessions; each accession has about 3,000 seeds. Photograph by Benjamin Rasmussen

What's making this particular operation unique is the deadline. Normally, the lab might try to preserve 100 buds in a year. To create a genetic backup to the Riverside grove, they need to process nearly 350 in six months—which is why the two lab technicians are working so frantically. They are trying to outpace a disease that's rapidly devastating an agricultural industry.

The lab not only met its goal of backing up the citrus collection, but it also finished two weeks early in late February. Although citrus greening can continue to kill, there's now a limit to what the disease can do. It can't exterminate these plants because the NLGRP will bring them back, again and again, until a cure is found.

**Seeds can be deceptive:** They are simple vessels with protective coatings that appear functional rather than awe-inspiring. Add water, though, and like something out of a fairy tale, seeds awaken and transform. What one day is a drab, hard shell will erupt into a green living thing within hours or days. If you speak with a self-proclaimed "seed geek" (farmers, chefs, scientists), they'll refer to seeds as "miracles of nature" or "the best material engineers." They'll point out that these containers are some of nature's most complex structures, rivaling architectural wonders. They can survive decades, wars, and natural disasters.

None of this is hyperbole. Seeds, a type of germplasm, have been used as currency, sacred objects, and, now, are considered commodities. They are typically inexpensive, but their value—what they produce, and what they tell us about living, growing, and dying—is almost impossible to calculate. "When you pour a little bit of seed out in your hand, you're holding life," says Eric Skokan, owner of Black Cat Farm Table Bistro in Boulder. "It's a huge responsibility, but it's wonderful to be able to look into the future in your hand."

The United States recognized the importance of supporting a seed-based agrarian economy early on. Seed collection important. The department's Agriculture Research Service wing helped develop everything from microwave dinners to permanent-press cotton, and it also had a grand plan for seeds. In 1958, the United States consolidated a variety of seed-saving initiatives into several labs around the country with a master lab—what is now called the NLGRP—in Fort Collins. The area's dry climate is well-suited for seed storage, and being close to the agricultural programs at CSU was an added benefit. The hope was to create a space to preserve and study seeds. It would be federally funded, staffed with seed scientists, and focused on agricultural commodities (a $985 billion industry today, or 5.7 percent of the U.S. gross domestic product).

**"When you pour a little bit of seed out in your hand, you're holding life."**

—ERIC SKOKAN

The result is hidden in a vault behind a series of locked doors, which whoosh and hiss when opening, like something out of a Hollywood film. The air is shockingly cold, at zero degrees; it's kept that way by a large-scale version of the same freezer you can buy at a store. Inside the 5,000-square-foot room are rows and rows of shelving units filled with foil-laminate, heat-sealed packages—called "accessions"—that contain seeds. The low temperature helps slow aging, ensuring that seeds that might only last for five to 10 years when stored at room temperature can last much longer than that. (Wheat stored in this room should keep for 400 years.) One floor of the four-story building can house 600,000 accessions, and each accession holds, on average, about 3,000 seeds.

From the outside, the building is unremarkable: a 1950s concrete structure reinforced with rebar and not recently updated. It was built to last, though. If Horsetooth Reservoir should fail and flood Fort Collins, the NLGRP's vault will endure. It can take on an EF4 tornado or the impact of a 2,500-pound object. It's one of the safest spots in the state.

But instead of acting like a museum or a safety-deposit box, the vault is quite accessible. The NLGRP adds about 13,000 accessions a year, and the system of seed banks around the country sends out 250,000 to farmers, scientists, and other countries looking for specific seeds. That's possible because the lab's scientists are constantly testing the collection, bringing seeds out of the vault, and germinating them to create more seeds. That process tells them when a seed is getting too old and when something finicky—like peanuts, seeds that are notorious for dying quickly—needs to be replenished.

It's a massive endeavor, and there's something comforting about standing in that freezing storage room. One gets a sense that if things were to go horribly awry—famine, drought, war, natural or human-made disasters—we could enter this room, take an accession of wheat from the shelf, and start anew. It is, perhaps, the ultimate chance for a do-over.

**Although it's a seemingly** apolitical operation, the NLGRP isn't immune to the machinations of Washington, D.C. When President Donald Trump took office in January, he put the USDA under a media blackout, and the lab—as part of the Agriculture Research Service arm of the USDA—was included. (The NLGRP, although located on considering. “Budget is a hardship for us,” says Christina Walters, a 30-year NLGRP veteran and research leader for the Plant Germplasm Preservation Research unit. “We’re infrastructure, and infrastructure doesn’t get a lot of publicity.”

The NLGRP may be relatively unknown in the United States, but it has an international reputation as a role model for other banks—and there are an estimated 1,750 collections worldwide. (One of the most famous ones is Svalbard, a photogenic vault cut into the side of a mountain on an island in Norway just 800 miles from the North Pole.) Instead of being competitive, though, seed banks tend to work together. The NLGRP regularly hosts scientists from around the world who hope to set up similar labs in their countries. That cooperation helps build a better system of collecting, sorting, and storing seeds. “I really look at [seed banks] as food security,” says Rick Novak, the director of the Colorado Seed Programs at CSU’s College of Agricultural Sciences. “The larger the germplasm pool, the better chance for genetics coming out of that gene pool.” In other words, the more seeds we have in global storage, the better chance we’ll be able to maintain food diversity if something goes wrong in one part of the world (thus ensuring we have more options for dinner than just eating wheat and rice).

The goal is to avoid catastrophes like Ireland’s Great Famine in the 1800s, when a potato blight devastated the country’s crop. To do that, NLGRP scientists are constantly trying to think ahead about what nature might do. Like a parent who just knows her toddler is about to knock over a glass on the coffee table, the lab’s scientists leap ahead to catch the proverbial cup before it falls.

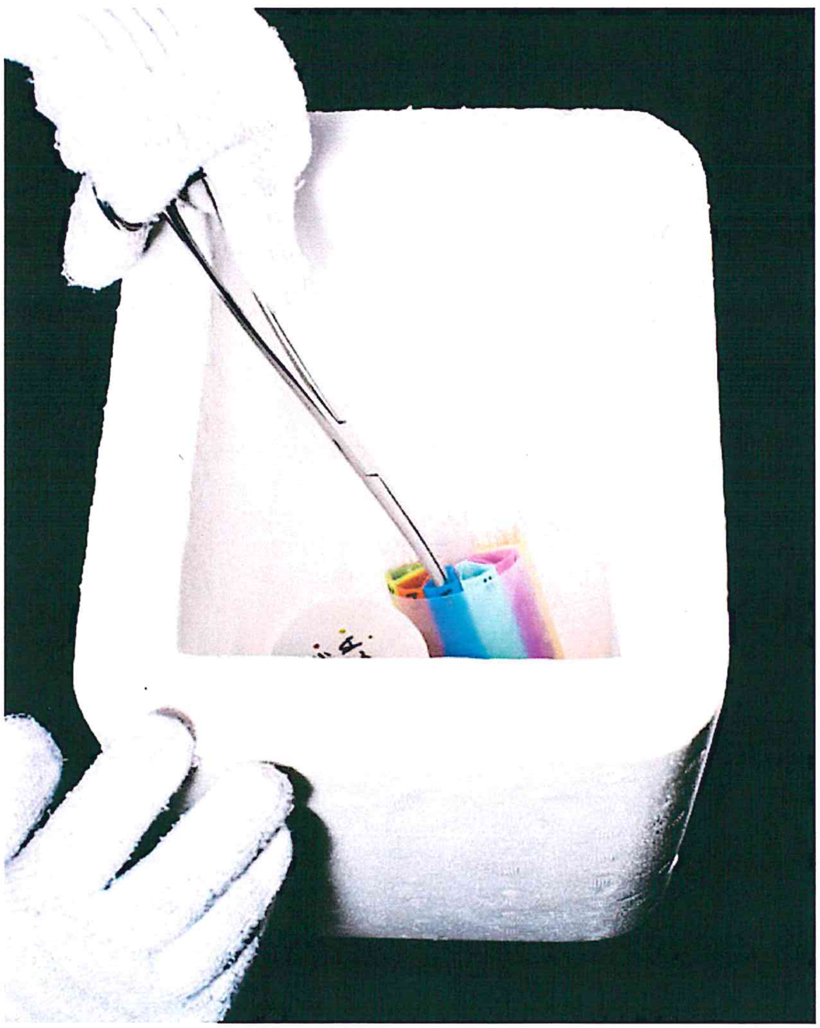
**Nitrogen is one of the most** abundant elements on Earth (it makes up 78 percent of the atmosphere) and, in its liquid form, is a frigid 321 degrees below zero. It’s also cheap, which makes it ideal for storing a large inventory of fragile seeds and plant parts like citrus buds. If used correctly, liquid nitrogen freezes something by holding it at a very cold temperature for a long period of time. It’s also an excellent way to store animal parts, specifically semen, ovaries, and embryos, and the NLGRP added a division that specializes in animal germplasm in 1999.

Like a small Noah’s Ark, the NLGRP’s liquid nitrogen rooms have dozens of tanks, each about 5.5 feet wide, that hold accessions from 220 animal breeds. There are samples of rainbow trout, goat, cattle, and inherited collections from other geneticists and breeders, who’ve frozen semen to preserve bloodlines for decades. “A lot of breeders look for particular animals,” says Harvey Blackburn, the geneticist in charge of the NLGRP’s animal program. “They treat units of semen like baseball cards.” Blackburn and his team add to the collection through donations. When they can’t find something they want, they’ll go out into the field and collect it—meaning his six-person crew is as comfortable in lab coats as it is boot-deep in muck on a farm.

The collection is always growing, because having semen from one bull isn’t enough to reconstitute a breed. The lab needs, on average, about 30 genetic samples—kept in plastic polymer tubes called “straws”—each from 50 individual animals to build back a type of cattle. But stopping there is a potential mistake, Blackburn says. He draws a bell curve and explains that what is desirable today may not be tomorrow. If the lab doesn’t collect samples all along the bell curve—especially along the long tails—they’ll lose animal traits we may want at a future date. “You’ve got the winners and the losers,” he says. “We want to capture all of those, because market trends will change.” Take, for example, pork. Over time, American producers sought animals with leaner meat. Fatty breeds, like Berkshire pigs, started to disappear. “They got those pigs so lean,” Blackburn says. “But who wants a pork chop as tough as shoe

The USDA used to fund more research flocks, but today the lab seeks out independent producers with small operations who are willing to partner up for free and run experiments on specific breeds. They found one such willing participant in Oogie McGuire, who raises Black Welsh Mountain sheep in Paonia with her husband. For 12 years, the lab has tracked breeding results on the rare flock, which has 53 ewes and 17 adult rams. "Having a lot of boys in one location means we can try a whole bunch of things," McGuire says.

One of the things they've figured out is a $15 method for artificially inseminating female ewes that is about as successful as the roughly $900 surgical procedure they had been using. They're still fine-tuning the process, but McGuire says discoveries like this wouldn't happen without collaboration with the NLGRP. "People don't understand why we need to maintain genetic diversity," she says. "Once you lose it, you can't get it back. The meat from a Suffolk [sheep] is not going to taste like meat from a Texel or an Icelandic, in the same way you wouldn't expect a Cabernet to taste like a Pinot."



Photograph by Aaron Colussi

tires, currents—to take them there. It's more unusual when a seed doesn't move, becomes cut off, and adapts to its unique climate independently, like many plants on the Hawaiian Islands. You might not expect to find this type of isolation in Colorado, but the NLGRP has identified exactly that scenario.

Take a walk along the Front Range in the summer, and you'll see Helianthus pumilus, a multistemmed, bushy sunflower species that blooms along trails. The canary yellow heads are native to this part of the country and thrive in the area's rocky clay soil. Amateur and expert seed savers have sent the NLGRP more samples than it needs to represent its diversity in the wild. And although Walters and her team are slow to throw away seeds, they agree it's possible to have too much seed, which was the problem with the Helianthus pumilus.

To figure out which seeds to keep, researchers genetically tested 29 samples from the region. The results were definitive. The seeds collected in the northern areas were very similar to one another, but the ones from the south were different. The scientists didn't understand why until they plotted the samples on a map. When they did, they found a giant blank circle between the two types of flowers. That dead zone was Pikes Peak, which has proven insurmountable for the hitchhiking seeds. The results meant the lab would keep the two genetically different samples but could discard the rest.

That sort of curation—based on physical chemistry, which in this case applies physics techniques and theories to plant chemistry—allows Walters and her team to figure out what the collection has and what it needs. They ask questions about climate and how seeds change in the lab environment versus growing in the wild. They wonder if they have enough of a certain plant (they have 40,000 accessions of sorghum, for example). They ponder how long a seed will maintain its ability to germinate in cold storage (zero degrees) versus cryopreservation (minus 321 degrees) to ensure that the collection remains a living thing, which is more difficult than it might seem. "I have a Ph.D. in plant stress," Walters says. "I can kill anything. It is easier to kill than not."

In the lab on a blustery, gray day this past November, Walters runs tests on thermal history using a differential scanning calorimeter to drop the temperature more than 160 degrees in a minute. She's working on a common problem: Water in seed or plant tissue expands when frozen, so if it is cooled too quickly, the force can rupture cellular walls and destroy the seed. She pulls up a scan on the machine's screen to illustrate the problem and immediately gives a satisfactory nod. "See this little peak?" she says, pointing to a dramatic jump in the line. "That means that this cell would die." She'll use the data to tweak the cooling rate and find a better way to extend the seed's life.

For people who deal constantly with questions of mortality, the lab's scientists are optimistic. Where others see death, they see a chance for regrowth, regeneration, and repopulation. New technology has made the lab's equipment smaller and faster and allows the scientists to uncover information long thought lost. When DNA isn't available, RNA (the message that comes from DNA) testing can reveal secrets about how a seed works. This creates opportunities to test ancient seed collections at museums or with cultural groups. This month, Walters will travel to Michigan to do just that with a repository of heritage seeds significant to several Native American tribes, including the Anishinaabe and Gun Lake tribes. She and a team of researchers want to help the tribes discover what the seeds can tell us.

When asked about what she'd do with unlimited funds, Walters jumps out of her office chair and steps on another to reach up high on her bookshelf for a copy of *Principles and Practices of Seed Storage*, a book—the seed bible—that the taxpayers and the federal budget for its very existence. "I'd update that," Walters says, pointing at the volume. "I want to solve the problem of how long seeds live, and I think we're so close. I think we can do it." She's got more questions about longevity and how a plant behaves after it sheds from the plant.

On the animal side, Blackburn's also got a long list. He'd like to expand the collection's diversity to include more yaks and water buffalo. He's interested in the progress made in preserving chicken germplasm through ovary transplantation since the eggs don't survive cryopreservation (the process kills the embryo). Breakthroughs in that procedure could be used to preserve other avian species. It's a daunting program, which would require decades of work and continued federal financial investment. Walters is unfazed, though, and says with a laugh: "We work on a different time frame here."

12 1

5280 › Feature

This article appeared in the 5280 May 2017 issue of 5280.

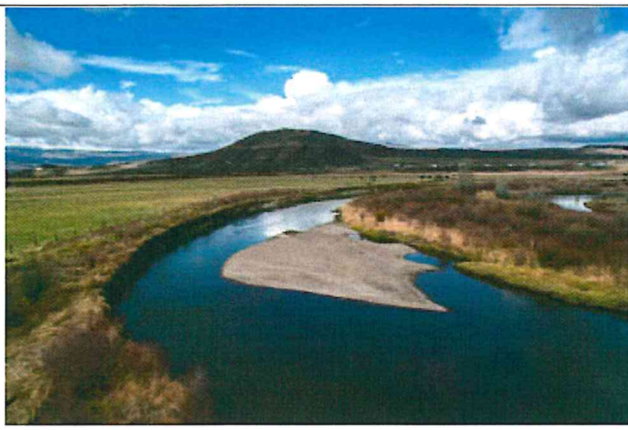
NATASHA GARDNER, ARTICLES EDITOR
Natasha Gardner writes and edits longform journalism and multimedia projects for 5280 and is a regular columnist for 5280.com.




RELATED STORIES



5280



News

River Revival

BY KELLY BASTONE

News

The Investment Bank

BY NATASHA GARDNER

News

"Sometimes You Have to Build a Wall Around Your Heart"

BY ROBERT SANCHEZ

News

Can I-70's Mountain Corridor Ever Be Fixed?

BY MICHAEL BEHAR



5280

Search 5280.com

Magazine

Subscribe to 5280

5280

Issue Archive

Subscriber Services:
1-866-271-5280

## 5280 Directories

Find a Restaurant
Find an Event
Find a Doctor
Find a Dentist
Find a Lawyer

## Best of 5280

25 Best Restaurants
Where to Eat Now
Denver's Best Bars
Top of the Town
Best Colorado Workouts
Hikes We Like
Best Places To Live

## 5280 Publishing, Inc.

About
Masthead
Advertising
Job Opportunities
Terms of Use
Privacy Policy
Get 5280 Newsletters

## Contact Us

5280 Publishing, Inc.
1515 Wazee St.
Suite 400
Denver, CO 80202

Phone: 303-832-5280
Fax: 303-832-0470