Where Our Food Comes From

Retracing Nikolay Vavilov's Quest to End Famine

Gary Paul Nabhan

Foreword by Ken Wilson

ISLANDPRESS / Shearwater Books

Washington • Covelo • London

the native crops in their contemporary diet are poorer in protein, minerals, and dietary fiber but flush in fats and sugars. Over the decades that native crops have been replaced in the diet by simple carbohydrates, more and more Hopi and Navajo have been afflicted with adult-onset diabetes, obesity, cancer, and heart disease. Belatedly, they are rediscovering that the best cures for those maladies may be the very crops that once grew outside their own back doors.

That pattern of accelerating crop loss since World War II—and of recent attempts to recover former elements of local food diversity—is not at all unique to the Hopi, Navajo, or, for that matter, to the indigenous peoples of North America as a whole. Over the entire continent, more than a thousand unique seeds, breeds, and wild food populations have become threatened or endangered over the last century, dramatically reducing the diversity and resilience embedded in American food systems. Yet, as the Renewing America's Food Traditions initiative has recently documented, all is not lost; many successful efforts to bring some of the historic foods back onto tables in homes and restaurants across the continent are already under way. It is once again a time when Americans are discovering the richness of their own continent, just as Vavilov once admonished us to do.

CHAPTER TEN

Logged Forests and Lost Seeds: The Sierra Madre

"The mountainous areas of Central and South America—the Cordilleras—" announced Vavilov in 1925 at the age of thirty-eight, "are of exceptional interest to us as globally significant centers of origin fundamental to understanding the evolution of a number of important plants." It seems that those regions were of personal interest to him, as well, for in a letter written that same year to Sergei Bukasov, he expressed a bit of envy that his colleague was able to explore Latin America before he himself had a chance to do the same: "For me, Mexico is a country of great interest: The history of its agricultural crops, the composition of its cultivated plants, the complexes of maize, tobacco, solanaceous plants [tomato, potato, and other nightshades], beans and gourds are all new to me. What do they really represent? What do *you* find in the markets of the towns? Do you take photographs? . . . Do you keep a diary?"

During his 1930 visit to the Americas, Vavilov made good on his pledge to follow Bukasov's earlier route down into Central America, to immerse himself in some of the most remote and rugged regions of Mexico and Guatemala. After a month in Arizona and Southern California, he left the United States on October 30, heading for Mexico City, edging along the western slopes of the Sierra Madre for much of the way. Along that route, he saw dozens of species of pines, oaks, and agaves growing atop the volcanic cliffs, or *cumbres*, of the sierras. He tasted dozens of varieties of maize, eaten right off the cob as they were maturing in the fields, or shucked and soaked in lime to make hominy-like *nixtamal* for tamales, posoles, or tortillas gorditas.

Just as he had done on other continents, Vavilov offered up from his travels to the Americas a litany of names of endemic crops hardly known to science, let alone used in other corners of the world. But then he took a Nureyev-like leap:

> *Mountain regions* are the primary centers of origin for the crops I have enumerated. It is there, as our research has demonstrated, that an exceptional wealth of crop varieties lies hidden. . . . [We still have] *the opportunity to discover a great new "America" there.* . . . I have given myself the task of trying to discover the areas with the greatest accumulation of diversity in crop varieties native to Central and South America. The journey along the Cordilleras has offered me a chance to fulfill this task, and now I am able to pinpoint with great accuracy where this diversity lies. . . . [emphasis added]

It was in Mesoamerica that Vavilov identified one stretch of the cordilleras—the Sierra Madre Occidental—as America's mother lode of food biodiversity. As the "Mother Mountains" running parallel to Mexico's west coast, this particular cordillera forms most of the continental divide from the U.S.-Mexico border nearly all the way south to Guatemala. The volcanic ridges of the Sierra Madre Occidental form the edges of a half dozen canyons nearly as deep and just as long as the Grand Canyon of the southwestern United States; from the patches of tropical palms on the bottom floor of those gorges, you can see pines high above you on the rocky rims.

Along those steep gradients Vavilov fully elaborated a hypothesis that he had first roughed out back in the Pamirs of Central Asia: that the topographic heterogeneity found in mountainous regions serves to harbor such high levels of biological and cultural diversity that they foster the origin, evolution, and divergence of crop varieties. He recognized that the same geographic factors that generate new wild species in the cordilleras—impenetrable physical barriers, steep climatic gradients, and bizarre juxtapositions of soils—also promote a diversity of varieties within the same crop species. This is especially true when the crop has long been nurtured by indigenous communities such as those nestled deep within the Sierra Madre.

We now recognize that the mountains of western Mexico are part of a larger mosaic shaped from two global centers of diversity, the more tropical Mesoamerican lowlands such as the palm-lined canyon bottoms, and the more temperate and subtropical Madrean pine-oak woodlands found up on the canyon rims. The former harbors an astonishing 17,000 plant species—18 percent of them endemic—plus 440 mammals and 1,120 birds. The pine-oak woodlands above harbor 5,300 species of plants—75 percent of them endemic—as well as 330 mammals and 525 birds. In Vavilov's time, there were few inroads into the Sierra Madre to give biologists a chance to encounter so many species, let alone name and map their distributions. The sheer ruggedness of the sierras and the poor transportation infrastructure of his era hindered his efforts to delve deeply into that montane region, but he skirted its edges in a number of places, using trains, cars, and pack mules to the best of his ability to gain an overview of the habitat heterogeneity there.

Life in any mountain landscape is much more complex than initially meets the eye. Once the seeds of a plant are dispersed into a remote canyon or watershed, the rugged terrain surrounding the patch of seedlings isolates them from others of their own species. The peculiar microclimate of the new habitat, with its attendant bugs, birds, and microbes, places new selection pressures on the plant population, and it sooner or later diverges from its source population. However, periodic floods, windstorms, fires, or landslides sometimes bring other seeds or pollen in from other areas, allowing some hybridization to occur with novel sources of genes. This recurrent swing between isolation and hybridization engenders a process called *reticulate evolution* and makes such canyons ideal nursery grounds for speciation and diversification.

Such phenomena are of interest not merely to biogeographers, but, at least metaphorically, to cultural geographers as well. Linguists such as Joanna Nichols have recently articulated another reason mountainous regions today tend to be richer than other regions in species, crop varieties, and languages. Compared to extensive plains and coastal valleys, they are not as immediately susceptible to rapid colonization by new settlers, imperialistic domination, ethnic homogenization, and agronomic monoculture. In other words, Vavilov would undoubtedly find seeds in the Sierra Madre that had already been lost from the more accessible valleys and plains below them.

While passing across the bridges spanning the gorgeous subtropical barrancas below, Vavilov stared wide-eyed at the chaos of wild palms, climbing bean vines, and strangler figs, as well as corn's closest relative, teosinte. He visited isolated *rancheria* farmsteads and multicultural vegetable markets. He also walked along the ancient trails between the milpas of indigenous cultivators, who sowed their seeds on the fertile floodplains that edged the raging rivers spilling out onto Mexico's Pacific coast. They offered him swigs of their corn beer or tequila-like mescal, pouring him cup after cup of the ancient brews, which they stored in bottle gourds and ollas of crudely fired clay.

At his southernmost destinations in Mexico and Guatemala, Vavilov spent considerable time perusing prehistoric Mayan ruins, contemplating the grandeur of some of the most ancient agricultural civilizations in the New World. But he also conversed with living descendants of those early agricultural innovators, bantering and bartering with the Zapotec traders of seeds, the cooks of toasted crickets, and the vendors of the myriad vegetable varieties stationed in the sprawling open-air market of Mitla, Oaxaca.

Vavilov in the field in Mexico, probably 1931.

The photos of the Mitla region are among Vavilov's best. They feature more than just the wild and cultivated plants of Mexico; they document indigenous farmers tilling their fields with what he termed "Egyptian plows"; boys using pots to irrigate their gardens; elders tending native bees that serve as pollinators; women storing their harvests; and whole families going to market to hawk their wares. Perhaps nowhere else did he focus his lens so intensely on the simple face of humanity expressed in a center of diversity.

Near Mexico City, a farmer wearing a multicolored poncho and a huge straw sombrero led him through his milpa of maize crowded with teosinte. Looking less like modern-day maize and more like a tall, spindly grass with tiny wedge-shaped grains, wild teosinte has remained present in the fields of fully domesticated corn for some eight thousand years, ever since maize and teosinte first diverged on their evolutionary paths. Vavilov was just vain enough to have his colleagues take photographs of him hugging mature plants of maize and teosinte, which his colleague Sergei Bukasov had documented in 1925 as spontaneously hybridizing with one another. Bukasov and Vavilov correctly inferred that Mexican teosinte was the closest wild living relative to corn in all its various forms. Subsequent studies by molecular biologists, population geneticists, and ecologists have obliterated the notion that the wild ancestor of maize is now extinct, placing certain fully wild teosintes at the very base of corn's family tree. By comparing teosinte to the diverse strains of corn in the markets of the sierra, Vavilov came to understand viscerally the simple aphorism my colleague John Tuxill later coined: "Crop biodiversity is the biodiversity that people made."

Satisfied that he had at last glimpsed the reputed mother of maize—and had peered into the depths of the Mother Mountains—Vavilov returned to the United States by traveling up the eastern foothills of cordillera. His return trip northward took him across the Mesoamerican highlands north of Mexico City commonly referred to as the *altiplano;* its ridges were lined with terraces of sword-leaved agaves and giant prickly pear cacti. He lingered for a while in Chihuahua—perhaps in the early weeks of 1931—where he collected a nonflowering branch of the desert shrub known as guayule, so familiar to me from years of wandering through the American Southwest, inserted it into his plant press to dry, and then crossed into Texas at El Paso.

Some seventy-five years later, Sergey Alexanian took me through the VIR herbarium to show me a few dried specimens that Vavilov had pressed in Chihuahua. Those scrappy samples of desert plants triggered much more of an emotional response in me than they might in a casual observer. Guayule (*Parthenium argentatum*) was the first specimen he showed me and it was one of the plants so familiar to me. Vavilov's dried specimen seemed to exude a peculiar elegance. That seemed odd to me at first, because in the wild, the plant is a rather unkempt shrub with chaotic clusters of woolly leaves. Yet this particular specimen had been meticulously prepared by one who had mastered the art of mounting botanical specimens, and whose own flamboyant signature on the label—*N. I. Vavilov*—gave it an added flare.

The very fact that this specimen was collected, much less transported out of Mexico—and then endured the siege of Saint Petersburg through World War II—filled me with wonder. In 1931, several months after his first visit to Mexico, Vavilov had returned to its southern border and requested permission to travel up through Yucatán and on to the northern desert states, where he wished to collect guayule seeds. He was caught off guard by the response: For the third time in his career, he was arrested as soon as he crossed the border into an another country. U.S. diplomats and corporate interests in the Mexican capital had been monitoring his movements and had tried to prevent him from reaching the guayule rubber patches in the Chihuahuan Desert.

Why did Vavilov's interest in studying and collecting seeds of guayule trigger such apparent xenophobia? Vavilov knew that for more than a quarter century, Mexico had been exporting guayule to the United States, so that tires

could be made there with an alternative to the hevea rubber plants of the tropics, which had been suffering from a blight. In fact, the Continental-Mexican Rubber Company had harvested and exported so much guayule rubber from northern Mexico that by 1912 its operation was both socially and environmentally unsustainable. As guayule historians have conceded, Continental's production ended due to "depletion of the native stands and civil unrest."

A year before his own venture into Mexico, Vavilov had seen the experimentally cultivated plots of guayule in California managed by the Intercontinental Rubber Company (IRC), an enterprise financed by the Rockefellers and Baruchs. Since guayule did not grow naturally in California, plantings there had been started from seed collected from the wilds of northern Mexico. But when the Great Depression began with the stock market crash of October 1929, IRC's investors were forced to shut down their marginally successful rubber production experiment so that they could reallocate their remaining wealth. Nevertheless, they were not willing to let the Soviet Union beat them to the punch in developing an alternative source of rubber. In the view of those Americans, Vavilov had to be stopped from taking seed back to Russia.

So, for the first time since his visit to Spain in 1927, Vavilov was being treated as an international criminal, a potential bio-pirate. It did not take him long, though, to deduce that the accusations against him were not really coming from Mexican officials; the shareholders of the U.S.-based Intercontinental Rubber Company were the more likely source of discontent:

> Later it became apparent that these difficulties were provoked [by] the Intercontinental Rubber Company of the United States, which was irritated by their knowledge of my errand in 1931 on behalf of the "Caoutchouconos" that underwrote my special expedition to Mexico to collect guayule. . . . [The American company] had started a campaign in the Mexican press about "the plundering of national treasures by the Bolsheviks."

The Caoutchouconos that Vavilov referred to ran an amalgam of Soviet rubber enterprises, which, like the American rubber companies of its era, were desperately attempting to find other sources of latex in the event that Germany or Japan cut off their access to the remaining hevea rubber plantations in the tropics. By the time Vavilov was arrested, IRC investors were already lobbying Congress to purchase their assets in guayule for some $2 million, arguing that securing an alternative source of rubber was of strategic interest to the United States. When those investors learned that the Soviets also had an interest in guayule research and development, they undoubtedly feared that Vavilov's well-trained team of economic botanists could outcompete their own.

In the end, it appears that Vavilov convinced Mexican officials that if U.S. corporations had removed enough seed from guayule plants in the Chihuahuan Desert to plant thousands of acres in California, the cat was already out of the bag. He could not be a pirate if he had explicitly asked their permission to take plants with him for long-term research, while other countries were already economically developing the same plant. Mexico temporarily backed off on restricting further collection of guayule and apparently granted Vavilov permission to gather at least herbarium specimens of the shrub. However, when World War II erupted a few years later, Americans once again put pressure on Mexico to be more restrictive with its natural sources of rubber. In 1942—while Vavilov sat locked in jail, starving to death—Mexico acquiesced to the U.S. government's demand to be the sole purchaser of all Mexican production of guayule.

Ironically, within months of the end of World War II, the formerly ailing American rubber companies were "feeling their oats." They demanded that the U.S. government destroy all of its guayule fields on both sides of the border, abandon all of its crop improvement and rubber extraction research on the shrub, and provide them with the political and military support to regain access to hevea rubber plantations in any tropical country where they wished to work. They wanted nothing less than exclusive control of the rubber industry through the tropical plantations of hevea they had appropriated. Within months, all guayule plantations in the U.S.-Mexico borderlands were torched by the U.S. government, and all but one barrel of the guayule seeds

improved by two decades of plant breeding were destroyed. Thirty years later, when U.S. government officials decided that it had been a mistake to suspend its entire guayule research program under pressure from the rubber companies, the man who had salvaged that barrel of seeds and guarded it for three decades offered to sell the improved guayule seed stock back to the government for $1 million.

But back in 1931, as news of Vavilov's detainment spread, Mexican officials were showered with telegrams and phone calls demanding his release. Mexican scientists offered both apologies and assistance to get Vavilov out of house arrest. No doubt Vavilov thought back to the prior winter, when he had first found guayule shrubs in the field.

By that time in his life, Vavilov was well aware that choosing which plants to harvest and which seeds to save was an inevitably moral act inseparable from the political and cultural influences of his time. He saw himself not as a plunderer of botanical treasures but as a conserver of future possibilities for humankind. Nevertheless, he knew full well that the act of collecting plants from one country for potential use in another was never ethically neutral. Whether he is ultimately seen as a pragmatic conservationist, a bio-pirate, or a botanical carpetbagger from the north intent on acquiring the culinary treasures of the south will depend on who is making that assessment and under what political context.

What ultimately motivated Vavilov to visit Mexico was not his interest in rubber, however important that was to his society in the short term. His ultimate motivation was evident in his lifelong quest to learn where various foods came from, both geographically and genetically. Perhaps that quest is why he was so enchanted by finding corn and teosinte growing in the same milpa, and why I myself metaphorically followed in his footsteps. Perhaps that is also why I chose to retrace Vavilov's steps into Chihuahua, Mexico, and then turn westward, heading into the Guadalupe y Calvo municipality of the Sierra Madre. That is where I had first seen maize and teosinte growing together in the same field some two decades earlier, and it was an area where considerable logging had gone on in the meantime.

The Sierra Madre remains a linguistically diverse landscape, where both the Tepehuan (*Odami*) and Tarahumara (*Rarámuri*) still farm over ten thousand hectares of traditional crops, and where the endangered *Tubaris* language hovers on the brink of extinction. It is also one of the more diverse corn-growing areas of the cordilleras, for within a two-thousand-meter-elevation gradient, the Tarahumara and Tepehuan grow sixteen of the twenty-five races of maize known in Mexico. The vernacular names of those maize races make my mouth water just by saying them: *chapalote*, *reventador*, *dulce*, *conico*, *dulcillo de noroeste*, *elotes occidentales*, *conico norteño*, *tabloncillo*, *vandeño*, *chalqueño*, *cristalina de Chihuahua*, *blando de Sonora*, *onaveño*, *Pima-Papago*, *harinoso de ocho*, and *pueblo*. Each has a different taste, a distinctive set of uses. According to an incompletely sampled archaeological record, at least ten of those races of maize have been consumed in the northern Sierra Madre since prehistoric times.

In 1988—roughly fifty-six years after Vavilov's last visit to Latin America—I went into the sierras to see if the cross-pollination of maize and the northernmost race of teosinte was still occurring in Nabogame, Chihuahua. Almost two decades after that, in the spring of 2007, I had a hankering to visit other Tepehuan and Tarahumara rancherias of that region to see if their fields and granaries were still as diverse as I remembered them to be. While their fields remain nestled on steep volcanic slopes, and most of the Tarahumara as well as Tepehuan women still wear their bright, multicolored *trajes* as in centuries past, there have been changes wrought in *serrano* (mountain) culture and agriculture over the last century. You can find Tarahumara women in traditional dress, sitting on the ground shucking corn while listening to an American football game on a solar-powered radio.

Although Vavilov himself did not reach into the sierras and barrancas around Guadalupe y Calvo, a contemporary of his—the Norwegian-born explorer Carl Lumholtz—directed a major expedition for the American Geographic Society that passed through Nabogame and the Barranca Sinforosa in 1892, about the time Vavilov was born. In his 1902 book, *Unknown Mexico*, Lumholtz recounted his discovery of Tepehuan farmers intentionally mixing their maize with teosinte as a means of reinvigorating their corn seed. They call teosinte, the wild grassy relative of maize, *konkoñi usidi*—"wild turkey's stalks"—as if the turkeys planted its little seeds just as humans plant the large kernels of corn.

When my friend Garrison Wilkes went to Nabogame sixty years later, he confirmed that teosinte was still growing and cross-pollinating with maize on the edges of cornfields and in woody thickets along the streams just below them. I first journeyed into Nabogame in 1988 as part of a team from Native Seeds/SEARCH, a nonprofit agricultural organization that works on both sides of the U.S.-Mexico border. When I accompanied cofounder Barney Burns into Nabogame on mules, we had detailed directions from Garrison to help us find the teosinte there and names of Tepehuan families, as well. By that time, Nabogame teosinte was world renowned among corn geneticists and archaeologists studying the origins of agriculture, but the Tepehuan farmers we met were amazed that someone had once again come into their community to confirm that that wild grass still intermixed with the maize in their fields and among the trees along their streams.

Yes, they said quietly, tipping the brims of their straw cowboy hats, they remembered a gigantic American who came and spent some time in their maize fields in the mid-1960s. Was he married, they wondered about Wilkes. Yes, other Tepehuan farmers from as much as fifty kilometers away in "distant" barrancas sometimes paid them to grow their maize seed in the fields near where teosinte regularly germinates and grows. The "injection" or hybridization of teosinte made their maize kernels more flinty—good for grinding into pinole—and ensured higher yields for several more years. Yes, they said, they were pretty much growing the same criollo races of maize they had always grown. No, they shook their heads—a bit tired by now of such questions—they did not buy seed for planting from afar. Their teosinte-enriched corn seed seemed to do the trick.

While in Nabogame, Barney Burns and I made separate collections of seeds from about a dozen different corn plants and a dozen different teosinte plants growing in the same field. A few months after I sent them off to John

Doebley—a young geneticist who had already done as much as anyone to solve the mystery of the origins of corn—he sent me back a note with results that at first seemed to be full of surprises. Yes, he confirmed, there was genetic introgression between corn and the teosinte but only in one direction—teosinte pollen enriched corn but not the other way around. In other words, corn pollen was not available during the time when teosinte plants required it for fertilization and seed set. Though the flow of new traits from teosinte into maize was really a trickle, it was probably enough to generate some "hybrid vigor" that could potentially increase the yield of corn the following year, wherever it was grown.

In short, Barney, John, and I had reconfirmed then with more accurate tools what Lumholtz and Wilkes has suggested earlier—a continuing flow of genes from corn's closest relative in the Sierra Madre could explain part of the diversity found among the races of maize grown by the Tepehuan and their neighbors the Tarahumara, with whom they traded seeds.

It was now 2007, and eighteen years had passed since John and I published our field report in the *Maize Genetics Cooperative Newsletter*. I wanted to see just what had happened to the diversity of maize and the intensity of its use in the stretch of the Sierra Madre centered on Guadalupe y Calvo. In the intervening years, major changes had taken place in the region, but even more dramatic changes had taken place in the maize itself. When John Doebley had sought to confirm the gene flow between Tepehuan maize and teosinte in his lab in 1989, he had used isozymes to do so, not direct analysis of their DNA. But by the time I had returned to Guadalupe y Calvo, DNA analysis was commonplace in the research institutes of the United States and Mexico, and products made from transgenic or "GMO" corn could be found in nearly every grocery store in both countries, even though their sale was illegal in Mexico. I wanted to know if transgenic maize had already reached back into the milpas of the Sierra Madre.

In April of 2007, my wife, Laurie, and I found ourselves bouncing like ping-pong balls down the dirt roads of Chihuahua. We were in a van loaded with Mexican and American conservationists and Tepehuan and

Tarahumara human rights activists. Over the following two weeks, we rose as high as 2,800 meters in elevation when passing through the foothills of the Sierra Mohinora—the highest point in the Mother Mountains—and then nose-dived toward the tropical canyon bottoms of the barrancas, some of them lying at less than 700 meters in elevation. Where we could travel in one day would have taken Vavilov or Lumholtz five to six days in the 1930s.

We left pavement somewhere around the mill and mining town of Las Yerbitas, and for the next eighty kilometers, we climbed up pine-covered ridges and down into barrancas until we reached a cluster of 180 Tarahumara rancherias known as Choreachi, or Pino Gordo. It is a gorgeous valley of pasturelands studded with log cabins and granaries, with long volcanic ridges on either side. There, some of the last remaining old-growth pine stands hung on tenaciously to bluffs of pale volcanic ash, sheltering a rich understory of oaks, madroños, manzanitas, and wildflowers.

Below those ridges, the Tarahumara had freshly plowed their milpa cornfields in the bottomlands, *mawechi* bean patches on the lower slopes, and pasture grasses in the apple orchards that were tucked into canyons or drainages descending the ridges. The apple trees were already in full bloom, and the corn from last year's harvest was fermenting in large clay pots in the log cabins of each rancheria. For the next four days, whenever we approached their homes, the short-statured Rarámuri would offer us *jicara* cups full of the fermented corn beer known as *batari* or *tesguino* as their way of celebrating Easter. We would indeed learn much about the importance of the corn in their community and the factors leading to its erosion.

Earlier, I had the chance to discuss both the positive and negative changes in the region with Randy Gingrich, founder of the Sierra Madre Alliance, Barney Burns, and another Native Seeds/SEARCH cofounder, Mahina Drees. Randy, Mahina, Barney, and I had been among a dozen or so activists who took on the World Bank in 1985 when it proposed large-scale logging and paved roadways reaching far back into the Sierra Tarahumara, the branch of the Sierra Madre Occidental around Guadalupe y Calvo.

Although the World Bank dropped out of the region once our studies revealed the potential cultural and ecological impacts of its proposal, we could hardly claim any victory, since private interests had since developed much the same infrastructure of roads, saw mills, and airstrips. Those roads and airstrips were accelerating the rate of negative changes in the region, as we would soon see.

Since then, the northern Sierra Madre Occidental has been recognized as a mega center of plant diversity, ensuring that the Sierra Tarahumara is regarded by the World Conservation Union (IUCN) as one of the regions on earth most diverse in wild species, native crop varieties, and cultural traditions of sustainable use. This international recognition, we hoped, would slow down plans to log its ancient forests. Perhaps most important, Barney and Mahina led Native Seeds/SEARCH staff in a comprehensive identification and collection of native races of maize and other crops to safeguard them for future generations. During the 1980s, Barney and Mahina gathered some 175 samples of twelve races of maize from the Tarahumara. Many of these have since been returned to Tarahumara families, who lost their own seed reserves during a fierce drought in the 1990s.

The Tarahumara are today still a "people of corn." As Chihuahuan ethnohistorian Victor Martinez has simply and straightforwardly put it, "Maize is the backbone of the indigenous culture of the Sierra Tarahumara." Maize remains the keystone crop sown on three-quarters of all arable lands of Pino Gordo. Nearly a hectare of corn is still planted for every person in Choreachi, but during years of drought, floods, or plagues, the yield can be meager. In good years, the Tarahumara typically harvested 300 to 450 kilograms of edible maize per hectare, but in recent drought years, the harvests have declined to less than a fourth of the average yield. All told, a family of six Tarahumara and their livestock typically require about 4,700 kilos of maize to meet their nutritional needs. That's about 800 pounds per person, far less than the average hectare in Choreachi produces. Six months before the next maize harvest, most of the granaries we observed were empty of all but the seed corn saved for a May planting. Some of Choreachi's families said they did not even have seed corn left and would have to barter for some from their immediate neighbors or bring it in from farther away.

It appeared that for lack of arable land or lack of harvestable runoff from the forests above their fields, the farmers this particular year had insufficient quantities of corn seed for planting and maize for eating. By maize for eating, I do not merely mean fresh corn on the cob. Albino Mares Trías, a Tarahumara practitioner of traditional foodways, has demonstrated that nearly every part of the maize plant is eaten except the roots. The kernels of maize are more often than not dried rather than eaten in their fresh, green "milk" stage. Even when the entire corn on the cob is eaten, it is first cooked, then dried for five days before it is cooked again, then eaten with meat and tortillas as a dish called *chacal*. For other dishes, the shelled kernels are soaked, then boiled, toasted, and coarsely mashed with water and *quelite* greens or roasted mescal for *esquiate*; ground finely to make a coarse flour called masa harina; or toasted and ground to make pinole with flint corns and *atole* with softer flour corns. The corn husks are used to wrap masa, meat, and greens into tamales or the leaves of the native *makuchi* tobacco into cigarettes; and the dried corn tassels are boiled in milk or water to make a sweet drink. The cornstalks of *maiz blando* (but not other varieties) are sweet enough to be eaten like sugar cane.

When the maturing ear gets infested with corn smut, the smut's mushroom-like fruiting body is harvested along with the bloated corn kernels as a *huitlacoche*. The corn beer we imbibed on Easter Sunday was particularly nutritious and is leavened with a strain of beer yeast known only from the clay pots that the Tarahumara use to ferment *tesguino*. In short, corn is eaten, drunk, and smoked; like another essential, water, it is in every cell of the Tarahumara people who hosted us, coming into their bodies as a liquid, as a solid, and as a smoky vapor.

This cultural dependence on corn makes the recent shortages of traditional maize varieties even harder for them to bear. In Choreachi, we wistfully witnessed villagers making tesguino using bags of "instant masa" cornmeal of the Maseca brand.

Maseca is produced by a multinational corporation known as GRUMA. GRUMA Mexico—itself partially owned by Archer Daniels Midland (ADM)—together with ADM's U.S. branch co-owns the Azteca Milling plant in Edinburg, Texas. That mill allegedly provided the genetically contaminated flour from transgenic StarLink corn that caused considerable controversy in 2000. StarLink was not yet approved for human consumption when it somehow showed up in Kraft taco shells; it has since been replaced by other genetically modified corns in the marketplace.

The governments of both the United States and Mexico, and the corporations that dump U.S. corn into Mexican markets, would like us to believe that such problems are fully behind us. However, there have been unconfirmed reports since 2000 that transgenic or genetically modified (GM) corn also has made its way into Mexico illegally, perhaps through the various brands of corn chips.

Well before the reports on GM corn chips were released, GRUMA announced that its Maseca brand tortillas would be free of genetically modified organisms (GMOs), in accordance with Mexican law. But Greenpeace México claims that Maseca continued to use transgenic maize imported from the United States in its corn products sold in Mexico well into 2006. Maseca has also been criticized by Greenpeace for using Mexican government subsidies to dump cheap U.S. corn into the Mexican marketplace, even though its billboards in Chihuahua claim that it uses "Maiz de esta tierra," or "Corn of this country." In bringing a consumer fraud lawsuit against Maseca in June of 2006, Areli Carreón, the consumer advocate for Greenpeace México, argued that because seven out of every ten tortillas sold in Mexico come from GRUMA's Maseca mills in the United States and Mexico where batches of corn from various sources may be mixed up, GRUMA can still not guarantee that the maize used to make them is GMO free:

> While Maseca pushes a big advertisement campaign [claiming it no longer uses transgenic corn in the United States] among Mexican-Americans, back home Maseca is using [transgenic or GMO] corn to feed their families. No company should be allowed to lie, exaggerate or deceive the public through their advertisements, especially if this company produces the basic food for Mexicans.

Unfortunately, GMOs have not only contaminated processed corn foods coming into the Sierra Madre, but there is growing speculation that they may have also contaminated the indigenous fields of diverse maize varieties there, as well. It is not known how much transgenic corn has gotten into traditional maize plantings in the Sierra Tarahumara, but a 2003 field sampling in fifty-three indigenous communities suggested that contamination of native corn by StarLink had already occurred in six states, including Chihuahua. Victor Martinez has reported that 33 percent of the samples taken from indigenous fields in the Sierra Tarahumara may be contaminated. While other reports of the 2003 survey do not specifically note the fraction of the Sierra Tarahumara samples contaminated by GMOs—that is, by transgenic maize releases from biotech firms—they do document physically deformed plants, as well as biochemical evidence of GMOs, in the Tarahumara homelands of the Sierra Madre. The sampling and testing techniques used have been criticized by some scientists, but concern remains, since so many Chihuahuan farmers purchase seeds in the U.S. when they make visits to bordertowns.

Pedro Turuseachi, a Tarahumara spokesperson with Chihuahua's Consultoria Técnica Comunitaria, had this to say about why the possible presence of transgenic corn is so threatening to his people: "Our seeds—of our own maize varieties—form the basis of any food sovereignty we have for our communities. Maize for us is much more than a food; it is part of what is sacred for us, part of our history, our currency, and our destiny."

In underscoring the importance of maize to every aspect of Tarahumara culture, Turuseachi argued that potential contamination of traditional maize varieties is not merely a technical "genetic" issue but a cultural and spiritual one, as well, since something as sacred as maize should not be desacralized by "impurities."

Maize for the Tarahumara and Tepehuan is many things, but there are also many maizes, each one of them fitted to a different microenvironment and use. Over the last fifteen years, the Native Seeds/SEARCH project called Treasures of the Sierra Madre has returned many kinds of native maize to farmers who lost them during droughts, while also helping Tarahumara families stabilize and restore many of the special microenvironments where those maizes were formerly grown. The Chihuahuan coordinator of the Treasures project, Juan-Daniel Villalobos, has assisted several Tarahumara communities and dozens of families with building stone-lined terraces, which help to retain the soil fertility and moisture required to grow traditional maize and beans. Where the terraces have been put in place, Juan-Daniel and his colleague Suzanne Nelson have reintroduced well over a dozen native maize and bean varieties that the Tarahumara farmers identified as once being prolific in their areas.

Despite such active efforts by the Tarahumara to maintain and regenerate their diverse maize legacy, some varieties are now considered to be endangered by all the recent introductions of particular hybrid maize cultivars. Even the notion that there might be one superior maize cultivar that will meet all community needs is considered to be a folly among the indigenous folk of the sierras; nevertheless it remains the pipe dream of some plant breeders.

Just three years after Barney Burns and I visited the Guadalupe y Calvo rancherias in 1988, the Chihuahuan state government began to distribute two "improved" (but non-GMO) cultivars of corn to the Tarahumara and Tepehuan of that region. The Vanta-1 and Vanra-1 cultivars were developed from crosses between a criollo maize from the sierras combined with others that were higher yielding (especially when fertilized) and produced larger grains and multiple ears per stalk. Over the last decade and a half, the large, white-seeded cultivars have been distributed by the state coordinator for the Tarahumara to dozens of highland communities.

The problem is that large, white, bland-tasting kernels are not very useful for the entire suite of foods that the Tarahumara and Tepehuan make from their diverse varieties of corn. They are virtually useless for making pinole, and the famous blue corn tortillas of the Tarahumara cannot be produced from them without adding food dyes. The blue anthocyanin pigments of highland maizes, as John Doebley once explained to me, are not merely for show. Blue and reddish purple pigments in highland maize seedlings absorb more heat early in the day and in the growing season, when cold temperatures may otherwise stunt the development of corn plants. Therefore, by distributing only white corn seed, the plant breeders are selecting *against* one of the most time-tried adaptations of maize varieties in the highlands of the Sierra Madre.

The more widespread varieties of traditional Tarahumara and Tepehuan maize remain viable and well cared for by many, Juan-Daniel Villalobos explained to me, but seed of the more place-specific varieties with special uses are growing increasingly rare. That may also be true of the Nabogame race of teosinte, which remains known from just three localities in the sierras; some have estimated that their total range is now less than fifty square kilometers.

Both traditional maize diversity and wild teosinte are unfortunately also vulnerable to two other pressures that have been mounting in the Sierra Madre for more than seven decades: logging and drug production. These two disruptive forces have been tearing the ecological and cultural fabric of the sierras.

Although the first European and mestizo miners settled in the northern Sierra Madre around 1708, almost all their logging was done for local uses, the building of homes and mine shafts and the burning of wood as fuel. After 1884, however, Mexican governmental policies fostered the building of railroads and company towns and the extraction of timber for extra-local uses. Around the time of Vavilov's visits to Mexico, U.S. investors began to back Chihuahuan mestizos to extract wood pulp and cellulose for U.S. markets. After World War II, logging companies made more and more inroads to remote parts of the sierras, in many cases taking lands away from indigenous communities so that they could be clear-cut. Today, as Randy Gingrich has written in the reports of the Sierra Madre Alliance (SMA), "Over 99 percent of the original old growth forests of the Sierra have been logged. Secondary forests lack the structure to sustain biocultural diversity—studies sponsored by SMA have indicated a significant loss of biocultural knowledge in secondary forest areas."

Where logging roads and airstrips were introduced in a region, other kinds of changes then filtered in—changes that erode the soils, the traditional ecological knowledge of indigenous farmers, the diversity of their crops, and the integrity of habitats surrounding them. One of those changes is the usurpment of arable land formerly dedicated to maize and beans by the sowing of opium poppies and marijuana. The narcos ride in to the region in their four-wheel-drive Ford Escorts or fly in with their Cessna Cubs and offer indigenous campesinos *a thousand times* more than what they can sell their corn for if they will grow drugs instead.

That's right, a thousand times the income from one hectare than what a poor farmer has ever made off his corn. According to Chihuahuan economist George Mayer the salable harvest from one hectare of Tarahumara or Tepehuan maize has seldom garnered the farmer more than five hundred pesos per year; marijuana from the same hectare will render as much as five hundred thousand pesos, if indeed that much cash ever stays with the farmer himself. Sadly, I had to ask myself, if you were in their sandals, what would you grow?

In essence, logging has become an economic "cover" for a much more lucrative business—drug production and trafficking—which now generates more income than all the other economic activities of the sierras combined. Road building and deforestation—and the cultural and ecological destruction that come in their wake—continue at a pace that Randy, Barney, and I could not have imagined when we thought we had "won" our case against the World Bank's promotion of logging in the Sierra Tarahumara.

While I was in the Guadalupe y Calvo reach of the Sierra Tarahumara in April 2007, the staff of SMA was anticipating a judge's decision in Chihuahua City on whether he would block plans to let non-Indians immediately log most of the remaining timber in the Pino Gordo *ejido* (collective), in what has been considered the last old-growth forest of any size in the Barranca Sinforosa, a major valley. Randy Gingrich was on pins and needles the days we traveled together, but the decision kept being postponed. His anxiety seemed justified, once I learned from him what was at stake.

"Maybe only 5 percent of the commercially suitable trees around Choreachi have ever been cut, but if the judge doesn't support our case for maintaining indigenous community control over these resources," Randy sighed, looking down at the ground, "90 percent of the old growth here will be gone in three years." The case remains in review and is hotly contested. The activists associated with SMA are not the only ones concerned about the impending threats of accelerated deforestation and road building for drug traffickers on the biocultural diversity of the Sierra Madre. Two eminent scholars of traditional ecological knowledge in the Sierra Tarahumara—Serge LaRochelle and Fikret Berkes—have recently expressed the same concern:

> Perhaps the major threat [to traditional uses] by the Rarámuri is the loss of control over the forest commons. Increased activity [of miners, loggers, narcos, and tourists] has impacted local ecological relations, and contributed to deforestation, soil erosion, and the loss of understory plants. Such changes are threatening the traditional ecological knowledge and the cultural integrity of the Rarámuri people.

There is also mounting evidence that the ecological and cultural changes that have occurred in the sierras since Vavilov's era are threatening the mother of corn in the Mother Mountains. At a 1995 meeting sponsored by the International Maize and Wheat Improvement Center at El Batán, Mexico, three prominent agricultural scientists all expressed their concerns about the future of Nabogame teosinte.

Garrison Wilkes considered Nabogame teosinte to be rare, with its historic distribution contracted. He suggested that the spread of roads into remote areas, the isolation of small teosinte populations, and the introduction of new cash crops (like marijuana and poppies) have cut teosinte's distribution in half since Vavilov's time. Two of Wilke's Mexican colleagues have made botanical pilgrimages like ours to Nabogame. In their independent assessment, Jesús Sanchez and José Ariel Ruiz determined that the teosinte there was rare and "threatened by deforestation." They also suggested that the current range for that race of teosinte may already be reduced to as little as thirty square kilometers. About the same time, geneticist Lesley Blancas reported that the majority of subspecies or races of teosinte in México are now in danger of extinction.

Every once in a while, when I am back home in Arizona, I look at photos I made in 1988 when I first harvested a handful of teosinte kernels from the Tepehuan fields of the Sierra Madre. One photo is a close-up of the wedge-shaped grains that neatly fit together like pieces of a jigsaw puzzle. The light on the little cluster of grains made them shine, as if they were almost glowing against the black backdrop on which I had placed them. As I look at them now, they offer me a glimmer of hope surrounded by a world of darkness. No wonder Nikolay Vavilov wished to hug the corn and teosinte plants that he met in the fall of 1930 on the outskirts of Mexico City, a place, no doubt, that is now surrounded by paved roads and populated homes. Perhaps he wished to hang on to them for just a moment, with the hope that somehow they might stay with us forever.

The dynamics of natural hybridization between maize and teosinte are perhaps peculiar to Mexico and Guatemala, but genetic contamination of ancient cereal grains, vegetables, and fruits by transgenic cultivars is a new dynamic and one that is becoming increasingly commonplace. Farmers may temporarily enjoy higher yields when they adopt certain GMO crops, but more and more case studies indicate what they are losing, not just what they gain. Whether they are canola farmers in North America, sorghum farmers in Africa, or rice farmers in Asia, more food producers around the world now see that by uncritically adopting any transgenic crop that becomes available to them, they may lose control of the way their crops and certain weeds have positively interacted over many millennia.

Many prominent biologists now point out that the heady claims about how transgenic crops would put an end to hunger have already begun to wither under careful scrutiny. As conservation biologist David Ehrenfeld recently summarized the situation,

> Despite the enormous popular enthusiasm whipped up by the press and the financial markets, only a small proportion of the simplest possible genetic manipulations among the many that have been tried have worked at all. And many of these have turned out to be disappointing, dangerous, or both. . . . It has become increasingly apparent that DNA is only part of the story [shaping a particular crop's success, because] it is subject to other regulating and modifying influences in the cell, influences that we hardly understand. . . . In other words, the idea that patented transgenic organisms (and there are now many) are genetically stable and capable of performing consistently as desired for long periods of time and through many generations, is not biologically warranted.

Warranted or not, the idea that transgenic crops will feed humankind in the future has now been "seeded" in nearly every center of diversity that Vavilov once visited. Even if the transgenic grains, fruit, and vegetables have not physically arrived in the fields, orchards, and gardens of these mountainous regions, it is only a matter of time before their presence will be felt in the food system of each of these centers of diversity. Corn chips, for instance, are transported from country to country with little recognition of the ingredients within them. Likewise, transgenic seeds may be cleaned and bagged in the same mills where traditional seeds are cared for, and they can inadvertently contaminate the next batch of seeds that runs through a cleaner. The genies have been let out of the lamp. And so have the genes.