The Land Report

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25th Anniversary Issue

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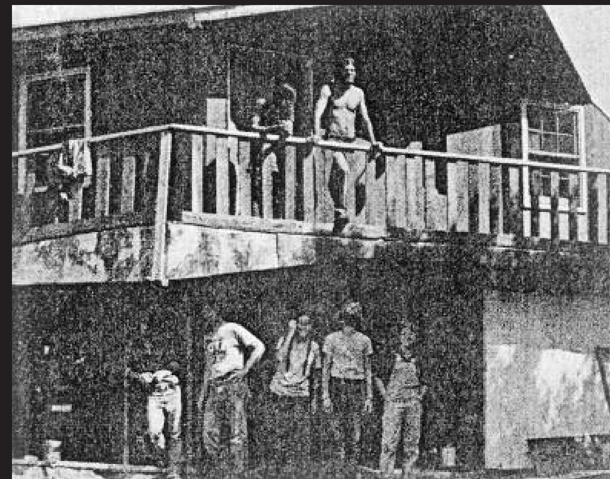

Our Mission Statement

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: Terry Evans. On Oct. 16, 1976, six weeks after our first session began, fire destroyed the classroom building, which had all of the books and tools. This picture was taken three weeks later, Nov. 6. The previous day, 15 friends of The Land worked from daylight until dusk on a log structure at the site of the burned building. Eight returned to work through the next day and raise two walls. The logs were power poles felled by an ice storm. The window and door jams were made from railroad ties. Planks purchased from the county when the bridge near the Land was rebuilt became stringers and ceiling joists. The construction crew on the week-end effort included Wendell Nickell, Steve Burr, Charlie Marsh, Steve Hetzke, Ken Baker, Dick Courter, John and Karen Black, Fred Elliott, John Simpson, Jim Rhodes, Steve Palmer, Jim Lawrence, Rob Mohler, Tim Frend, and Laura, Scott and Wes Jackson. Photographs from The Land Institute's 25 years begin on page 9.

Above: Gayle Giesecke. The class-room building that burned.

Back cover: Scott Bontz. Longhorn Lydi and her calf this spring. Freckles, a bull loaned to us, impregnated 27 of the 28 cows and heifers. Two calves died before or soon after birth. The other 25 are growing, and all the mothers are fine. Freckles is with them again this summer.

The Land Report is published three times a year.

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Energy in Agriculture and Society: Insights from the Sunshine Farm

Marty Bender

The importance of national food security dictates reducing farmers' dependence on fossil fuels. As part of The Land Institute's mission to use nature as measure for developing sustainable agriculture and culture, the Sunshine Farm explores farming without fossil fuels, fertilizers or pesticides. This 10-year project is in its last field season of data collection, to be followed by several years of analysis, research publications and a book.

We measure Sunshine Farm energy dynamics by weighing all that goes into and out of it. Inputs used on the farm are made either by industry or by the farms themselves. For inputs made by industry, our computer accounting framework converts the weight of each farm input to an energy value based on what it takes to mine, process and fabricate raw materials and ores into finished products. For inputs produced on the farm, embodied energy is calculated from the material and fuel used.

Our accounting shows the Sunshine Farm could supply about 40 percent of its embodied energy needs through animal feed, electricity and biodiesel fuel. A 4.5-kilowatt photovoltaic array turns sunlight into electricity for tools and electric fencing. About one-fourth of the cropland is devoted to soybeans and sunflowers for biodiesel fuel that could be commercially processed to cover all of the farm's field operations and off-farm transportation. The solar panel and biodiesel fuel are renewable, producing more energy than they consume.[1] The farm's oats, grain sorghum and alfalfa have fulfilled almost three-fourths of feed needs for its draft horses, beef cattle and poultry. The remaining 60 percent of the farm's embodied energy needs comes through buying and importing things such as commercial feed and seed, buildings, fences, water lines, tractors and the solar array.

These results do not factor in a farm family's demands, an unknown ranging from the austere Amish to typically affluent Americans, although we do keep track of human labor on the Sunshine Farm. Nor do they include the food processing, marketing, distribution and preparation that nationally consumes more energy than farming.[2] We aim to determine how much energy farms can supply for their inputs. Involvement of family and commerce is not unique to agriculture, but common to all industrial activity. They are social considerations beyond the scope of our project.

The purpose of the renewable energy technology in our project is to reduce our dependence on fossil fuels but not our dependence on local energy systems. Virtually all farms are part of the local community in many ways, and energy is no exception. For example, from our study we learned that high-quality biodiesel fuel, for which engine manufacturers would guarantee their engines, can be produced by farmers' co-operatives, but not by individual farms producing various, unregulated home brews. Also, although our photovoltaic array has a bank of batteries and could stand alone, it is connected to the power company grid to sell excess electricity. Incidentally, we don't account this excess as a Sunshine Farm output, because increasing array size could artificially enlarge measured productivity.

Just as important as income from excess electricity is its availability to community. Given limits of energy production in an all-solar future compared with current conventional technology, it will likely be considered uncivic to own an electricity source near but unconnected to a grid. This would squander some of the hard-won, solar-based energy embodied in the manufacture of the technology. Since any solar technology exposed to the weather will slowly deteriorate whether or not it is used, there would be little gained from using its energy only when the owner needs it. The obligation to sell excess electricity would be quite contrary to the current popular aim of achieving energy self-sufficiency to disconnect from the grid. This notion is made possible by the current abundance of fossil fuels and minerals embodied in renewable-energy devices.

Agriculture's potential to provide energy as well as food for society can be seen in various farms and national systems' energy balances. The energy balance of a farm is the caloric energy of its marketed outputs divided by the embodied energy of its purchased inputs. The outputs and inputs are qualitatively different types of energy, but in this measure their unit, the calorie, is the same.

The Sunshine Farm's energy balance of 1.7 compared well with other mixed crop and livestock farms. Amish farms in Pennsylvania and Wisconsin ranged from 0.7 to 1.6.[3] Conventional farms near the Amish farms were lower, 0.3-0.6.

This strong contrast between Amish and conventional farms includes the fact that the former also provide the energy for their field traction, raising draft horses fed by their crops, while the latter do not make their tractors and fuel, but purchase them.[4]

The Sunshine Farm's energy ratio was higher than Amish farms' partly because of what it takes to feed animals. The Amish have more of them and so incur large metabolic energy losses. But when they practice intensive animal production, the Amish aim is not high energy ratios, but income.

Another reason for the large energy ratio of the Sunshine Farm is the low amount of purchased inputs — no synthetic fertilizer or pesticide, no irrigation. Less energy-intensive production helps yield a higher energy ratio.

A wide range of energy balances appears across countries. (See first table.) The agricultural structure of industrial countries is generally a mix of conventional crop and livestock production, and their energy balances 1.0 or less.

As farming has become more energy-intensive, energy ratios have declined. In 1940, the United States' energy ratio was 2.3, but with the widespread adoption of commercial fertilizers, pesticides and irrigation, it declined to 1.0 by 1974 and 1978. China's agriculture has rapidly increased its use of commercial fertilizers and other inputs, resulting in a ratio of 1.2 in 1978. This value reflects an industrial economy instead of one that relied mostly on peasant farming methods as late as the mid-20th century, as described in *Farmers of Forty Centuries.*[5]

The 1978 ratio for the United States came from surveys by the Department of Agriculture after energy price shocks of the 1970s, and none has been published since. Recent econometric studies have not provided actual values, but they have shown that energy productivity in United States agriculture has increased since 1980 with improved technology and management, withdrawal of marginal cropland through the federal Conservation Reserve Program, and the economy of scale accrued from larger farms.

Energy ratios for farming are higher in less-industrialized countries like Egypt and Pakistan because of fewer purchased inputs and less machine-harvested crops fed to animals. Australia is an exception among industrialized nations with its high ratio of 3.1. The figure was calculated in the late 1960s but probably has not changed greatly. Much of Australia is dry, and it relies mostly on low-input crops such as wheat, free-range animal raising and extensive use of grazed legume cover crops instead of more costly commercial fertilizer for nitrogen.

These energy ratios are not great enough for agriculture to meet demands both for food and the factories producing farm inputs. Agriculture now relies on embodied energy subsidies. A ratio of 2 would barely fulfill embodied energy needs of a farm growing its own fuel stock, because of unavoidable chemical and physical losses in manufacture.[6] With most output in any country already going to food, it appears that energy ratios for most must be at least roughly 4 for agriculture to cover its inputs. Only then will farm energy no longer be subsidized, and agriculture be regarded as a net energy source.

Countries Compared

Marketed energy outputs divided by purchased inputs for farming.[7]

Country	Year	Energy ratio
Israel	1969-70	0.3
United Kingdom	1950	0.4
	1972	0.3
Netherlands	1964-65	0.5
France	1970	0.7
United States	1940	2.3
	1970	0.9
	1974, 1978	1.0
China	1978	1.2
New Zealand	1978-79	1.4
Egypt	1972-74	1.8
Pakistan	1977	2.9
Australia	1965-69	3.1

Farming's challenge of providing energy for society is immense. Industrial energy sources generally have greater energy returns than analogous renewable sources from agricultural. Petroleum and natural gas have returns of about 10, while renewable liquid fuels from crops generally give 5 or less. (See second table.) Coal's return of 30 dwarfs the ratios of 5-10 for solid fuel from crops.

Energy requirements for crop production and processing account for agriculture's low returns. Conventional forestry is an exception, with balance of about 40, because it requires less input than other crops. However, the United States already consumes the net annual growth of its forests. Conventional forestry will not meet the nation's energy demands.

For electricity, renewable sources including solar cells and wind turbines can match the returns of coal and nuclear power. Burning crops for electricity gives ratios less than 5, although advanced cogeneration of electricity and heat, not yet commercialized, might yield values twice as high.

Using crop residues instead of crops for liquid fuels or electricity would not increase the returns much. This is because wastes should be regarded not as secondary by-products with only collection costs, but as primary products with their prorated share of production inputs.

Agricultural energy ratios can be raised by reducing purchased inputs and increasing marketed outputs. Many farmers have been using less purchased fertilizer and pesticide, mainly to cut expenses. Farms could, like the Sunshine Farm, supply their own fuels and electricity instead of purchasing them. Inputs can also be reduced by using biological efficiencies in crops and animals, such as letting animals obtain their own feed through grazing and foraging, which involve no embodied energy, instead of feeding them machine-harvested grain and hay.

Mixed farm crop yields will not increase under a regime of less commercial input. They are expected to fall a little with diverse farming, which will require more use of land, biological efficiencies and human labor. Substituting fuel crops for feed and food crops will have little effect, since they yield similarly under equivalent practices.

Large output increases would come by switching cropland from supplemental animal feed to food for direct human consumption. Slightly more than half of U.S. crop production goes to animals. Since the feed conversion efficiency of animals is only 10-20 percent, each pound less of animal products derived from supplemental feed would permit an output of 5-10 pounds more human food. There is plenty of slack for reducing the consumption of animal products. Americans on average eat twice the minimum daily protein recommended by the international Food and Agriculture Organization, and two-thirds of it is from animals.

Renewable electricity sources will be particularly important in meeting national energy needs in an all-solar future, since they have greater energy returns and, including solar flat-plate heat collectors, require ten to 100 times less land area than renewable fuels from agriculture. Some energy scholars have presented data showing that conservation and efficiency should make it quite possible to power our current standard of living with renewable energy sources.[8,9] There is hope for an all-solar future that would not sacrifice options for future generations. The research and infrastructure needed for such a future should be accomplished now while we have the luxury of fossil fuels' high energy returns.

A more technical and documented version of this article is on our web site, www.landinstitute.org.

Fuels Compared

Outputs divided by inputs for nonrenewable and renewable energy sources in the United States. A table listing the energy return for each technology is with the article at www.landinstitute.org.

Source	Energy ratio
Liquid and gaseous fuels	
Oil and natural gas	10 or more
Ethanol, methanol, biodiesel, digester biogas, wood gas	5 or less
Solid fuels	
Coal	30
Woody biomass, herbaceous biomass	5-10
Conventional forestry	40
Solar flat-plate heat collectors	2-5
Electricity	
Coal-fired (U.S. average)	9
Nuclear light-water reactors	4
Photovoltaic arrays, parabolic thermal collectors, wind turbines, hydroelectric, biomass-fired	10 or less

[1] We calculated that over its projected 20-year life the photovoltaic array will produce 1.6 times more energy than was consumed in its manufacture and installation, including a bank of batteries and a prorated portion of the power company grid to which it is connected. The 25 percent of the farm's cropland devoted to oilseeds was determined on a net-energy basis in which the gross energy content of the biodiesel fuel is reduced by the energy inputs for raising the oilseed crops and chemically converting them into biodiesel, including amortized embodied energy in machinery and buildings. It is also increased by an energy credit for high-protein meal cake, a by-product from biodiesel production that would be fed to livestock.

[2] The percentage of energy use in the U.S. food system: farming, 18; food processing, 30; distribution, 10; commercial food service, 17; and home food preparation, 25. A.B. Lovins, L.H. Lovins and M.H. Bender. Agriculture and energy. 1995. Pp. 11-18 in *Encyclopedia of Energy Technology and Environment.* Vol. 1. John Wiley and Sons, New York.

[3] W.A. Johnson, V. Stoltzfus and P. Craumer. 1977. Energy conservation in Amish agriculture. *Science* 198:373-378.

[4] An energy analysis of draft horses and biofueled tractor can be found in the discussion section of Bender's article this year comparing the economics of traditional and conventional agricultural systems at a county level in *American Journal of Alternative Agriculture* 16(1):2-15.

[5] F.H. King. 1911. *Farmers of Forty Centuries: Permanent Agriculture in China, Korea and Japan.* Reprinted in 1973 by Rodale Press, Emmaus, Pa. For a quantitative treatment of nutrient data in this book see Bender's 2000 article comparing nutrient return and plant uptake in agricultural systems in *Journal of Sustainable Agriculture* 15:89-105.

[6] D. Spreng. 1988. *Net-Energy Analysis and the Energy Requirements of Energy Systems.* Praeger, New York. See page 222 for table of bioconversion efficiencies.

[7] M. Green. 1978. *Eating Oil: Energy Use in Food Production.* Westview Press, Boulder, Colo. And G. Stanhill. 1984. Agricultural labor: From energy source to sink. Pp. 113-130 in: G. Stanhill (ed.). *Energy and Agriculture.* Springer-Verlag, Berlin.

[8] A.B. Lovins, L.H. Lovins, F. Krause and W. Bach. 1981. *Least-Cost Energy: Solving the CO_2 Problem.* Brick House Publishing Co., Andover, Mass.

[9] J. Goldemberg, T.B. Johansson, A.K.N. Reddy and R.H. Williams. 1987. *Energy for a Sustainable World.* World Resources Institute, Washington, D.C.

The Emperor's New Chromosomes

Stan Cox

The widespread adoption of transgenic plants now under way promises to accelerate the degradation of human health, rural life and the environment. But too many critics are neglecting to zero in on transgenic technology's Achilles heel: its inherent inability to deliver on its promises. Longstanding theory and practice predict, and growing evidence confirms, that transgenes cannot dramatically accelerate plant breeding, let alone revolutionize agriculture, save the family farm or feed the world.

In the the 55th Annual Corn and Sorghum Seed Research Conference proceedings published this year by the American Seed Trade Association, Drs. Major M. Goodman and Martin L. Carson of North Carolina State University add to growing evidence that transgenic technology isn't all it's cracked up to be. Taking a hard look at transgenic corn, the authors — highly respected in genetics and plant pathology, respectively — conclude that it will not speed development of new hybrids, and that its costs vastly exceed those of breeding through sexual hybridization.

How Costs Stack Up

The expense of developing an exotic inbred corn line vs. a transgenic inbred line, not including federal fees, as estimated by Major M. Goodman and Martin L. Carson of North Carolina State University.

Step	Cost: Exotic	Cost: Transgenic
Choice of source/ discovery of gene	$14,000	$1,000,000
Breeding/modification	38,000	100,000
Efficacy testing		50,000
Transformation of model species		50,000
Construct comparisons		50,000
Maize transformation		50,000
Backcrossing		1,200
Total	**$52,000**	**$1,301,200**

No faster, much costlier

Corn hybrids grown in the Midwest set new yield records almost every year. Most farmers and breeders regard the U.S. Corn Belt gene pool as closer to agricultural perfection than just about any other species bred by humanity. But Goodman has spent the past 25 years demonstrating that there remains much to be gained from the vast array of corn varieties grown across the tropics of Central and South America. He has used them to breed competitive, genetically diverse inbred lines — the parents of hybrids — adapted to the United States. His work is considered to be long-range, basic research with strictly long-term payoffs. Some would liken it to taking an Indy 500 car and substituting parts from a 1938 Ford sedan to improve its speed.

Goodman and Carson cite the example of NC296, an inbred line adapted to North Carolina but developed from all-tropical parentage. Released in 1990, it has been used to produce commercial hybrids in the United States and at least two other countries. NC296 took 15 years to develop and five more years for hybrid seed production and distribution — a long process, typical of breeding that uses so-called exotic germplasm, with parents adapted to another part of the world.

But compare that with the timetable for *Bt* corn, the collection of transgenic hybrids that have been making headlines in recent years because they carry a bacterial gene coding for an insecticidal toxin. Goodman and Carson write,

> *Bacillus thuringiensis (Bt)* was used as an insecticide by the 1950s. The first gene encoding the *Bt* toxin was cloned by 1981. ... *Bt* gene regulation was known by 1986. ... *Bt* was [inserted] into corn in 1990. ... *Bt* hybrids were first sold in 1997. Because *Bt* was a well-known entity with a long history of use as an "organic" insecticide, little toxicity and allergenicity testing were required for its initial use as a transgene. Even so, its transgenic use took 17 years.

Of course, *Bt* was one of the very first transgenes commercialized. But the great advances made in biotechnology over the past two decades won't make gene discovery, cloning and transfer faster and more efficient. No matter how quickly one can carry out laboratory procedures, a certain number of plant generations are needed to accomplish any genetic manipulation, and the life cycles of crop plants can be sped up only so much. Goodman and Carson list the steps that must occur before a transgenic strain of corn — with a truly novel gene, not just another version of *Bt* — can even be tested in yield trials:

1. Discovery of the gene.
2. Modification, producing what is known as a "construct" that can be transferred to a new species and, one hopes, perform as expected.
3. Efficacy testing.
4. Transformation of model species.
5. Construct comparison.
6. Transformation of maize plants.
7. Backcrossing the gene into best inbred lines.

These steps occupy nine seasons, more or less. Then, the authors point out, at least as much time is needed to bring the gene to the farmer. That process includes apply-

Christopher Picone: Senior scientist Stan Cox and his daughter, Sheila, cut and bind wheat that he is breeding through traditional crosses and selection.

ing for experimental permits, three years of small-plot trials in different hybrid combinations, Environmental Protection Agency clearance, two years of large-plot trials, inbred and hybrid seed production, and sales. Even with the use of winter nurseries in the tropics to achieve two generations per year, and even if no unforeseen delays occur, Goodman and Carson estimate 10 to 15 years for development and deployment of a hybrid with a new transgene. This is similar to the timetable for developing a hybrid with new germplasm through traditional sexual methods. Many of the steps required to produce the two types of hybrids are the same.

But there is a big difference between the two methodologies: the transgenic hybrid costs at least 25 times as much to develop and release to farmers — 28 times when the current $150,000 in federal permit and clearance fees are included. The table shows itemized costs estimated by Goodman and Carson. Their million-dollar estimate for discovering a new gene is based on the assumption that discovery is "a one-in-10-year event by a $100,000-a-year postdoc or equivalent (including salary and lab costs)." In other words, we are assuming that for every ten postdocs or scientists searching for new genes to clone, one gene per year will be discovered and eventually utilized successfully. The authors don't estimate the number of postdocs and scientists worldwide engaged in such activity, but it is huge, with only a handful of useful genes discovered. So, to date, the cost of a transgenic hybrid has been much, much more than 28 times the cost of other hybrids.

One gene vs. many

Genetic engineering doesn't speed up the breeding process, and it costs a lot more, but it produces plants with new traits that we can't get any other way. *If* the new trait is one that improves the lot of the farmer, and *if* it gives us more or better food on our table, and *if* it protects or restores the rural environment, then something might be accomplished. But the only genes that have been deployed to date are ones that are expected to provide a return on investment for the companies holding the patents. They have not increased farmers' yields or profits, enhanced food quality or improved the environment. Indeed, transgenic technology — that is, single-gene technology — is not equipped to solve complex problems.

For decades, basic textbooks on plant breeding have included a section on something called backcross breeding, a traditional technique for moving a gene from Parent No. 1 into Parent No. 2 while keeping most of the other thousands of genes of Parent No. 1 intact. Sound familiar? Transgenic technology is just a high-tech form of backcross breeding, the only difference being that it can import genes from more distant branches of the evolutionary tree.

Textbooks also tell us that backcrossing is a useful *adjunct* to a breeding program, but that it is limited to producing updated versions of yesterday's crop varieties — nothing truly new. The forces that do produce new crop varieties:

1. Genetic diversity.
2. Recombination, the shuffling of the entire genetic deck that occurs in the production of every egg or sperm.
3. Selection.

These are the forces behind evolution in natural populations as well.

Sexual recombination in diverse crosses almost always produces some offspring with unexpected expression of traits and unprecedented trait combinations. Breeders must sort through large populations to find the "keepers," but the effort is rewarded when unique trait combinations are identified and new varieties developed. Almost all new crop varieties, traditional or modern, have arisen from cycles of hybridization and selection in diverse gene pools, with widespread exchange of seeds, cuttings, tubers, etc. among breeders. Without diversity, recombination and selection, breeding grinds to a halt.

The sacrifice to engineering

Genetic engineering is not simply being superimposed on healthy, well-funded breeding programs, it is undermining them. To understand how, consider the economic tradeoff, based on Goodman and Carson's estimates. To produce as many transgenic hybrids as non-transgenic but exotic ones, a breeding program would need a 28-fold increase in funding. (And, even then, the resulting hybrids would embody far less genetic diversity.) That kind of increased investment is rare. More often, 28 non-transgenic hybrids or varieties will be sacrificed to produce one transgenic product. Here, we should quote Goodman and Carson at length:

> Once the euphoria over the promise of transgenics fades, the closing of so many quality breeding programs, the loss of valuable sales staff, and the centralization of decision-making at company headquarters are almost certain to be regarded as tragic, even by stockholders interested in short-term profits. There are few good investments that are more long-term than rational plant breeding. Repeated studies have shown that very high returns on investment are available from expenditures on [non-transgenic] breeding ... but the returns are not the instantaneous sort favored by the five-year funding plans currently in vogue. The usefulness of a breeding program is probably more dependent on continuity than ingenuity. The probability of great success by any one breeder is small, but the odds of success of a group of reasonably competent breeders working independently and continuously [and, we might add, sharing seed] is high. At present, the evidence that these same rules apply to biotechnology is almost nonexistent.

The seas of corporate and venture capital on which plant biotechnology has floated for two decades will indeed begin to dry up sooner or later. As Goodman and Carson point out, genetic engineering has followed the classic trajectory of all the bandwagons that have come and gone in the history of plant and animal breeding, such as mutagenesis, polyploidy, haploidy, somaclonal variation and ideotypes. It has lasted a bit longer than most fads, maybe because it has a more pronounceable, non-Latin name, but probably because of its patent potential and the flood of investment that it has brought. But before this bandwagon rumbles off into the sunset, it will have dealt serious blows to science, to the environment and to our food supply.

What it Would Take to get Transgenes in Natural Systems Agriculture

Drs. Goodman and Carson's paper was prepared for and presented to a meeting of the American Seed Trade Association, private-sector breeders of corn, sorghum, soybeans and other crops for industrial agriculture. But all of the foregoing analysis applies equally to breeders at The Land and other institutions who are working to develop perennial crops for Natural Systems Agriculture and other systems. Proven techniques, including interspecific hybridization, embryo rescue, chromosome identification, recurrent selection and, of course, extensive field trials, are our preferred methods. Transgenic technology simply isn't necessary.

We could speculate on the potential for transforming annual into perennial plants by gene insertion, but with the meager state of knowledge on the subject, we can go no further. No research to date suggests that perenniality is governed by a single gene, or even two or three genes, in any crop or crop relative. In rye, triticale, sorghum, maize, soybean and sunflowers, it is often observed that unless 50 percent or more — i.e., tens of thousands — of the plant's genes are inherited from a perennial parent, that plant is not perennial. This, along with breeders' failure to backcross a single gene or chromosome conditioning perenniality into any annual crop genotype, attests to the complexity of the trait.

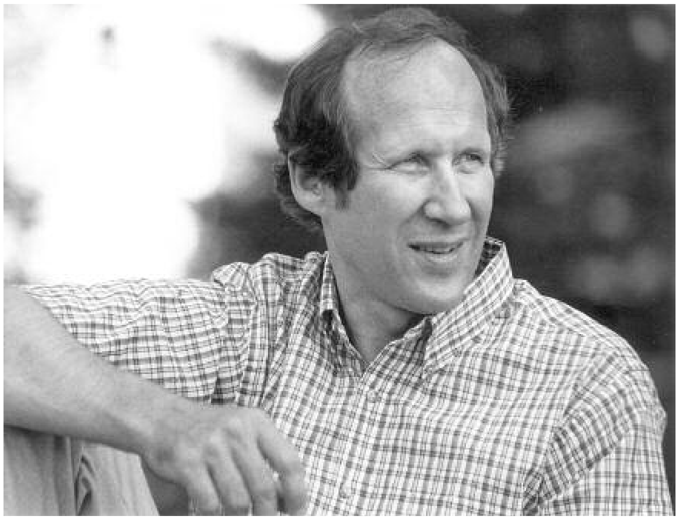
It is not impossible that a gene might be isolated that conditions the perennial growth habit when transferred to an annual plant. But if a perenniality gene is identified in a particular species and cloned, its effect when transferred to any but very closely related species is entirely unpredictable. Transgenic technology conceivably could be used, once perennial grain crops have been developed, to improve their pest resistance, food quality or other more simply inherited traits. But other breeding and ecological methods will always be available, and preferable.

Before we at The Land Institute would consider utilizing transgenic technology, all of the following conditions would have to be met:

1. Any gene to be transferred would be in the same botanical family as the target species and govern expression of a necessary trait that we could not introduce via any other practical method.
2. Resulting varieties would not be patented or burdened by any other intellectual property agreements, so they would be open to public use.
3. In our judgement and that of our Scientific Advisory Team members, the gene and its carrier DNA, and the methodology used to insert it, would be thoroughly tested and represent no threat to gene pools, the environment or human health.

It is clear that none of these conditions come close to fulfillment today for any gene, and we do not expect all of them to be fulfilled for many years, if ever.

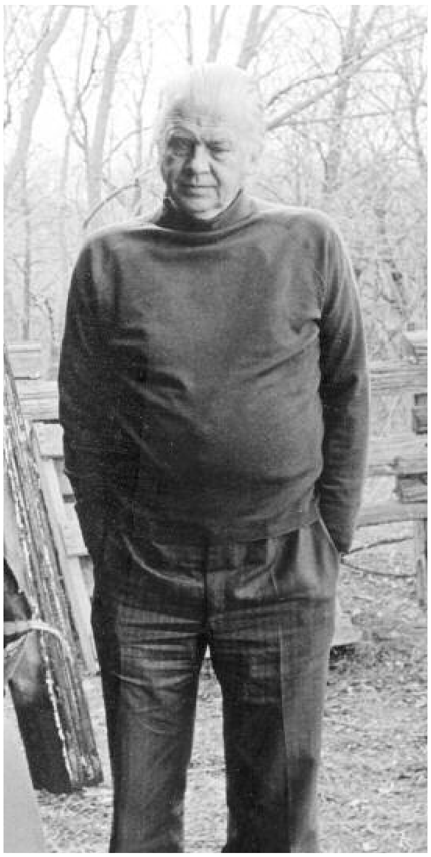
Next issue of the Land Report: Stan Cox and USDA scientist Dick Beeman face off over genetically engineered food plants' effects on health, economics and environment.



The Land at 25

Left: Ann Carlin Ozegovic. John Simpson. At a weenie roast during the summer of 1976, Wes Jackson mentioned to John, then a Kansas state senator, that he was thinking about starting a school. After discussion, John said, “If you want to start a school, Wes, I’ll help you.” John did the legal work to obtain the institute’s nonprofit status, then paid half of the tuition for each of the first students and became a member of the board of directors. With Wes, John is the only founding member still on the board.

Below: Terry Evans. Fire destroyed our classroom building soon after we opened. Two weeks after reconstruction began, this photo was made with the first interns, people close to our heart who stayed on in spite of the fact that no building, no books and only a few hand tools were available. Standing, left to right, are Wes Jackson, Dana Jackson, Sue Leikam, Dave Henderson, Nancy Vogelsberg, Kyle Mansfield and Eric Herminghausen. In front are Russ Brehm and John Lawson. The dog is Sparky.



Above left: Terry Evans. E.F. Schumacher, author of *Small is Beautiful: Economics as if People Mattered*, visited The Land Institute on March 8, 1977, and delivered a public address at the Salina Community Theater. This photo was taken during his tour of The Land.

Above right: Terry Evans. Our first effort to implement sustainable or appropriate technology was a 32-volt, 500-watt generator, bought for $150 in 1977, complete with tower, blades and control box.

Right: Terry Evans. We try building with adobe brick in 1977.

Left: Terry Evans. In 1977 we attempt to make a dwelling out of newspapers, chicken wire and concrete. Left to right are interns John Jankowski and Cindy Jones, and staff member Julio Tomballo.

Below: Terry Evans. Early attempts to analyze the vegetation of a never-plowed native prairie, owned by Nick and Joyce Fent, in spring 1978. From left to right are Jim Peterson, Joyce Fent and Maureen Hosey.

Bottom: Terry Evans. Marty Bender plants the first accessions of eastern gama grass in fall 1978.

Right: John Schwartz. Marty Bender visits Mexico to collect perennial corn in 1980.

Below. Interns Dana Price, Martin Gursky and Ann Zimmerman spread manure in 1984.

Bottom: Wes Jackson. During the early 1980s, we began to establish an herbary. Herbary director Marty Bender and interns planted and nurtured nearly 300 species. Any plant that was herbaceous, perennial, winter-hardy and a seed producer was given at least a 5-meter-long row. These were maintained during research to find the wild plants best suited to answer some basic biological questions. Later, each species was left to fend for itself in what was the herbary. Most species have died out, though a large number persist.

Above. Interns dig a soil profile pit in 1987. From top, clockwise, are Veronica Mecko-Ray, Bruce Kendall, Doug Dittman, Amy Kullenberg, an unidentified Kansas State University host, Patti Boehner and Jess Ennis.

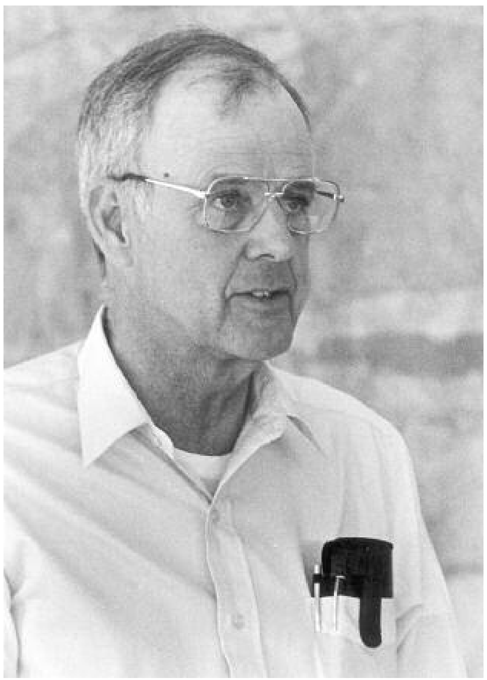
Far left. Orville Bidwell, Kansas State University soil scientist and former Land Institute board member, describes a soil profile.

Left. Ann Zimmerman, a former intern, has been the featured musician at nearly all Prairie Festivals since they began in 1979.

Right. Paul Rasch, former intern and major planner and construction superintendent of our greenhouse, describes the new structure's features in March 1988.

Below. Wendell Berry gives the greenhouse dedication speech.

Bottom. Ginnie Streamer, a volunteer from Maryland, intern Colin Laird, staff member Jake Vail, and interns Pamela Cubbage and Berni Jilka in 1989.



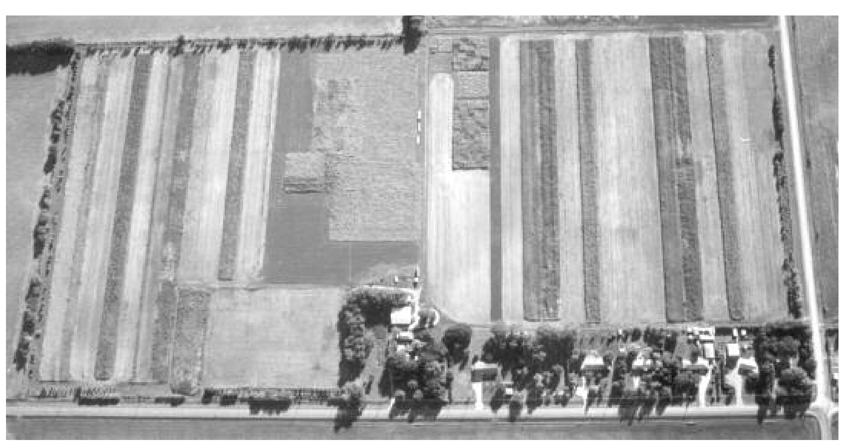
In 1992, “Farming in Nature’s Image,” by Judy Soule, former Land Institute ecologist, and Jon Piper, her replacement, was published by Island Press. This has become a landmark book for those interested in Natural Systems Agriculture.

Left. Jon Piper.

Below. Judy Soule.

Bottom. 1996. Seated, left to right, are interns Jerry Glover, Jim Boyd, Sheri Walz, Tammy Hinman, Aron Gannon and Jon Richardson. Standing are education director Brian Donahue, research assistant Dave Tepfer, and interns Thomas Ruppert and Robin Mittenthal.

Above: Terry Evans. The Land Institute, looking north. On left is the Smoky Hill River. The buildings on the left, from bottom up, are the Big Barn, the Red Barn and the classroom building, the downstairs of which last year became a laboratory. North across Water Well Road is part of the Wauhob family's land that we bought in 1997. This year that acreage featured wheat grown in alfalfa. (See *At The Land* on page 22.) The buildings at right, clockwise from the top, are our office, a building with shop tools, a shed for hay, and the greenhouse. The 160 acres north across the road from that cluster has fenced experimental plots but mostly is pasture for our longhorns. Much of the land between the two building groups is restored prairie. There also is the ground where Prairie Festival visitors camp.



Right: Steve Renich. The Sunshine Farm and homes that abut it. The strips are rotated crops of milo, oats, sunflowers and soybeans.

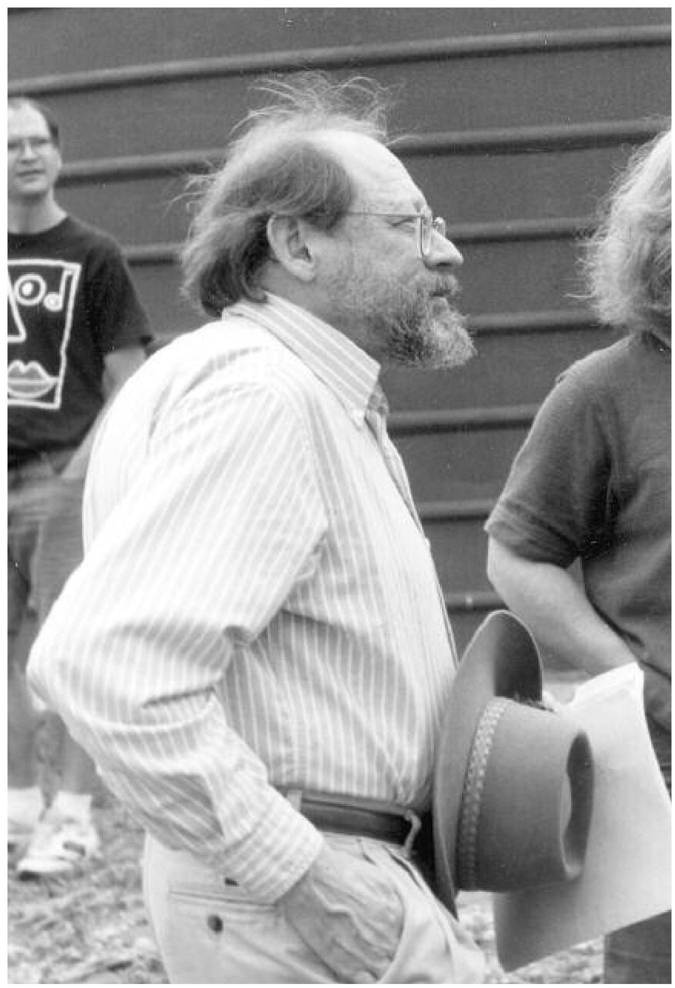
Two decades ago we began to think about comparing the current industrial hard agricultural path and the appearance of a soft one employing more benign technology. This was the seed idea for the Sunshine Farm. Over 10 years ago Dick Austin and Wes Jackson began discussing the possibility of creating the farm. Marty Bender was about to finish a doctorate and would be ideal to head the project. Funding of $50,000 per year was made possible by the Austin Foundation, whose family includes Dick Austin and Sally Cole, who is his cousin and a current board member. This year is our last field season of the Sunshine Farm project. For an introductory comparison of energy balances at the Sunshine Farm and elsewhere, see Marty's story on page 3.

Left. Dick Austin with Kathy Collmer.

Below. Jack Worman drives Percherons near the solar array that helps supply the farm with electricity. Surpluses go to the power grid.

Bottom right. The tractor that used biodiesel fuel on the farm for energy analysis that included comparison with the draft horses.

Bottom left. The farm's rotational cropping.



Top. Interns bundle and stack sorghum at the Sunshine Farm.

Above left. Conn Nugent, right, is chairman of our board of directors. He also is executive director of J.M. Kaplan Fund, a philanthropic foundation in New York. Pictured with Conn is Michael Orr, son of Oberlin College environmental educator David Orr.

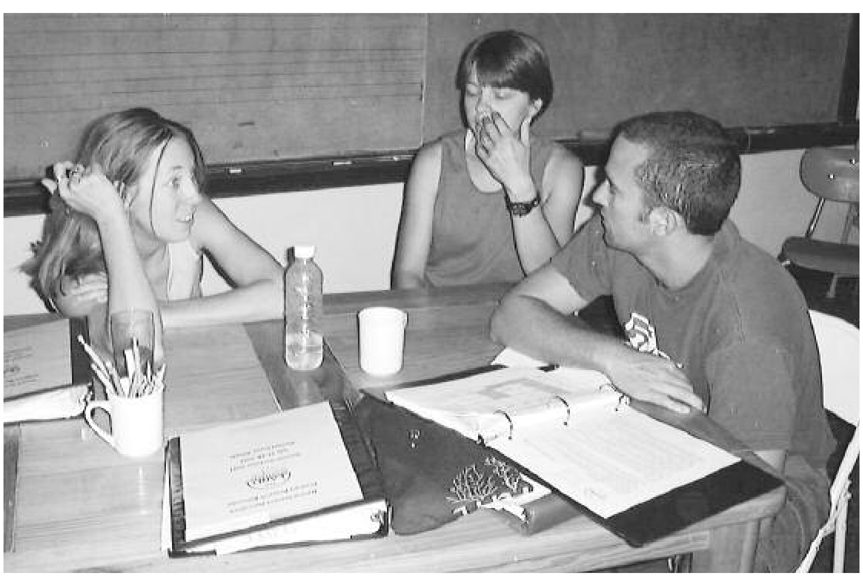
Left. Bev Worster is education director, leading an effort with a consortium of Kansas school districts.

Above: Terry Evans. Don Worster, Bev's husband, has spent the longest time as board chairman, for 10 of our 25 years. He remains on the board. He also is a history professor at the University of Kansas.

Our presence in Matfield Green, Kan., became more formal in 1993. The former schoolhouse was purchased for $5,000 and donated to The Land. Residents, the institute and the larger environmental community use the building. We bought other property in the town, including a former hardware store. It became housing for staff and visitors, and a favorite meeting place for small gatherings.

Left. A home and housing for conference participants, but still called The Lumberyard.

Below: Wes Jackson. The schoolhouse.



Left: Christopher Picone. Left to right: Pamela Scheinost, Jill Liske and Rob Sirrine at our 2001 fellows workshop in Matfield Green. From the fall of 1976 through December 1998 we featured an intern program with students engaged in a broad range of learning. In its last year we launched a graduate fellows program dedicated to expanding within universities our research agenda. Each year for one week these fellows meet for presentations in Matfield Green. Nearly all of these students are on Ph.D. paths. See *At the Land* on page 22 of this issue for details of the fourth fellows workshop. After it are sketches of the nine new fellows' research.

Seeking Harmony Beyond Hard Facts

Wes Jackson

Recipients of last year's Right Livelihood Award were invited to Salzburg, Austria, in July to open a project for sustainable energy and agriculture. The project centers on the thinking and ideals of Leopold Kohr, a major inspiration for E.F. Schumacher, author of Small is Beautiful: Economics as if People Mattered.

In a recent, thoughtful paper, Professor Richard Levins of Harvard University outlines the need for and possibility of "a science for sustainable, humane and productive development."

"The world faces a dilemma," he said. "On the one hand, the peoples of the developing world demand a rising standard of living. On the other hand, if that standard of living and the productive processes to support it take the form of the Euro-North American-Japanese pathway of development, we will destroy our life support system. We can neither suppress the demand for a fair share of the world's riches nor accede to a pathway that sinks us all. Therefore, the only solution is an alternative pathway of development, one which meets the criteria of productivity, justice and sustainability. The world is rich enough and our scientific potential broad enough to make the enhancement of life a criterion for development. Within such a pathway of development, agriculture plays a central role. The design of a pathway of agricultural development that is productive, enhancing of productivity, reliable, equitable in its rewards, enriching for its participants, preserves rural life and participates along with natural preserves in the preservation of biodiversity, is the challenge. The development of such a science is daunting in its complexity. But the study of complexity is perhaps the central intellectual problem of our age. Far from requiring ecologists to sacrifice intellectual concerns for practical needs, such an agenda enriches its intellectual content along with its urgent practical value and allows us to establish new kinds of relationships that combine the detailed, intimate knowledge that farmers have of their own circumstances with the scientific knowledge that requires some distance from the particular."

Impressed by these words of one of America's most respected scientists, I began to incorporate his thoughts into language of our overall mission at The Land Institute. In so doing, I mailed the remarks of Professor Levins to my good friend Dr. Charles Washburn, emeritus professor, School of Engineering at California State University, Sacramento.

His first comments were, "Of course. This must be the future for the less-developed world." But then he continued, "My reaction after pondering it while hiking for a couple of days is, 'There's no way this can happen.'"

And then he expanded: "I'm not comfortable with the assumption that it is inevitable that the human life support system will be destroyed by the undeveloped trying to follow in the Europe-North America-Japan pathway. One can say with at least as much validity that it is inevitable that the human life support system will be destroyed by continual economic growth in the developed countries. I think they (less-developed countries) will never get there but I also think that there's no way they're going to give up a right to try. (I also think there's no way Europe-North America-Japan are going to stay over-developed.) I just can't imagine the less-developed countries buying this prescription from us. I think it would be easier (but highly unlikely) to get Europe-North America-Japan to back off a bit and stop their consumption growth — that would make a lot available for the less-developed countries and would also go a long way towards getting them to accept a bit less."

What are we to do with these opposing viewpoints? Both authors share a common understanding of the problem. Both are highly moral men interested in justice, sustainability and alternative modes of production to meet human needs. Unlike most economists and the lay public, these scientists routinely expand the boundaries of consideration to overlap the boundaries of causation. Both would endorse the idea that the intimate knowledge of farmers needs to be combined with "the scientific knowledge that requires some distance from the particular."

To deal with this seemingly intractable problem, the voice of the late Leopold Kohr from the little town of Oberndorf near here rings true. He would not have argued with either of these two professors, because his considerations transcended economics. Though he was interested in human welfare and the social structures of humans, his subject was not economics.

Leopold Kohr saw the human condition as a derivative of social organization being scale-dependent. Explaining Leopold Kohr, his friend Ivan Illich said, "If the scale is proper, each community can engage in discussion about what ought to be allowed and what ought to be excluded. To consider what is appropriate or fitting in a certain place leads one to reflect on beauty and goodness. Judgment, therefore, will be primarily moral, not economic." Illich further explained that Kohr's use of the concept does not fit into an economic calculus. Because "economics assumes scarcity, ... it deals with values and calculations. It cannot seek the good that fits a specific person within a given human condition. Where scarcity rules, ethics is reduced to numbers and utility. ... Economics demands the evaluation of desirable goals under the assumption of scarcity." Ivan Illich continues: "Economic assumptions, once incorporated into one's way of perceiving reality and constructing arguments, exclude ethical options whose object is the good." Leopold Kohr "is insisting on the correlation between a certain size and the harmony that shines forth in appropriate proportions."

To this point I have advanced the thoughts of three intellectuals addressing the human dilemma. Two of them address the problem of economic disparity and disagree. The third, Leopold Kohr, sees the solution to be in a non-economic realm. To help illustrate the feeling of Leopold Kohr's ideas beyond social organization to the workplace, I turn to the book written about the years 1884-1891 in England. The book is *The Wheelwright's Shop,* by George Sturt. "What we had to do [in that shop]," Sturt said, "was to live up to the local wisdom of our kind; to follow the customs, and work to the measurements, which had been tested and corrected long before our time in every village shop all across the country. A wheelwright's brain had to fit itself to this by dint of growing into it, just as his back had to fit into the supplenesses needed on the saw-pit, or his hands into the movements that would plane a felloe. ... Science? ... The work was more of an art — a very fascinating art — than a science; and in this art, as I say, the brain had its share." And later, after having described that they often worked 12 hours a day, he said, "Eight hours to-day is less interesting and probably more toilsome than 'twelve hours' then." This is the spirit Leopold Kohr is describing.

We have tried to capture this spirit at The Land Institute, where our science is devoted to building an agriculture nearly opposite of industrial agriculture, one which mimics Nature's never-plowed native prairie. That prairie features perennial species grown in mixtures as opposed to our high yielding crops which are annuals. We look to Nature's prairie, which features material recycling and runs on contemporary sunlight. Our work in genetics is to perennialize several major annual crops, such as wheat, rye and sorghum. In the future, with those perennial roots to hold the soil, we hope soil erosion can go to zero. Our ecological studies include species mixes so that we may have chemical diversity confronting any pest whose enzyme system is not complex enough to devour the entire species assembly. We also want plants with biological nitrogen fixation in the mix. With reduced plowing and tillage, our goal is for fossil fuel dependency to go to zero. We believe that if we don't get sustainability in agriculture first, that it is not going to happen. By featuring biodiversity we are also featuring cultural diversity and proper scale as derivatives.

My two professor friends assume a world in which the industrial mind rules. For a world on that path, it is the right kind of argument. The implementation of an ecological agriculture, however, means that we feature a more creaturely life, with the potential to turn the tide away from the extractive economy toward a renewable economy. The feeling of farmers associated with such an agriculture would be more like the workers in the wheelwright's shop over 100 years ago. The modern industrial mind assigns high standing to the rigor characteristic of high energy physics, mathematical game theory and molecular biology. The wheelwright craftsmen dealt with hard facts and did assign value to rigor, but both were always tempered by common sense, intuition and practical wisdom derived from practice and experience in the context of particular places. Leopold Kohr was a champion of this latter ideal and his life serves as an inspiration for all of us today.

Thank you Salzburg. Thank you Oberndorf for giving us this great man — Leopold Kohr.

On Freedom and Wisdom

Thoughts of Judge Learned Hand

"We were wrong in supposing that native intelligence or stupidity have much to do with the workings of democracy or the gift of liberty. It is a question of the habit, so hard to acquire, of detachment in forming beliefs, in the end of a character of a people, not of its brains. A group of pretty dull men can manage fairly well, if they be disposed to suspend judgment where they do not know the facts, but nothing — I think you will agree — is more exasperating than a group of clever disputants each concealing behind his front of argument determined and uncompromising convictions which no evidence can touch."

"The spirit of liberty is the spirit which is not too sure that it is right. The spirit of liberty is the spirit which seeks to understand the minds of other men and women. The spirit of liberty is the spirit which weighs their interests alongside its own without bias. The spirit of liberty remembers that not even a sparrow falls to earth unheeded. The spirit of liberty is the spirit of Him who, near two thousand years ago, taught mankind that lesson it has never learned, but has never quite forgotten; that there may be a kingdom where the least shall be heard and considered side by side with the greatest."

"If I were to do it over again, I think perhaps I would be a physicist — open new vistas, move in step with the world. You know, I used to hope that I might be able to garner a harvest of wisdom. That has turned out to be a mistake, for I cannot see much further into the tangle of life than I could fifty years ago. I'm less disappointed than I should have thought. Indeed, there is solace in a companionship where all are groping their way equally in the same fog."

— From Philip Hamburger's *Matters of State,* 1946

At The Land

Natural Systems Agriculture

Breeding programs in wheat, rye, perennial grasses, sorghum and sunflower are picking up steam. In the spring greenhouse, we produced approximately 125 hybrids by intercrossing annual and perennial wheat, annual and perennial ryes, and several species of wheatgrass. We are also evaluating populations of perennial rye and intermediate wheatgrass in the field, with the goal of improving them through selection. In July, we began making hundreds of crosses between our perennial sorghums and annual grain sorghums, to combine perenniality with larger seeds and higher yields. We also established a nursery to evaluate more than 1,700 plants from 100 seed collections of maximilian sunflower that we made across Kansas last year. The experiment will help us choose parents for crossing this perennial species with cultivated sunflower.

New breeding programs tend to expand rapidly, and the acreage and effort devoted to all crops will be scaled up in the coming fall and spring. The breeding section of our 25-year Big Chart plan has been reorganized to show the specific steps we will take over the next 25 years in producing new perennial gene pools.

Our human gene pool is expanding as well. We hired a third plant breeder, Lee DeHaan, who will join the staff in September. Although all of our breeding staff will put effort into all species with which we work, we have assigned responsibilities for overseeing the individual species:

David Van Tassel: sunflower, rye, intermediate wheatgrass.

Lee DeHaan: wheat, Illinois bundleflower, other legumes.

Stan Cox: sorghum, coordination of all crops.

We received a request last year from the journal *Critical Reviews in Plant Sciences* to submit a paper titled “Breeding Perennial Grain Crops.” After surveying almost 200 articles related to the subject, speaking with plant breeders around the country, and putting the manuscript together, we submitted it July 1. The article should appear early next year. *Critical Reviews in Plant Sciences* was ranked fourth among 140 plant science journals in “impact factor” by *Journal Citation Reports.*

Intercropping Wheat and Alfalfa

We had our first wheat harvest from a new experiment that attempts to simulate a prototypical perennial polyculture. Annual winter wheat planted with no-till equipment ecologically mimics a high-yielding perennial wheat. Alfalfa, a hardy perennial legume, provides nitrogen for the wheat and high-quality hay for livestock. Thus we have the two basic functions of an early perennial polyculture: production of cereal and fixation of nitrogen. Although this experimental biculture is neither fully perennial nor very species-rich, it is much closer to our NSA ideal than the highly tilled or heavily chemical dependent wheat monocultures common in this region.

Wheat yields varied according to the experimental arrangement of the wheat and the alfalfa. Predictably, wheat grown in monoculture yielded the most bushels per acre, in the high 50s. These plots received a big nitrogen dose from the decaying alfalfa plants that had been plowed under before planting. More interesting and encouraging was that wheat intercropped with alfalfa that had been lightly disked also yielded very respectably, in the range of 40 bushels per acre, while simultaneously producing hay. Wheat drilled into undisked alfalfa yielded lower.

Laura Skelton, a graduate student of Professor Gary Barrett from the University of Georgia, did much of this work and is taking data on soil fertility and insect populations.

While that data is not yet available, the bicultures won out over wheat monocultures in aesthetics: Golden heads

Above: Scott Bontz. Farm manager John Mai, with summer intern Alyssa Irlbeck, cuts the winter wheat that was intercropped with alfalfa.

of wheat were surrounded by monarchs and other butterflies seeking the purple alfalfa blossoms.

We predict that over the next few years fertility and yields will decline in the wheat monocultures but stay steady in the systems using alfalfa to capture nitrogen from the air. We are experimenting with different systems to learn about how this nitrogen can best be made available to the wheat plants.

Graduate Fellows Program Expands

This year our graduate fellows program received 36 applications — a record. This good news is due to growing awareness of the program from current fellows, NSA advisors, the website and a new advertising campaign directed at graduate secretaries in 360 departments and organizations.

Many external reviewers noted better applicants than in the past. With that high quality, we accepted a large number of new fellows: nine. We renewed funding for six other fellows. Abstracts describing the new fellows' research are presented following *At The Land*. Abstracts of all current and former fellows are on our website.

In July we completed our fourth annual workshop, a critical component of this program. The fellows had a week of "yeasty" discussions with generous speakers: Gary Barrett of the University of Georgia, Chuck Francis of the University of Nebraska, Tim Crews of Prescott College in Arizona, Stephen Doherty of Slippery Rock University in Pennsylvania, Ghillean Prance, who directed Kew Botanical Gardens in London, Ray Dean, emeritus University of Kansas, Jim French of Kansas Rural Center, Jerry Glover of Washington State University, Jerry Smith of University of Michigan, David Orr of Oberlin College in Ohio, Don Wyse of University of Minnesota and Don Worster of University of Kansas. Topics included ecosystem ecology, soil nitrogen, rural economics, farm policy, fisheries, architecture's nature and rainforest ethnobotany. Participants toured experiments at The Land, visited board member Pete Ferrell's ranch of rotationally grazed prairie pastures, and enjoyed an ice cream social and dance with the folks of Matfield Green.

Sunshine Farm

As planned in the 1992 feasibility study for the project, the Sunshine Farm is in its final field season, accumulating data on energy, materials and labor until December. We have completed nine years of research on soil quality in our cropland and eight years on plant species composition in our grazed native pasture. Several years will be required to analyze the remaining data, publish research papers and write a book on the project.

Director Marty Bender has written a preliminary chapter, "Energy in agriculture and society: Lessons from the Sunshine Farm," a version of which appears on page 3 of this *Land Report.* It compares the energy return of the Sunshine Farm and various energy technologies in industrial society. It also explores what this comparison implies for the prospect of agriculture providing energy as well as food.

Bender also recently published an economic comparison of traditional and conventional agricultural in the summer 2001 issue of the *American Journal of Alternative Agriculture.* It studies draft-horse farming by the Amish in Ohio, including a comparison of the area that would be required for powering horses and ethanol-fueled tractors to farm U.S. cropland.

Bender is writing a research paper comparing the embodied energy that was required for the draft horses and the biodiesel-fueled tractor to plow and cultivate Sunshine Farm crops.

Rural Community Studies Program

Spring brought a flurry of activity in the communities served by the Matfield Green Consortium for Place-based Education. Bev Worster, our education director, visited all twelve schools at least once for informal coaching of individuals and small groups, and to participate in their work with students. Barbara Poore, the Midwest steward for our major grantor, The Rural School and Community Trust, visited the Baldwin schools with Bev in April.

In Baldwin City, high schoolers cleaned streets, yards and public spaces. Charter school students built benches and landscaped in the city pool area. Marion Springs Elementary schoolchildren nurtured seeds into plants for Environmental Center gardens. They also researched the six one-room schools once in their area and visited those still standing.

Folks of Vinland joined with their elementary school for Founders Day. Children loaded hay, did farm chores, experienced an early school, visited a historical home and heard fiddling.

Flinthills high school students interviewed elders and presented their oral histories to the public. Science classes continued research on the effects of river willows along the shores of El Dorado Lake and mapped their prairie restoration project. Community members assisted primary students as they culminated their yearlong soil studies with a program that featured songs including "Dirt Made My Lunch" and skits about worms, their garden and greenhouse, soil testing, and work in Prairie Park. Art classes involved the prairie and communities in field photography.

Teachers at Chase County High School met for three days to plan a project on water. Teams of mixed-grade students will study the theme during the 2001-02 school year, culminating in displays and reports to the student body and county residents. Teachers are integrating the water theme and field studies into the curriculum in all subjects.

High school students teamed up with elementary schoolchildren for field work at the Tallgrass Prairie National Preserve, learning about plants and making charcoal landscapes. Elementary school students continued their prairie plant landscaping on the school grounds, and classes explored the life cycle of butterflies and prairie bird life, with reports on the prairie chicken. Middle schoolers continued to oversee the recycling project begun a year ago, monitored a stream and studied wildlife, including at Camp Wood.

Chase County High School sophomore Seth Fowler won an Annenberg scholarship offered by The Rural School and Community Trust. He was one of six students selected for a six-week summer course at the University of Southern California.

In June, Bev conducted two week-long workshops for teachers, one with Emporia State University and one with the University of Kansas. Forty-four of the 46 participants were from our consortium schools.

The theme of this summer's Reading the Landscape of Home was habitats. Led by botanists, ornithologists and other wildlife specialists, teachers evaluated forests, prairies and wetlands. Speakers and discussions involved art, agriculture, land use, pollinators, soils, plants and water quality. Bev provided a display of teacher resources, and teachers displayed student work. Teachers will create studies based on the workshop.

New Faces at The Land

Amy Goldman joined our board of directors in July. She lives in upstate New York, and is an expert gardener, a seed saver and collector of heirloom squash, and writes a column in Rodale's *Organic Gardening.*

In summer several people joined the staff as research assistants or to conduct their own research.

Laura Skelton, a master's degree student from the University of Georgia, worked on the ecology of wheat-alfalfa mixtures. (See item in Natural Systems Agriculture section above.)

Carol Gordon, a master's degree student from the University of Maryland, tested prairie soil properties associated with different proportions of grasses and legumes.

Three undergraduates joined our staff for the summer: Sheila Cox from the University of Kansas, Dorothy Stowe from Cornell University and Alyssa Irlbeck, on an internship from Austin College in Texas. Alyssa set up an experiment to see if prairie soils, and in particular the mycorrhizal fungi in native soils, can suppress bindweed, a pernicious agricultural weed.

Two others have helped in the field this hot summer: Mitchell Pounds from Southeast of Saline High School and Alex Blanding from South High School in Salina.

Lee DeHaan

Jerry Glover

Plant breeder Lee DeHaan, from the University of Minnesota, will become part of our staff in September. Jerry Glover, a former intern, will join the staff in January, after soil ecology studies at Washington State University. Both will have doctorates upon arrival.

Public Notices

Visitors

Kevin Danaher from Global Exchange talked about globalization, agriculture and the economy. About 30 people from Salina attended.

Richard Levins, of Harvard University's School of Public Health, made a presentation to staff members.

Forty University of Kansas faculty members from many disciplines participated in the Wheat State Whirlwind Tour 2001.

Some others who visited: Charles Washburn and Bea Cooley, colleagues on energy analysis; the high school group Progressive Greens; a University of Kansas class on biodiversity in agriculture; the Konza Research Experience for Undergraduates at Kansas State University; a conservation biology class from Bethel College in Newton, Kan.; a McPherson College physiology class; an Augustana College ethnobotany class; Salina Central High School's agriculture class and Future Farmers of America; agronomists and soil conservationists from the U.S. Department of Agriculture Risk Management Agency in Topeka, Kan.; the federal Environmental Protection Agency National Agricultural Compliance Center tour; and Bike-Aid cross-country cyclists, who camped here for two nights.

The Emporia State Elderhostel tour group visited Matfield Green.

Presentations

Staff members spoke at a Stanford University biology seminar, a Charles A. & Anne Morrow Lindbergh Foundation board meeting, Phi Delta Kappa at Kansas State University, Hastings Center in New York, the University of Vermont, St. Michael's College and Green Mountain College, both also in Vermont, Smoky Valley High School in Lindsborg, Kan., the Unitarian Universalist Church in Salina, a sociology class at Kansas Wesleyan University in Salina, the Earth Day convocation at Kansas Wesleyan, the Farming, People, Land & Community conference at Denison University in Ohio, and the opening of a sustainability center in Salzburg, Austria.

Talk titles included "Environmental Ethics: What makes us human?" "The Changing Relationship between the Tree of Knowledge and the Tree of Life" and "Place Matters."

Media

Staff members gave interviews on a live radio show about the environment and agriculture for the University of Manitoba and on a Kansas television news show, and to Geo Magazine and Washington University's *The Sciences.*

Contributors to This Issue

Marty Bender is director of The Land Institute's Sunshine Farm. Stan Cox and Christopher Picone are staff scientists. Scott Bontz is a staff member.

Graduates' Study of Natural Systems Agriculture

Nine Natural Systems Agriculture graduate fellows were chosen for 2001-02. Here are abstracts for their work.

Heather Darby, Oregon State University

Organic soil management and induced systemic resistance
Ecological approaches to disease control are of interest because of environmental, social and economic risks associated with pesticides. This project's primary aim is to see whether soils from natural or organic agriculture ecosystems can activate plant immunity to foliar diseases, better known as induced systemic resistance (ISR). This is the plant's ability to enhance resistance to pathogens. It can be turned on by microbes, chemicals or other environmental stimuli. It has been shown to reduce the severity of root and foliar diseases caused by bacteria, fungi and viruses. The project's second aim is to see how ISR is influenced by: 1) the duration of organic management, 2) light fraction content, 3) microbial activity, 4) soil texture and 5) other soil properties, such as nutrients. In the summer of 2001, soils will be collected from natural ecosystems and farm fields under conventional and short- to long-term organic management, and screened for the potential to generate ISR. We hypothesize that soils that have had several years of annual organic matter amendment — those under organic management — will have the ability to generate ISR in plants.

Cindy Cox, Kansas State University

Perenniality, cytogenetics and disease resistance of *Thinopyrum* spp. X *Triticum aestivum* hybrids and genetic heterogeneity effects on disease epidemiology
Soil erosion from cropland degrades U.S. natural resources and reduces air and water quality. Genetic uniformity of crops leads to epidemics. Perennial wheat cropping might conserve soil and natural resources, bring land back into production, save taxes and make for profit. Its sound ecological management of pests and fertility might be the most sustainable approach for resources, economics and the environment. The proposed research has two objectives. The first will be to evaluate *Thinopyrum intermedium x* wheat hybrids for regrowth and perennial habit, chromosome compositions and characterizations, and disease resistance. The second will be to study diversity's effects on tanspot and wheat streak mosaic virus, two diseases potentially important to perennial wheat production. The information gained from this multidisciplinary project will be valuable in the development of perennial wheat adapted to Kansas and will give insight for managing disease in perennial grain cropping.

Inge Armbrecht, University of Michigan

Biodiversity loss and the function of beneficial litter ants in contrasting coffee management systems
Coffee growing is one of the most remarkable examples to show how the intensification of agriculture hurts biodiversity. The traditional system of growing coffee plants under a canopy of diverse trees is being rapidly replaced by a "sun coffee" system, in which no shade is required. The harm of this on biodiversity including migratory birds, other vertebrates and arthropods calls urgently for investigating the mechanisms of species loss and the possible advantages that biodiversity might provide to the coffee farmers. This research is intended both to investigate whether the lack of nesting resources on sun coffee plantations causes a lower diversity of leaf litter ants, and to explore the potential of these ants to prey on the coffee berry borer, a major pest. The first objective will be pursued by augmenting litter volume and twigs in two contrasting coffee management systems. Litter ants' potential as predators will be examined in the field and under laboratory conditions.

Jill Liske, University of Minnesota

Temporal escape of severe stress in herbaceous perennial plant populations: Long-term underground dormancy
Long-term underground dormancy followed by robust recovery as a stress response in herbaceous perennial plants was first described following the great drought of the 1930s. However, the phenomenon has never been specifically studied or documented. Missouri goldenrod (*Solidago missouriensis,* Asteraceae) is a species known to display the behavior in severe drought or herbivory. This experiment will explore how plants induce and maintain dormancy, by measuring carbohydrate and nutrient allocation in Missouri goldenrod under severe stress. Its exploration in one species is the necessary first step in determining the actual role in natural systems. Applications for natural systems agriculture include understanding of plant resource allocation under stress, community diversity and stability maintenance mechanisms, pest control, and the dynamics of genetically identical plant populations.

Pamela Scheinost,
Washington State University

Agronomic practices and selection of perennial wheat

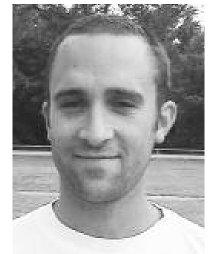
Perennial wheat offers a new solution to the longstanding problems of soil erosion and degradation associated with conventional annual small-grain cropping in the Northwest. Using classical breeding methods, new types of wheat have been developed that maintain the key characteristics of annual wheat but continue to grow after harvest. Following dormancy in the winter, growth initiates from the roots or crowns in the spring, allowing a crop to be harvested every fall. By keeping constant soil cover over years, wind and water erosion would be dramatically reduced. In addition, the costs of annual seeding and tillage would be minimized, and unlike for much reduced tillage, it is expected that standard seeding equipment will work. Other potential benefits include improved wildlife habitat, more efficient use of available water, the provision of a potent carbon sink, and the possibility of integrating straw retrieval into a small-grain cropping. Research in the first half of the last century failed to develop perennial wheat as a viable crop primarily due to low yields, and the effort was abandoned. Perennial wheat production might now be viewed as acceptable for highly erodible land or for carbon sequestration credits. My research involves managing the current perennial wheat lines at Washington State University, assessing agronomic practices and evaluating wild species for use in breeding.

Sasha Kramer, Stanford University

Linking microbial community composition and function in agroecosystems

Understanding the effects of different farming practices on soil communities is essential to designing agroecosystems that will conserve microbial diversity and minimize nitrogen loss. Microorganisms play a central role in the decomposition of organic matter and nutrient cycling in natural and agricultural ecosystems. I propose to investigate the effects that different kinds of agricultural management have on microbial community composition, biomass and nitrogen cycling in Washington orchards. In addition, I will examine the relationship between microbial community composition and function. This study will test the hypothesis that multicropping management supports greater microbial biomass and diversity than both organic monocultures and conventional management. I will examine the differences in microbial community composition in agricultural soils and the surrounding uncultivated ecosystem using chemical and molecular techniques. Shifts in microbial community composition might change biogeochemical cycles, particularly functions by a relatively restricted group of microorganisms, such as nitrification and denitrification. Therefore, I will also attempt to correlate differences in community composition between treatments to differences in nitrogen fluxes. For alternative cropping this study will provide much needed understanding of the relationship between microbial community composition and function.

J. Robert Sirrine,
University of California at Santa Cruz



A natural systems framework for sustainable orchard production

National awareness of the detriments of conventional agriculture, consumption of rural space and weakening economic status for farmers justify the need for an alternative agriculture. In this dissertation research, the natural lakeshore forest ecosystem in northern Michigan is used as a framework for establishing structural and functional analogs in an orchard agroecosystem. The proposed two-tiered agroecosystem — understory vegetation and crop trees — is a simplified replica of the existing multi-tiered forest ecosystem, which contains naturally occurring wild relatives of the main production tree, *Prunus cerasus L.* and mixed herbaceous understory vegetation. Using ecological theory as a guide, this research incorporates The Land Institute's following research trajectories. In a two-tiered perennial production system, I will try to replace chemical inputs with ecosystem services by increasing herbaceous understory diversity, address soil fertility questions through a two-pool (soil-tree) nutrient cycling analysis, determine the optimum management of pests in this perennial polyculture, and use allelopathic understory vegetation to inhibit nutrient and water competition from weeds. By mimicking the structure and function of the natural forest ecosystem, this research will not only provide ecological benefits associated with chemical elimination, but also enhance economic gain by reducing input costs. The results of this study will be applicable to other perennial tree crop systems attempting to mimic natural systems and will broaden the scope of The Land Institute's natural system research.

Catherine Worster,
Oregon State University

The influence of spatial patterns and diversity on productivity within a natural systems agriculture

Various spatial arrangements can be found within natural plant populations and communities. Theory and observation indicate that the spatial arrangement of plant diversity influences the resilience and productivity of an ecosystem, though experimental data are lacking. In this experiment I will vary spatial arrangements of combinations of two genotypes within a species, two species within a functional group, and two species of two functional groups, grasses and legumes, for both domestic agricultural species and native Willamette Valley upland prairie species. Grasses and legumes are appropriate, as they vary in traits relevant to nutrient cycling. Experimental plots will include mixtures of genotypes within species and species within functional groups, as research shows that a species or functional group benefits from an increase in heterogeneity. Plots will also include two-species combinations between functional groups — a grass and a legume — as such combinations have been found to provide greater disease suppression and niche complementarity. I will plant both a series of domestic agricultural species and a series of native prairie species to determine whether spatial pattern influences depend on the evolutionary history of the plants, to account for the sampling effect of just using high-yielding agricultural species, and to determine the role, if any, of domestication on plant interaction. By noting presence of weeds, insects and disease, I will measure responses in terms of productivity and resilience, both agriculturally and ecologically relevant measures.

Laura Skelton, University of Georgia

A comparison of conventional and low-input sustainable agriculture systems: An ecosystem approach
Intercropping different species has been shown to help combat pest infestations and to maintain sufficient nutrients, reducing the need for fertilizers and tillage. I propose to intercrop winter wheat (Triticum aestivum) and alfalfa (Medicago sativa) as an integrated pest management strategy. I predict that bicultures will experience less damage from insect pests than will monocultures. The reduction in herbivores may be caused by an increase in abundance and diversity of predators in heterogeneous agroecosystems. Key insect and predator species will be compared among treatments. Intercropping also represents an alternative strategy to increase the nitrogen available in the agroecosystem. Alfalfa, a legume, might fix enough nitrogen for the wheat so commercial fertilizers will not be needed. I will compare nitrogen available to winter wheat monocultures with nitrogen in wheat-alfalfa bicultures. This study will also measure nitrogen released into the soil through decomposition, and how that process is affected by tillage.

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		Saturday, May 27	
___	S1	From Forest to Sea*	Joan Lederman & Jesse Sedler
___	S2	Far Afield—How Landscapes Affect Our Lives*	Lucy Lippard
___	S3	Reclaiming The Commons: On Beyond Suburbia	Brian Donahue
___	S4	The Poetry of People and Place	William Kloefkorn
		Poetry Round Robin: Harley Elliott, Twyla Hansen, James Thomas Stevens, Patricia Traxler	
		Sunday, May 28	
___	SU1	Communicating Art with Nature as Measure*	Panel: Bob Sayre, Scott Jost, Katherine Kormendi
___	SU2	The Legacy of Landscape Photography	Merry Foresta
___	SU3	Down the Great Unknown	Don Worster
___	SU4	Landmarks Versus Monuments	Saralyn Hardy
___	SU5	The Need to be Versed in Country Things	Wes Jackson

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Agri-Dynamics Consulting
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A Big View of Industrial Agriculture's Effects

Fatal Harvest: The Tragedy of Industrial Agriculture will be the first large-format book to comprehensively display and describe ecological destruction by industrial food production, and present a vision for sustainability.

It will have more than 250 photographs and more than 40 essays by ecology writers, including Wes Jackson, Wendell Berry, David Ehrenfeld, Helena Norberg-Hodge, Vandana Shiva and Alice Waters. The book aims to inform and influence the growing public movement of activists, farmers, policymakers and consumers trying to make food safer for ourselves and for the planet.

Advance orders can be placed at The Land Institute's 25th Anniversary Prairie Festival Sept. 29-30. Copies will be available at bookstores in April 2002, or by calling Island Press at 1-800-828-1302.

PRAIRIE FESTIVAL 2001 REGISTRATION

Pre-register Sat. $12/$16, Sun. $6/$8 **At Festival** Sat. $15/$20, Sun. $10/$15

You are a Friend of the Land if you have given since 9/28/00 or if you join with this registration.

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Saturday, September 29	____ x $12 = $______	____ x $16 = $______
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• *We will not confirm your registration.* • *Program, prepaid nametags and meal tickets will be available at the Registration Desk.*
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