The Land Report

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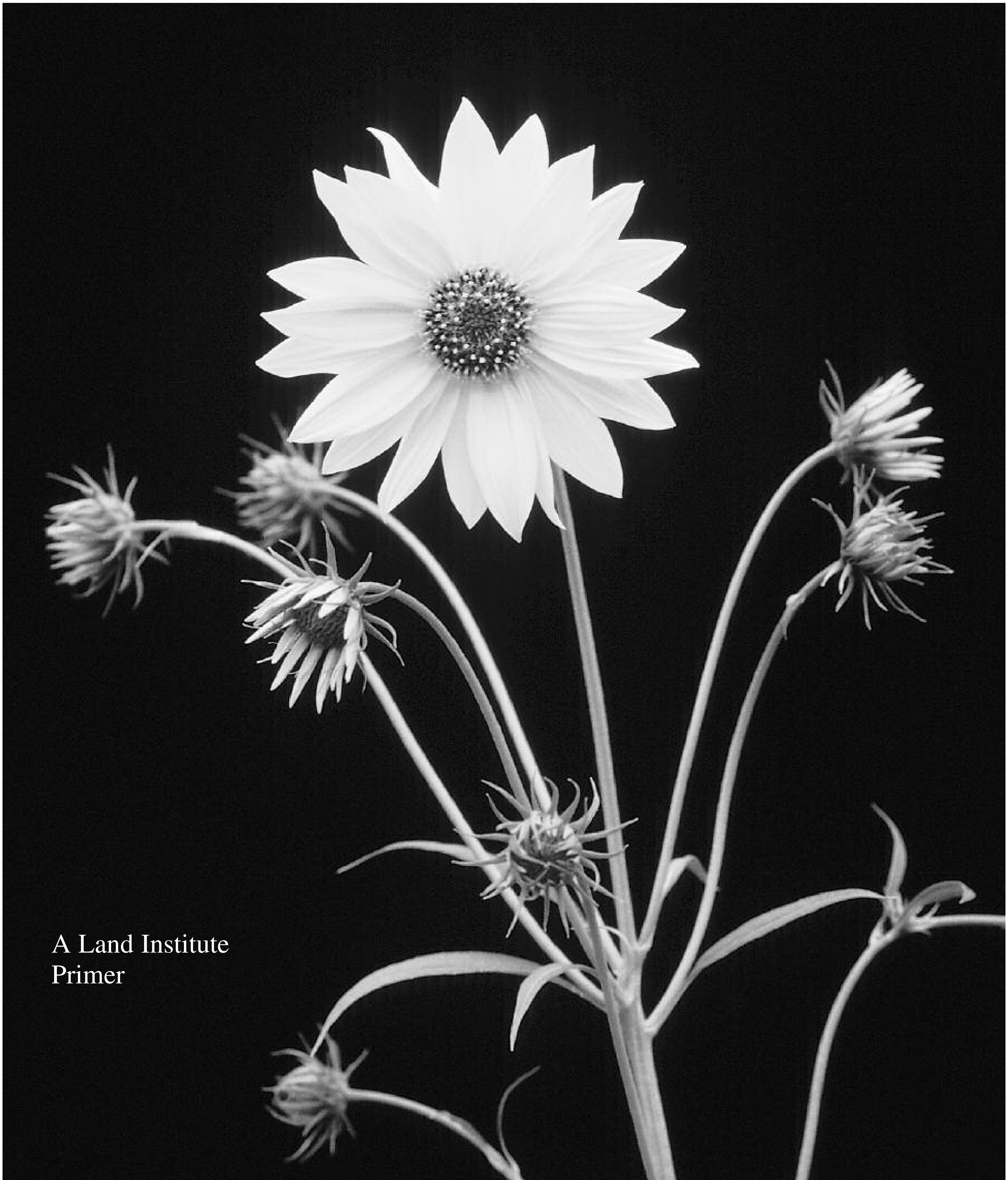

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Our Mission Statement

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.

Cover: Scott Bontz. Sterile flowers produced by one of the rare hybrids between Maximilian sunflower and annual crop sunflower. The Land Institute is working to produce more hybrids and increase their fertility. We want to move genes for high seed production from the crop plant into the perennial Maximilian species, creating a new crop that does not require annual replanting. We are also screening wild populations for plants that produce seeds that are larger and have large heads which do not shatter open before harvest. Another desired trait is shortness, for ease of harvest, less competition for other plants, and less energy and nutrients wasted on taller stems.

Above: Scott Bontz. A Maximilian sunflower with unusual fused heads. This plant and several others with similar heads grew from seeds collected from wild Kansas populations. The biology of head fusion is not yet clear, but genetics, environmental influences or both might cause many small heads to grow close together. Could the giant heads of domestic sunflowers have a similar origin?

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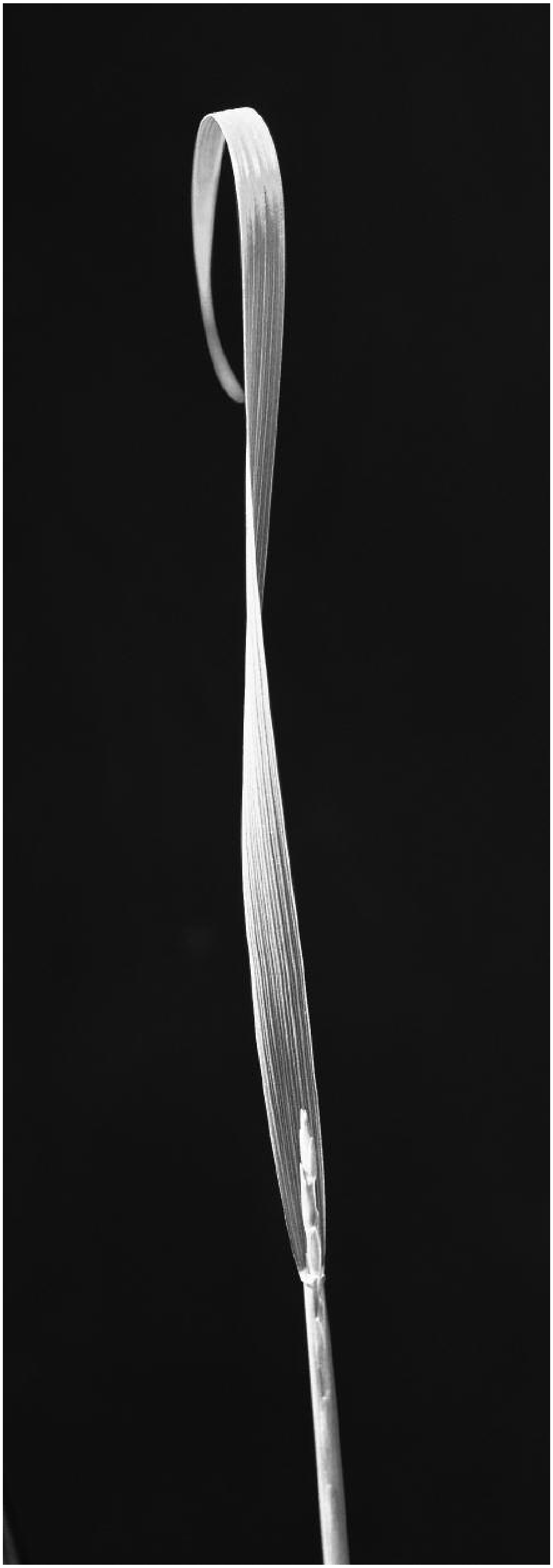


Introduction

It is one more letter than oil, but immeasurably more valuable. It was the seed money for civilization, and remains the foundation, though literally washing away. The great nations build themselves taking from it, and without it they fall. In it is our final security, and in its conservation the truest patriot act.

It is soil.

The world really is at our feet. Yet this is scarcely noticed, even as it disappears into the seas.

To hold ground, The Land Institute is building a new agriculture. It will be the first to both sustainably produce grain and conserve soil.

Our model and measure is nature. Ecosystems have enjoyed millions of years of refinement and run on nothing but sunlight. Specifically we look to the prairie. It is the great grassland soil builder yielding much of the richest agriculture.

Here is what the prairie and most of the rest of the world's plant patterns tell us works best: perenniality and diversity.

Agriculture runs oppositely. It is mostly annuals, and planted in crops of one plant type.

Turn the page and compare them.

Scott Bontz. A new agriculture emerging: One of our hybrids begins to send up its seed head. This is a cross of the annual grain plant triticale and the wild perennial tall wheatgrass. Triticale itself was the first entirely human-created species of grain crop, combining the wheat seed's bread gluten and the rye plant's tenacity in harsh conditions. We are cross-breeding species similarly, for annuals' grain production and perennials' superior efficiency with water and nutrients, plus less need for soil-destroying tillage.

Perennial polyculture	**Annual monoculture**
Plants live for years, so little re-seeding is needed. Time and money spent on preparing soil is minimal, bettering returns to the farmer.	Plants die each year. They must be totally re-seeded, and require a pampering environment that takes costly time, machinery and fuel.
Roots grow to many depths and live through the year. They make the most of water and nutrients, needing little to no irrigation.	Roots start growth from seed after much precipitation is lost, and die in less than half a year, wasting more resources.
Continual plant mass above ground and dense roots below shelter and hold soil in place.	For most of the year, the ground is bare and roots are dead or relatively small, allowing erosion.
The system is so efficient, soil levels can actually build up and a high natural fertility is sustained. With little to no fertilizer added and little natural fertility removed, water remains clean.	Most soil is lost faster than it can be replaced, and natural fertility inevitably falls. Much of the fertilizer then applied goes unused, running off or leaching to pollute surface, groundwater and even ocean depths.
The worms, fungi and microorganisms that make soil healthy and beneficial to plants are undisturbed.	Tillage and chemicals repeatedly violate soil life and structure.
The isolating effect of diverse species mixtures thwarts pests and disease, reducing pressure to use pesticides and herbicides and lowering the threat to wildlife and human health.	Crops unvaried by species or genetics are ripe ground for epidemics. Biocides raise costs, pollute land and water, expose farmers and consumers, and build resistance in pests and pathogens.

So when you see rich grain fields, realize that they are amber waves of drain. The 10,000 years of agriculture have come at a net loss of ecological capital, building nations but wrecking land.

We can't go on like this. To see it continue meeting our expectations, we must meet the land's own.

Finally, we may. On top of know-how begun in the Neolithic, we have genetic insight born of the past two decades. We can merge the grain production traits of annuals with the sustaining growth habits of perennials.

That is what The Land Institute is doing. We're working with agriculture to work more like prairie. By making it diverse and long-lived, we can keep those waves of grain.

Why We Do What We Do

Jerry Glover

Grain plants replanted in bare soil every year occupy as much as two-thirds of global cropland. These annual cereal grains, oil seeds and legumes satisfy a similar proportion of humanity's food calorie needs. Fruits and vegetables are relatively small players. As the world's population swells from the current 6 billion toward 8 billion to 10 billion over the next 50 years, the importance of grain crops will almost certainly increase, even with widespread adoption of vegetarian diets. But annual crops, grown in disease- and pest-prone monoculture, often lead to severely degraded soil and water. Can we satisfy humanity's growing demand for grains without destroying much of the planet's non-agricultural species and ecological foundation on which we depend?

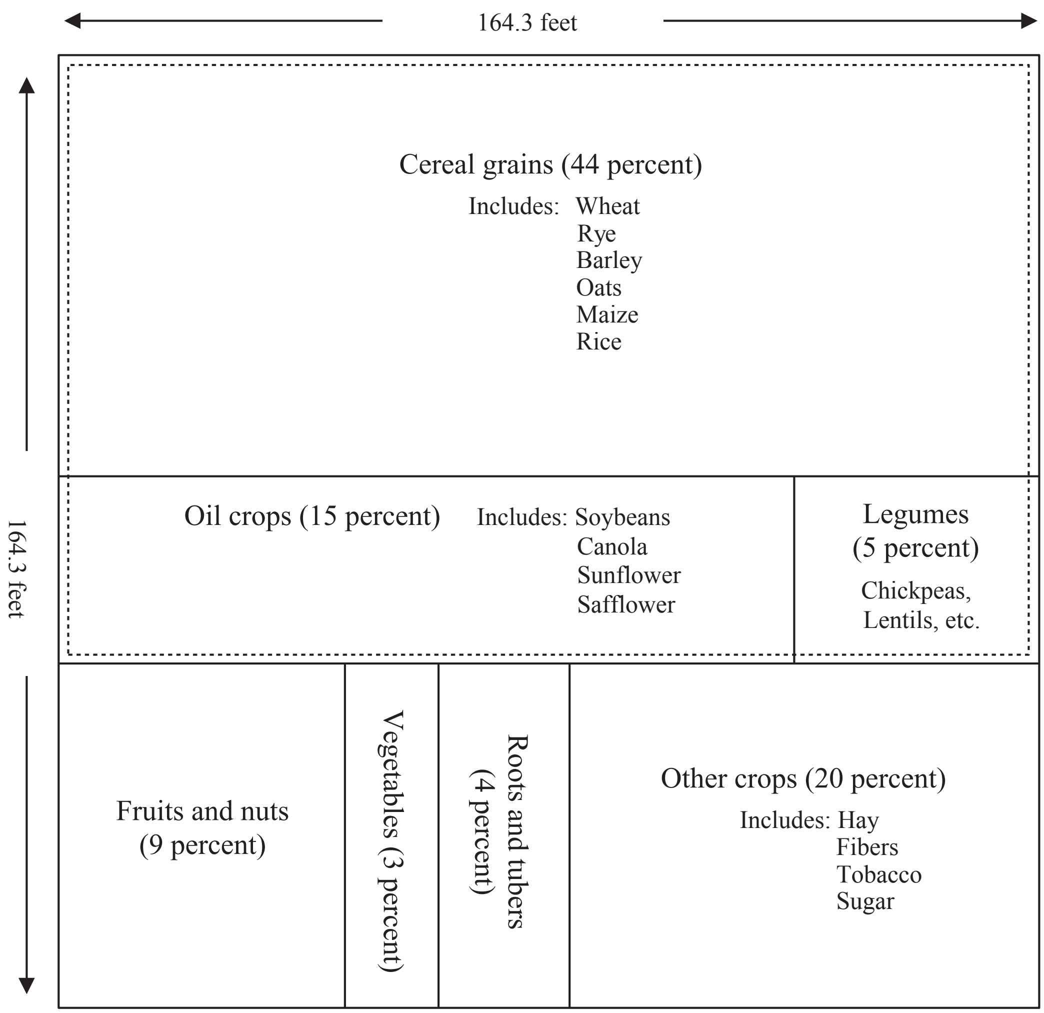
The upper Midwest: a case study

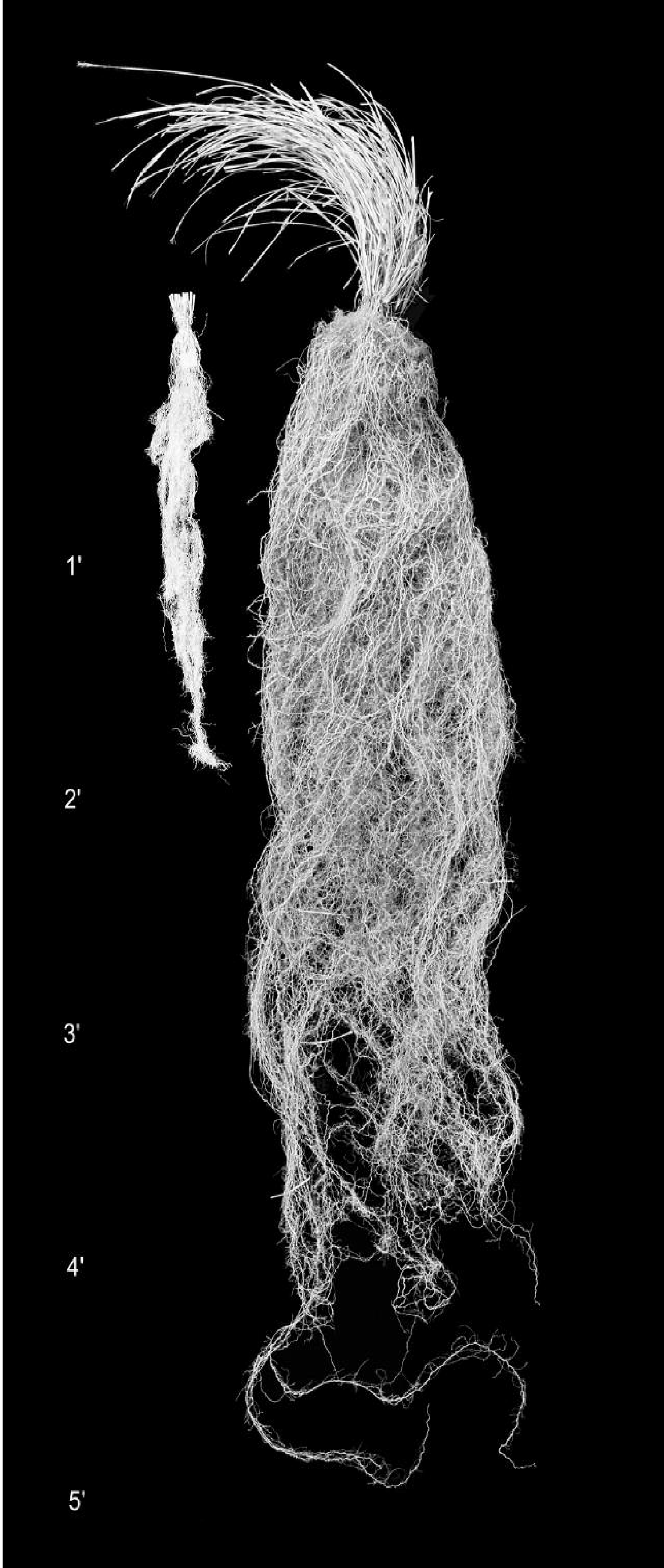
To help answer this question, let's look to the fertile fields of the upper Midwest. Environmental conditions make annual grain production here potentially more sustainable than in any other extensive region of the world. It has a sufficiently long growing season, abundant, well-distributed rain, and deep, fertile soils. The soils' parent materials, ground from bedrock by recent glaciers, is abundant with nutrients to fuel plant productivity.

The upper Midwest also has a well-developed social infrastructure of capital, equipment, energy, chemicals and professional expertise. The nation's, and probably the world's, largest agronomy department, is at Iowa State University. More nitrogen fertilizer is applied to fields here than in any other region of the country, giving the tremendous yields of which Americans are so proud.

So, does this best-of-all-possible-worlds situation offer the planet a model for ensuring sustainable grain production for 8 billion to 10 billion people while also

There is 0.62 acre of cropland for each person in the world. Here is how it would be divided by crop type. Annual grain crops take nearly two-thirds of the land. Their energy and transportability give them this status. While the world's population rises, grains' importance can only increase, and it will become more vital to grow them in a way that does not degrade the land. The annuals grown now and for the past 10,000 years cannot fill that bill.





Scott Bontz. During spring rains, the roots of annual wheat are poorly developed and take up water and nutrients only from shallow depths. The wheat at left in the picture is mature, as it appears come summer. Meanwhile, a perennial such as the big bluestem on the right is ready through the year to work over much greater depth. Consequently, as shown by the table on the opposite page, annuals lose magnitudes more nutrients than do perennials.

ensuring continued functioning of crucial ecosystems and not condemning non-agricultural species to extinction? The answer is no. The upper Midwest's farming of annual plants is increasingly identified as the source of critical environmental problems extending thousands of miles.

Perhaps the most significant long-term problem is soil erosion. National erosion rates have declined slightly over the past decade. But the federal Conservation Reserve Program, which pays farmers for planting cropland back to mixtures of perennial grasses and forbs, accounts for more than 60 percent of that decline. More than one-third of the nation's cropland continues to lose soil faster than even the most optimistic estimates of replacement rates, and roughly 15 percent loses soil at twice the rate of replacement. We can confidently call this unsustainable.

Then there are worsening effects of upper Midwest farming on water. Because life cycles of annual crops are not well synchronized with annual climatic and soil conditions, they compete poorly with weeds for water and nutrients. Up to 45 percent of precipitation can escape to subsurface soil in annual cropping, five times that lost by a prairie's plants, which are deep-rooted and alive year-round. Annual crops lose 35 times more nitrate nitrogen. So, large amounts of fertilizer are added, along with herbicides to battle weeds.

The large volumes of water flowing through and across fields carry soil and chemicals into surface and groundwater. Soil dumped in Lake Pepin on the upper Mississippi has risen 12-fold since European settlement and the beginning of annual cropping. Raccoon River nitrate levels reached so high in spring 2001 that Des Moines, Iowa, switched to the Des Moines River for its drinking water. The 2000 National Water Quality Assessment program found at least one pesticide in nearly every water and fish sample collected from streams and in over 50 percent of farm area wells. Federal agencies and independent research organizations attribute roughly 70 percent of the nation's water quality problems to farm practices. In 2002, Iowa witnessed its largest fish kill-offs, from agricultural contamination.

Downstream 1,000 miles that year, the "dead zone" at the mouth of the Mississippi ballooned larger than Lake Erie, its largest in history. Excessive concentrations of nitrate nitrogen flowing from farm fields, more than half from Minnesota, Iowa and Illinois, fed rapid growth of microorganisms that deplete the water's oxygen too low for the typical highly diverse marine populations.

Added fertilizer is only part of the problem. A significant portion of the nitrogen comes naturally from organic matter, soil's savings bank, when soils warm enough in spring for biological activity but are still bare of annual crops such as corn and soybeans.

Then there are pesticide and herbicide effects. Tracking them can take decades. Last summer, two reports in the prestigious *Proceedings of the National Academy of Science* revealed that the cocktail of agrochemicals now found in nearly all farm area water bodies inhibits normal sexual development in frogs and impairs their immune systems in fighting parasitic infec-

Annual nutrient losses under different land uses
(pounds per square mile)

	Nitrogen	Phosphorus
Perennial: native cover	63	21
Annual rotation: corn, wheat, clover	2,774	652
Annual: continuous corn	6,938	2,002

tions. In the four decades since its introduction, atrazine became the most widely used herbicide and the most commonly detected in our nation's waters, while frog populations eerily declined. Only in recent years have we been able to measure atrazine at concentrations of less than 0.1 parts per billion and link them to frog problems across the country.

The lesson from the upper Midwest is that our global ecosystem is seamless. We cannot accept as a model of sustainability an agriculture that, although high-yielding over a relatively short time, threatens natural habitats and wildlife hundreds or even thousands of miles away. Nor can we, in the face of a rapidly growing population, accept as a model for ecological conservation the removal of cropland from production. What we must do is develop an alternative in which ecological seamlessness is acknowledged and production conserves its ecological foundation.

The mission: diverse, perennial vegetation

If we study how vegetation around the world appeared before conversion to simplified, annual crops, we consistently find two common traits: It is diverse, and it is perennial. This holds true whether in a tropical rainforest or in an arid shrub steppe. Diverse perennial plants use nutrients and water more effectively and over a greater part of the growing season than do monocultures of annuals. Diversity also helps to thwart pest and disease outbreaks and keep weeds at bay.

Perennials regrow each year from living roots often extending much deeper into the soil than do annuals. They are better poised to take advantage of nutrients and water when the soil is warm enough for growth. More importantly, living roots not only hold soil in place, but, by transferring plant sugars belowground, feed the diverse microbial populations so important in building new soil. The deep, rich topsoil of the Midwest developed under deep-rooted, diverse, perennial vegetation.

Rather than work on the many individual problems of annual agriculture, which is not in the long term sustainable anyway, Land Institute researchers look for a model in the whole of natural systems. In particular, we look to the ecosystem of tallgrass prairie. The prairie's vegetation is conveniently composed of species analogous to the warm- and cool-season grasses, legumes and oil seeds of our annual crops. With perennial crops grown in mixtures, future grain farms would essentially be domestic prairies.

Land Institute plant breeders approach this two ways: perennialize current annual crops and domesticate promising wild perennials. Wheat, sorghum and sunflower have proven promising candidates for perennialization. We are beginning domestication of Illinois bundleflower, intermediate wheatgrass and compass plant by improving seed yield, size and quality. In addition to efforts at the institute, nineteen science scholars in universities across the country research for us as part of their Natural Systems Agriculture Graduate Student Fellowships.

Recent advances in computing and plant breeding, and greater understanding of our global ecosystems, put within reach, for perhaps the first time, truly sustainable grain production that also brings conservation.

The 25 to 50 years expected for achieving this appears impractical in a world of three-year research projects. But the problems of soil erosion and degraded water from annual cropping have been with us for millennia. These will worsen with the rising pressure to meet the planet's expanding food needs. If, in 50 growing seasons, there is in place an agriculture that both provides adequate yields and supports our ecological foundation, the time required for success will have seemed short.

What We Do and How

Stan Cox, Lee DeHaan and David Van Tassel

A prairie holds a wide range of species belonging to four plant groups: cool-season grasses, warm-season grasses, legumes and composites. The Natural Systems Agriculture that we are developing will be based on diverse species of those same four groups in mixtures, with perennial roots to hold the soil and capture water and nutrients, as well as sufficient crop biodiversity to protect against pests and fill all niches of the ecosystem, above and below the soil surface. But first we have to breed the perennial grain crops.

The Land Institute does not aim simply to breed *a* variety of each perennial crop species. A single variety does not contain enough genetic diversity to sustain future breeding. We are developing entirely new, deep gene pools, each the collective genetic information of what is effectively new species, to make sustained improvements possible.

Perennial small grains

In our field plots, greenhouse and shadehouse, which is a sort of halfway house for tender new plants, we are maintaining and expanding a collection of annual and perennial species: wheat, triticale, intermediate wheatgrass, tall wheatgrass, lyme grass, mammoth wild rye, quackgrass, and, increasingly, hybrids between species.

In winter 2001-02, we produced thousands of hybrids in the greenhouse. Most of these were between different species and required rescue of the embryos on an artificial growth medium. For more about this process, see Land Report No. 72, spring 2002.

The plants were kept over the summer and early fall of 2002 in the shadehouse, which is attached to the north side of the greenhouse. In the winter of 2002-03, most hybrids were hybridized back to the parent species, either the annual or the perennial, or to both.

In the season just past, about 500 plants have been generated from rescued embryos, and about 250 mature seeds have been produced. We are maintaining plants and seed of hybrids and so-called backcross plants as a genetic resource for breeding fertile, genetically stable, perennial plants that produce grain.

In addition to crossing wild perennials with annuals, we are also directly domesticating into a grain crop the perennial intermediate wheatgrass. This continues a

Scott Bontz. After pulling quackgrass from a pot, Sheila Cox tears away rhizomes. These are the underground stems by which some perennial plants grow and spread. Quackgrass makes them profusely, and The Land Institute is hybridizing this species with wheat to begin possible transfer of rhizome genes into our most important food grain.

10-year domestication program by Rodale Institute and the U.S. Department of Agriculture. We will select for increased grain production, larger individual grains, grains that thresh free of the indigestible hull, and other traits.

Perennial sorghum

In our greenhouse and field plots, we have perennial, winterhardy sorghum plants from previous breeding efforts. These plants are more robust than their original, wild parents, johnsongrass, and have much larger seeds. We have other plants that are hybrids between these perennials and annual grain sorghum lines that have large seed and good food quality.

We have some large populations that contain, at various frequencies, genes for winterhardiness, large seeds, light grain color, early flowering and short stature, but not necessarily all in the same plant. Through selection in the population, we will increase the frequency of all of these desirable genes and eventually bring all of the traits together. In summer 2003, we are harvesting seed from the most crop-like plants.

In spring 2003, we sowed a three-acre crossing nursery that contained the best winterhardy plants, the good agronomic, crop-like lines, which we are testing for grain yield, and domestic grain sorghums. We have made hundreds of pollinations among these over the summer.

Perennial legumes

The wild perennial Illinois bundleflower is easy to establish, produces abundant, protein-rich, non-toxic seeds, and can move nitrogen from the atmosphere into the soil's organic matter, potentially eliminating the need for applied fertilizer.

Although some collections of Illinois bundleflower produce much seed, most of it shatters from the pod and falls to the ground before it can be harvested. The small seed size alone makes mechanical harvesting difficult. Our collection and evaluation of seed from plants growing wild across the Great Plains has identified high-yielding, large-seeded and shatter-resistant populations. By combining shatter resistance and large seed size from some collections with the high seed yield from

Scott Bontz. On the opposite page, Stan Cox works his way through a sorghum plot. At left, he pulls out a head of a perennialized sorghum from a paper bag to see if it is shedding pollen. In the few hours that it remains viable, Cox harvests bags of collected pollen and puts them on the heads of crop-quality plants that have been manipulated, either genetically or physically, to prevent self-fertilization. Offspring with desired traits build The Land Institute's gene pool and breeding program for a sorghum of food-quality, agricultural quantity and resilient perenniality.

Scott Bontz. The blossoms of Illinois bundleflower are small and particular about when they will pollinate. We are testing how to best control pollination so this wild, perennial legume with high seed yield can be bred for agriculture.

other collections, we will take a big step in bundleflower's domestication.

But in plant breeding, combining traits requires the ability to make cross-pollinations, and controlled cross-pollination has not been done in bundleflower. Small, fragile flowers and natural self-pollination make it particularly challenging. In summer 2002, we experimented with several promising techniques for making crosses. For details, see Land Report No. 74, fall 2002. This year we are watching the offspring of those crosses in the field for results and are experimenting with additional techniques. If the methods prove useful, we will start crosses to combine the trait of high seed yield with large seed size and shatter resistance.

Because Illinois bundleflower will be a new grain, research on how to use it is critical. In the past year, we began collaboration with researchers in agronomy, crop breeding, animal science and food science at the University of Minnesota to fit bundleflower into human and animal diets. Initial nutritional analysis showed extremely high levels of antioxidants, which are linked to cancer prevention. A feeding trial with pigs is under way. This summer we are growing several thousand pounds of seed that the Minnesota researchers will use in additional feeding and food science experiments.

Another legume, the well-loved chickpea, might be made a perennial. In cooperation with Clare Coyne of the USDA's Agricultural Research Service in Pullman, Washington, we established field observation plots of several perennial species that are closely related to the domestic chickpea. Observing the growth, development, survival and seed production of these species under Kansas conditions is the first step in attempting to develop a perennial version.

Perennial sunflower, compass plant, and *Liatris*

We are evaluating more than 1,500 Maximilian sunflower plants produced from 100 samples collected across Kansas. This is a perennial that we are trying to breed with grain-producing annual sunflower. Traits that we are looking for in perennial parents are reliable germination, compact growth, flowering near the same time, disease and drought resistance, good seed yield and long life. We'll also seek plants that reach peak productivity quickly and maintain it for several years.

We have hybridized one strain of Maximilian sunflower with two lines of annual crop sunflower and are working on new hybrids.

To increase the success of our interspecific crossing, we tried crossing both parents first with *Helianthus tuberosus*, a perennial commonly known as Jerusalem artichoke, as a "bridging species." That's because it is easier to cross either of our two species of interest (annual and Maximilian sunflower) with Jerusalem artichoke than with each other. Results are not in yet.

We have begun to evaluate the grain crop potential of several other members of the sunflower family.

Silphium is a genus of large, sunflowerlike species that have a reputation for drought tolerance. They also have very large seeds, though not many seeds per head, because most of the individual little flowers packed on the head have only male parts, for pollen production.

Silphium laciniatum, compassplant, caught our attention several years ago because it has large seeds and taproots that can go 15 or more feet deep. The recent discovery of a mutant with more fertile florets makes a grain-yielding *Silphium* more promising. We and our collaborators collected *Silphium* from 70 locations, mostly in Kansas but several in Texas. We sowed them in an observation plot in fall 2002, and they appeared good this year. Seed from vigorous specimens will be evaluated in large-plot experiments by 2005, once seed supplies have been built up. In the meantime, we will begin to make crosses with the mutant and various *Silphium* species.

Scott Bontz. Sunflowers of different species and seed characteristics, assembled in our greenhouse. The bags are for controlling how the plants pollinate and what results. We're aiming for a sunflower with many big seeds and plants that live for years.

Where We Are

The Land Institute is a few miles southeast of Salina, Kansas, near the center of the contiguous United States and the once vast prairie after which the institute's agriculture is patterned.

We have river bottom cropland and rolling prairie. You can see research plots spring through fall, and a greenhouse packed in winter. In all grow the new plants being bred to save our soil and water while still yielding good amounts of seed to feed our growing population.

We're happy for people to visit. You can take a self-guided tour, or call and have a staff member explain the place and process. Dial 785-823-5376 weekdays.

From east or west, you can reach Salina on Interstate 70. From there take I-135 south to Schilling Road, go east 1¼ miles to Ohio Street, south a mile to Water Well Road, then east 1½ miles on gravel to our office at the top of the hill. From the south on I-135, go east on Mentor Road a quarter mile to State Road 104, north 2 miles to Water Well, then 2½ miles east.

Salina has air service, but Wichita and Kansas City are less expensive. Greyhound serves Salina going east and west.

Terry Evans. A view of much of The Land Institute, looking northeast. The bottom half of the picture is the former Wauhob farm, now used for plant studies and breeding as well as farming. In the tight cluster of buildings at upper right is our office, greenhouse, workshop and storage shed. To the left of that is our 160 acres of prairie. Running through the scene is the Smoky Hill River and Water Well Road. We also have a 72-acre farm to the west. There we gradually devote more space to breeding plots as our plant gene pool grows. To the north is 208 acres for restoration and eventual study of our perennial crop plants in sloping ground, where they will be most valuable at controlling soil erosion.

Where We Are Going

Wes Jackson

Imagine you're reading this 100 years from now.

Early May: Rain. Three days in a row now, and into the night it kept coming. The south bottom is flooded. Half-Day Creek was over its banks and had spread into the east pasture this morning when Dad moved the yearlings. More rain is in the forecast.

It's calving time. Eight have arrived and there are four more to come. This is the family's concern. It is not soil erosion, or muddy washes or replanting corn after such weather. All of these are memories held in family lore.

The rain is relentless but welcome. The two-year drought is over. Last year's precipitation, less than half the average, has been recouped with rains of the past month.

The drought had not seriously cut last year's yields. Farmers now have mixtures of perennial plants whose varying root architectures are nature's designs to handle drought, absorb water and manage nutrients efficiently.

Some reach 10 feet down and more; they use water stored earlier. Now, in a downpour, those roots hold the soil, and everybody in the house this morning knows that the soils on the farm are weatherproof.

It was not always so. They knew of the 50-year transition their grandparents made on this land. Gone from the rolling Midwestern countryside are the monocultures of annual crops. Corn, soybeans, wheat and other former annuals have been perennialized and are grown in mixtures.

But with the perennial root mixtures anchoring grain crops now, for the first time in 10,000 years farmers are not forced to roll dice against gravity.

They had won rarely. Less than a century before, the farmer who stayed with it was like the gambler who stays at the casino betting against the house. Because wind and rain are the norm, anyone with annual crops on sloping land lost soil. And no matter how deep, there was only so much good soil to lose.

Farming with annual plants like corn and soybeans, there was little living cover from fall to mid-spring to stop soil erosion. And with the soil went fertility. The annual crops with their often small and temporary roots leaked nitrogen fast. Naturally occurring nitrogen, and then the artificial substitute that fed unsustainably high yields, ran off in streams to both create and expand scores of "dead zones" in the seas, even when minimum or no till methods had become widespread.

Controlling erosion and runoff became a major challenge as prices for liquid fossil fuels escalated. No matter that farmers had priority to use such fuels once food was seen as a necessity instead of a commodity or weapon. As incentive increased to reduce input costs, decreased application of chemicals revealed the industrial era's impoverishment of natural soil fertility. Replenishment would require time, natural processes and better practices.

□ □ □

Late October: The combine whines through harvest, mowing a mixture of nearly even heights of perennial corn, sorghum, sunflower and soybeans. The shelling of the corn ears creates a rasping sound. A digital readout in the cab tells the farmer-operator that the bin is full. She signals her teenage son, waiting in the pickup, to pull the wagon alongside. With a lurch, the combine's auger starts and pours the grain into the wagon. The farmer returns to harvest, and the boy heads to the local co-op, where a combination of shaking screens and the centrifugal force of a rotating drum separates seeds into a bin for each kind.

By Thanksgiving, all of the fields of these modern domestic prairie patches will have been harvested. The sunflower seeds are pressed for oil, refined for on-farm diesel engines. The farm makes its own fuel.

What makes this a different agriculture is not the aboveground drama at harvest, which is still industrial. It is the shift of attention over the past century to processes below the land's surface.

With the perennial polyculture arrangement, farmers and agricultural scientists alike have combined the skills of naturalist, ecologist and farmer. This new agriculture arose when ecologists forcefully emphasized that the land before agriculture was mostly covered with perennials in mixtures—the story for millions of years. Soil abuse began when agriculture was introduced, reversing the land's cover to short-lived annual plants. Scientists recognized the need for grains' plentiful calories to feed large populations. But to sustain them would require perennial roots. They committed themselves to a challenge whose practical results would not come in their lifetimes. They teased their colleagues by wearing T-shirts that read, "If you expect to finish your work in your lifetime, you're not thinkin' big enough."

Genetics and plant breeding recovered; both disciplines had been in decline. This new generation of geneticists and breeders first perennialized sorghum, followed by sunflower and wheat and later corn and more. Domesticated were the wild perennial legumes Illinois bundleflower and chickpea and members of the wild composite genus *Silphium*.

Other disciplines joined the effort—plant ecologists,

Scott Bontz. Storm clouds over The Land Institute's 160-acre prairie.

soil ecologists, landscape ecologists and students of environmental history. As perennial crops were being developed, ecologists worked with analogs and prototypes of the various species in combinations. Later they and their intellectual and philosophical descendents worked with the perennialized crop plants themselves. The need to know the vegetative history of various landscapes across the ecological mosaic turned environmental history into one of the most practical of all disciplines.

Biographers' attempts to derive psychological profiles of these agricultural pioneers were unsatisfying. They did believe that it was within their power to help solve humanity's oldest environmental problem. They knew that sustainability in agriculture had to come first, because standing behind agriculture were the disciplines of ecology and evolutionary biology. The industrial sector, a product of human cleverness and lots of nonrenewable, energy-rich carbon, had no such discipline. Finally, they knew how to begin, and they did. It amounted to a history-making change in collective will.

Historians have explored this shift that began about 2000:

1. Culture at large became conscious that ten millennia ago most of the land of the planet had been covered with perennial plant mixtures. Such ecosystems tend to preserve ecological capital.

2. Discoveries of new oil deposits no longer kept pace with increased demand. A person born in 1936, who had lived two-thirds of a century by 2003, had been alive while 97.5 percent of all the oil ever pumped had been burned. No alternative technology could match the quantity and convenience of liquid fossil fuels. The food supply of humanity depended to a large degree on such fuels. Many of the young concluded that agriculture needed a new paradigm. They began to explore the efficiencies inherent in the natural integrities of wild ecosystems, aiming for these efficiencies to offset the fossil fuel energy then being used for traction, fertilizers and pesticides.

3. The biodiversity of the planet was crashing as more human mouths arrived. Some ecologists argued that to save biodiversity, humans would have to intensify agriculture "where the land is already screwed up," as one put it. Others insisted on bringing processes from wild diversity to the farm and changing the agricultural landscape. Rather than trying to subdue nature, the promoters of the new paradigm posed three questions to land use: What was here? What will nature require of us here? What will nature help us do here?

4. These questions led students to systematically examine landscapes between the extremes of ecological and historical determinism. Ecological determinism must prevail in the most fragile environments. To farm there loses ecological capital, so the original vegetative structure must prevail. But in valley agriculture where flooding replaces fertility and erosion is not beyond replacement levels, such as the Nile before Aswan Dam, annual monocultures grown in rotation can work. Unfortunately, very little land is in this latter category. Farmers had to begin learning where on the continuum their land lay.

5. A major cultural barrier began to fall. Agricultural scientists had the necessary burden of being prescriptive. Ecologists had the luxury to participate in the tradition of descriptive science, with Copernicus, Galileo, Newton, Darwin and Einstein. We now see the results of this luxury to have yielded knowledge of practical value. The merger of these two cultures provided the skeleton of the new paradigm.

6. Funding in university departments, particularly in agronomy and crop science, had withered as biotechnology expanded. Offices, laboratories, growth chambers, greenhouses and acreage were all in place, but with little funding to support the research of plant breeders, plant pathologists and soil scientists. Leverage of these public assets was slow at first. The idea had to be sold that it was possible to develop an agriculture in which progress could be measured by its independence from the extractive economy.

With the reward running to the farmer and the landscape rather than to the suppliers of inputs, the social justice issues in the food system began to be addressed.

The timing was perfect for solving the 10,000-year-old problem of agriculture:

- Knowledge accumulated in ecology and evolutionary biology over a century was available to be taken off the shelf and applied to agriculture. Long-standing management practices of pastures, including the role of fire and grazing, were easily translatable to managing perennial grain polycultures.

- Molecular markers, chromosome "painting," and embryo and ovule rescue enabled geneticists and breeders to select perennial plants with good grain production from hybrids between species that had previously been considered incompatible. (They did so only if it was ecologically sensible.)

- Computational power increased the ability of researchers, from those analyzing genomes to those modeling species assembly in ecosystems. The genome of corn was sequenced, followed by other major crops. This helped not so much to advance transgenics as to increase subtle understanding of the genome as a whole.

- Almost precisely at the time this new paradigm for agriculture was seen as feasible, Green Revolution technologies had added another serious ecological consequence—about 150 dead zones, hypoxic areas largely caused by nitrogen from agriculture.

The time was right in about 2000 to begin to see our land with new eyes. The people who understood causes and solutions had begun to influence citizens and their policy-makers. The improved health of rural and urban citizens was a derivative, but that is another story.

Prairie Festival Tapes

From September 20-22, 2002, at The Land Institute

Tape	**Quantity**
Natural Systems Agriculture Round Robin *Land Institute scientists*	_______
Pharmaceutical Plants and Their Threat *Margaret Mellon*	_______
Getting Over Pesticides *Monica Moore*	_______
Future Harvest: Fatal or Otherwise? *Wes Jackson*	_______
Join the Home Team *Kamyar Enshayan*	_______
The Farmer as Conservationist *Catherine Badgley*	_______
A Conversation with Corn *Claire Cummings*	_______

Total individual tapes _______ x $8 =	_______
Complete set of tapes _______ x $50 =	_______
U.S. handling and shipping: $2 for first tape, 50 cents for each extra, $18 maximum	_______
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Why and When to Meet Us for a Festival

You'll see and hear farmer and writer Wendell Berry, native American activist Winona LaDuke, *When Corporations Rule the World* author David Korten, *Native Son* Mas Masumoto and innovative farmer Charlie Melander. You'll enjoy Kansas food prepared by a California chef. You'll get to dance.

And you'll not be alone in the wilderness: People who celebrate The Land Institute's Prairie Festival share a caring about sustainable living and our land, and they say these warm people are the best thing about attending.

We invite you to be part of it, the 25th Prairie Festival, September 26-28.

Institute scientists will tell what they've achieved since last year's festival, and founder Wes Jackson will present his annual inspirational.

The festival will open with a barn dance Friday evening, September 26. You're welcome to visit and jam afterward. If conditions permit, we'll have a bonfire. Primitive camping is free.

Saturday will be an all-day happening, with talks and music, tours of plots where we're developing perennial grain plants, and supper with food grown in Kansas and prepared by Donna Prizgintas of Southern California, who has been a private chef to Hollywood celebrities. Then there will be a road trip to the Salina Art Center for photos of Field Museum specimens by Land Institute board member Terry Evans (see opposite page), and paintings of natural artifacts by Mary Kay.

Displayed through the weekend at the institute will be art by Salina's Priti Cox, whose work *The Invisible Hand* appeared on the back cover of the fall 2002 *Land Report*.

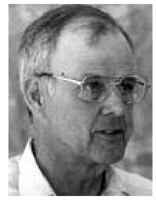
Following a morning of talks, the festival will conclude at noon Sunday.

A registration form is on the following page.

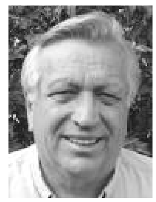
We hope you'll come and bring along friends. We want to make The Land Institute's audience bigger and younger. It's time to add new members to the choir.

Opposite: Terry Evans. The Prairie Festival will include a trip into town for an art show called re*collection*. This is Terry Evans' large-format photos of Field Museum plant and animal specimens, and Mary Kay's scores of paintings of natural artifacts. There will be art displayed at The Land Institute, too, by Priti Cox.

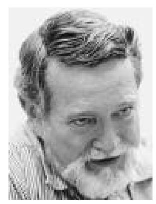
The Speakers and Their Topics



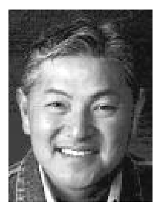
Wendell Berry
Reading from his *Citizenship Papers*



Wes Jackson
Life on the Farm: 100 Years Hence



David Korten
The End of Empire and the Step to Earth Community



Mas Masumoto
The Memory Economy—Farmer/Artisan Stories and Microbrewed Peaches

Charlie Melander
Farming Well: Buying Time Until Natural Systems Agriculture is Ready

Winona LaDuke
Topic unannounced. LaDuke was the Green Party's 2002 vice presidential candidate and wrote *All Our Relations: Native Struggles for Land and Life*.

I MANAGE BY STORIES. My fruits begin their journey with a history of tales, a series of linking poems about the earth and human hands."

—Mas Masumoto,
who will speak at the Prairie Festival

Registration for Prairie Festival, September 26-28

Friday evening barn dance only ______ x $ 5 = ______
Saturday (includes dance)
Friends of the Land ....______ x $12 = ______
Others ....______ x $16 = ______
Sunday (includes dance)
Friends of the Land ....______ x $ 6 = ______
Others ....______ x $ 8 = ______
Student rate, $10 for weekend,
not including dinner ....______ x $10 = ______
Attending: ❐ Saturday ❐ Sunday
Children under 12 attend free ....______ x $0 = ______
Dinner Saturday evening,
to be paid by September 19 ______ x $10 = ______
Vegetarian (not vegan) meal? ❐ Yes ❐ No
Enroll as Friend of the Land, one year,
tax-deductible, $25 minimum. (You are already a Friend of The Land if you have given since September 25, 2002.)................$ ______
Additional tax-deductible contribution ....$ ______
Total enclosed **$** ______

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To register by phone, call 785-823-5376 from 8 a.m. to 5 p.m. Central Time weekdays.

Names of those attending:

____
____
____
____
____
____

Street ____
City ____
State ____________________ Zip _________________
Phone (day) ___________________________________
(night) ___________________________________
E-mail ____
How I learned about Prairie Festival 2003:
____

We will not confirm your reservation. Programs, nametags and meal tickets will be at the registration desk.

❐ Send map.

The Land Institute
2440 E. Water Well Road, Salina, KS 67401
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What Will Come After Fossil Fuels?

Marty Bender

Instead of flexing our muscles in Iraq, we should be using our brains at home. The invasion of Iraq will increase our political access to Persian Gulf oil—two-thirds of the world's reserves. However, that oil will eventually run out, as will other fossil fuels like natural gas and coal.

Around 2025, give or take a decade, humans will have consumed half of all conventional oil resources that ever existed on Earth. With the rest increasingly hard to pump, production will begin to decline, leaving us vulnerable to a global economic crisis as oil supplies tighten and prices climb.

We should develop other energy sources now, while we still have abundant fossil fuels to do it.

Also, the sooner we adopt environmentally benign energy sources, the less we will suffer from the problems caused by the use of fossil fuels—ozone pollution, acid rain and global warming. Global warming may not be obvious now, but geologic evidence warns us that the greenhouse effect from burning all of the planet's oil, natural gas and coal reserves could easily melt enough Antarctic ice to raise the sea level 200 feet. This would submerge the nation's coastal areas containing major cities and producing one-third of the gross domestic product.

Which energy sources are to replace fossil fuels?

We should take a cue from U.S. insurance companies and drop nuclear power. Insurers have never been willing to fully cover the potential liabilities of reactors' huge risks. The nuclear industry would not exist except for repeated congressional acts since 1959 limiting commercial liability for accidents and sabotage. Claims of safer designs are irrelevant as long as the industry refuses to operate without a liability limit.

Another energy source is fusion, which powers our sun, but engineering difficulties indicate this is at least half a century from being commercially viable. And although predicted to be safer than nuclear fission, it will still have huge risks that require unacceptable liability limits.

Without nuclear power, fossil fuels must be replaced by renewable fuels and solar energy.

This transition will be hard. It takes energy to get energy, and we do not get as much energy back from renewable energy sources as from fossil fuels. During the past century, the U.S. economy has largely been powered by fossil fuels that returned as much as 100 times the energy spent taking them from the ground. In contrast, the ethanol in your car's gasohol barely contains more energy than was needed to make it from corn. Other renewable fuels are only slightly better. At most we get back 10 times the energy consumed in building things such as wind turbines, hydroelectric dams and solar cells.

This means we cannot expect renewables to produce the amount of energy our economy now consumes.

So we must aggressively pursue efficiency and conservation, reducing our consumption to what can be met by renewable sources without slowing our national economy. Our vehicles could get much better fuel mileage, and there is great room for more efficiency in commerce and manufacturing. Things such as double-pane windows, ceiling insulation and passive solar housing have high energy returns, often saving 25 to 100 times the energy used to make and install them.

Concerned, dedicated citizens and strong political leadership will be needed to launch this effort while fossil fuels are abundant. Our descendants will not forgive us if we squander this opportunity and leave them to make an energy revolution in crisis.

With the Prairie Writers Circle, The Land Institute invites, edits and distributes essays to newspapers. We appreciate receiving clippings of published pieces, or e-mail about them. Our address is theland@landinstitute.org. For all essays as they are released, see our web site, www.landinstitute.org.

Thank You to Our Contributors, March Through July 2003

Thousands of tax-deductible gifts, from a few to thousands of dollars, are received each year from individuals and private organizations to make our work possible. Our other source of revenue is earned income from interest and event fees, recently about 6 percent of total. Large and small gifts in aggregate make a difference. They also represent a constituency and help spread ideas as we work together toward greater ecological sustainability.

Thank you to you, our perennial friends.

The first section of contributors below lists Friends of The Land who have pledged periodic gifts. Most have arranged for us to deduct their gifts monthly from their bank account or credit card. They increase our financial stability, a trait valuable to any organization.

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The Writers and Photographers

Jerry Glover, Stan Cox, Lee DeHaan, David Van Tassel and Marty Bender are Land Institute scientists. Glover is a soil scientist and ecologist. Cox, senior scientist, is a plant breeder concentrating on small grains and sorghum. DeHaan is breeding small grains and legumes. Van Tassel focuses on the sunflower family plants. Bender ran the 10-year Sunshine Farm project and studies energy in agriculture. Wes Jackson is the institute president. Terry Evans is an institute board member and the arts associate for *The Land Report*. Scott Bontz is the report's editor.

Scott Bontz. Sam Siegrist harvests wheat in Charlie Melander's field southwest of The Land Institute. Between the light swaths of wheat are bands of perennial grass that Melander planted on contours to help control erosion. He'll talk September 28 at the Prairie Festival about how to farm until The Land Institute's agriculture of perennial plants in mixture is ready.

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