# Land Report

*Number* 131, *Fall* 2021 · *The Land Institute*

# About The Land Institute

MISSION STATEMENT
When people, land and community are as one, all three members prosper; when they relate not as members but as competing interests, all three are exploited. By consulting nature as the source and measure of that membership, The Land Institute seeks to develop an agriculture that will save soil from being lost or poisoned, while promoting a community life at once prosperous and enduring.

OUR WORK
Thousands of new perennial grain plants live year-round at The Land Institute, prototypes we developed in pursuit of a new agriculture that mimics natural ecosystems. Grown in polycultures, perennial crops require less fertilizer, herbicide and pesticide. Their root systems are massive. They manage water better, exchange nutrients more efficiently and hold soil against the erosion of water and wind. This strengthens the plants' resilience to weather extremes, and restores the soil's capacity to hold carbon. Our aim is to make conservation a consequence, not a casualty, of agricultural production.

LAND REPORT
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# Land Report

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## Cover

*A hybrid of two silphium species, S. integrifolium and S. perfoliatum. The first is The Land Institute's prime oilseed crop plant, but the latter can contribute valuable traits such as disease resistance. And juxtaposition of both sets of chromosomes in a hybrid can make* DNA *sequencing easier. This plant is being used for the first silphium reference genome, an electronic representation of the entire* DNA *code of one or a few individuals representing a species. Sequencing small bits of genomes for "fingerprinting" as used in work like genealogy has become relatively cheap and easy, but examining the whole genome remains time consuming and costly. Scott Bontz photo.*

# Nationalize fossil fuels

*Government has taken charge in war, and climate danger demands no less*

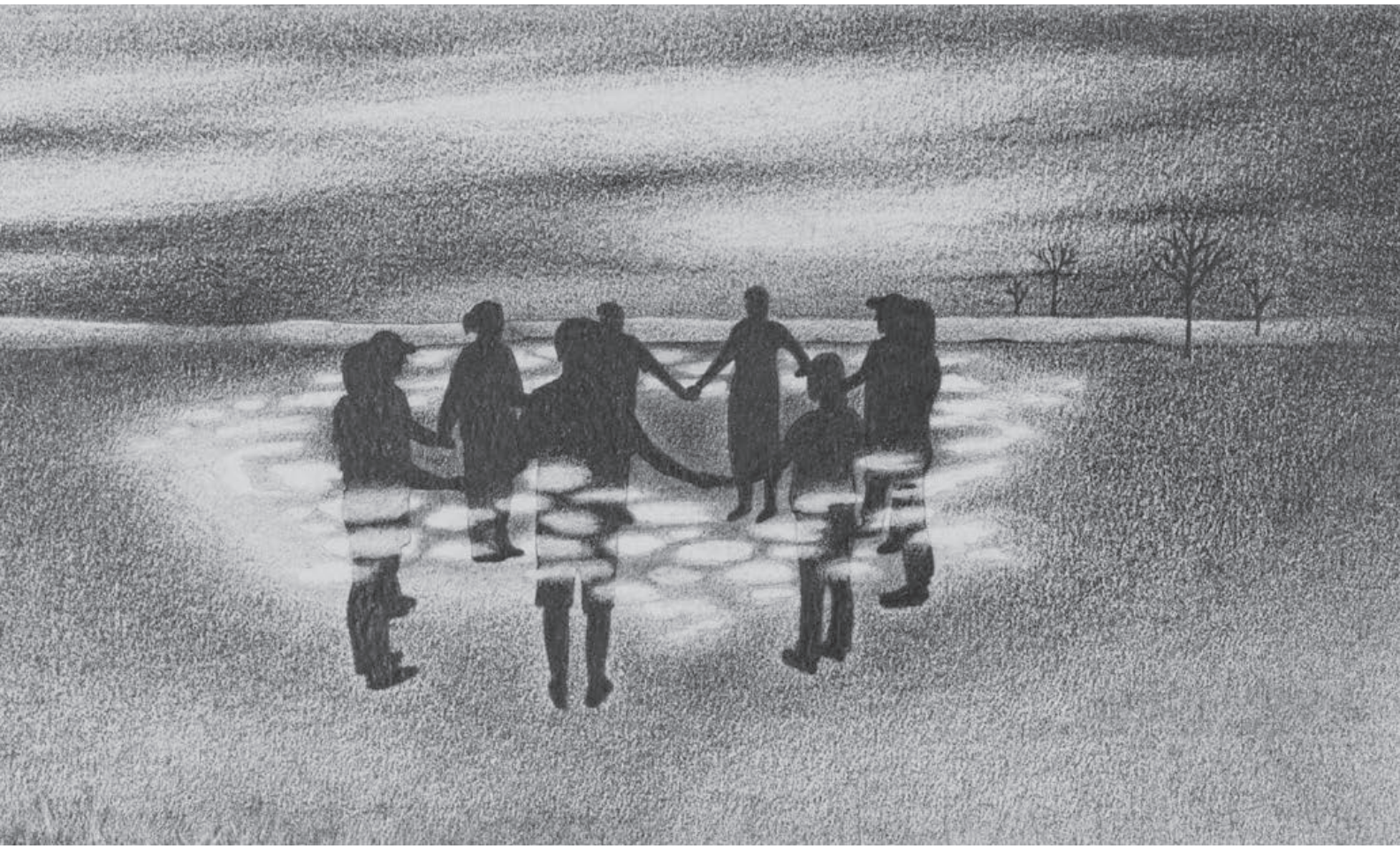
STAN COX

Disasters the size of the whole Earth, several of which are now raging all at once, require a cooperative international response. But one thing we have learned from three decades of failed global climate negotiations is that there can be no effective global action as long as individual nation-states fail to take action on their own. Nations will have to adopt their own very ambitious climate goals and policies to lay the foundation for international coordination. National policies will also provide umbrellas under which local communities can take action, keeping the whole effort just, equitable, and small-d democratic.

We learned the hard way that when an emergency as dangerous as the Covid-19 pandemic is not met with both decisive leadership in Washington and unprecedented actions on the ground in communities, workplaces, and households, failure is certain. This same principle has long been exemplified by our failure to address the climate emergency. We need a national policy for the fair and just elimination of fossil fuels, accompanied by local, democratic management of resource allocation, working as

a single, seamless system while also serving as part of a global system. Similar policies could rescue local, national, and global food systems.

There is growing awareness that we must stop using oil, gas, and coal, and that doing so will require that fossil fuels be removed from market control. The fuel industries and their oil, gas, and coal reserves must be nationalized. In a white paper titled "Out of Time: The Case for Nationalizing the Fossil Fuel Industry," scholars in energy and economics laid out a tight, convincing case that public takeover of all fuels is the only way to overcome systemic hurdles for decarbonization in a way that provides for workers and supports communities. The authors, from New College of Florida and The Next Systems Project, wrote their report during the early days of the pandemic, when the dollar value of fossil fuels had crashed. Anticipating that prices would remain low for years, they suggested that the US government could buy out the industries and



*Federal guidance out of our extractive economic murk should be put to action by local communities.*
*"Human Miasma No. 2", graphite on paper, by Priti Gulati Cox.*

ensure a just transition for their workers (but not for their executives and investors), at bargain prices with money borrowed at historically low interest rates.

Nationalization will be necessary because fossil-fuel industry executives, knowing full well the role their products have played in triggering catastrophic warming of the Earth, continue to deceive the public while pumping, mining, processing, and selling fuels at handsome profits. The companies are committed to this course of action and could not cease and desist even if they wanted to; they must recoup their heavy investment in capital. (US electric utilities are certainly counting on the persistence of fossil fuels; The New York Times reported that they plan to build a staggering 235 new natural gas-fired power stations in coming years.) The oil and gas companies will continue to use their vaunted political power to resist all efforts to reduce their output. They must be nationalized, and extraction and use of the fuels must be reduced at a rate of at least 8 percent per year until we are finally and completely free of them.

There is ample historical precedent for nationalization around the world and even in the United States. During World Wars 1 and 2, the government was compelled to take control of critical resources and industries: coal mines, meatpacking plants, shipyards, railways, the telegraph system, and much more. Unable to convince manufacturers to scale up production of essential goods, or to stop expending scarce resources on production of nonessential goods, Washington had no choice but to nationalize factories. There was further nationalization in the immediate postwar years, as well as the government takeover of more than 1,000 savings and loan institutions during the scandal-ridden financial crisis of the late 1980's and early 1990's. A simple way to nationalize would be for the Federal Reserve to simply buy a majority share in every fossil fuel company. This might be more affordable than the corporate bailouts handed out during the Great Recession and Covid-19 pandemic. If its value doesn't rise too much, the whole industry could be bought out to avoid endless conflict with minority shareholders.

Nationalization and a rapid decrease of the fossil fuel supply would have to be accompanied by policies to protect workers in the oil, gas, and coal industries as well as energy consumers throughout society. This "just transition" will require creation of good new jobs in other sectors for workers currently in fossil fuel and related industries, along with retraining and social support. Not every job lost will be matched by a job created at the same location, but that geographical mismatch can be evened out by fostering new employment in all marginalized communities and economically disadvantaged regions, whatever the cause of their economic stress. The just transition will also require the restoration of landscapes and waters that have been ruined by extraction of fuels, and the return of those lands and waters to indigenous communities from whom they were stolen. It will require dismantling of refineries, power plants, and all the rest of the vast infrastructure that processes and transports fuels, and remediating the air, land, and water that has contaminated the people surrounding the refineries – most often communities of color and first-generation immigrants.

If it's to be accomplished quickly enough, the phase-out of fossil fuels has to occur simultaneously with, and move faster than, the development of new energy sources and infrastructure. That will require much more equitable access to energy. Today, more affluent, predominantly white

households have much higher than average consumption of energy in all forms, while millions of lower-income households cannot afford as much energy as they need. Just as market forces are unable to reduce the supply of fossil fuels at the source, they are powerless to ensure that some businesses and households don't hog the diminishing energy supply while other workers and consumers cannot get access to a share of energy sufficient to get to their jobs or keep the heat and lights on at home. Here, where the market fails, fair-shares rationing must bridge the gap.

Rationing is not a means of reducing fossil fuel consumption or greenhouse emissions. That's going to have to be accomplished with a declining cap on total fuel supplies. Rationing is instead an adaptation to that reduced supply, ensuring sufficiency and fairness. According to the foundational ecological economist Herman Daly, a society successfully living within ecological limits has to have rules that can achieve each of the society's goals, and each of the rules has to be "nested" within all higher-priority rules. He says a sustainable economy must obey rules of scale, distribution, and allocation, in that order of priority. Briefly, the maximum scale of the economy's material input and waste output first must be etched in stone, so to speak. Then rules for distribution must be established for producing essential goods and services and ensuring equitable access. But crucially, the distribution rules cannot violate the scale rules. That prohibits, for example, increasing the size of the resource pie in order to increase the size of the smaller slices. Instead, distortions in access to resources must be eliminated. If allocation of the diminishing supplies of fuels is left up to the market as envisioned in Daly's nested economy, the result is all too predictable. Not only will we see blackouts and endless queueing at gas stations, but there will be too many private jets in the air and too little public transportation on the ground, too many electric cars sucking from the grid and not enough electricity to keep the lights on in apartment buildings, too many yachts in the Caribbean and not enough staple foods on store shelves. Along with a fossil fuel cap declining briskly year to year, we need progressive economic policies, enforcement of equality and justice, rationing, price controls, and a just transition away from fossil fuels, all to ensure equitable access to energy.

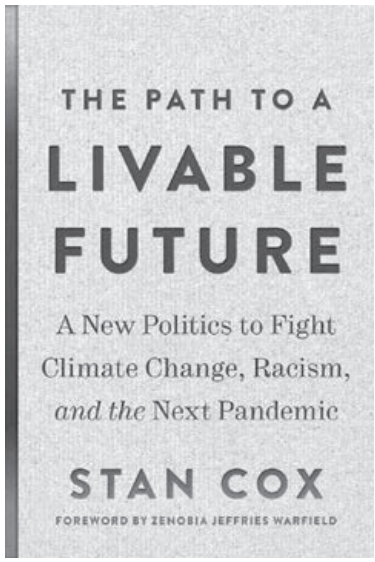
One of the most critical needs is to have all electric power generation become the exclusive domain of democratically run public utilities, with all of them linked to a national grid and a cooperative management network. The longstanding need to have electricity under control of the people and not corporations became blindingly obvious when the deep freeze of February 2021 triggered a power-grid crash that crippled the state of Texas. In a society that aims to end greenhouse warming, energy and other resources must be allocated not where they will generate the most profit but where they will meet the most important human needs. Seen in this light, the path to a livable future is clearly not going to be a capitalist one. That might be hard for some to imagine, but it doesn't have to be. "We live in capitalism," wrote Ursula K. Le Guin: "Its power seems inescapable." But, she reminds us, "So did the divine right of kings. Any human power can be resisted and changed by human beings." National policies for allocation of energy supplies among industries, and fair-shares rationing among households have been proposed by The Climate Mobilization group's "Victory Plan" and the "Cap and Adapt" framework by Larry Edwards and me, both available online. History suggests

that such policies would succeed in containing society's ecological impact within required limits. But to be broadly accepted, they would also need to allow plenty of room for community decision-making, in the form of what has come to be called deliberative democracy. An umbrella of nationwide rules limiting total quantities of fossil fuels and providing for their fair allocation would change the means by which the fuels and electric power are dealt with at street level in counties, cities, and neighborhoods. Today, fuels are traded as private goods; you compete with other customers for them, and you get as much or as little as you pay for. But with nationalization and Cap and Adapt, fossil fuels would be treated instead as if they were what economists call "common-pool resources," meaning that consumption by one person or business leaves a smaller quantity for others to consume, while no consumers may be barred access to the good.

For decades, the Nobel Prize-winning economist Elinor Ostrom and colleagues studied common-pool resources from the standpoint that "forests, water systems, fisheries, and the global atmosphere are all common-pool resources of immense importance for the survival of humans on this earth." They studied a wide range of community efforts to govern the distribution of common-pool resources and came up with a set of "design principles" that could improve the odds of a successful effort. Rules for sharing the resource, for example, must conform to local social and ecological conditions. Those who are affected by the rules must be the ones who make the rules and also monitor the resource and its use. Sanctions for those who violate the rules should start out mild but become harsher with repeated violations. Modest, friendly arenas for conflict resolution must be created to provide ample opportunity for face-to-face communication. Finally, and crucially, community control of the common-pool resource should be compatible with regional and national efforts – in Ostrom's words, it should be "closely connected to a larger social-ecological system", with governance "organized in multiple nested layers".

We don't have to invent from scratch such local, nested, deliberative, democratic processes for allocating scarce energy and other resources in accord with national policy. There are plenty of precedents, past and present, for local administration of scarce resources: local rationing boards the US during the 1940's, participatory budgeting in communities around the world, mutual-aid movements, and others. Once we the people have wrested control of national energy resources from the corporations, those forms of local organization can guide us in sharing energy at a human scale.

*Adapted from Chapter 3 of the writer's book "The Path to a Livable Future", was released November 16. Used with the permission of City Lights Books, www.citylights.com.*



# Winter-light

*– on seeing "Winter from Four Seasons" (detail at left), by A. Mary Kay, oil on canvas*, 2018

KRISTIN VAN TASSEL

In the painting winter's bones float
as blue fern snowflakes lighter
than star dendrites, drifting
into mothwing dust
below, wind
blown.

Mom tells me the barn cat Dee
has grown small, her frame
pared close by age, and I
see her flexed on my
classroom
bone

shelf, creature parts displayed
of fifty years past. The cat's
skeletal arch beside a wire
thin bat—wingspan
stretched into
night.

When after dinner I hold Mom
against my height, embrace
the spare frame, her
bones rise and
float

to the surface. She is a fern
stellar snowflake, light as
a mothwing stretched
out toward
flight.

*The writer teaches English at Bethany College. The painting is at marykaypainting.com.*

## A prospect bejeweled

*Summer morning in a field producing seed of a Kernza® perennial grain variety candidate. Lee DeHaan photo.*

# Land Report shorts

## $12.5 million NSF grant

The National Science Foundation awarded $12.5 million to the Donald Danforth Plant Science Center in Saint Louis to use with eight other organizations, including The Land Institute, for study of how the interactions of plants with other plants, microbes, and soil affects growth both above and belowground. The five-year program, with opportunity to renew, is called New Roots for Restoration Biology Integration Institute. Our own Tim Crews and Aubrey Streit Krug helped write the proposal. Crews said this appeared to be the first NSF grant to include The Land Institute and explicitly support perennial grain research. The project also features education, with paid internships at The Land Institute for high school students often excluded from science opportunities.

Crews noted two important concepts that NSF reviewers apparently viewed with favor. One was the proposal's use of the word "restoration" to describe ecological changes that take place when agriculture turns to perennials. "Historically, restoration ecology was really restricted to the restoration of natural ecosystems, like grasslands or forests, emphasizing the re-establishment of biological diversity, and to a lesser extent ecological functions like nutrient retention or soil organic matter accumulation. But the NSF panel appeared to appreciate how the new approach to grain agriculture we described involving diverse perennials was in

fact a type of restoration." The proposal also used the word "ecosphere", a word not well known apart from ecologists. But it brought attention to the interaction of what would typically be divided belowground into the living – plant roots and microbes – and the not-living – soil minerals, water, nutrients – and how all of this changes when highly disturbed tilled land is converted to perennial crops.

How interactions affect growth might sound simple, but Crews said, "Not knowing what plants are doing belowground has greatly curtailed our ability to understand positive and negative feedbacks that influence plant competition, cooperation, and productivity." The research group will use new tools to see what goes on belowground with wild perennials from the prairie and with The Land Institute's intercropping of two species. One example is a portable system that uses fluorescence to see and measure roots in soil cores much faster and cheaply than the old manual method.

## The scope of their jobs

*There was no Prairie Festival this year, but Land Institute employees got a day to explain their work to each other. Rachel Stroer views mold mites that are fed to the predator mite that kills greenhouse pests. Photos by Scott Bontz.*

The new program will also educate young people for the work of integrating agriculture and natural systems. Labs will host summer interns to follow the research and learn the methods. They'll also have training in leadership and diversity, equity, and inclusion.

The new institute will be directed by Allison Miller, our longtime collaborator in Saint Louis. The other organizations involved are the Danforth Center, Saint Louis University, and Missouri Botanical Garden – all places where Miller wears a hat – plus the Saint Louis Science Center, Chicago Botanic Garden, University of Kansas, University of Vermont, and University of Missouri.

## Taste tests

Centuries of cultivation around the Andes in Peru and Bolivia have brought quinoa grains colored white, black, red, and other hues, but little data on how these varieties might differ in nutrition. And is one better for noodles, another for pancakes, another for baby food? Barley for malting poses a flip question. The grain is well known in the lab but has been single-mindedly bred by industry as a powerhouse for converting sugar to alcohol. What if this ancient grain's genome has untapped flavors for beer? Evan Craine makes these queries for his doctoral dissertation at Washington State University, and as a side project this summer conducted sensory evaluations – it was about more than taste – of two crops at The Land Institute.

Craine, who grew up in Madison, Wisconsin, studied organismal biology and ecology at Colorado College. He initially aimed for pre-med, but a sociology class on urban agriculture turned him toward health and wellness with food. At Washington State he studies plant breeding, not for things like disease resistance and yield, but for end use – what's best for food, forage, and fiber. With quinoa he is measuring traits like protein, fat, ash, and starch, and how they are associated with seed appearance. About barley he said varieties vary in how much extract – basically sugar – comes from the early beermaking stage of the grain steeped in hot water. Barleys can also impart different flavors, but hops, the other key ingredient in most beer, often masks this. If barley was bred to bring more flavor to beer, brewers might rely less on the more costly hops. Following the rise of craft beers, there are now craft malters who aim at decentralization and avoiding the commodity system, with rules about independent ownership, tonnage limits, and getting at least half of their grain within 500 miles of the shop.

*Craine*

Craine's dissertation funding encourages internships or working with a different lab. He is excited to ask questions that lead to more questions, as an opportunity to be creative, and said, "It seemed like the work here fell into that category." Sainfoin, a legume, and silphium, a sunflower relative, were the two Land Institute crops for which Craine conducted evaluations. His method was meticulous so others could make comparable experiments. Land Institute staff members showed him how to use our seed cleaning equipment so his samples were pristine, which is crucial for testing. A programmable pressure cooker assured more precise control than would various open

pots on different stoves. Craine's evaluators were Land Institute employees and interns. The variable for sainfoin was cooking time: five, ten, and fifteen minutes. The small beans were served unseasoned and cool. Participants rated texture, appearance, aroma, and flavor. The shortest cooking time was most favored. Those who already like beans and lentils are more likely to find sainfoin tasty, and participants rated best its texture. With silphium, Craine made a drink that also used cocoa and dates in different amounts. For comparison he made a drink with commercial sunflower seed – though participants didn't know about this ingredient. Their ratings were higher for the silphium with more cocoa and less dates, and they judged the silphium as good as the sunflower – so the perennial might replace the annual in such concoctions.

In addition to conducting the tests, Craine took a big set of data from our lead legume researcher, Brandon Schlautman, and is interpreting it to learn the nutrition value of sainfoin compared with other legumes, such as soy and lentils.

## Record wheat survival

Tens of thousands of Land Institute wheat plants – over 90 percent of the population – survived for two years that included drought in 2020 and severe cold last February. This was a first in Kansas for researcher Shuwen Wang's wheat, and something of a first since

*Aubrey Streit Krug evaluates the aroma of a drink made from silphium.*

*Shuwen Wang's perennial wheat population survived like none before it.*

attempts to develop perennial wheat began in the early Soviet Union. A few of those earlier varieties lived for two years, but not with the same survival rate across a population, even in milder Italy and Australia, if fields weren't irrigated. Most breeding has used bread wheat as one parent and a wheatgrass species as the other. Wang's success has been with durum wheat, which makes pasta, and intermediate wheatgrass, which The Land Institute is also domesticating directly as a perennial grain.

Most of Wang's breakthrough plants did not survive this summer for a third year of production. He and other researchers are still trying to solve the problem of the hybrid wheat beginning regrowth too soon after harvest in mid-summer, when the plants should go dormant. Wang is also working to make his plants more easily threshed and higher yielding, but this is typical for developing perennial grains.

The plants regrew well shortly after second harvest. But more and more plants died in the third year, probably due to drought stress. Plants from the same population are in their fourth year of growth in a greenhouse, suggesting that if conditions were right in the field, they could also survive there. Wang is collaborating with a Kansas State University agronomist about techniques to help more plants continue to produce in the third year.

The Land Institute's civic science program, which had already enlisted a few dozen volunteers across the nation to grow and observe our silphium and sainfoin plants, greatly expanded this fall with 106 participants growing wheat. Wang hoped to see it survive longer in other conditions. To the same end, Tessa Peters, our crop stewardship director, has arranged larger, replicated plot trials at eight locations.

*Chase Stratton hunts for the pest eucosma, which flies for miles but can be confused by scent.*

## Putting moths thru their paces

How far can a pest moth fly to lay its eggs in a crop plant? What chemical signals could draw it to traps? You can't band a moth like a bird and hope to find it later. But you can catch it and put it on an aerial treadmill. You can also try tempting it with aromatic compounds. So went a study this summer of *Eucosma giganteana*, which specializes in feeding on silphium, The Land Institute's oilseed crop. Our postdoctoral researcher Chase Stratton led nighttime moth hunts, which included co-workers and researchers from Kansas State University and the USDA's Agricultural Research Service Center for Grain and Animal Health Research. Each wore a headlamp and slowly walked rows of blooming silphium in search of a moth about half an inch long. (The species name comes from its relative size in a moth family.) On green plants the insect's white-and-brown body looked like a bird dropping. Finds were snapped into condiment cups. These went with the K-State/USDA crew for testing. A paper by lead author Kaitlyn Ruiz and others describes the "flight mill". A fine, 11-inch needle was balanced on a magnetic pivot with virtually no friction, and a fine copper wire attached a moth to one end of the needle. Sensors counted how many circles the moth flew. The subjects made lots of starts and stops, with a mean flight time of only 30 seconds, as they might flit from plant to plant. But the average distance covered in 24 hours was 14 miles, which shows an insect very able to find what it wants, posing a "landscape-level risk". The good news is that certain scent chemicals that have worked with moth pests already studied also distracted this eucosma species, reducing flight distance up to 80 percent. The paper is under review and work remains for how to use the compounds.

## New Jackson & Jensen book

Journalist Robert Jensen and the Land Institute's Wes Jackson have written a book about the end of growth as we've known it and how to think clearly through the "apocalypse". The writers work with religious phrases turned to secular purpose. Their apocalypse ends unjust and unsustainable systems. For "ecospheric grace", they say we must take ourselves down from dominant species and see the world as one that can provide for us but does not favor us. An early chapter critiques the environmental movement's common avoidance of hard matters such as how little energy we'll have to live with after fossil fuels. A later chapter argues that on top of immediate policy and technology changes we must face how to dramatically shrink our population and what it consumes. The book's working title is "The Old Future is Gone", and it is scheduled for the fall 2022 catalog of The University of Notre Dame Press.

## Art without ego

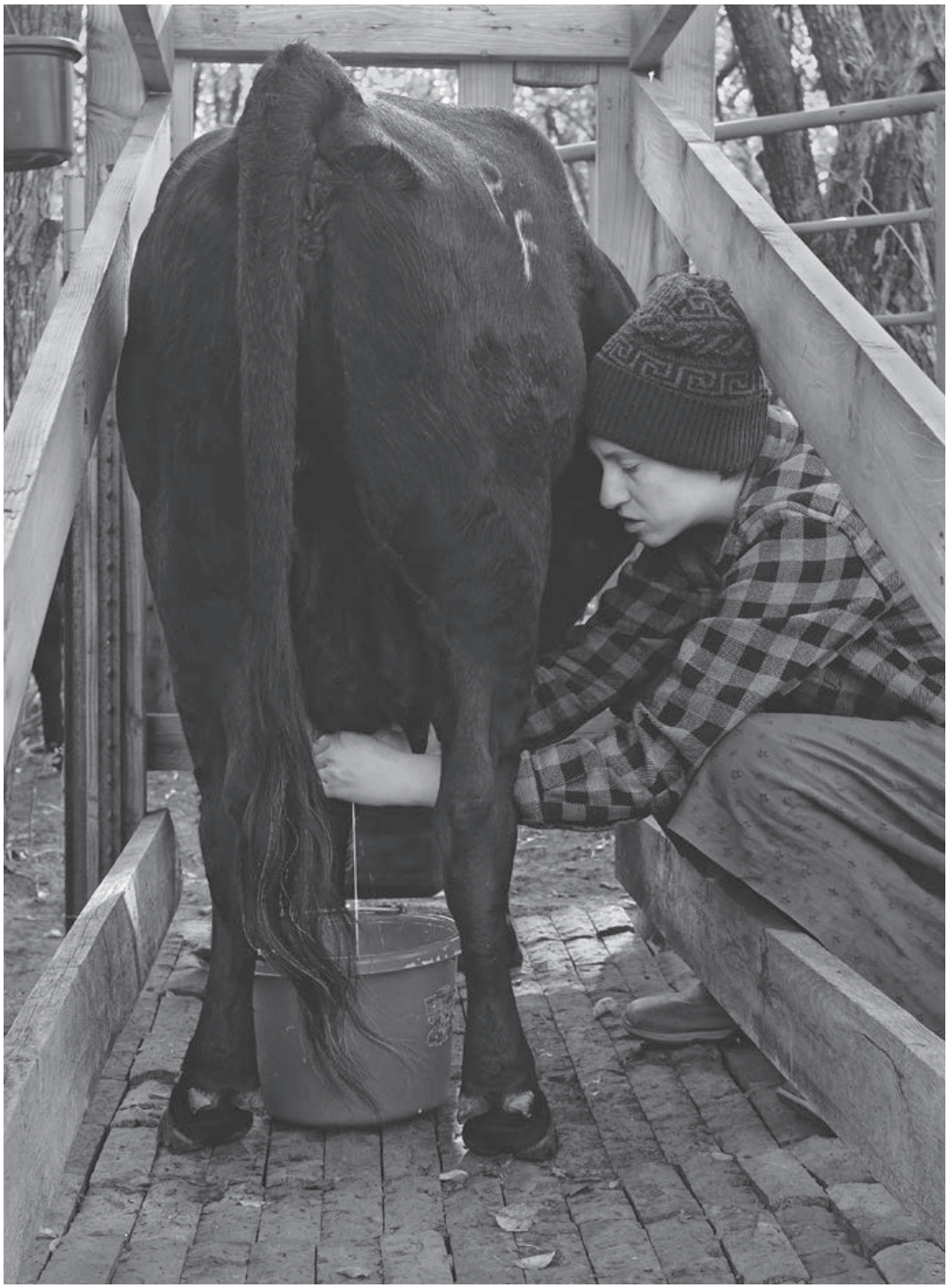
Before his book (see above), Wes Jackson is offering two suggestions for how to deal with consumerism and the approaching collapse of what made it – for how to quit the industrial mindset. His suggestions are good humored toward serious end. One is to get to saying to each other, "Tell me something interesting." For an example, he explored how some dinosaurs evolved bones with air spaces that might have given more surface area to their breathing system and more efficient gas exchange in a time when the atmosphere was relatively low in oxygen. Birds came from these dinosaurs and used the lighter bones to fly. The modern bar-headed goose has further evolutionary edges in special hemoglobin and profuse heart capillaries: It can fly over the Himalayas, where oxygen is one-third that of sea level. Jackson also offered for talk how the moon has slowed Earth's revolutions from the early six-hour days. (They're getting longer yet.) The natural world is full of wonderfully interesting things, he said, and discussing them can keep us out of Walmart.

Which leads to his second suggestion. That is to see there is art made without ego – nature's supreme beauty. "Almost anything you look at in an art gallery can't compete with some of the simplest stuff you see through a window", he said. On the large roundtable in the classroom above his office stood a two-foot-tall section of osage orange tree. He has had it sandblasted to heighten color and lines that remind him of Southwest sandstone grandeur. He pointed to how the trunk took three paths and then – "like it wanted to" – came together again. A sheet of paper by the undulating form offered a title: "Picasso Takes a Bow". Jackson has also hung as art several pieces from a collection that could be measured in board-feet – just sawn planks, but revealing not only beautiful grain, but sometimes labyrinthine insect tunnels. He doesn't oppose people making art. But in his view covering wood with a painting devalues it from a ten to an eight. His gallery would have curators but no artists – unless they accept the devaluing. Like his older provocation, to burn the "Mona Lisa" rather than plow an acre of native prairie, Jackson's goal is to create discussion. "Nick away at the superficial and conventional", he said. Ask, "How are we going to live in this new world?" The answer could be, "We all become curators of egoless art." We look to nature to overcome domination by the industrial mindset. And so, Jackson thinks, we could have overcome domination by empire or church.

Look around his office and barns, and you'll also see displays of industrial artifacts. He salvages them, and recently has taken to having them painted. From a natural-gas booster station there are 5½-inch nuts threaded onto 2½-foot-long bolts, colored, respectively, deep red and deep blue. Such presentations can be seen as contrast to nature's work. But Jackson has one of these nuts and a much smaller bolt centered on a table in his office and will ask if you think it beautiful.

That's how he felt about the artifact now standing just outside his office corner. It's a 1,000-pound, 40-inch-wide bell made 111 years ago in Ohio and long gone from a steeple in Green, Kansas. The bell somehow ended up at Sam and Terry Evans's farm north of Salina, and when Jackson was visiting these friends, he was struck by it. They made it a gift. The bell is at the Classroom Building, where The Land Institute began, and Jackson sees it as a monument to our first donors, John Simpson and the Evanses, including Sam's father, Dean. Jackson had the bell and its yoke sandblasted and painted, respectively silver and gloss black, and he built of osage orange wood a replacement for the lost wheel to ring it. The volume can jar Stan Cox in the office just above the bell if he isn't warned. (To respond he now keeps a handbell on his bookshelf.) But people who are ready for the ringing, Jackson said, cannot help but smile.

*Wes Jackson finds nature – here insect channels in tree wood – more interesting than stuff we work to buy.*



*The cow Velvet is a Dexter, picked by milker Emily Rude and the writer/photographer because it is a dual-purpose breed suited for the smallholder, and, as a small breed, suited for beginners.*

# Cattle call

*An audition for life with humanity's co-domesticate*

SCOTT BONTZ

In 2000, when I arrived as a 38-year-old suburbanite wanting to learn about agriculture, The Land Institute was in the last of a decade of calculating energy flow in and out of the farm. The study included a diverse crew of Texas longhorns. It was not the most productive type, but after a long feral history it was supposed to be as trouble-free and native to the place as cattle can be. We gave ours no help in calving. But in winter we took them hay, and in spring we tagged newborns. And I enjoyed it. More than I enjoyed wading through dead plant stalks and bagging seed heads. That's work I was educated to appreciate – it was for the long haul of achieving herbaceous perennial grain polycultures. But our dozen and a half or so longhorns were immediate, afoot, and majestic. Not just horn spans, but horn shapes and coat swaths and flecking made each animal an individual. Their build might've struck a modern rancher as scrawny but to me seemed elegant – perhaps not so fine as a horse, yet just as fit. To search spring fields for their newborns was adventure. A few adults let me scratch their heads. I don't know if I'd risk that today, but they presented as much appeal as threat. I see the same fascination at The Land Institute's Prairie Festival, where visitors reach through the fence to pet Wes Jackson's cattle. Baling hay for the longhorns was the hardest job of my life, but I enjoyed that too, pulling up bales with a hook and stacking them over my head on a moving trailer with two other men behind the chugging tractor and clanking baler as insect-hunting barn swallows twittered round. It was a harvest, and we were a team.

Five years later I had 40 acres – the first time I'd owned real estate – and was no longer so naively romantic. Or so I like to think. I wanted to get the land under perennial vegetation, and for this to somehow feed me and others without me artificially feeding the land. In one area I planted cool-season grasses and alfalfa, in the other a dozen native warm-season perennial grasses and forbs. The idea was to extend time for animals to enjoy fresh, nutritious grazing. After the perennials settled in, I started small, with sheep. The first year I butchered the flock of four myself and canned the meat. Not a pleasant job, especially alone, and not that good a meat, at least as I prepared it. Next year I took a bigger flock to a slaughterhouse and sold the meat. But to see the co-op freezer finally empty of the cuts took two years and didn't even pay the butcher.

For three months in 2011 I left the garden to weeds and visited India. Between exploring cities, my partner, Emily Rude, and I volunteered at organic farms. Our last employer milked cows and used their manure for building – patties made a pyramid for storage in the dry season of our stay. The farm's breed was Gir. These were splashed

with brown and cream like some of the longhorns, but were of the zebu branch of the species, with a large hump and loose skin, and adapted to tropical heat and pests. Panchvati Farm's several dozen Girs were led each day to graze surrounding hillsides. For most of the time, however, they lounged in an open-sided circular barn and were fed from a mountain of straw. It couldn't have been very nutritious, but Indian cattle are thrifty. With frequent sweeping, the barn bore no rank odor and showed few if any flies. The animals were short-tethered on an earth floor with no bedding. I would've worried to confine any mammal this way. These weren't agitated, earnest, or yearning, however, but accustomed and placid. Amid their great cud-chewing circle I felt a peaceful power.

The man who milked the Gir let Emily and me try. We got just a few squeezes, but with some success, and the sips we had were of the best milk I'd ever tasted. I can't say if it was it the richness or the sweetness, or even say how much credit was due the breed versus the novel circumstance.

Back home in Kansas, I bought milk from the Thelander family. It went raw into gallon pickle jars. Kellie Thelander let me empty half a gallon into quart jars to carry home by bicycle. She also patiently took my many questions. Her animals were a few Jerseys and Jersey crosses. She milked by machine in an open shed with a steel stanchion. When it was clear that Emily and I were interested in a cow of our own, Kellie let us try milking hers. Emily was a natural, shooting steady, thick streams. Me, not so good, but, surely, I could learn.

For that I went to the library for Dirk van Loon's book "The Family Cow", which was entertaining as well as enlightening, and Valerie Porter's encyclopedic "Cattle: A Handbook to Breeds of the World". I bought her helpful "Cows for the Smallholder" and borrowed Julius Reuchel's "Grass-fed Cattle", which was more for a commercial rancher but suited my aim for minimal inputs. I am also of a sort who often would rather read than decide, and Porter's "Breeds" could've been overwhelming. Most of the world's hundreds of cattle varieties are not found in the United States, however, or at least not without difficulty. And being at the nation's center brought me luck: the association for one of the most interesting breeds, the Dexter, was holding its annual convention in Salina.

A Dexter isn't a miniature but is the smallest European breed. A cow stands 36 to 42 inches at the shoulder and weighs less than 750 pounds. A Holstein, which dominates industrial dairying, stands more than a foot taller and weighs about twice as much. These numbers are from Oklahoma State University. Dexters originated in southern Ireland, where, OSU says, "They were bred by smallholders and roamed about the shelterless mountainous districts in an almost wild state of nature." They are supposed to be hardy, good foragers, not needy of feed or help with calving, tolerant of heat and cold, good mothers, and friendly. That fit my bill. So did their breeding for both milk and meat. I primarily wanted cattle for milk, but not necessarily in the high volume of a pure dairy cow. Emily and I hoped that small cattle would make safer handling for novices, and reduce the amount of water to pump and haul to them by our muscle over acreage a half-mile long. Because we didn't want just one cow, but at least two, for their psychological well-being.

Between showings at the convention, the Dexters stood or lay in wood shavings in a barn. Despite being a small breed, they were big enough to make me fear what I

was getting into. The longhorns and Girs hadn't been *mine*. Encouragement came from the Dexter breeders and owners, proud and happy to talk about their animals. Mary and Norm Hoover invited Emily and me to see their whole herd near El Dorado, Kansas. I made a deal to buy a heifer named Sassy at the next convention. There came introduction to Robin Pittack, of Shelton, Washington, who invited me to take the halter of her nearly full-grown heifer for a walk from barn to show ring. Velvet challenged me all the way, but Robin praised my persistence and keeping the rope short – thank goodness I'd had horse riding lessons. With encouragement there and from the Hoovers, I bought Velvet. Robin and the Hoovers drove their trailers to our place after the convention, unloaded the heifers, and suddenly Emily and I were cattlepeople.

After acclimating in a pen, Velvet and Sassy went to pasture and a paddock that would frequently change by use of step-in fenceposts and a reel of electric rope clipped to a solar charger. The sheep had required a whole net of electric fence, but the cattle were to be contained with one strand. Velvet, who had spent all her year and a half of life eating hay, took right to grazing. And cattle tongues rip, rip, ripping off the top of green grass was for me a song.

Velvet and Sassy actually brought three cattle genomes. Two weeks earlier, Velvet had been artificially inseminated. Labor came on a freezing morn in March. Velvet bellowed, and soon two hoofs appeared. Encouragement and anxiety together came for Emily and me when the nose peaked out but head and shoulders were long in following. Then, when those were clear, and half a calf dangled lifeless from her hind end, Velvet stopped bellowing – and began to graze. Now I readied to invade her space. But I waited a little longer, and the calf plopped into an inch of snow. And at this slimy little alien the mother roared. She turned newborn into snowplow, shoving it hard across the ground. Did she really see this first calf as a threat, or was she grossly impatient to get baby's torso off the cold earth? The calf was now clearly alive, and apparently suffering no great injury from a love so tough. Velvet gradually came around in her opinion of this oddity or felt she'd spanked the baby enough for it to clear its lungs. We let her lick the little bull for a while, but he wouldn't stand, so we went inside to towel and warm him. Not long, because the books tell how vital it is for the calf to quickly nurse and get colostrum, the first milk, rich in antibodies. The calf tried to stand on the kitchen floor, slipped and fell, and we took him back to Velvet, where he stumbled his way to all fours, then fumbled over mother's various lower body parts until finding a teat and accumulating evidence that this was the place. He suckled, and the humans were pacified.

I've handled subsequent calvings with more patience but not yet with aplomb concerning how long it takes and how many mistakes are made – going back to suck an elbow after success with a teat – before the newborn shows the brains to live. But each time it does. And in 24 hours it can outrun me. Next May I again got to see Velvet calve, and this time she calmly went right to tending baby.

In the morning I hand-pump up to 35 gallons of water, maybe half that in winter, and pour it into a plastic tank on a cart of two-by-fours and bicycle wheels. Because house and well are on low ground, the haul of sometimes more than 300 pounds to any paddock beyond the front yard is uphill and a workout. While the tub at the paddock fills, we put halter ropes on the cattle, who

are trained and willing, and take them to the pen by the house. Velvet goes into the milking stanchion for the enticer/appetizer of cattle cubes, a molasses-laced protein supplement. We spray her for flies, brush her, wipe her teats, and squeeze each to see if any quarter of her udder shows clotting signs of infection – which hasn't happened yet. Grab a bucket, throw a pile of cubes in the cow's feeder, and begin milking. Emily sits on a one-legged stool at Velvet's right, I squat portside. We squeeze the teat between thumb and forefinger, then middle finger, in quick sequence. Working fast gets about two squeezes per teat per second. It doesn't take great strength, but the repetition soon makes our hands and forearms ache. Dirk van Loon says this pain fades as you master technique and grow fit, but Emily and I are in our third year at this and still hurt enough to like breaks just long enough for me to empty the bucket into another hanging nearby. Milk spilt by a kick has been rare, but the heavier the bucket, the slower it is to move.

More than two years of practice has not seen great improvement in my technique. I'm stronger than Emily, but she has the touch, splashing the bucket with streams that look and sound twice as thick as mine. When I seem to have nearly exhausted one of my quarters of the udder, she reaches across and gives the teat new life. I most wanted with my cattle to be a dairyman, so my meager ability has been a letdown. I might not continue milking without my dairy queen's help. But I am thankful that we can be a team. And I can hope that my experiment this year of crossing Velvet and Sassy's heifer with a Jersey bull will not only give us more cream and with better separation from the milk, but also make a cow with teats that give me better purchase. Who knows? Virtually all our experience

*A Texas longhorn that was part of The Land Institute's study of energy flow in and out of the farm.*

milking has been with one animal. At least I can claim to be the dairyman after the cattle go back to the field. I filter the milk and pasteurize it on the stove – though I may take a sip of it raw or add it to coffee. Pour the hot milk in canning jars or add vinegar to coagulate farm cheese. When the milk has cooled a bit, inoculate it with yogurt and put it under a blanket to ferment. This winter I hope to regulate temperature well enough without a refrigerator to make hard cheeses like cheddar. Then we might have our own dairy protein through the months that Velvet needs to "dry off" in the buildup for a new calf.

At her peak, Velvet can give us more than five quarts in a morning, with the calf getting what she makes during the rest of long summer daylight. We don't milk in the evening. She can produce at about half that rate near the end of her eight to nine months of lactation. To carry ten pounds of fresh milk from pen to house is a walk of fulfillment. First, I thank Velvet.

I wish I could say as much for Sassy, who more than lived up to what the Hoovers named her. She led well but had an explosive side-kick and a temper. In impatience for cubes, she came an inch from taking off my kneecap, and I limped for more than a week. She took obligingly to the stanchion after calving but got punchy with us near her udder. We brushed and petted her for weeks and got her to be calm. The work advanced to getting a few squirts of milk for a while, graduating to a cup or two. And then came a kicking *tantrum* that rended my lumber stanchion. The Hoovers, their own faith unshaken and no doubt their expertise exceeding ours, took her back.

Sassy's daughter, May Bell, not only looks a duplicate, but like her mother can put on like she'd kill for cubes. From her birth we have touched her all over and trained her to the stanchion. This almost daily routine went months without incident until Emily kindly swatted a horsefly and was repaid with a kick. Again, over days we cautiously made our way back to touching her teats, and rewarded good behavior. There's been a little stomping, but none of her mother's haymakers. We still have hopes for her as a milk cow.

There are other reasons that having cattle gives me pause, all to do with our treatment of this fellow feeling creature. For half the year they are tormented by flies, and I have yet to solve the problem. A dairy-safe systemic insecticide might be killing adults, and a growth inhibitor in the mineral supplement might be preventing larvae from maturation, but the cattle's backs are still home to flies by the hundreds. A fly sheet made to belt onto a horse didn't fit. I've never seen such on cattle but want to tailor one and try.

Then there is putting them behind fences. I sometimes worry that cattle and other livestock are essentially prisoners. But cattle don't yearn for arts, learning, romance, and the excitement of novel experience. They spend almost every waking hour grazing or chewing cud. Young calves can run around the paddock – and escape under the electric rope, but they never go far from mother. And though the paddock can seem small, as little as a 75-foot square if the grass is lush, each day the cattle move to a new one. This way what they've eaten can recover and not be overgrazed. The paddock provides more square feet per pound of body weight than Emily and I have in our house.

I've not trained my cattle to pull. Perhaps with the great powering down after fossil fuels we'll again see animals used for traction. Is this enslavement? I've heard that draft horses like to work and that saddle

horses like to be ridden. They certainly are *willing*. But what if given the choice to go where and how they pleased under no command? It would be nice for my cattle to haul their own water each day after I pumped it, and this does not seem unreasonable labor. But it would take lots of training for both of us, as well as leaving me less fit.

I have had cattle only long enough to slaughter one. It's a hard thing to pull that trigger, and, as a friend who grew up on a farm said, it should be. My father, an avid hunter, doesn't think he could kill an animal he had raised. Maybe I also wanted to avoid it when I chose to not castrate Velvet's first calf and instead sell him as breeding bull. This was naive. The world needs very few bulls, and they should be proven in a way that I, a beginner with the smallest of herds, could not do. Emily and I now accept at a male calf's birth what his end will be. Within a few days, he gets a local anesthetic and The bull is emasculated. We will try to make his life as good as that of the rest of the herd during his one and a half years, and to kill him with neither pain nor stress. For the bull there was no separation-terror trip to the slaughterhouse. I led him with cubes just out of sight of the other cattle, and while he was eating his last treat, placed a shot to end his consciousness instantly. He fell and was still. For a great many wild animals, including game, and for a great many people, including in nursing homes and hospitals, death brings far more suffering.

Unlike with the sheep, for butchering this much larger animal I had help from Emily and friends, including one who knew cattle and one who was a chef and brought a good saw. All were glad to lend a hand, and cutting up the animal was less onerous when part of a team and conversation about the job.

To a vegan friend who said we should not deny animals of their wildness, my argument for keeping livestock was that eating grains and other annual plants has caused more ecological damage than eating animals raised on perennial cover. I will still eat grains and other annual plants, like anyone else, at least until perennial grains begin to sweep the field. But in addition to helping toward that goal as well as I can as a journalist, I want to do something more direct to hand. I'd been half-blindly seeking this well before I quit newspapers and came to The Land Institute and met their longhorns. I'd read Jackson and Berry and books about prairie. And when I bought 40 upland acres and saw the annual wheat cutting leave that sloping ground bare, the best thing seemed to build perennial cover of the kind that has fed people for millennia. We don't know yet if polycultures of perennial grains can equal the ecological tightness of well managed pasture. Grains certainly will feed more people. But most hunger and malnutrition is not from farmers growing too little food. I can't show that machinery and fertilizer used for annual grains on 40 acres added more to the greenhouse effect than does methane from my little herd. I can't prove that the roots of my pasture perennials are restoring the soil carbon lost during decades of grain cropping. But the net gain seems sensible, if not almost certain. Such carbon accumulation won't go on forever, and even if occurring worldwide wouldn't by itself solve the problem of climate change. But it's where I've planted part of my hope.

And even with perennial grains in the offing, I still put hope in the cow. In "The Botany of Desire", Michael Pollan argued that domesticated plants have used people as much as we have them. Corn, originally confined to highlands of Mexico, has us perpetuating its genes all over the world. So do

about 1 billion cattle. (And almost as many dogs.) We animals domesticated one another. In that course over something like 8,000 years, hundreds of cattle types developed to fit purpose and place. It's fascinating to read about it in Porter's book. The story includes Robert Bakewell, who revolutionized sheep and cattle breeding – actually began breeding as we know it – in 18th century Britain with scientifically methodical selection and culling. His Leicestershire longhorn swept the field with superior meat and tallow production. And about as quickly lost it to the more versatile shorthorn – a lesson about specialization, at least for that time. Porter warns that many types and breeds face extinction by shortsighted government regulation and industrial homogenization.

We have brought cattle far enough from the original aurochs that they enjoy their own species name. (The taurine and zebu types went their separate ways so near the start that they can be considered separate subspecies.) This recognition might just show our civilization bias. An auroch skeleton looks pretty much like a cow's, only bigger. And agricultural civilization has got us into great trouble. So The Land Institute is breeding perennial grains to feed people with fewer inputs, less soil loss, more "ecosystem services". Beef and dairy cattle were bred without that phrase in mind but on pasture can be in that service. Institute collaborators are studying how cattle who forage among the new perennials could improve grain crop ecology and productivity.

One day in my first winter as a would-be cattleman, Emily alerted me on her way to work that our two head had skipped their paddock and headed south. I found them more than two miles away, with a sheriff's deputy cautioning traffic and the farmer who'd cut hay for me trying to catch them. It was a dangerous situation and an embarrassment – I hadn't built perimeter fence in case the paddock fence failed. It also showed that Velvet and Sassy wanted to roam. I turned down the offer of a trailer and we walked back in penance. This year, now with four cattle, there was another early morning escape. But they didn't hit the road. They walked a quarter-mile to the home corral and waited, for brushing, milking, and cubes. Cattle and people alike have taken to this life.

I could say that the novelty of having cattle and milking a cow is gone. It's a lot of work – two hours or more of my time each day of milking and processing, and even when we don't milk I still pump and haul water and often move the animals. A co-worker who grew up on a farm warned me that a milk cow makes you a slave – an interesting contrast to the concern I expressed earlier. It's true. And it's fair.

Not entirely true is the novelty being gone. Every day, Velvet, May Bell, Stearman, and Ulmo, each an individual, take a path that's at least a little different – and sometimes a lot, such as wanting to explore the garden. And when I can put aside my worries about doing right by the animals and about everything else in my life, put aside the mindset of choredom and just take in the sight of our four cattle working the pasture, I feel a touch of a wonder. And that can be everything. Thinking through for you what Emily and I are doing further stimulates my appreciation – a funny animal we can be, finding milk in the arrangement of words. At real milking time, crouched near enough to put my head against a creature fivefold my mass, it's important to stay focused on what's at hand. But when her gut rumbles, I hear it tell what grass and sunlight of our home are on their way to be.

# Extracts

ANXIETY IS ONE of those evolutionary compromises – optimized so there will be a next generation, but painful to this generation. – Carl Sagan, "Billions & Billions"

BEES HAVE collective decision-making skills that, in their efficiency, put any academic faculty committee to shame. – Christof Koch, "The Feeling of Life Itself"

WHEN WE TALK about the big bang or the fabric of space, what we are doing is not a continuation of the free and fantastic stories that humans have told nightly around campfires for hundreds of thousands of years. It is the continuation of something else: of the gaze of those same men in the first light of day looking at tracks left by antelope in the dust of the savannah – scrutinizing and deducting from the details of reality in order to pursue something that we can't see directly but can follow the traces of. – Carlo Rovelli, "Seven Brief Lessons on Physics"

MONEY, EVEN GOLD, is but a metrical device … not the substance of wealth. Our capital is the accumulation of material and energy with which we can work. Soil, water, minerals, vegetables, and animal life – these are the basis of our existence and the measure of our future. – Paul Sears, "This is Our World"

IT IS THE incomplete revolutions which are remembered; the fate of those which triumph is to be take for granted. – Tom Holland, "Dominion: How the Christian Revolution Remade the World"

EVERY RELIGION SEEMS to begin with mysticism and end up in politics. – David Steindl-Rast, "Common Sense Spirituality"

A PEOPLE CAN BE just as dangerously overpowered by the wattage of its tools as by the caloric content of its foods, but it is much harder to confess to a national overindulgence in wattage than to a sickening diet. – Ivan Illich, "Energy and Equity"

THE FACT THAT an opinion has been widely held is no evidence whatever that it is not utterly absurd. – Bertrand Russell

WONDER IS our erotic affiliation with all of life. – Stephanie Mills, "Epicurean Simplicity"

WHATEVER WITHDRAWS US from the power of our senses, whatever makes the past, the distant, or the future, predominate over the present, advances us in the dignity of thinking beings. – Samuel Johnson

SELF-ORGANIZATION is such a common property, particularly of living systems, that we take it for granted. If we didn't, we would be dazzled by the unfolding systems of our world. And if we weren't nearly blind to the property of self-organization, we would do better at encouraging, rather than destroying, the self-organizing capacities of the systems of which we are a part. – Donella Meadows, "Thinking in Systems"

WHY NOT GO OUT on a limb? Isn't that where the fruit is? – Frank Scully

*Flower of the hybrid silphium pictured on the cover and described on page 3. Scott Bontz photo.*

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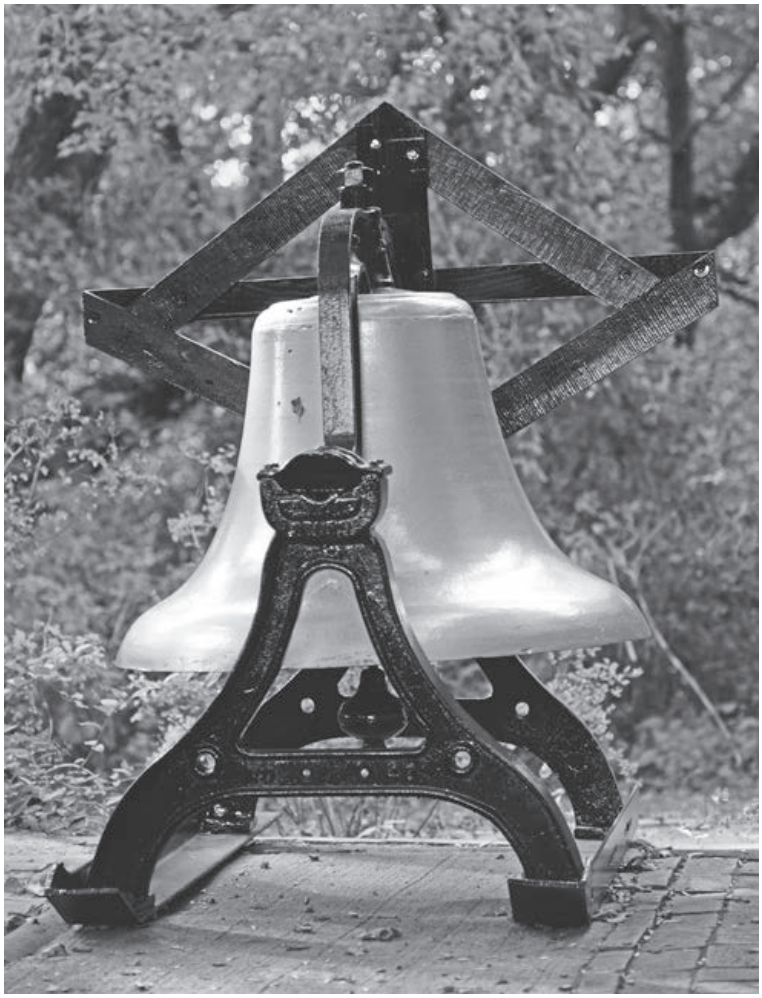

*Wes Jackson restored a 111-year-old church bell for its esthetic appeal but feels greater admiration for nature's beauty.*
*See page 18.*