

Land Report

Number 128, Fall 2020 · 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

Land Report is published three times a year. ISSN 1093-1171. The editor is Scott Bontz. To use material from the magazine, reach him at

bontz@landinstitute.org, or the address or phone number below.

ELECTRONIC MEDIA

For e-mail news about The Land Institute, write to info@landinstitute.org, or call. Website: landinstitute.org.

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TO REACH US

The Land Institute
2440 E. Water Well Road,
Salina, KS 67401
phone 785-823-5376
fax 785-823-8728
info@landinstitute.org

DIRECTORS

Brian Donahue
Tiffany Durr
Sam Evans
Terry Evans (emeritus)
Pete Ferrell
Jan Flora
Ruth Anne French-Hodson
Jill Isenbarger
Nancy Jackson
Kenneth Levy-Church
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Ricardo Salvador
Corey Samuels

Lloyd Schermer (emeritus)
John Simpson (emeritus)
Donald Worster (emeritus)
Angus Wright (emeritus)

STAFF

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Eric A. Cassetta
Anita Chase
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Marty Christians
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Sainfoin, a perennial legume being tested as food crop by The Land Institute, and by volunteers across the West. For more about that expanding civic science program, see page 20.



Billy Mills's upset win in the 1964 Olympics 10,000-meter run – and any foot race – excites us because at heart we are less products of the computer age than natives of the Upper Paleolithic.

The day I discovered that I am a groupie

WES JACKSON

I'm fond of pointing out that we are a species out of context, meaning the patterns of the world we live in are not the patterns of the world in which our species evolved. The genus *Homo* is about 2.5 million years old, and the species *Homo sapiens* is about 200,000 years old. Before the domestication of plants and animals began 10,000 to 12,000 years ago, human beings were all gatherers and hunters. After agriculture, everything changed except us. We're still essentially the same animal, just living in a dramatically different world. Everything around us – gadgets, buildings, highways as well as forms of political organization, religions, races, and classes – is new. We are a species trying to live in a world we built, but it's a world that in many ways was not built for the kind of animals we are.

One not-so-obvious point: For virtually all of our evolutionary history, we humans lived in small band-level societies, typically in the range of 15 to 50 people. Those societies did not have hierarchies as we know them today. There were no kings and queens bossing people around, no homecoming kings and queens to be jealous of.

One obvious point: For virtually all of our evolutionary history, we humans moved across the landscape under our own power. We walked and ran.

That is why I'm a devoted fan of track and field and why I love to spend time with others equally devoted. I'm honoring my species' evolutionary history. That's all important to the story of one amazing footrace. First, a bit of backstory.

The University of Kansas has a reputation for recruiting and turning out exceptional track and field athletes. The late Bill Easton was controversial, but he knew how to recruit and coach. The KU Relays each spring bring in top competitors year after year. During my high school days, I was a great fan of various top performers. The Glenn Cunningham Mile was named after a great Kansas runner whose 1934 world-record time (4:06.8) stood for three years. In 1936, Cunningham also set a world record of 1:49.7 in the 800 meters, overcoming a lot of adversity along the way. When he was in grade school, his legs were severely burned in a schoolhouse fire that killed his brother. Doctors told him he would never walk again. In addition to being one of the world's premier runners, he went on to earn a PhD from New York University in 1938. A great Kansan.

In the mid-1950s, there was much interest in the possibility of running the mile under four minutes. Kansas had a fast young man from ranch country in the western part of the state near the town of Ashland, Wes Santee, who was called

the Ashland Antelope. He was considered America's leading candidate to be the first to break the four-minute barrier, but British doctoral student Roger Bannister got there first in 1954. Kansas soon had a first, though. As a senior at Wichita East High School, Jim Ryun became the first high school student to break the four-minute barrier.

Billy Mills was a member of the Oglala Sioux Tribe, part of the Lakota people, from the Pine Ridge Indian Reservation in South Dakota, where he had been orphaned at age 12. He had gone to the Haskell Institute, now Haskell Indian Nations University, in Lawrence, Kansas. After his days at Haskell, Mills trained under Easton and eventually joined the Marines, and when the Olympics were held in Tokyo in 1964, he qualified for the 10,000-meter run. Mills was relatively unknown before the event and was not expected to finish in the top three.

But as the race progressed, Mills was keeping up with two other runners ahead of him. One summary of the event put it this way: "Then suddenly, as if an apparition had come upon them, Billy Mills sprinted past both and won by three metres." His victory took everyone by surprise. "Asked if he was concerned about Mills, the third-place finisher replied, 'Concerned about him, I never heard of him'. One Japanese reporter asked Mills, 'Who are you?'"

Were someone to ask me about the most exciting race ever run, ruling out the meets when I coached both high school and college track, it would have to be this race for Mills, who won in what is widely considered one of the greatest upsets in Olympic history.

Tom Rupp, who had been a distance runner at KU, later coached the track and cross-country teams at Sacred Heart High School, which was across the street from the Kansas Wesleyan University track and

field facilities. Tom and I worked together in a wonderfully cooperative manner during those few short years when I was teaching and coaching track at Wesleyan.

Tom eventually quit teaching and coaching and went into private business in Salina. One Sunday morning, up early and in my easy chair reading the Salina Journal, I saw that Tom was hosting former KU track and field alumni right here in Salina for the entire weekend. Here is where I learned that I was a groupie. I called Tom and told him I had been reading the paper about those former great stars. He immediately said they were all at his house at that moment and were about to have breakfast. "Come on over, Wes". I went.

Well, it was a great morning talking about all the great moments in track history at KU and what everyone was doing now.

I told Wes Santee that I had wrecked my five-tone-green Dodge coupe and spun another driver's '51 Mercury around, all to watch him run in Lawrence. For the first three quarters he had a "rabbit", a fellow runner who kept the pace for Santee to follow and then fell back to let him finish the last quarter-mile sprint on his own. Well, he failed to finish under four minutes, making it a disappointing moment, for sure.

But now about Billy Mills. After breakfast, he and I sat alone in the kitchen, and I told him that his victory in Tokyo represented a huge emotional high for me and how I wept without shame as he sprinted down the stretch. The movie "Running Brave" is about Mills's life and that race. During the few times I have seen the film about his challenges, I've found it impossible not to tear up. Mills was modest. His reply to my praise, my admiration, my recounting moments within the race and his strong sprint across the finish line, was simply this: "Well, Wes, it wasn't me."

This was a sacred moment for me, and I did not ask, “What do you mean?” or “How so?” I wasn’t sure what he meant, but it didn’t seem like my place to probe further. Instead, I excused myself and went to the restroom. What could I say, remembering how he had set the Olympic record that day for the 10K race at 28 minutes, 24.4 seconds?

I’ve met a lot of very smart people in my life, including Nobel Prize winners. I’ve met talented artists. But my short conversation with Billy Mills is one of my most precious moments. Call me a groupie if you like, and I suppose it’s accurate. But I also think there’s something else at work in this story.

We are all more creatures of the Upper Paleolithic than we are of the Internet age. No matter how much time any one of us spends behind a desk or the wheel of a car, we really were born to run. How much of the activity at a track meet is simply modern people yearning for a return to their evolutionary context?

And what of Mills’s humility? Why was I so moved by it and so unwilling to ask him to analyze it? Why was I so happy to be included in that small gathering of track and field folks? Was it, again, simply my desire to be in the kind of relationship to a fellow human that was the norm in that same evolutionary context?

Am I trying to divert attention from the more parsimonious explanation, that I’m just a track and field groupie? Perhaps, but I’ll press my point a bit further. At least in the affluent sectors of the developed world, we’ve lived with the assumption that there’s always more. But I believe the future is going to be defined by living within limits, with learning to adapt to less. In other words, our success in the future is not in returning to the past but in getting closer to being a species in context. One part of that

process involves looking at our current lives for the echoes of the Upper Paleolithic.

We can look back to how those ancestors managed pride and jealousy. We can look at how outliers today have escaped the siren call of consumerism.

Jackson, president emeritus of The Land Institute, works in its ecosphere studies program. This is a chapter from his book “Hogs Are Up: Stories of the Land, with Digressions”, to be released in early spring by University Press of Kansas.

Persephone

JESSE NATHAN

Maybe it was you.
Startled forth by a passing car.
I saw quick rumps
leap from the cedar bower.
Swimming the spring,
a moment was
in your wildered element
immediate and personal.
Free of the underworld.
Sister of the field,
green things legion,
little bearded repetitions
conceal your retreat.
Your messages, messengers.

The writer teaches literature at the University of California in Berkeley.



By using less energy, and more of it from sunlight – panels, turbines, plants – the US could set a powerful example.

A fossil fuel non-proliferation treaty

STAN COX

In the previous Land Report, I urged that the United States place a cap on extraction and use of oil, gas, and coal and ratchet the cap down quickly year by year until, by 2035, the fuels are no longer being burned. By finally taking the lead on climate, the United States would not only reduce its own emissions but would finally have moral standing to push the rest of the world toward phasing out fossil fuels.

We could begin by forming alliances with other countries that commit to employing direct, nonmarket mechanisms for eliminating fossil fuels. Such alliances would help breathe life into an existing global movement that advocates for a “Fossil Fuel Non-Proliferation Treaty”. Recognizing that the toothless 2015 Paris Agreement is incapable of preventing runaway atmospheric warming, the nonproliferation movement aims to do on a global scale what we at The Land Institute are urging in our own country: push fossil fuel use down to zero on a crash schedule.

The proposed treaty is modeled on the Nuclear Non-Proliferation Treaty, which has been signed by almost all the world’s nations. Under the nuclear treaty, nations agree never to develop nuclear weapons, while under the fossil fuel treaty, nations would agree to reduce their rates of extraction of oil, gas, and coal to zero on a speedy timetable. The nuclear treaty’s goal is to eliminate weapons, while the fossil fuel treaty would eliminate the infrastructure that makes fuel extraction and use possible.

Whereas the nuclear treaty provided technology for “peaceful” development of nuclear energy to states that agreed not to develop weapons, the fossil-fuel treaty would provide for a “Global Transition Fund” to help low-income countries with the funding and technology necessary to develop renewable energy capacity.

Citing the example of yet another landmark treaty, the Chemical Weapons Convention, advocates for a fossil fuel treaty foresee provisions for “mutual verified compliance” among nation states, through careful accounting of oil, gas, and coal reserves and production, as well as monitoring and inspection of mines, oil and gas fields, pipelines, and power plants.

Getting signatures from almost 200 nations on a Nuclear Nonproliferation Treaty was an astonishing achievement. Doing the same with a treaty to end fossil-fuel extraction could be an even more daunting prospect today. To jumpstart such an effort, some treaty supporters are suggesting that smaller alliances of nations could work out their own joint fossil-fuel elimination plans. Then, at some point, alliances and nations could gradually coalesce into a movement toward a global nonproliferation treaty and away from climatic catastrophe.

*For Peter Newell and Andrew Simms’s full story on the treaty in the journal *Climate Policy*, go to tandfonline.com and search for “fossil fuel non-proliferation treaty”.*



A beauty we walk all over

Soil can delight our sense of sight, touch, and smell, as well as make our food

Hans Jenny's 1941 book "Factors of Soil Formation" has been compared for effect on pedology – soil science – with that of Charles Darwin's "The Evolution of Species" on biology. In 1985, Jenny led Land Institute founder Wes Jackson on an ascent of California's Coast Range, showing him how soil and the life it can support will decline with age, even under perennial, natural vegetation. Until then Jackson hadn't appreciated how much soil formation depended not just on an ecosystem, but on geology. He still tells the story. Jenny, 1899-1992, taught at University of California, Berkeley, after a childhood and education in Switzerland and a decade at the University of Missouri. In 1984, he gave the following interview to University of Hawaii graduate student Kevin Stuart, about his view of soil as a thing of beauty – its part in art history, its dynamic ecological life – and as deserving as much protection as plants and animals.

Would you tell me what the basis is for your appreciation of the aesthetics of soil?

I am surprised – how did you know of my interest in soil art? Well, soil appeals to my senses. I like to dig in it and work it with my hands. I enjoy doing the soil texture feel test with my fingers or kneading a clay soil, which is a short step from ceramics or sculpture. Soil has a pleasant smell. I like to sit on bare, sun-drenched ground and take in the fragrance of soil. As yet, neither touch nor smell sensations have been accorded aesthetic recognition, but colors delight painters, photographers, and writers, as well as you and me. In loess country, plowed fields on slopes show wide bands of attractive color gradations from dark browns to light yellows, caused by erosion of the surface soil. Warm brownish colors characterize fields and roofs in Cezanne's landscape paintings of southern France, and radiant red soils of the tropics dominate canvasses of Gauguin and Portinari. Soil profiles viewed in pits may reveal vivid color and structure patterns of layers or horizons. I have seen so many delicate shapes, forms, and colors in soil profiles that, to me, soils

Facing page: A soil called Myakka, near Labelle, Florida. To soil scientist Hans Jenny, the shapes and colors of such profiles were beautiful. Soil esthetics influenced artists including Cezanne and Gauguin. And like state birds, some soils are recognized legislatively. So it is for Myakka. This Indian word means 'big waters'. It is Florida's most common soil, and occurs only there, tracing back to marine deposits. Myakka supports "flatwoods" of pine and grass. Sandy and wet, without irrigation it's usually left to native range or pasture. But it can grow citrus trees and fruits and vegetables. Photo by Tyler Jones, University of Florida Institute of Food and Agricultural Sciences.

are beautiful. Whenever I offer this reaction to an audience, I notice smiles and curiosity, but when I follow up with slides that depict ebony black mollisols of Canada, titian red oxisols of Hawaii, and gorgeous soil profile paintings by such famous artists as Grant Wood of Iowa, Dubuffet of France, and Schmidt-Rottluff of Germany, the hesitancy turns into applause.

How would you explain the lack of aesthetic appreciation of soil on the part of many soil scientists?

I don't know. Maybe they lacked early exposure to art appreciation. My grandfather was a wood carver, and his sons and daughters kept an interest in art. In high school I had an art teacher who took us regularly to current art exhibits in local galleries and museums. Soil profile art is not akin to classic paintings with themes; rather, it resembles abstract art. And if you are used to thinking of soil as dirt, which is customary in our society, you are not keyed to find beauty in it.

Why talk about soil imponderables, like beauty, and should this be an important aspect of soil science?

Confronting an exposed soil cut may be an exciting event. Soil speaks to us through the colors and sculptures of its profile, thereby revealing its personality; we acknowledge it by giving soil a name, albeit in a foreign tongue, but we don't mention our emotional involvements. In fact, our soil language is lifeless, and the soil descriptions in our publications are utterly boring to the farmers, ranchers,

foresters, sportsmen, and newcomers who are supposed to read them. Articulation would strengthen our feelings about the soil body. Casually and in formal lectures, we may want to talk more openly about soils and do it more enthusiastically. We may even become more interesting persons. We may gain new friends, and they might hold a positive opinion of the soil resource.

How important do you think soil science and soil scientists are in influencing the rest of the society's ideas about soils?

Quite unimportant, I'm afraid. Our technical articles are being read by a small coterie of fellow specialists, and the leading

national press ignores them completely. In its heydays of the 1930s and 1940s, the Soil Conservation Service electrified the nation and got the school children involved, but those days are over. Some months ago the Christian Science Monitor published a lengthy discourse on soil deterioration, but I could not detect an echo in the city press. Perhaps as long as supermarkets are well stocked with food, the city dweller does not look beyond. It is a shame that the many excellent and interesting papers by soil scientists remain confined to

library shelves. New findings by chemists, geologists, geneticists, and ecologists are regularly reported by the media, and commented upon, but the subject of soils seems to be taboo. I suspect that our intellectual isolation and our invisibility have to do with the lack of formulating exciting ideas about soils themselves and



Hans Jenny saw destruction of a soil profile by machinery to cut timber or to build a museum as a sad loss. And for that sensibility he was glad.

their relations to people, and the shortage of popularizing soil science writers. In an eight-part television series and in an accompanying book [“Bellamy’s New World”], David Bellamy offers a remarkable botanical history of America in which he stresses the significance of soils for plants and men, and describes, with charming enthusiasm, important soil profiles.

How would you describe the idea of soil as interpreted by the discipline of soil science?

To my famous teacher G. Wiegner, soil was an object to apply known principles of colloid science and to discover new ones. He expressed little interest in the contract of humans with soil. My former colleague Richard Bradfield studied soils in the laboratory and field with the aim of helping farmers manage their soils and provide food for humanity in general. That’s why he worked for years on international agricultural projects with the Rockefeller Foundation. A soil creed that began to spread in the 1920s states that soil is a natural body that deserves scientific study and contemplation, as is accorded other natural bodies, the organisms, rocks, oceans, and stars. This formulation marked a radical change from viewing soil as merely a cog in the agricultural production machine, yet the creed has benefitted farming in many important ways. My own approach to soils has changed several times. In my younger years, with my farm background, whenever I thought of soil I visualized a plowed field. You seed a crop and what yield you get depends a great deal on the nature of the soil. Later, during my Missouri work on soil humus contents, I soon realized that the prime source of organic carbon in soils resides in the organic matter furnished by tree litter fall, grass mats, crop residues,

and root production. In California, I got involved with pristine and near-pristine grasslands and forests and began thinking in terms of the “larger system” that is composed of soil plus vegetation plus animal life, a combination that is now known as ecosystem. Hence, I see soil in the context of a living, dynamic ecosystem, either a natural, or an agricultural, or a silvicultural one.

You talk about living systems. Why is it important to you to include this aspect?

Many ecologists glibly designate soil as the abiotic environment of plants, a phrase that gives me the creeps. Is the bark of a tree the abiotic environment of the tree? And what about the bacteria-rich rhizosphere? Looking at the root-soil boundary under the powerful electron microscope, an observer cannot tell where the biotic part ends and the abiotic part begins. Soils contain over a thousand different species of lower animals, the earthworms, pill bugs, nematodes, millipedes, termites, ants, springtails, and amoebas, not to mention the millions of molds and bacteria. My late teacher, Professor S. A. Waksman, discovered in soils the microbes that produce the antibiotic streptomycin that cures tuberculosis; he, who signed his letters as “soil microbiologist,” was awarded the Nobel Prize in medicine. When I add up the live weights, exclusive of roots, estimated by soil biologists, I find more living biomass below ground than above it, amounting to the equivalent of 12 horses per acre. The soil organisms consume oxygen from the soil air and give off carbon dioxide, and the summation of the multitudes of respirations characterize the metabolism of a soil individual. Hence, I designate soil as a living system. Bellamy talks about the living

soil. It is, however, not an organism because soil does not multiply; you don't find two masses of soil where there was one. If all the elephants in Africa were shot, we would barely notice it, but if the nitrogen-fixing bacteria in the soil, or the nitrifiers, were eliminated, most of us would not survive for long because the soil could no longer support us. I can't help thinking of the claim that healthy soils make healthy people, and as an extension, I am intrigued by the thought that good soils make good people, but that notion seems untenable. Well, not wholly so. Working in the garden with spade and hoe soothes the minds of many people.

You described how Wiegner and Bradfield looked at the soil, but I wasn't sure where you placed yourself.

Observing soils, studying them, and reflecting on them induces respect, if not wonder. All of us relate to soil unconsciously in our daily nourishments that make us participants in the continuous flow of nutrient atoms that originate in the soil. And in the final act, our bodies are returned to the soil. Over the years I have acquired a kind of reverence for the soil, for the creature world inside it, and for its character expressed in the profile features. Where big logging equipment turns soil upside down to make earth beds for falling redwood trees, the mass of soil remains at the site and no "environmental damage" is said to occur. Yet the soil profile, the soil's signature and identity, is obliterated. Though I consider such profile destruction an irretrievable loss, I have never seen anybody shedding tears about it. My attitude may be a personal quirk, or a result of lifelong interest in soil. In the latter case, I might not be alone. Whatever, I am glad I feel the way I do.

Has this train of thought led to your actions for preserving virgin soils and their landscapes?

Reverence for the soil has turned me into a preservation advocate of natural, undisturbed soil, regardless of whether it is a good soil or a poor one, or a rare and endangered soil species or not. My wife, friends, and well-wishers helped preserve several soils in California: the pygmy forest ecological staircase (Jug Handle State Reserve), which is an age-sequence of marine terraces and their old soils; the Mount Shasta mudflow area, composed of incipient ecosystems; Apricum Hill, with a fossil laterite crust; and Jepson vernal pool prairie, held by The Nature Conservancy. These natural areas were set aside as benchmarks for assessing man-induced soil changes and for preserving unique segments of landscapes that possess pedological and ecological potential for teaching and research. While reverence for soil was not explicitly invoked, it helped sustain the efforts to secure these lands. Society grants human beings the right to exist, regardless of whether we are useful or not, and that right cannot be abrogated without due process of law. The same privilege has been extended to a few endangered plant and animal species. I wish society would grant the same right to soil. The prospects are bleak.

Does the soil have a right to be protected for any reason other than that based on what is best for humans? For example, if gold is of value to our society, then why not dig for it and in the process destroy a fertile, producing soil and perhaps even push its remains into the sea?

Your case is not fictitious. Extensive areas of good soils have been demolished during extraction of their minute particles of gold.

The way you phrase the question brings up nature's edict that we humans cannot live without sacrificing plant and animal lives, and that land must be cleared for growing crops and building habitations if we do not want to live as nomads. Today, the idea of stewardship of land is pitted against the belief in soil exploitation for personal gain and that soil is merely an economic commodity in the marketplace. And who decides "what is best for humans"? I place natural soils and ecosystems, the nature museums, on par with art museums, automobile and railroad museums, golf courses, racetracks, music halls and gambling halls, even colleges and temples. They all use up space and appeal to special groups of people who are not called "elitist", and all these places get public financial support and protection in one form or another.

As a student of the sciences, how did you get interested in soil?

It was the other way around. I had an interest in soil and to comprehend it I needed science. In my research I tried to learn how soils are formed, how nature creates soils, and how long it takes to make a soil. In such studies, investigators locate soils of known ages that may extend over decades, centuries, and millennia. They analyze the soils, arrange the data according to soil ages, which yields "time sequences" of soils, and deduce how fast the soil bodies are changing. One question looms large: What does nature have in mind, what is her goal of soil evolution? For the animal kingdom, evolution is said to improve the design of organisms, leading to higher, more complicated beings, with humankind at the apex.

What plan would you say nature has for soil?

On soft rocks the several dozens of time sequences so far on hand suggest that in high rainfall regions and in the absence of catastrophes, such as earthquakes and severe erosion episodes, the production of organic matter as biomass rises from near zero at the beginning of the sequence to a maximum in a few thousand years, and then very slowly declines because the endless water infiltration under high rainfalls leaches out the nutrients of the soil, raises the acidity, and may establish hardpan and claypan horizons that curtail root growth. Often these areas harbor unusual plants and animals that grow nowhere else, and such soils may play a role in the evolution of species.

Is your query on what nature has in mind for soils a legitimate question, and if it is, why shouldn't we also ask about the purpose nature has for an entire ecosystem?

You might go a step further and ask what is the purpose of all nature? And if you include ourselves as a part of nature, what is our role on this earth? Soil science, or any other science, cannot provide an answer, only religion or mysticism might do that.

Reprinted with permission from the Journal of Soil and Water Conservation, May/June 1984.



Malachi DeHaan and his 3D printer, which lays molten plastic to make a sieve for silphium seeds. Their unusual shape doesn't work with conventional seed cleaners.

Suited to the seed

17-year-old with a 3D printer builds a tool for cleaning a new shape of crop

SCOTT BONTZ

Young Malachi DeHaan saw his father hoeing the garden and wanted to make him a plow. He fashioned one of cardboard and tape. The result was frustrating, but a beginning. Lee DeHaan, who breeds intermediate wheatgrass at The Land Institute, said his son from early on was fascinated by machinery – lawnmowers, weed eaters, trucks. He used and understood tools by age two. “He loved to hand me tools and sometimes gave me the next tool I needed before I asked for it by name”, Lee said. “I always liked things that move”, said Malachi, who is now 17 and a home-school senior. “I always was into mechanical things”.

Part of the machinery of agriculture is seed cleaners. They sort out stems, leaves, and other trash that accompany seeds at harvest. The typical cleaner, or sieve, runs the collection over an agitated tray full of holes large enough to let seed fall through and too small to admit larger stuff. But the holes also pass small trash. A second tray uses holes too small for the seed, but which sift out smaller bits. The seed falls into a draft that blows away lighter material. The remainder falling in the collection bin is, ideally, nothing but seed.

That hasn’t happened with the seed of silphium. The Land Institute’s oilseed crop is a relative of the crop sunflower, but the hull is even less round, with thin, flat wings.

The shape and lightness don’t make for easy passage through the first tray, and neither are they conducive to air cleaning.

But seed cleaner trays are two-dimensional. For Christmas, Lee gave Malachi a 3D printer. His first project was to make a game called Gobblet, a sort of tic-tac-toe in layers. This summer he began a model boat – both hull and propulsion fan. That was put on hold for schoolwork and lending his skills to The Land Institute. He wrote a computer program for photographic counting and measuring of intermediate wheatgrass seed. Thousands of samples were processed in record speed and with no errors. Lee and silphium breeder David Van Tassel also enlisted Malachi and his printer to improve silphium cleaning.

Malachi, who had begun computer programming at middle-school age, tried a sort of funnel, then a slotted trough with rotating bars, and moved on to a small cube that he could attach to a drill and spin, rather than just shake. Much better was an octagonal cylinder with an interior of triangular peaks and valleys. The slopes were to funnel silphium seed edge-first through slots in the valleys. Malachi initially ran the grooves around the cylinder. It was when he reoriented them parallel to the rotation axis that they properly tumbled and channeled the seed. This breakthrough allows seeds to quickly exit the narrow slots while thicker stems remain inside,

David said. His team recently passed the 1,000-sample mark using the new spinning sieves with almost none of the hand-picking of stems and sticks required in years past.

“Each time I design a sieve”, Malachi said, “I think of a better way to do it”. He had chosen the octagon because he didn’t feel knowledgeable enough with the design program to make a pure cylinder. “You have to do things like math, and that’s hard”, he joked. But by the end of October, while he talked in a workshop by his bedroom about the tool’s evolution, he had the printer steadily, quietly dispensing a thin stream of molten yellow plastic to build a round cylinder of about five by five inches.

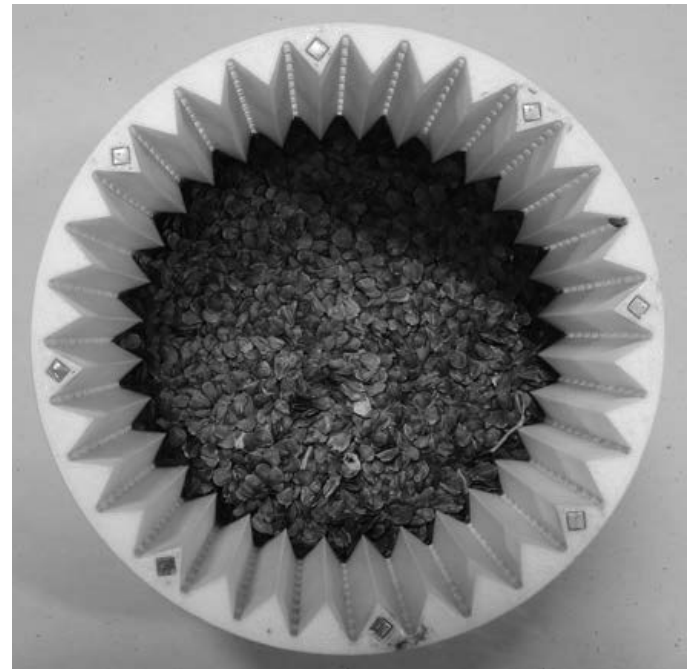
Motors on three planes move both the sieve and the nozzle. The printer starts with a solid circular base, and from this erects on end the triangles with slotted valleys. To get there is not just a matter of programming and pressing a button. There’s fiddling with temperature, depending on the plastic used, and other adjustments. Lee compared it to a finicky old car. When Malachi has everything set right, the printer builds a sieve in about 24 hours.

On The Land Institute’s silphium sieve bench, which Malachi also built, a motor about the size of a D battery turns a shaft and the cylinder. Attachment is by powerful little neodymium magnets, for quick loading and emptying. There are four of these motorized assemblies, each with its own speed knob.

Industrial-size cylindrical seed cleaners already exist. But they’re expensive and not suited to processing the seed from one plant at a time, as breeding can demand. Malachi and his 3D printer suit both that small scale and rapid prototyping. An hour and half to modify the design and a day to let the printer build it beats waiting weeks or months for an outsourced injection molding.

The sieve would cost \$200 to \$600 from a 3D printing shop, Malachi said. His are costing David \$5 to \$10, for the plastic filament. The Land Institute has a civic science program, in which laypeople across the nation grow and observe our plants for us. (See page 20.) Call Malachi’s endeavor civic engineering. He is learning, and thinking of college and a major in some kind of technology.

“I always wanted to do things with Dad”, Malachi said. Together they built a deck. “I always wanted to fix things, to build things. I’ve always wanted to make the real deal”. Now instead of a real plow, he’s building a tool that will help make plows obsolete.



The sieve – here shown on its side – will be rotated, and the silphium seed will slide flat against the triangles and edge-first through the slots. Magnets in the face hold on a cap during the cleaning.

Extracts

EVERY TIME you see a dust cloud, or a muddy stream, a field scarred by erosion or a channel choked with silt, you are witnessing the passing of American democracy. – Sterling North

THE VISIBLE EVIDENCE may well be scant, but right under our wheat fields and city streets, just below our feet, lie the bones of hundreds of generations of Plains Indians, slowly turning into soil, then geology, still belonging to the place. – David J. Wishart, “Great Plains Indians”

WHERE COMMUNITY EXISTS, there likewise exists the true body politic, and where the latter is, there too is justice. – Victor Hugo, “Les Misérables”

THE DESIRE FOR MEANING still slumbers, though submerged, beneath the extroversion of American life. – William Barrett, “Irrational Man”

WE NEED INSTITUTIONS to foster and protect those emotions to which we are sincerely inclined but which, without a supporting structure and a system of active reminders, we will be too distracted and undisciplined to make time for. – Alain de Botton, “Religion for Atheists”

IF YOUR HEADS were stuffed with straw like mine, you would probably all live in the beautiful places, and then Kansas would have no people at all. It is fortunate for Kansas that you have brains. – Scarecrow in L. Frank Baum’s “The Wizard of Oz”

IT IS A GREAT MORTIFICATION to the vanity of man, that his utmost art and industry can never equal the meanest of nature’s productions, either for beauty or value. – David Hume, “The Epicurean”

EXPERIENCE CAN DO MUCH, and all that he had learnt in England and Europe was an assistance to him, and helped him towards clarity, but clarity prevented him from experiencing something else. – E. M. Forster, “A Passage to India”

IT WOULD BE TRAGIC, to say the least, if, after billions of years of arduous effort on the part of organic life, effort that has gotten us to the verge of a global community of minds, we let the natural distortions in these minds blow the whole thing apart. – Robert Wright, “Why Buddhism is True”

FEW THINGS BETTER SERVE our species-wide vanity than an obsession with intelligence. – David P. Barash, “Through a Glass Brightly”

OUR LIVES WERE ENTWINED around something we all cared about more than anything else in the world. The farm. – James Rebanks, “The Shepherd’s Life”

THE INDUSTRY that most closely conforms to the competitive ideal – to the purest of pure competition – is the least able to tolerate the result and lives, therefore, under the greatest measure of state control of prices and production. – J. K. Galbraith on farming, in “A Journey Through Economic Time”

Land Report shorts

The growth of civic science

Last year The Land Institute enlisted more than 40 lay people across the nation for a pilot experiment called civic science. These volunteers grow our perennial oilseed crop, silphium, and share with us their observations. We aimed to learn how to organize a community for information gathering and group learning. With results from 18 states, we also could be helped in breeding silphium for broad adaptation.

Civic science this year became a regular program of our ecosphere studies, directed by Aubrey Streit Krug. She is looking to hire a civic science technician,

and already collaborates with Land Institute researchers in plant breeding and ecology. Civic science now focuses on how hands-on, collaborative research of plants and soil affects participants' awareness, attitude, and tenacity about agriculture, domestication, and conservation. It seeks to engage a range of people outside of large research schools and corporations, taking the approach of ethnobotany, the study of human-plant relationships. This public involvement might be needed to bring and keep cultural changes necessary for seeing perennial grains spread over the land. Civic science is decentralized and affordable, and it could give communities a voice in



In diverse soils and climates our supporters are tending our plants for civic science.

research that affects their food. This year the program offered events online, and for growers it developed guides to identify insects and a fungal disease of silphium. The latter guide may also go to graduate school students and other silphium researchers. Civic science also launched a pilot study for a perennial legume called sainfoin. Seedlings went to participants from the Dakotas to the West Coast – the plant does well in semi-arid climates. And work with silphium expanded. The Land Institute had previously collected seeds in remnant native prairies from Kansas to Kentucky and from Michigan to Mississippi. This should provide broad genetic diversity for improving the crop. To preserve the unique populations – ecotypes – while increasing the seed needed for selection and breeding, they must be planted at least a couple of miles apart. In a new pilot cohort, households each received 36 seedlings of different ecotypes. Growers will cut the brown, drying heads of the plants after they bloom next year and send them to us.

For more about civic science, at our website click the heading “Our Work” and look in the left column.

Bringing down carbon

In 2016, University of Kansas researchers Nathaniel A. Brunsell and Gabriel de Oliveira began measuring how much carbon was going in and out of a field that had been restored to perennial grassland a decade earlier. They metered carbon dioxide with what is called an eddy covariance tower. There’s another such tower just downhill from our office. (See the summer 2012 Land Report for more about how they are used.) The 16 acres of restored grassland was at the Perennial Agriculture field station near KU.

In fall 2017 the field was tilled and planted to the legume alfalfa and intermediate wheatgrass, a biculture we are studying to eliminate the need for synthetic nitrogen fertilizer on grain crops. Intermediate wheatgrass is a perennial crop that produces Kernza®, our registered trademark for the grain and its food products. The prairie vegetation and the soil organic matter pool it fed had been accumulating more than 800 kilograms of carbon per hectare per year, which means tons of climate-warming carbon dioxide removed from the atmosphere. The year after conversion, the field lost more than 1,200 kilograms per hectare. This was inevitable with tillage, and why annual grains are such a huge carbon loser. But two years later the perennial alfalfa and wheatgrass were well on the comeback, losing just 30 kilograms. Next year, and for many years to come, the field almost certainly will once again be a carbon sink, Research Director Tim Crews said, testimony to what perennial grains could do for stemming climate change.

Intercropping grain, legume

In traditional crop rotation, a legume was grown for a year or more to build soil nitrogen. Then it was plowed up and followed by years of annual grains and annual tillage, which would suck out the nitrogen, rend soil structure, and invite erosion. With perennial grains The Land Institute aims to keep the soil, and to keep it fertile. We also want to minimize the synthetic fertilizer that largely replaced legume-based crop rotations. For that we need to grow grains and legumes together, at least in alternating strips. But starting the perennial grain intermediate wheatgrass and the legume alfalfa together

in bare ground did not work as well as the grain crop fertilized with nitrogen, in five years of study by Tim Crews, our research director. Nor has the combination availed other researchers and farmers. Same for intercropping annual grains and legumes. The problem is that without the legumes going first, grains start with a nitrogen deficit. But Crews, putting to use research technician Ron Kinkelaar's mechanical ability, has devised a way to meld the soil fertility benefits of traditional rotation with intercropping.

In spring of 2014, about three acres of alfalfa were sown. We hayed that field over the next two and half years, while the legume grew vigorously and built up soil nitrogen. In fall of 2016, Kinkelaar, towing a tool he had made, undercut – rather than tilled, minimizing carbon and nitrogen loss – two-foot-wide strips in the alfalfa. Each opened strip was sown with two rows of intermediate wheatgrass, producer of Kernza®, our registered trademark for the grain and its food products. Alternating between the pairs remained two-foot bands of alfalfa – the field was half grain, half legume. With the legume “frontloading” nitrogen and improving soil structure for more than two years, the grass following it established well and by its third year produced 227 pounds of grain per acre. This year, its fourth, brought a yield of 327 pounds. The grain planted in alfalfa undercut in 2018 made 314 pounds per acre by its second year. This might not sound like much, but the rows are at half the density they would be in a solid stand, the crop got no nitrogen fertilizer, and breeder Lee DeHaan has improved intermediate wheatgrass yields since 2016.

There is good reason to think that the intermediate wheatgrass benefits not just from the nitrogen left by the undercut

alfalfa, but from the living alfalfa around it. Crews is thinking about experiments to parse this.

New ecology technician

After four years as The Land Institute's ecology technician, James Bowden is pursuing a master's degree in agronomy from the University of Minnesota. For now, because of the pandemic, he still lives in Salina, his hometown, and studies online. He conducts his thesis research here and at sites in Minnesota, measuring the movement of greenhouse gases and water where two crops are grown together and where crops are fertilized with manure. This is not just for data on how to grow perennial grains, but also serves a USDA-funded program for research and education in using intermediate wheatgrass for both grain production and livestock forage. After grad school, Bowden would like to be a cosmopolitan extension agent, traveling worldwide to teach farmers about growing intermediate wheatgrass as a grain crop.

Our new ecology technician is Madeline DuBois, who last year was a Land Institute intern.



DuBois

DuBois, from Poolville, New York, returned to us with a bachelor's degree in environmental engineering from Northeastern University in Boston. There she helped a professor develop treatment of wastewater with

plants and bacteria – her introduction to study of nature for inspiration to solve

problems sustainably. Here, DuBois works with ecologist Tim Crews, who is also our research director. He plans studies, and DuBois executes them in field and lab. For example: pounding tubes into the ground to measure the rate that microbes turn organic nitrogen into ammonium that plants can use; measuring greenhouse gases leaving the soil; sampling soil; and sampling soils and plants for nitrogen analysis.

New fund raiser

Rebecca Tong joined us this summer as a development officer. She lives in Wichita, Kansas, home of the airport she'll need for fund-raising travels after the virus is controlled. At Illinois Wesleyan University, Tong studied political science and international studies with a concentration in development studies. She has worked



Tong

in development since graduating in 2009. Tong enjoys connecting people with causes that stir their passions. “We are all capable of making lasting change, and one incredibly meaningful way to move our causes and passions forward is by

contributing money”, she says in her profile on our website. “I am excited to join this team during such a critical time. Now that perennial grain crops have been proven possible, it is time to accelerate the work, and that requires more researchers, field sites, and growers doing this work with us”.

Perennial wheat landmark

More than 8,000 plants of three perennial wheat advanced lines survived the past summer, which is a first. In earlier summers there already had been survivors among breeder Shuwen Wang’s hybrids of perennial intermediate wheatgrass and annual durum wheat. But they were not yet stable – over generations they lost chromosomes. The advanced lines that survived this summer are stable. Wang found survival much improved with relatively late planting. Most of the plants from the same advanced lines died this summer after planting in mid-September of 2019. Sowing just a few weeks later, in early October, apparently made the difference. Wang sent seed of advanced lines for evaluation in New Mexico, Wisconsin, Australia, Romania, and France.

Sorghum expands to Georgia

Sorghum originated in Africa, where in the tropics the plant can grow as a perennial. It has been more productive for farmers when treated like an annual, however, sown anew each year. Kansas is by far the biggest grain sorghum producer in the United States. The cold here prevented perennial regrowth until The Land Institute developed winter-hardy hybrids. Plants that can survive below zero are what we continue to breed. But for several years, researchers and farmers in Kenya, Uganda, and Mali have tested our plants and crossed them with local varieties. And there are milder US climes, where plants that were relatively poor performers in Kansas might find their niche and excel. This summer, Pheonah Nabukalu sowed and established about 16,000 sorghum plants at Tifton Research Farm in southern Georgia.



On September 23, Land Institute staff moved intermediate wheatgrass seedlings from the greenhouse to a trailer for planting the next day. Everyone had gathered for tours to learn of one another's work, as a substitute for the annual Prairie Festival, when 1,000 people might have visited to learn, if not for the pandemic. During a break, staff members and interns pitched in to move about 19,000 plants in about five minutes. The seedlings are to make a commercial variety of the perennial grain, which has a registered trademark name of Kernza®.

The climate is subtropical, with average January highs of 59 and lows of 37, some 20 degrees warmer than central Kansas. Tifton also sees about half again as much rain. Nabukalu worked with sorghum for six years at The Land Institute as a post-doctoral researcher. She is now a visiting scientist at the University of Georgia, and is funded by the Perennial Agriculture Project, which we run with money from two foundations. The university's Andrew Paterson is a longtime collaborator in our sorghum work, and his lab deciphers perennial sorghum genetics. Nabukalu will select plants with stable rhizomes, the underground stems that survive winter, and grow perennially in subtropical Georgia.

Wheatgrass landmark

In 2010, Lee DeHaan set the 10-year goal of pushing his intermediate wheatgrass plants from grain yields of about 500 kilograms per hectare to producing 1,000 kilograms. Through the process of selecting and breeding the best plants over a decade, he made it. One population this year in one field hit the 1,000 kilogram mark, and another yielded over 950 kilograms. (A thousand kilograms per hectare is 892 pounds per acre.) This is still less than half the average yield of wheat in Kansas, but making for better soil, sinking carbon, and potentially taking less machinery and energy.

The two populations yielded only about 600 kilograms in a field a mile away. But that drop was consistent across more than 20 populations grown in both places. The best new lines produced 60 percent more grain than those being used by most farmers, in fields sown in recent years. "We have yet to achieve these yields on a farm",

DeHaan reported, "but we can now see the potential to achieve such yields under optimum conditions". He also evaluated the performance of breeding lines selected in the northern United States, and not surprisingly found that lines selected in Kansas are better suited to the local environment. All these improved lines are far above an intermediate wheatgrass variety developed only for forage, not grain, which yielded under 200 kilograms.

This year DeHaan also made his first harvest from plots for increasing seed to eventually make commercial varieties. He's evaluating four candidates and hopes for a release within a few years.

New help for collaboration

Westen Gehring, an intern last year, returned to The Land Institute and filled a new position, operations associate for the Perennial Agriculture Project. We



Gehring

run this program with money from two foundations, and Gehring's job involves keeping track of the budget and communicating the awarding of grants to our collaborators. "It's exciting to be able to participate in a project that has done so much to

fund perennial agriculture research around the country", he says in his profile on our website. Gehring grew up in Santa Fe, New Mexico, and Winnipeg, Manitoba. He earned bachelor's degrees in biology and music performance at Bethel College,



From left, interns Emma Baker and Hannah Mellecker, and technician Edy Chérémond assess silphium stems for infestation by eucosma, a pest moth of the new oilseed crop. Mesh bags held the harvested plants.

south of The Land Institute, and then a master's degree in music performance – jazz saxophone – at Wichita State University, in the city that's now his home.

Silphium: diversity, progress

David Van Tassel, The Land Institute's lead silphium researcher, and Sydney Schiffner, his technician, this summer found plants with traits or trait combinations not seen before, including plants with some of the best features of *Silphium perfoliatum* – many heads, disease resistance – and the best of the main domestication species, *S. integrifolium* – big heads and seeds. There were also many plants with the worst traits of one or both species, but that's to be expected. The researchers were delighted with the good combos. Another thing expected with interspecies crosses is tall plants. But this year there were also dwarfs, which Van Tassel has sought for years. Wild plants grow tall to compete for sunlight, but if all crop plants are short, they can put more energy to making seed.

Broad genetic variation in breeding populations can bring these good results, but we had a dearth of samples from the Southeast, which has been identified as origin of the genus and so should be most diverse. Driving for five days and looping through Arkansas, Mississippi, and Alabama, research resident Alex Griffin found about 50 silphium populations: the familiar *S. integrifolium* and four other types that enjoy their own species names but are close enough alike to naturally hybridize. They were usually by a tree, fence, or telephone pole, where they escaped being tilled, mowed, or sprayed. Griffin's trip was in summer, when the plants bloom and are easier to see. To collect seed in early

October, she enlisted people who live closer to the plants. One was a retired surveyor-turned-naturalist met through the website and app iNaturalist, the other a friend of a friend.

Perennial wheat resists fungus

Rain and humidity during pollination and seed growth made 2019 a ripe year for the fungal disease Fusarium head blight and its toxin that can keep a grain crop from market. In Land Institute geneticist Kathryn Turner's study, susceptible annual wheat varieties exceeded the Food and Drug Administration's limit of one part per million by almost 15-fold on average. Resistant annual wheat and our perennial intermediate wheatgrass on average had two to three parts per million under these adverse conditions. But our perennial wheat plants, produced by crossing annual wheat and intermediate wheatgrass, scored below the limit. This was exciting to see, though timing of the rain might have played a role in the lower levels. Turner doesn't have results yet for this year. Analysis of samples, at North Dakota State University, usually takes two to three months, but this year lab closures due to the pandemic pushed the time to seven months.

30 extra research acres

Technique has sped improvement of perennial grain crops, but the work remains a numbers game of finding stars among tens of thousands of plants. With technical ability to screen more plants, The Land Institute could use more field space. And we will get it, thanks to the city of Salina. Thirty acres borders the city's new water

treatment plant across the road from our 72-acre field a mile and half west of our office. This fall we planted the new field to smooth brome, a perennial forage grass. We'll leave it be for a couple of years to help empty the weed seed bank. Then we can put it to use for experiments and breeding plots. The city will let us use the land indefinitely.

New controller

Tara Sauber is our new controller, meaning head of accounting. She has bachelor's and master's degrees in accounting and holds a certified public accountant certificate. "I



Sauber

have always excelled at math, so naturally I was drawn to accounting", she said. Sauber lived in Florida and New York before moving at age four to Kansas and settling in Salina in the sixth grade. While at Kansas State University, she served as an

accountant for the Kansas 4-H Foundation. She worked for a CPA firm in Virginia before moving back to Kansas as an analyst for the health care system and then serving as the city of Salina's deputy finance director. Sauber is the mother of two boys and volunteers at their school. She also runs, and aims to complete a half-marathon in every state.

Managing a moth

A modest looking moth called *Eucosma giganteana* makes larvae that eat only silphium, our perennial oilseed crop, sometimes to devastating effect. Because the insect is a specialist and silphium as a crop is new, so too is how to manage the pest. After three years of experiments, crop protection ecologist Ebony Murrell claimed a success. Silphium fields were mowed down in August 2019, while most eucosma caterpillars were still in flower heads. The fields were later sprayed with nematodes that kill the larvae. The number of eucosma moths caught in traps next to our fields this summer was far less than in the previous years. The daily haul in 2018 repeatedly reached more than 40 moths, and once was 127. This year the highest count was 13 and the usual was three or four.

Publications and presentations

Wes Jackson and longtime collaborator Robert Jensen present online conversations in "Podcast from the Prairie". Jensen, retired from teaching journalism at the University of Texas, has interviewed Jackson, The Land Institute's president emeritus, on the themes "Intellectual Grounding", "Respect Your Tools", and "Mad About Science". They aim to add episodes at least monthly. Links can be found on our website: look under the heading Learn. Under Learn also find the video and audio library, scientific publications by our researchers, and past issues of the Land Report. Another heading, News & Events, leads to media coverage.

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Jim Bender, from Grace Menzel & J. B. McCombs · Lester Birch, from Kathleen Birch · Earth Island Institute, from Philip Hodges Hannah Frank, from Connie Taylor · GAI, from anonymous · Megan Gieseler, from Marisa Stansfield · Reed & Laurel Huser, from Susie Huser · Wes & Joan Jackson, from Catherine Badgley & Gerald Smith, Sandhill Farm Foundation · Wes Jackson, from Roger McDaniel, Patricia Michaelis, Henry & Dianne Schaffer · Michael Johnson, from Kathryn Behlman · Marilyn Long, from Andrew Long · Rhea Miller & Sandy Bishop, Lopez Island Land Trust, from John & Eleanor Butler · Kevin Markey, from Karen Markey · Andrea Miller, from Stephen Campbell Miller · Pat Miller, from Gail Stratton · Heather Niese, from Susan Niese · Emily Rude, from Matthew D'Asaro · Megan Tysoe, from Claire Johnson · Vita Wallace, from anonymous

MEMORIALS

Terry Booth, from Kenneth Bertelson, Tracy Caddell, Lora Carlson-Eaton & Kevin Eaton, Gail Gall, William Jenkins, David & Hope Krug, Anne & Richard Linenberger, Nona Pankonien, Sanda Petersen, Ramon & Eva Powers, Veanna Rousseau, Kip & Carma Shawger, Ann Sorebo, Edwin Sorebo, Mark Stillings, Charlotte Taggart, Byron & Sara Welch, James W. Wingate, Larry & Anita Wolgast · Virginia Elizabeth Beazley Chambers, from Gretchen Chambers · Frank Clow, from Michael Clow · Harold Hall, from Aimee Corrigan · Palmer Haynes, from Everett & Dorothy Ann Bullock · C. Dale Johnson, from Michael & Cheryl Johnson · Wayne Johnson, from anonymous, Janet Mathistad, Karen Rasmusson, Bill & Doris Robinson, Rebekah St. Clair, Konul Amrahova & Anmol Soni · Kevin Jolly, from Jonathan Stettin · Gary Tegtmeier, from Kristen Golden, Ann Simpson, Aaron Viets, Lisa Weatherholt · David Zahrt, from Linda M. Zahrt

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Eric Cassetta looks for disease among silphium plants at Ogg Road Prairie near Kansas City. Silphium is The Land Institute's oilseed crop, and the silphium team is combing diverse wild populations like this for traits including disease resistance. For more about the search and progress with silphium breeding, see page 27. Photo by Anna Andersson, a Land Institute intern in 2018.