CHAPTER ONE

The Art Museum and the Seed Bank

During the White Nights of 1941—around the time of the summer solstice, when the twilight lingers beautifully and indefinitely in the skies of the northernmost latitudes—Hitler's forces first crossed from Poland into the Soviet Union, with their sights set on taking Leningrad. Soviet military intelligence was well aware of the seemingly endless caravans of German and Finnish troops, tanks, and artillery that were on the move, and surmised that those forces could converge on the city by summer's end. Stalin and his generals feared that if the German and Finnish forces were to take control of Leningrad—old Saint Petersburg—they would deal economic, strategic, and symbolic blows to the Soviets and their allies, for more than any other in the nation, that city was home to considerable monetary as well as artistic wealth.

On July 15, 1941, Stalin authorized an emergency evacuation of what the Soviets considered to be the city's most priceless treasures, those they believed the Nazis sought to confiscate and control for their own purposes. The rest of the world held its breath while the fate of those treasures was being decided

by the head-on clash between two of the greatest armies ever assembled on the planet.

Most Western intellectuals were particularly concerned with the safety of the extraordinary art collections held at the Hermitage, one of the world's oldest and largest museums of human history and culture. Well over two million paintings, sculptures, coins, jewelry, and artifacts were housed there in the six hundred rooms of the Winter Palace, built by the czars in the heart of Leningrad.

While Stalin had been deliberating how to authorize an evacuation without causing panic in the population or admitting his own vulnerability, the keepers of those cultural treasures in Leningrad had already taken action. It took but two days after Hitler's invasion of the country for the Hermitage director, Iosif Orbeli, to initiate a plan for emptying Russia's greatest art museum. He recruited not only his curators, but also hundreds of artists, historians, students, and laborers. With the utmost urgency, they would have to take roughly a million paintings out of their frames, label them and roll them up or pin them down in boxes, and cushion them in packing material so that they could be hidden away. In a mere six days, more than a million and a half works of art were readied for secret storage in vaults hidden in the Hermitage basement, in a nearby cathedral, and in the hinterlands of the Russian steppe. Before dawn on the morning of July 6, 1941, a half million paintings, drawings, frescoes, artifacts, gems, vessels, and ornaments from the Hermitage were boarded onto the first train leaving Leningrad, headed to sanctuaries in a locality known only to a few Soviet officials. On July 10, another seven hundred thousand masterpieces, filling fifty-three Pullman cars, were sent toward the village of Sverdlovsk some 2,500 kilometers away. There they would spend the next three years cloistered in a Catholic church, sequestered in an art gallery, or sentenced to the death-tainted basement of the Ipiatev Mansion, where the family of Czar Nicholas II had been shot almost three decades before. The best and brightest of the Hermitage's conservation staff were dispatched to stand watch over the collections in Sverdlovsk, to protect them from fires, looters, and other potential dangers.

The interpreters and guides at the Hermitage today love to detail how successful those efforts were in safeguarding some of the greatest masterpieces of the Greek, Roman, Medieval, and Renaissance eras. They seldom if ever mention, however, another priceless world-class collection of our shared heritage that lay just a few blocks away, unheralded, on Saint Isaac's Square.

That second treasure trove harbored—and harbors still—more than 380,000 living, breathing samples of seeds, roots, and fruits of some 2,500 species of food crops that had been collected by Russia's world-class cadre of plant explorers who had worked for the Bureau of Applied Botany since 1894. Those seeds came in all colors, sizes, and shapes, some dull-coated while others glistened like jewels, as if hinting at a more priceless bounty of diversity still out in the fields of peasant farmers around the world. The tubers, roots, and bulbs came in all sorts of textures, from knobby and gnarled to as smooth and burnished as a clay pot shaped on a wheel, glazed, then fired in a kiln. The myriad fruits exuded nearly every fragrance imaginable to a perfume chemist—musky, fermented, citric, and floral. The fruits and nuts came in all kinds of arrangements, from cascading clusters of berries to the geometric wonders of pineapples and pine cones. Most of them were not only good to gaze at, like the art in the Hermitage, but exceedingly good to eat.

That treasure had myriad potential uses: The seeds could be multiplied and distributed to farmers, who could grow them to feed their families; selections of seeds could be used by plant breeders to improve the disease or pest resistance of more vulnerable varieties whose susceptibility was leading to famines or food shortages; some deeply rooted varieties were useful for soil erosion control and for the restoration of damaged landscapes; still others were key to unlocking the stories of where our food originally came from, helping us to elucidate the origins of agriculture and the earliest domestication of plants on several continents. Some seeds had remarkable stories associated with them, and all had genetic histories embedded within their seed coats. Most of the seeds were priceless, in the sense that they could not easily be re-collected or replaced, for

the agricultural landscapes from which they had been derived had changed dramatically over the previous century. They represented dynamic populations of plants that shifted and evolved through place and time—if they were lucky enough to avoid political and physical upheavals—and, for that reason, were all the more irreplaceable.

Yet few Russian residents passing by the seed bank hidden within the bowels of a stodgy building on Saint Isaac's Square ever fathomed its paramount significance to human survival, let alone its uniqueness as a living record of some of the greatest achievements made by the diverse cultures of this planet. In 1941, even fewer of the artists, intellectuals, politicians, and bureaucrats distraught over the impending fate of the Hermitage could have imagined that the German troops engaged in Operation Northern Light were just as eager to control this genetic repository of seeds as they were to capture and sell off the artistic treasures housed in the Winter Palace.

Despite the damage done to Leningrad during the *Blokada* that began that September—a siege that lasted for nine hundred days and eliminated 1.5 million human lives from that bleak landscape—the building on Saint Isaac's Square that housed that priceless bank of the world's seeds miraculously survived. It has remained on the square to this day, harboring both seeds and scientists associated with what's known as the N. I. Vavilov All-Russian Scientific Research Institute of Plant Industry. The institute is nicknamed VIR by the relatively few Russians alive today who recognize its vital place in history and honor the memory of its charismatic founder, Nikolay Ivanovich Vavilov (1887–1943). Vavilov's legacy is more than just the seeds he collected from around the world, for what he most valued were the seeds that remained in a peasant's field, adapting and changing, along with the traditional knowledge of where, when, and how to plant them.

My friends at VIR cannot tell the story of this seed legacy without tears welling up, for their story ultimately leads to the fate of the seed bank that sits below their offices today. Although I had met a director of VIR in Rome

Vavilov in the field, Ethiopia, 1926.

in the 1980s while working as a consultant to the United Nations Food and Agriculture Organization (FAO), I didn't get to VIR itself until the spring of 2006. I went to Saint Petersburg then with an old friend, Kent Whealy, cofounder of the Seed Savers Exchange and recipient of the Vavilov Medal in honor of work he had done to conserve heirloom seed stocks and bring them back to our tables. Over the years, Kent and I had heard from Russian friends something of what had occurred at VIR during the darkest hours of the Siege of Leningrad. But we both wanted to hear the stories told in the place where they occurred—the heart of Saint Petersburg—by the very people who best knew Vavilov and those he had entrusted with keeping his seeds alive.

As our colleagues reminded us, in 1941, none of the support offered to the Hermitage staff was offered to those in charge of Vavilov's seed bank and the farms in the surrounding countryside—known as plant introduction stations—where the seeds were periodically grown out and replenished. Yet, from what Vavilov's staff knew of the strong German interest in eugenics, they could not imagine that the Nazi bureaucracy did not realize the importance of their genetic repository. As German and Finnish forces drove toward the city, the VIR staff feared that the Nazis would confiscate whatever seeds were available in the plant introduction stations associated with VIR's mission. The staff was at least able to hide some of the Saint Isaac's seeds at an experimental farm adjacent to Catherine the Great's palace in the suburb of Pushkin, just outside of Leningrad. But no staff was granted safe passage away

from the fray. VIR's employees were to remain at their desks, continuing to do the work they had been assigned, as if neither war nor any other pressure was plaguing them.

By the end of the first autumn of the Blokada, Leningrad had been fully surrounded, and no food or fuel could reach the millions of Russians remaining in the city. While artillery fire escalated, food supplies dwindled to a thirty-day supply and were strictly rationed—down to 125 grams per person, or about a quarter pound of bread daily. Then the harshest and bitterest of winters set in, leaving the stranded masses with no heating oil or coal, little firewood, limited electricity, and, in most homes, no running water. Once grain and sugar supplies were depleted, families were given rations of mutton guts, malt flour, cellulose, and calf skins; both their health and their hope began to deteriorate.

By February of 1942, at least two hundred thousand people had died from starvation in Greater Leningrad or from the illnesses that pounced on the crippled immunity of the hungry. Despite those losses and their own lack of safety, many in Leningrad tried to continue their normal work, taking one day at a time. Those who had volunteered for the evacuation of the Hermitage could at least feel satisfied that they had done all that was possible to protect their city's most enduring works of art so that they might be enjoyed by future generations.

Much of that other great collection remained in grave danger, however. The extraordinary bank of living seeds that Vavilov had built and nurtured over the previous quarter century had been left exceedingly vulnerable. Reports had come in that the seeds left in the plant introduction stations in the Ukraine and Crimea had already been seized by the Germans; it was later learned that Heinz Brücher, a German geneticist, had sequestered them away at the Grannagh Castle in Austria. At the same time, even the portion of VIR's holdings that had been taken to the experimental station at Pushkin stood in harm's way. Pushkin was being shelled regularly, and the "Road of Life" leading beyond the city limits across the ice of Lake Lagoda was under such attack that it was renamed the "Road of Death."

In a daring move, the caretakers of the seeds loaded the portion of the collections held in Pushkin onto twenty trucks, whose drivers managed to pass through the German lines pretending to be peasants delivering grain to other German troops. That convoy of seeds eventually arrived, undetected, at the University of Tartu Experimental Station in Estonia in the summer of 1942. Those seeds thus fortuitously escaped the battle, but they could not escape the war. In the fall of 1944, the German army seized them in Estonia and began to pirate them off to Lithuania.

Unbeknownst to the VIR staff remaining in Leningrad, the life of their mentor Vavilov was then in as much peril as the seeds he had collected. For reasons I will later elaborate, Russia's greatest scientist had been taken as a political prisoner—not by the Nazis but by his own government—and was kept from public view while the Soviet government continued to issue press releases that he was simply helping Stalin and Soviet biologist Trofim Lysenko with a new strategy to feed the people. Although none of his coworkers had heard from him or of him since his departure for an "important meeting in Moscow" in the summer of 1940, they remained steadfast in their efforts to safeguard the seed bank. Even while starving, they demonstrated as much dedication to their mission as did as their counterparts in Sverdlovsk.

The only difference—a critical one—was that Stalin supported the evacuation of the Hermitage but considered the seed bank to be a costly indulgence of "bourgeois science." Although the Nazis could see the value for future plant breeding of controlling the world's largest seed bank, Stalin's Soviet cronies looked at the state support of the seed bank as a tremendous financial burden that had not offered much in return. Stalin had jailed Vavilov and dozens of other scientists for being elitists and traitors whose research had paid few dividends to the Russian peasantry or to the state itself.

The staff remaining in VIR's building on the square continued to work, with virtually no government support. They feared that the hungry masses lurking in the streets outside might attempt to break into their stores and consume the bags of wheat, barley, beans, and peas that the staff had hoped would provide the stock to feed future generations. So they barricaded

themselves inside the stout walls of their building on Saint Isaac's Square and stood watch over the living collections that they hoped would help Russia and the rest of the world recover, should the war ever end. The workers, led by Abraham Kameraz and Olga Voskresenkia, divided the most valuable of the four hundred thousand seed collections into duplicate samples and put them into boxes for hiding at different locations. Kameraz personally convinced a small tactical unit of the Red Army how important it was to everyone's future to remove a set of these seeds to another building off Saint Isaac's Square.

The ensuing tragedy has often been recounted to scientists visiting VIR, but hearing it in person still sickened and silenced Kent and me. The scientists and curators locked themselves into the dank, unheated building, guarding the other set of seeds as well as all of their potatoes in the dark, damp conditions of the near-freezing basement. Numb with cold and stricken with hunger, the staff took shifts caretaking the seeds around the clock. Nine of Vavilov's most dedicated coworkers slowly starved to death or died of disease rather than eat the seeds that were under their care. They were not alone. Over seven hundred thousand citizens of Leningrad had died from hunger by the spring of 1944, when the siege finally ended.

Perhaps it is fortunate that the starving seed guardians never learned how close their building was to being seized by the Nazis, for such news might have broken their spirits and weakened their tenacity. Unbeknownst to any outsiders, the inner circle of Nazi strategists had early on targeted the Russian seed bank as being a far more important collection to capture than that of the art they believed to be still within the Hermitage. As soon as Hitler set his mind on invading Russia in 1941, he established a special tactical unit of the S.S.—the *Russland-Sammelcommando*—to take control of the seed bank and retrieve its living riches for future use by the Third Reich.

That Hitler had a prevailing interest in the genetic research of the Russians should come as no surprise. Hitler based much of his racist philosophies on the pseudoscience of eugenics, which argued not only for the selective breeding of humans for racial improvement, but also for the advancement of agriculture through highly selected seeds; his agricultural

programs were managed by scientists influenced by social Darwinism and eugenics. Some have claimed that Hitler became a strict vegetarian and raw-foodist, as well as an adherent to some rather bizarre philosophies of dietary purification that complemented his notions of racial purification. Hitler or his scientific advisors may thus have envisioned ways that the diversity of seeds stored in Leningrad could ultimately serve those purposes.

Assuming that he would soon take control of Leningrad, Hitler had planned to make his victory speech from the balcony of the Hotel Astoria on Saint Isaac's Square, from which he would literally look out across the street to where the treasure of seeds lay before him, barely a hundred feet away. He even had invitations to the victory celebration printed up, with the address of Hotel Astoria prominently featured. The seed guardians never knew that Hitler planned to celebrate his conquest on their very doorstep.

While that was set to unfold in Leningrad, another tragedy was playing out in the little town of Saratov, some nine hundred kilometers away, on the Volga. That was where, in 1918, Vavilov had been awarded the title of professor in agricultural sciences at the rather precocious age of thirty-one. In 1941, Vavilov found himself back in that beloved town in the heart of the wheat-growing country where his career as a seed conservationist had begun to skyrocket; this time, however, he was a political prisoner, not a professor.

Vavilov—the only man on earth who had collected seeds of food crops on all five continents, the explorer who had organized 115 research expeditions through some sixty-four countries to find novel ways that humanity could feed itself—was himself dying of hunger. From the spring of 1942 until his death in January of 1943, having been fed nothing but a raw mash of flour and frozen cabbage, Vavilov was undernourished and emaciated, with little subcutaneous fat left on his skeleton. He suffered from chronic diarrhea, an itchy edema had broken out on his legs, and his muscle tissue had wasted away to the degree that he would soon be diagnosed with dystrophy. Adding insult to injury, the KGB was trying to break him down mentally, interrogating him for as much as fourteen hours a day. They were intent on making him confess that he had squandered the Soviet Union's financial resources

to build his own empire of a hundred-some field stations to conserve and evaluate the world's plant diversity; in their minds, the seed empire was an extravagant diversion from the task of immediately feeding the masses. A famine in the mid-1930s caused by forced collectivization and confiscation of grain by the Soviet government had killed at least five million people, and now, with trade routes disrupted within and beyond the Soviet Republics, the Russian populace had less food security than ever before.

Vavilov's colleagues could never have fully fathomed the perils that both their seeds and their former leader had been facing around that time. When the summer of 1942 came, they planted cabbages and seed potatoes in the churchyard of Saint Isaac's Cathedral and in the fields surrounding the czar's former palace at Pushkin. The previous winter, they had found enough fuelwood to heat the Pushkin storehouse where some of the tubers lay dormant, hoping to keep the seed potatoes from perishing. Unlike other years, they had to stand guard over the potato plants twenty-four hours a day—sometimes while artillery fire sailed over their heads—and attempt to replenish the tuber stock to keep it viable for larger plantings in the future. Not only did they have to discourage their fellow Russians, who hungrily eyed each row of potatoes, but they also had to kill hundreds of Norway rats that invaded their garden.

Years later, the Russian writer Genady Golubev interviewed Vadim Lekhnovich, one of those who had helped dig the frozen earth, guard the sprouts, and watch over the garden of edible delights that spring. Was it hard, he was asked, not to help himself to some of those selections when he had already been starving for many months?

"It was hard to walk," he replied. "It was unbearably hard to get up every morning, to move your hands and feet. . . . But it was not in the least difficult to refrain from eating up the collection. For it was *impossible* [to think of] eating it up. For what was involved was the cause of your life, the cause of your comrades' lives."

After the current VIR staff had recounted what they knew of this history to Kent and me, one of them—Dr. Sergey Alexanian—told us that he'd like to offer us one last insight regarding his predecessors who had worked for

VIR during the siege. An Armenian of slight build, but with a powerful command of words and gesture, Sergey was conversant with both political history and agricultural sciences in ways that made him the ideal guide. He led us to a display of aging black-and-white photo portraits of former VIR staff on the stairway just outside his office. He wanted to explain how the sudden explosion of rats invading the potato gardens of Leningrad and Pushkin had occurred during the siege.

Nikolay Dzubenko, director of the Vavilov Institute, with Kent Whealy and Sergey Alexanian, April 2006.

"You see, the only meat available for people to eat by the summer of 1942 was that of the cats remaining in Leningrad. Without cats to control the rodent population, rats were out in the streets and yards night and day, digging up anything that might be edible. Do you see the picture of this woman here? She was in charge of the potato collection, and she died while protecting them from the rats. . . .

"And it was these men and women," Sergei said quietly, as he pointed to several other photos one by one, "who died while standing watch over the seeds."

Among this group, Alexander Stchukin died at his writing table, holding in his hand a packet of his most prized peanuts that he had hoped to send off for a grow-out. The custodian of Vavilov's many oat collections, Liliya

Rodina, died of starvation, as did Dimitry Ivanov, who as his own life failed, stowed away thousands of packets of rice that he had held so dear. There were others as well—Steheglov, Kovalesky, Leonjevsky, Malygina, Korzun—some who perished by starving, some riddled by sickness, others by shrapnel. Wolf, the herbarium curator, was hit by a missile shell fragment, and bled to death. Gleiber, the archivist of Vavilov's field notes, died in the midst of those papers rather than leave his post vulnerable to the infidels.

Kent and I stood next to Sergey, filled with sorrow. Several minutes passed before any of us could say a single word to one another, the presence of the Russians' sacrifice so palpable within those walls. The seeds had survived, but many of their proponents had not.

That same day, Sergey showed us row after row of the tin boxes where Vavilov once stored the seeds he had collected, as well as the gigantic vats of vaporous liquid nitrogen in which the progeny of those seeds remain frozen but viable. Knowing in advance that I was coming from the deserts of North America, where Vavilov had trod some three-quarters of a century before, Sergey had asked the herbarium curator to lay out the very plant specimens that Vavilov had brought back from there to the Soviet Union. Even in their desiccated, two-dimensional positions, plastered down and glued onto heavy sheets of herbarium stock, the plants felt like old friends: a thorny pad of prickly pear cactus, and a branch of guayule, a rubber-bearing shrub. I presented Sergey with photos taken of Vavilov by Homer Shantz, the plant geographer who had hosted the Russian scientist on his trips through the American deserts, and who had preceded me at the University of Arizona. While working on my master's degree in plant sciences at that university, I had stumbled upon a dozen images of the Russian scientist that had never been seen in his home institution. Now they could be integrated into VIR's archives with the thousands of field photos that Vavilov himself had taken.

Only after Kent Whealy and I had said good-bye and were on our way to see the fabulous art collections at the Hermitage, did I think of the question I wished I had asked Sergey and the other scientists: How was it that the art collections at the Hermitage could be so clearly seen as an important element

in the common heritage of humankind, but an equally large and representative collection of seeds—of the very food we require for our physical survival—has been so blatantly undervalued by society at large?

Sergey had sidestepped such issues with us, but during his own tenure in the Vavilov Institute, its staff had been cut down to a fourth of what it had been in the years just prior to perestroika and a fraction of what it had been during Vavilov's tenure. Alexanian and the other fine scientists who are the current stewards of some 380,000 seed samples held by VIR are provided with resources for their work that are in no way commensurate with their talents as professionals or with the importance of their endeavor. That endeavor, simply stated, is to maintain the supply-and-delivery stream of genetic resources essential to feeding present and future generations, offering us a critical modicum of food security in the face of global climate change, new hyper-virulent pests and diseases, declining freshwater supplies, and the potential for wars and acts of terrorism to disrupt the transportation routes on which our food supplies flow.

Although most who work to conserve the biodiversity and vitality of our food resources in the United States and other developed countries are certainly paid better than their Russian counterparts, they still lack many of the essential resources needed to fully accomplish their tasks. In short, Russia is not the only nation that currently fails to make an adequate investment in the conservation of agricultural biodiversity in gene banks and as part of on-farm conservation. And now, to make matters worse, some decision makers have made the erroneous assumption that biotechnologies can "develop" in vitro all the genetic variation that will ever be needed to protect our food crops from disease, climate change, and other stresses, thereby making efforts to conserve biodiversity *seed by seed* somehow obsolete. More and more of the funding for biological sciences has shifted away from genetic conservation and evaluation and toward investments in biotechnologies, as if they were the ultimate panaceas.

The current paucity of funds to adequately conserve the biodiversity held in seed banks, botanical gardens, and experimental farms is only part of the

problem, for the bulk of conservation work must be done on farms and in orchards in the regions to which the seeds are adapted. The seeds remaining in the very fields from which Vavilov gleaned them are at risk, as is the traditional knowledge among the farmers who know best how to cultivate them. Most of us living today hardly know where our foods come from. At best, we are dimly aware of the geographic and cultural origins of the crop genetic resources that form the living foundations of our food supply. We seem to believe that as long as we wish to eat, those resources will be invariably provided to the seed curators, plant breeders, nurserymen, and farmers who make our agricultural supply-and-delivery chain function. But as the seed keepers in Leningrad realized in 1941, we are in a race against time to ensure that the remaining seed varieties on this earth are not extinguished like so many candles in a sudden gust. No biotechnology can "invent" or replace the genetic variability already present in the diverse seeds found in the fields of local farmers scattered around the world; we have barely begun to classify those seeds on morphological grounds, let alone understand their genetic relationships and potential uses. Whether or not biotechnologies will be used in developing new seed strains, those locally adapted seed varieties—which continue to be dynamically bred and selected by peasant farmers as they have for millennia—will remain the primary wellspring of—or "gene pool" for—all future crop improvement efforts.

Vavilov and his American friend Harry Harlan were among the first scientists to notice that traditional seed stocks were indeed blinking out; they recognized early on that agricultural modernization was driving into extinction some of the locally adapted varieties they had collected on their earliest expeditions. Coming back into the same agricultural regions of Asia two decades after his initial visits to particular fields and orchards around 1916, Vavilov was shocked to learn that the same seeds could no longer be found there. Such shifts particularly disturbed scientists such as Vavilov and Harlan, for they recognized those regions as the historic centers of origin of certain domesticated cereals, where certain varieties and their ancestors had been sown by an unbroken chain of farmers since the beginnings of agriculture.

In correspondence with one another, Vavilov and Harlan were among the first to articulate the concept of *loss of agricultural biodiversity* through the process now known as *genetic erosion*—the gradual and irrevocable diminishment of the gene pool from which new varieties would otherwise emerge.

During World War II, Hitler's geneticists may not have been aware that the planet's crop genetic resources were facing declines in diversity in some regions, but within another two decades, just about every scientific plant explorer had reported declines in food crop diversity in the regions where they worked. Like the more recent global declines in amphibians, at first the scattered reports seemed merely anecdotal and did not foster much alarm; by 1970, however, the consistency among many reports made it clear that such losses were pervasive, reaching nearly every agricultural region on the face of the earth.

Today, scientists take as a given what Vavilov first articulated, a message that ultimately cost him his life: Agricultural biodiversity is the cornerstone for building greater food security for humankind; without it, our food system will be crippled by pestilence and plague, drought and flood, global warming, and the economic or environmental side effects of globalization. Although Vavilov himself never used the particular term *agricultural biodiversity*, I think he would have embraced the following definition of it, one that I had the good fortune to help forge for current discussions at the FAO:

> Agricultural biological diversity is embedded in every bite of food we eat, and in every field, orchard, garden, ranch and fish pond that provide us with sustenance, and with natural values not yet fully recognized. It includes the cornucopia of crop seeds and livestock breeds that have been largely domesticated by indigenous stewards to meet their nutritional and cultural needs, as well as the many wild species that interact with them in food-producing habitats. Such domesticated resources cannot be divorced from their caretakers. These caretakers have also cultivated traditional knowledge about how to grow and process foods; such local and indigenous knowledge—just like the seeds it has shaped—is the legacy of countless generations of farming, herding, and gardening cultures.

What delighted Vavilov were the patterns of relationships that this diversity formed as it spread across the face of the earth: the gradients in the length of beards on the spikes of barley as they ranged from Turkey to Ethiopia or from the floodplain fields along the Silk Road to the high plateaus perched above them in the Hindu Kush. He relished the various names local farmers gave to the same group of beans, for he could use them as clues in tracing their origins and dispersals. He was fascinated by the shapes, sizes, and tastes of all the wild apples found along a single mountain range in Kazakhstan, for they offered him a fresh view of the location where the original domestication of these fruits may have occurred.

Many historians of science have assumed that Vavilov's greatest contributions to agricultural botany and conservation were the world collection of seeds, fruits, and tubers in Saint Petersburg and the notion that efforts to fit crops to their agricultural environments would do well to use the diversity of land races that indigenous farmers have already adapted to similar conditions. Seeds from those vast gene pools, whether put directly in the soil or used in plant breeding, are our best means of dealing with pests, droughts, diseases, soil nutrient deficiencies, salinity, and short growing seasons. Others might point to Vavilov's two-hundred-odd published journal articles and books that documented in a way no one had before the astonishing genetic variability among the world's major crops. There are, however, two other important elements of his legacy that have not been well recognized or fully understood.

Intellectually, Vavilov's greatest contribution to science may have been his articulation in a 1926 publication of the concept of *centers of diversity*. Although he first articulated them as centers of origin for cultivated plants, he explicitly chose areas where genetic variation within the gene pools of domesticated crops and their wild relatives was high for both. Contradicting most archaeologists of his time, he argued that the cradles of agricultural civilization were *not* nestled in the valleys or broad floodplains of great rivers, but were found in mountainous regions. Vavilov tallied up a list of more than six hundred crops that had their greatest number of varieties in montane

landscapes and noted that those same regions were rich in indigenous languages and wild biodiversity as well:

> The centers [of diversity] for most cultivated plants turn out to be regions which are the scenes of a vigorous speciation process. Naturally, it was in these regions that early humans flocked, for their floras are rich in edible species. . . . It is therefore very probable that mountainous regions are not only the primary centers of varietal diversity among crops, but also the most ancient nursery grounds of agriculture.

Recently, archaeologist David Harris pointed out that Vavilov should properly be considered the first to recognize most of the important centers of agricultural as well as wild biodiversity, but noted that Vavilov's assertion that these were the natal grounds of the earliest domesticated plants and agricultural practices has not been validated:

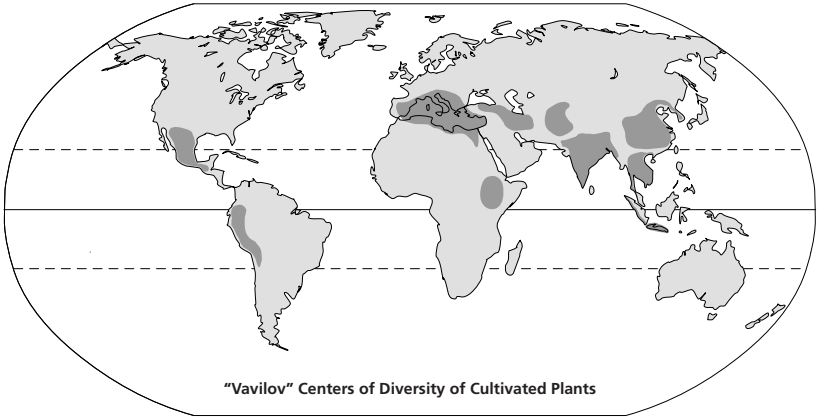
> Ever since Vavilov himself equated centers of crop diversity with the homelands of agriculture, there has been conceptual confusion between the two. Despite the massive investment of archaeological effort since 1950 that has gone into investigations of early agriculture, we cannot be confident that plants were domesticated and agriculture developed earlier in the so-called nuclear centers than in other regions of the world. . . . It is time that we conceptually decouple the world pattern of crop-plant diversity that Vavilov so brilliantly demonstrated [from the notion that those nuclear centers are necessarily the places] of the origin and early development of agriculture.

In this narrative, I will call those "nuclear" regions centers of diversity, for that is how they have been widely understood by geneticists, conservation biologists, and biogeographers. Although Vavilov's mapping of those centers had a profound impact on most Russian scientists during his lifetime, his maps did not reach many English-speaking scientists until after 1950. That was when prominent scholars and field scientists such as Carl Sauer, Jack Harlan, J. G. Hawkes, and C. D. Darlington first included modifications of

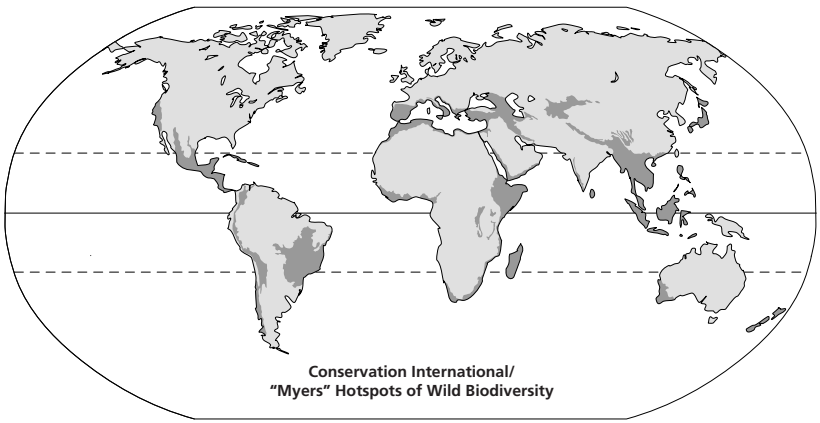
Vavilov's maps in their own influential works regarding agricultural origins and dispersals. Those scientists clearly understood the immense utility of Vavilov's work in terms of plant exploration and genetic conservation, for although those centers cover far less than a fifth of the land surface of the planet, they harbor a disproportionately high percentage of all wild and domesticated plant diversity.

Roughly a half century after the initial recognition of those centers of diversity by scientists, many of the same regions received a conceptual "makeover" that attracted renewed attention to them. After British environmental analyst Norman Myers released his own map of areas rich in biodiversity in 1988—based on both plant and animal distributions—those centers began to be known as "hotspots of biodiversity" by Conservation International and "Global 200 ecoregions for biodiversity" by the World Wildlife Fund. A new generation of biologists, geographers, planners, and policy makers began to think of such regions as priority "targets" for conservation. Ironically, few of the contemporary enthusiasts of such regions acknowledge their intellectual debt to Vavilov, for their hotspots and critical ecoregions clearly circumscribe many of the same places that Vavilov first mapped. Curiously, even though Vavilov lacked good geographic data on animals of all kinds, and Myers initially lacked much data on insects, their first approximations of diversity-rich regions have largely stood the test of time.

Nonprofits such as Conservation International, World Wildlife Fund, and The Nature Conservancy have promoted the concept of hotspots to fund their purchase and protection of lands harboring high biodiversity. Unfortunately, as anthropologist Mac Chapin has revealed, there have been cases in which nonprofit programs have attempted to either purchase the lands from their original stewards or comanage them for bio-prospecting. In a few well-documented cases, these changes in land management have inadvertently been at the expense of the indigenous farmers and forest cultivators who have long managed the diversity. A recent critique of this approach in *Science* magazine argued that "the bottom line is that biodiver-



"Vavilov" Centers of Diversity of Cultivated Plants



Conservation International/
"Myers" Hotspots of Wild Biodiversity

sity will only be conserved if local people and interests want to save it for both ethical and broadly utilitarian reasons."

As if foreshadowing the current debate, Vavilov began to articulate a groundbreaking principle in plant geography that implicitly *includes* human cultures rather than ignoring them, a principle that he explained in *Phytogeographic Basis of Plant Breeding*, published in 1935:

> *The distribution of plant species on earth is not uniform.* There are a number of regions in the world which possess exceptionally large numbers of varieties. . . .

> As far as the crops [concentrated in each of those exceptional regions] are concerned, it is possible to witness there the great role played by Man in the selection of the cultivated forms best suited to each area. [Emphasis added.]

Vavilov not only paved the way for biogeographers to map the patterns of biological diversity, he was also the first to note that biodiverse regions harbored considerable cultural diversity. The individuals participating in those diverse cultures expressed themselves through many indigenous languages and dialects that encoded an enormous wealth of traditional ecological knowledge. Vavilov and Alphonse de Candolle were the first two biogeographers to use linguistic data from diverse cultures as aids in discerning where certain crops originated. In addition, Vavilov proposed that members of various dialect groups sometimes selected their crop varieties for different purposes and environments, and named them differently to encode those distinctions.

Those and other insights first surfaced not in Vavilov's scholarly writing accomplished back in Saint Petersburg, but in the volumes of notes generated while he was visiting fields and gardens in the course of his travels to five continents. Those field notes often provide inventories of the seeds he collected from particular markets or fields; they often give the precise elevational range over which a crop species or variety occurred in a particular valley that he visited. Ultimately, Vavilov's field observations may be seen to be as valuable as the seeds themselves, for they record the historic conditions in which the seeds were grown—conditions that in most cases have dramatically changed over the last nine decades.

Several scientists, historians, and conservationists have written about Vavilov, his rise and his demise, but none to my knowledge have used his field notes to guide them through the same landscapes to ascertain just what kinds of changes have occurred there. Vavilov's photographs and his journals provide extraordinary "snapshots" of the agricultural diversity extant in a particular place and time. They provide a benchmark by which we can measure the rapidity and severity of ecological, agricultural, and socioeconomic changes in particular rural landscapes over many decades.

By retracing Vavilov's steps, and rephotographing the fields, plantations, and markets he visited, it is possible to determine whether (or how much) genetic change has occurred. By interviewing local farmers, ecologists, climatologists, and historians, it is also possible in some instances to discern *why* changes have occurred. In short, Vavilov's notebooks and field photos can remind us not only of where our food comes from, but also of how and why fundamentally important resources are vanishing. Such knowledge may also help motivate us to do whatever is within our power to curb such losses before it is too late.

When one walks the streets of Saint Petersburg, hearing the stories of the dreadful siege it suffered more than a half century ago, it is easy to imagine a world where hunger rages while the great historic legacies of humankind become increasingly imperiled, caught in the crossfire between political powers. I offer this journey in Vavilov's footsteps in the hope that we can more fully value such legacies, that we can more effectively reduce the human suffering associated with such hunger, and that we can sow the seeds of a more permanent peace. But like the seed keepers of Leningrad in 1941, we are in a race against time.