The Next 50 Years: US-Russia Cooperation on Perennializing the Major Crops With the Ecosystem as the Conceptual Tool

Wes Jackson, The Land Institute

Khrushchev in Iowa Celebration; Whiterock Conservancy, Coon Rapids, IA

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September 23, 1959. A pivotal moment in history? For us assembled here today, it is. We have gathered today to think about that time 50 years ago and all that has happened since. It is also worth thinking backward a hundred years from 1959 to 1859 when Colonel Drake's oil well was drilled in western Pennsylvania. That was the first one ever. 1959 was also the 100th year since Charles Darwin's *Origin of Species* was released in London's bookstores. And 1959 was the 50th anniversary of the most important invention of the 20th century, the Haber-Bosch process which made it possible to turn atmospheric nitrogen into ammonia fertilizer. According to energy scholar Vaclav Smil, without this process 40 percent of humanity would not be here today.

September 23, 1959. Neither Nikita Khrushchev nor Roswell Garst or most anyone else could imagine the speed of change to come over the next 50 years. They could not know, for example, that a 10-year-old in 2009 would have lived through the burning of 25 percent of all the oil ever burned. How could Khrushchev or Garst or anyone else have imagined the scale of the consequences of burning the manure of the farmstead and substituting chemical fertilizer, as Mr. Garst advocated? Mr. Khrushchev thought the idea a good one. None of us, I'm betting, could have foreseen the number of nitrogen polluted wells in rural America or the cost, for cities such as Des Moines, of removing nitrogen from the public water supply. Nor could we have foreseen that nitrogen runoff would cause dead zones in the oceans.

The Industrial Revolution was a bit over two centuries old when the early stages of agriculture's Green Revolution were getting under way in 1959. Within three decades, yields of several major crops had doubled in some places, tripled in others. Oil supplied the fuel for traction and other mechanical operations. Natural gas sponsored the ammonia to fertilize the crops that realized the yield potential developed by the plant breeders. Every gain in bushels per acre or kilograms per hectare was praised. As the food supply went up, antibiotics and other drugs forced death rates down. The world population doubled. By means of all these successes what we can call the Industrial Mind now permeates the world.

As fossil fuel consumption accelerated, only a handful of scientists speculated on the costs to the ecosphere of the released carbon. But now global warming is generally recognized as a public enemy.

Nikita Khrushchev and Roswell Garst did know one big thing, as true today as it was then: people will want to be fed, every day, every week, every month, every year. This need must have been most poignant for Mr. Khrushchev. The Siege of Leningrad and the resultant starvation, sickness and death lasted from August of 1941 until January of 1944. Only 15 years before the Iowa meeting. No matter how long and dark the tunnel might be for countless problems sure to face us, both the farmer and the premier knew that if we could produce enough food, most problems would be manageable. Their question then is our question today: How do we help assure an adequate

food supply, not just in our two countries, but around the world and for centuries to come? Next year our earth is expected to feed seven billion people.

Solutions to the energy and climate crisis will require extraordinary political will both to conserve energy and to develop renewable energy technology. We might succeed. **But once soil has eroded there will be no technological substitute.** And in spite of all our efforts so far, soil erosion and other landscape degradations are increasing globally. In a few places it has been slowed by minimal till or no-till farming, but with this so-called fix, pesticides accumulate. We are poisoning our soils to save them.

I want to propose a solution now that both of our countries can embrace. If we cooperate, success will come faster. Annuals grown in monocultures dominate agriculture. But essentially all of nature's ecosystems feature perennials growing in mixtures. We need to breed perennial grains. The literature of ecology and evolutionary biology has been accumulating on the shelf for a century, more or less for its own sake. It is a great untapped potential to draw on. Ecologists have learned to detect many of the efficiencies of the various ecosystems, both above and in the soil. The ecosystem becomes our conceptual tool. Nature's way of operating on the land becomes the standard against which we judge our agriculture.

Imagine two ends of a spectrum—human cleverness at one end and nature's wisdom at the other. The Industrial Mind, over the last 100 years has increasingly relied on human cleverness. I am not proposing that we quit being clever, but instead, cleverness should be subordinated to nature.

Advancing this idea will be a great challenge. Our 10,000-year history of growing food has been tied to the notion that nature is to be subdued or ignored. But this attitude has made for relentless deficit spending of the earth's capital. Now, finally we face the need to change course. The possibility of doing so resides in exploring the efficient processes of nature which are sponsored by contemporary sunlight.

This look to nature begins with the soil itself. For tens of millions of years, nature's arrangements have managed the twenty-some elements that go into all living things. Only four of these elements—carbon, hydrogen, oxygen and nitrogen—are found in the atmospheric commons. Our future lies in the soil.

This brings me to why Russians need to be major players in this effort for a new agriculture. I have five stories out of Russia's rich culture. Three are about scientists, one is about a moment in history and the fifth is about an historical period. After I have told all five stories, I will explain what our two countries could accomplish over the next half century, to 2059.

1. Vasily Dokuchaev is the Father of Soil Science. In the 1870s, Dokuchaev was given the task of describing the structure, origin and evolution of the deep rich grassland soils of western Russia. Classifying them had been elusive. The belief of the time was that weathering alone was responsible for soil formation. Soils were thought to have no emergent properties of their own, no properties due to interactions with organisms, nothing that would give them standing beyond what mere weathering would cause.

To accomplish this task of soil classification Dokuchaev traveled over 10,000 km (6,000 miles). From his observations he concluded that "soil exists as an independent body and has its own special origin and properties unique to it alone." More is involved in soil formation than merely moisture and temperature. He identified five factors that govern formation of soil: climate, parent material, organisms, topography and time. His conclusions revolutionized soil science, earning him the title of Father of Soil Science. Lacking translation from Russian, Dokuchaev's idea was not recognized in the West for decades. But when Professor Hans Jenny, father of American Soil Science, published his seminal book *Factors of Soil Formation* in 1941, he accepted and used Dokuchaev's five factors. Professor Jenny's contribution was to create a formula that required differential equations. By providing quantitative measures of the state factors of Dokuchaev, Jenny began a revolution in soil science.

2. Dr. Nikolai Ivanovich Vavilov, born in 1887, was internationally known as an agronomist, botanist, plant breeder, geneticist and plant geographer. He had a big- picture view of our earth, both geographically and in time. Early in his career he set out to determine where the cultivated plants originated, traveling worldwide and making massive collections. His published conclusions set the standard for all subsequent investigations. Plant breeders still turn to them again and again. His passion and intellect were supported by a rich Russian culture notable for its love and honoring of natural history.

3. Theodosius Dobzhansky was a Ukranian immigrant who came to the U.S., became a citizen and is regarded as the most important evolutionary biologist of the 20th century. In 1937, 22 years before Khruschev's 1959 visit, Dobzhansky published his landmark book *Genetics and The Origin of Species*, in which he bridged a wide gap between experimental geneticists and naturalists. He was the first to successfully integrate understanding of evolutionary problems, from his naturalist perspective gained in the Ukraine, with experimental genetics, from his more recent experiences in the U.S. **The great American evolutionary biologist, the late Ernst Mayr, said that Dobzhansky's 1937 synthesis, so long in arriving, was the most decisive event in biology since 1859, the year of Darwin's *Origin of Species*.**

Now for two important times in the history of Russian culture.

4. During the 872 day Siege of Leningrad, not tens but hundreds of thousands of people died from hunger. There was every reason to believe—given its huge quantity of seeds collected from all over the world—that the Institute of Plant Industry would be overrun by the hungry people. But the institute's staff guarded the collection. And in the midst of the seeds, they too starved. The collection remained untouched.

5. Finally, there is the extensive work carried out in Russia on the remote hybridization of plants. A team of plant breeders made countless wide crosses between species and varieties. Their desire was to speed crop plant evolution. According to N.V. Tsitsin, one of their efforts was to develop a wheat with "perennial character, remarkable for dwarfness, resistance to lodging, an ear structurally similar to that of conventional wheats, and easy threshability." He also said "among the primary features of the perennial and feedcorn

wheats we are currently putting through selection is **their ability to develop a powerful rooting system**, a factor rather important for the maintenance and betterment of the soil structure, but one of prime importance for the regions susceptible to wind erosion." (Emphasis mine) Tsitsin acknowledged that "it will be some time before the newlybred varieties can be cleared for production, lagging far behind the best wheat varieties in terms of their yields."

He went on to say, "The fields under perennial wheat need not be reploughed, the stub will be highly snow-retentive and thus very likely to promote the accumulation of soil moisture. In sum, these factors will provide for **sustained and progressively increasing fertility of the fields**." (Emphasis mine.)

Of course, one wonders what happened. Why did the work on perennial wheat not continue? Perennial wheat development was a part of a larger program in the Soviet Union. It was pursued, more or less, as a sideline, because: 1) farmers and governments need assured high yields every year, so the bulk of research funding went to that end, and, 2) Any research effort of a long-term in agriculture is the first to be cut when funding is reduced.

Breeding perennial grains to gain high yield is a long-term venture. Abundant fossil fuel inputs in agriculture were then available to offset some of the consequences of soil erosion. Fossil fuels make it possible to mine, package and transport nutrients from afar. Commercial nitrogen is made possible by the energy intensive Haber-Bosch process. For whatever reason, the perennial wheat breeding faded away before it was farmer-ready.

In Conclusion:

Those five stories bring us to the modern challenges of achieving sustainable food production. We need to:

- Feed the expanding population as we work to stop its growth.
- Prevent soil erosion beyond natural replacement levels.
- Manage nutrients and water more efficiently.
- Greatly reduce the use of toxic chemicals.

A Proposal for a Cooperative Effort

I propose that our two countries jointly undertake a massive breeding program devoted to perennializing the major crops currently responsible for occupying at least two-thirds of the agricultural land of the planet and responsible for two-thirds to three-fourths of our calories: mostly grains and pulses (legumes). Joint ecological studies of agricultural landscapes could get underway at the same time.

A few years ago in the Upper Midwest of the United States, a coalition arose which now calls itself the Green Lands/Blue Waters Initiative. Central to their efforts is advocating the need to perennialize the landscape of the Mississippi Basin out of concern for soil erosion and the leaching of nitrogen, now responsible for one of the largest dead zones of the world. GLBW partners include the University of Illinois, Iowa State University, including

the Leopold Center for Sustainable Agriculture, Louisiana State University, the University of Minnesota, North Dakota State University and the University of Wisconsin, and the Audubon Society, the Illinois Stewardship Alliance, the Institute for Agriculture and Trade Policy, The Land Institute, The Land Stewardship Project, the Minnesota/Iowa Farmers Union, The Nature Conservancy, Trout Unlimited, Practical Farmers of Iowa, and the Rural Advantage and Agricultural Watershed Institute.

More recently organic and local food organizations have added their support to the common principles and goals of Green Lands/Blue Waters.

The vision and the work of the members of this coalition has now produced a 50-year Farm Bill, which proposes a gradual systemic change in U.S. agriculture. It is a scientifically feasible plan for preserving the landscape for food production. This plan, at a minimum, will shape the future work of our coalition. We offered it to our Secretary of Agriculture, Tom Vilsack, with the hope that he and his department will see the need for it.

Until the plant breeders develop farmer-ready perennial grains, ecologists can use analog species to experiment with various mixtures, various root architectures, yielding various ecological functions. At the outset the proposal advocates more perennials in rotations, and more pasture. It further states that our five-year farm bills should serve as mileposts of progress over 50 years to move the U.S. agricultural land from 80% in annuals and 20% perennials to 20% in annuals and 80% in perennials. To accomplish this task the proposal advocates funding for 80 Ph.D.-level geneticists/plant breeders and 30 ecologists.

A modest global effort is already under way. Canada, Australia and Turkey are working on perennial wheat. In China, a perennial rice is being developed for the uplands. But the effort needs a major boost. So let’s imagine that our two countries were to become full partners in this enterprise.

- Russia produced the father of soil science, Vasily Dokuchaev. And soil science will be a must.
- Russia produced the first work on the centers of origin of our major crops under the direction of N.I. Vavilov. As they have over the decades, plant breeders will be going back again and again for germplasm to those centers of origin.
- The Ukraine produced the foremost evolutionary biologist of the 20th century, Theodosius Dobzhansky, who gave us the most important synthesis since Darwin. Ecology and evolutionary biology have become, more or less, one subject since his time, forming a broad discipline now being drawn on by those at work on sustainable food production.
- Researchers and curators who died to protect the seed collection of the Institute of Plant Industry will remain a source of inspiration and hope.
- Russia initiated the first effort to produce a perennial grain.

Though it is not asking for itself any form of official support, The Land Institute will offer to the common effort, free germplasm and more than 30 years of experience with perennials. Its staff in this decade has greatly enhanced the diversity of crops and increased

the speed of change. We have hybrid prototypes of perennial wheat, sorghum, sunflower and other crops.

After three decades of collaboration with several land grant universities and other institutions we are convinced that we now have a critical mass of researchers who understand the need for systemic change in agriculture. So we in the United States would offer to this effort our trained professionals. We have more Ph.D. level geneticists, plant breeders, ecologists and evolutionary biologists than any other country. Our country's Morrill Act of 1862 made possible our land grant university system. The Hatch Act of 1887 placed Experiment Stations in every state. The Extension Service was established by the Smith-Lever Act of 1914. This system worked effectively, but within the context of a country rapidly industrializing by the extravagant use of petroleum, and other non-renewable resources. The now-foreseeable exhaustion of these limited resources is forcing us to adopt a new concept for agriculture. I have spoken here of our reasons to hope that the world's agricultural system can be corrected before it fails.

Finally

Cosmonauts and astronauts, representatives of our two countries, shared a tiny capsule in space. But they brought with them food raised on the soils of our earth.

It seems that we have to be reminded that Earth is in space too, as much as are Mars and the moon. Why do we neglect the Earth's food producing system? Why do we allow it to be damaged by erosion and toxic chemicals, all the while depending on fossil fuels which we are rapidly using up and which will never be cheap? Why do we tolerate this deficit spending?

If we begin now, together, to move agriculture from an extractive to a renewable economy, perhaps 50 years from now at this Coon Rapids, Iowa farm, those assembled will celebrate the 200th anniversary of Darwin's *Origin of Species*, the 100th anniversary of the friendly meeting between Nikita Khrushchev and Roswell Garst, and the 50th anniversary of our effort to end deficit spending of ecological capital. And maybe this day will be seen also as the moment we began to make nature's economy the standard by which to judge our agricultural economy.

[i] The Leopold Center for Sustainable Agriculture, along with the Iowa Natural Heritage Foundation and the Iowa Department of Natural Resources, are the "supported organizations" of Whiterock Conservancy, an Iowa non-profit land trust formed in 2004 to conserve and protect Iowa's natural resources, demonstrate sustainable rural land management, and engage the public with the environment through outdoor recreation and education.