

MOLLY CLIFF HILTS

Beyond the Empire, 2008

Oil, powdered pigment, wax, graphite, lithographic
ink over traditional gesso ground on panels, diptych,
48 x 78 in



COURTESY THE ARTIST AND SESNON ART GALLERY

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The Great Awakening

Where We
Are Headed with
Agricultural
Management

Not long ago our ancestors had a *Great Awakening*. It began small, but gained in size in the twentieth century. What aroused the people on Earth Island? Global warming was the major concern then, and land use was the number two source of greenhouse gases, behind fossil fuel power plants and ahead of all transportation.

Thirty million acres a year ecosphere-wide were experiencing land degradation. Our food source was under siege. The world population, still growing in 2014, had tripled in the previous eighty years.

Our ancestors had a hard time getting a grip, primarily for two reasons: they were addicted to fossil fuels, and their ancestors were children of the Enlightenment, which included in its ideas “enlarging the bounds of human empire to the effecting of all things possible.” A reductive approach to the world. Many of our ancestors’ motivations were good. Like us, they wanted a world without hunger. There was also a certain industrial heroism among them. Their dominant slogan was telling: “We must feed the world!”—often uttered in a puffed-up way.

Thankfully, a few were more modestly saying, “Sure, the world must be fed, but then what if we have failed to stop greenhouse gas accumulation, soil erosion, and depletion of fresh water?” These were the days of The Great Awakening, when only a few appreciated that soil is more important than oil, and is as much a nonrenewable resource. Millennium Ecosystem Assessment scientists concluded that agriculture was the number one threat to Earth Island’s wild biodiversity. It was time to confront the problem of agriculture instead of only addressing problems in agriculture.

An increasing number of agricultural scientists and ecologists had accurately diagnosed the negative consequences of grain production. Noting that the virtues of natural systems mostly featured perennials and more-or-less-constant ground cover, they called for *ecological intensification*. That is about where the agreement ended, for there were already two camps of agricultural scientists ready to address the problem.

The dominant camp was like most early twenty-first-century scientists. They were intellectual descendants of Francis Bacon. The generation before them—indeed some of their major professors—were the agriculturists

responsible for the twentieth century’s Green Revolution, which, by industrial agriculture standards, was a great success. That is what the new generation pointed to. After all, grain yields had doubled, sometimes tripled. Almost everywhere into the twenty-first century the Green Revolution was still hailed as a success, and in a limited sense it was. Its core assumptions went back to Francis Bacon’s utopian novel *New Atlantis*, in which he wrote that “the end of our foundation is the knowledge of causes, and secret motions of things; and the enlarging of the bounds of human empire, to *the effecting of all things possible*.”

Obvious to all, but seldom mentioned, was the revolution’s fossil fuel dependency, degraded soils, poisoned water, and greatly accelerated greenhouse gas emissions from agricultural land. In less than half a century, farms ecosystem-wide industrialized and increasingly depended on the extractive economy. Before the new genotypes could respond, fertilizer, pesticides, and, when necessary and possible, irrigation wells were required.

The Green Revolution success story had another shadowy side: the collateral damage to the small farmers who, for credit, mortgaged their farms to buy inputs. When the inevitable crop failure came, they lost their small farms, usually to larger farmers. Where was the more thoroughgoing critique of this to come from? Not from the scientists.

Professor Angus Wright, a historian of Latin America and the environment in the twentieth century, wrote books and articles still widely read today. Wright was a major diagnostician of the assumptions leading to the negative consequences of the Green Revolution. He was also a student of the movement of landless people. His description of the implicit and explicit goals of the Green Revolution shock us now, especially the implicit assumption that agriculture was not vitally linked to nature! With the Green Revolution, more than food was on the line. Economic development was also on the line, and for good reasons: two world wars and a global depression. With that in the background, it was held that agriculture was to serve as an instrument for the advancement of industry and economic development. Adoption of the entire Green Revolution package was considered essential. Technology was considered neutral. If persuasion failed, one was to use compulsion. Starting with the idea that the problem is low productivity, chemicals were needed. If more chemicals

were needed, build a chemical plant. Soil degradation was factored in, but as a cost in the economist’s emphasis on the input/output ratio. The gap between the social and scientific cultures was largely ignored. Techniques of traditional farmers were regarded as more of an obstacle than a resource. Those in the developed world thought of themselves as the teachers. The poor were considered learners.

By the twenty-first century, agricultural scientists had heard the critique and were aware of the social and physical consequences. They wanted to do better next time. That is how “ecological intensification” became a mantra. But what did that mean? Well, more technological cleverness: precision planting, molecular tools, GMOs. Biological diversity was given a nod through rotations and cover crops. It was a combination of agriculture engineers, molecular biologists, geneticists, and agronomists, all ready to launch a second, but this time more benign, Green Revolution.

There was another problem. It derived from the same paradigm as the first. Given past successes with annual grains, technological cleverness still reigned. Radical thinking was difficult. The dominant camp still saw annual grains as the necessary “hardware,” even though the “software” of how to grow them had proven limited. Grain fields need high nutrient retention. Agricultural fields need to accumulate organic matter and manage soil water. These goals are hard to meet once vegetation is cleared from the field, whether with the plow or herbicides. Annual grain plants were not in the ground long enough for soil microbes and invertebrates to fully protect and enhance the soil quality. And soil erosion still continued.

A major effort was started in the second decade of the twenty-first century to domesticate more herbaceous perennials to increase the variety of “new hardware.” This new effort made possible the new paradigm. A few scientists had looked for their standard to nature’s natural ecosystems, those perennial mixtures which had evolved over millions of years. That represented *ecological intensification*! Would it not be easier to achieve the goal that both camps agreed on if they were to mimic a prairie or grassland with perennial grain mixtures? Perennial hardware made it possible in one stroke. It took half a century. The paradigm for grain agriculture, which had existed for 10,000 years, was changed.

Researchers were encouraged by the rapid response to selection by two wild species: intermediate wheatgrass and *Silphium*, a relative of the sunflower. The former became Kernza, and the latter an important oil seed crop.

So an effort was launched to do a thorough inventory of herbaceous perennials or shrubs that produce hard seeds. This part of the mission was anticipated to be like—“screening microbes for novel antibiotics like penicillin” as David Van Tassel, a scientist at the Land Institute, a science-based organization in Salina, Kansas, that promoted an alternative to destructive agricultural practices, put it. That was the inventory phase.

Researchers also set themselves the task of analyzing what happened during domestication of the annual grains, and from there explored how it could be repeated with their wild perennial candidates.

But there was more to the equation. It had long been known that any new crop requires more than breeding and genetics. Interdisciplinary teams featuring agronomy, plant pathology, soil science, food science, plant breeding, economics, and social justice were assembled.

The challenge was lessened considerably for some species. For example, Kernza, a relative of wheat and other grains, allowed plant breeders to transfer knowledge from those other grains. In Kernza, Land Institute scientist Lee DeHaan found what is called the *q gene*, which is also in wheat, providing both shatter resistance and free threshing.

Also, new genetic technique helped achieve breakthroughs in domesticating complex wild species. Domestication also required evaluating large numbers of plants and selecting the best to intermate. New computational power made that possible.

Unlike agriculture scientists before them, they were every day mindful of what Wendell Berry had to say in 1974:

Few people, whose testimony would have mattered, have seen the connection between the modernization of agricultural techniques and disintegration of the culture and the communities of farming.

Ever mindful of those who would develop the crops and grow the food, Berry also asserted:

In the long run, quantity is inseparable from quality. To pursue quantity alone is to destroy those disciplines in the producers that are the only assurance of quantity. The preserver of abundance is excellence.

Scientists were needed who were both broadly educated and well trained.

How did it Happen?

It didn’t just happen. Late in that period, a few in establishment science had been watching, reading the papers of a few young scientists scattered here and there. The National Academy of Sciences and the Natural Resources Defense Council publicly endorsed the value of perennials; the Royal Society did too. World Bank officials visited the Land Institute three times. The Food and Agriculture Organization (FAO) of the United Nations hosted a workshop in Rome in 2014 for twenty-eight geneticists from around the world, scientists interested in perennial grains. And to top it off, in October 2014 the Land Institute hosted a workshop on “Ecological Intensification through Perennial Grains” at Estes Park, Colorado, sponsored by a Friend of The Land, philanthropist Melinda Merrill. Fifty scientists assembled for a week. They were mostly young scientists in plant breeding, genetics, ecology, microbiology, and soil science. They addressed the research challenges for the new paradigm. Following the opening session, for the rest of the week they assembled in small groups to review past research and current work, and to plan collaboration. They explored opportunities to scale up the research agenda. They wanted nothing less than to bring the processes of natural ecosystems to the ecosystem’s grain fields. Participants agreed that agriculture needed a fundamental course correction, and that for this, more scientists were needed.

Scientists were frequently asked, “What makes you think acceptable yields can be attained out of such a diverse system?” Two reasons, they answered: It is well known that natural ecosystems tend to have greater net primary production than the annual monoculture systems managed by humans. So, to the extent that we can imitate the structure, we have data to support that we can be granted high net primary production at the ecosystem

level. And at the individual plant level, perennials can have a longer growing season.

The Estes Park meeting opened with an explanation of why our ancestors had not developed perennial grains, and why we now could. Land Institute scientists David Van Tassel, Lee DeHaan, and Stan Cox had described earlier in a refereed paper that because annuals tend to accept their own pollen—the tightest form of inbreeding—the mutation load does not build up. It gets purged every generation. If a desirable mutant does appear, however, like resistance to seed shatter, the desirable mutant can be quickly fixed in the population.

Perennials, on the other hand, tend to outcross, to not accept their own pollen. The mutation load accumulates. When closely related offspring are crossed, lethal or otherwise undesirable genes lead to aborted embryos or otherwise undesirable plants. Our ancestors lacked this knowledge, and the know-how for dealing with it.

But now geneticists had computational power and molecular tools. They grew out tens of thousands of plants, and purged the genetic load. They still made wide hybrids between wild perennials and their annual relatives—wheat, sorghum, sunflower, and rice. They began solving the oldest environmental problem, grain agriculture.

The new “hardware” won the geneticists *new* colleagues. These young ecologists and evolutionary biologists were eager to apply their knowledge and skills to grain agriculture. From their fields, billions of dollars’ worth of research results, accumulated for the previous 150 years, could now be *applied* to the restoration of agriculture. The scientists had the software for the new hardware. The long path to a sustainable grain agriculture could be seen.

Imaginations went wild. Rangeland ecologists used grazing livestock along with fire as management tools. Feedlots for cattle, chickens, hogs, and turkeys emptied as animals returned to the farm to eat and deposit their urine and manure along with sheep and goats. Even camels were used in places for brush control. People with naturalist bents, but who had abhorred farming, became farmers. They loved their farming and were able to witness wildlife returned to rural areas. In 2018 a stable legume-Kernza bi-culture developed by Tim Crews at the Land Institute was sustained by biological nitrogen fixation. It was the same year that key nutrient-supplying and pathogen-suppressing

roles of the soil *microbiome* were identified in perennial polycultures. That caught the attention of the scientific community. Soil carbon sequestration rates were modeled.

That was all by 2020. Two years later, the soil microbiome was intentionally managed through crop breeding, inoculation, and cultural practices. In 2025 a stable triculture was sustained by biological nitrogen fixation, leading to overyielding, which then became the rule.

In 2025, perennial sorghum developed by the Stan Cox team was well established in sub-Saharan Africa. It too was sustained by biological nitrogen fixation.

Shuwen Wang’s perennial wheat hybrids had expanded to dozens of trials throughout Asia, Africa, Latin America, Europe, and the U.S. Through the work of plant pathologists and ecologists, by 2030 the levels of crop diversity required to regulate pests were implemented on field and landscape scales.

Sunflower hybrids and *Silphium*, as oil seed crops, were expanding their range.

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An agricultural historian at the University of Kansas, writing in the mid-twenty-first century, began a concluding paragraph with the following: “There was still much work to do after Estes Park.” Her book was about the “Institutionalization of the Paradigm,” describing how it happened, the courses that were taught, the research disappointments and breakthroughs, adoption by farmers, and much more. She described *ecological intensification* as an “information-intensive” paradigm, one that had replaced the *energy-intensive* industrial approach. By “information,” she meant a combination of human knowledge and the DNA of individual plants and their interaction with the rest of the biota. She described the various releases of the new perennials, field trials of species ensembles, and how they made their way to the land.

A long-expected and major challenge had been met. But the new paradigm demanded more farmers. Where would they come from? Land ownership had become increasingly concentrated in the expanding fossil fuel era. It was deemed necessary to keep all current farmers in farming, even the bad ones. Nearly all farmers embraced the new paradigm as a compelling alternative. Their existing cultural knowledge was invaluable, and their know-how

was being learned by new farmers who had grown up in cities and suburbs, farmers with countless limitations, but ready to try. They made it because they found farm life satisfying—a good thing, because the industrial era was about to close.

The Berry Center and St. Catharine College in Kentucky and Middlebury College in Vermont developed programs around the new agriculture. More schools joined by the year. Kansas Wesleyan, near the Land Institute, early on added an Ecospheric Studies program. Some of its students worked in the research plots with Land Institute scientists, and some continued on to graduate work at various places where the paradigm had expanded beyond Kansas, to Cornell, the University of Georgia, University of Minnesota, and elsewhere.

What helped the young farmers to “hang in there,” as one put it, was that most of them had a broad liberal arts education for operation within the new paradigm. Universities began to add entire colleges to rank alongside the School of Engineering, Arts and Sciences, or School of Education. Catalogs filled with courses under new *Schools of Ecospheric Studies*, the first at the University of Kansas and Kansas State University. There were courses for would-be farmers and for majors in public policy, agriculture history, sociology, psychology, and the history of science.

The role of people in changing the face of the earth was the organizing question for the Schools of Ecospheric Studies. It was an old idea that came to prominence in 1864 when George Perkins Marsh, a Vermont Yankee, published *Man and Nature*. Nearly a century later, in the 1950s, Princeton held a conference dedicated to Marsh, called “Man’s Role in Changing the Face of the Earth.” This background was an essential part of Ecospheric Studies 101. It reminded one old-timer of the close adherence to dogma in the church-related colleges. In a major sense it was, for it was a moral contention.

As more and more people began to see the world in more of its wholeness, the word *environment* fell from use, as did the term *biosphere*. As students learned the ecology of Stan Rowe, they developed a coherent philosophical view that “biology by itself is incomplete,” that unified ecological systems confer the properties we call life. The environment was regarded as “out there,” separate, part of *our* natural heritage, something we own, and part of

the old subject-object dualism. No longer do we do something “for the environment.” But because of our relationship to the earth, most of us looked from the inside out. It was common sense to do so, just as it was common sense before Copernicus to believe the sun moved around the earth. We now all see organisms, including ourselves, as enclosed within a “miraculous skin.”

Unfortunately we in the West, too deeply and for too long, were descendants of those European ancestors who around 1600 gave us the Enlightenment, gave us a way to reason. For more than four hundred years we operated under the belief that a major way of knowing was to break a problem apart, to be reductive, to place priority on the part over the whole.

What we are advancing now is not exactly new. Greeks and Romans alike believed in universal orders of organization, and those orders they regarded were more important than individual organisms. Rowe cited the “Greek theory of natural science, from Plato to the Stoics, whose worldview carried over to Romans such as Cicero. Leonardo da Vinci was a late holdout ‘of this outlook,’ but it was mostly plowed under during the Middle Ages.” A few remnants survived to grow seeds among the nineteenth-century Romantics in Europe and North America, who in turn provided the philosophical framework for a growing number of modern conservationists.

And now, finally that is our worldview.

Wes Jackson, founder and president of the Land Institute, which is headquartered in Salina, Kansas, is the author of several books, including *New Roots for Agriculture*, *Becoming Native to This Place*, *Consulting the Genius of the Place*, and most recently *Nature as Measure*. A Pew Conservation Scholar in 1990 and a MacArthur Fellow in 1992, he is widely recognized as a leader in the international movement for a more sustainable agriculture. He received the Right Livelihood Award in 2000; *Life* magazine included him among eighteen individuals it predicted to be among the hundred most important Americans of the twentieth century; and Smithsonian.com included him as one of “Thirty-Five Who Made a Difference.”