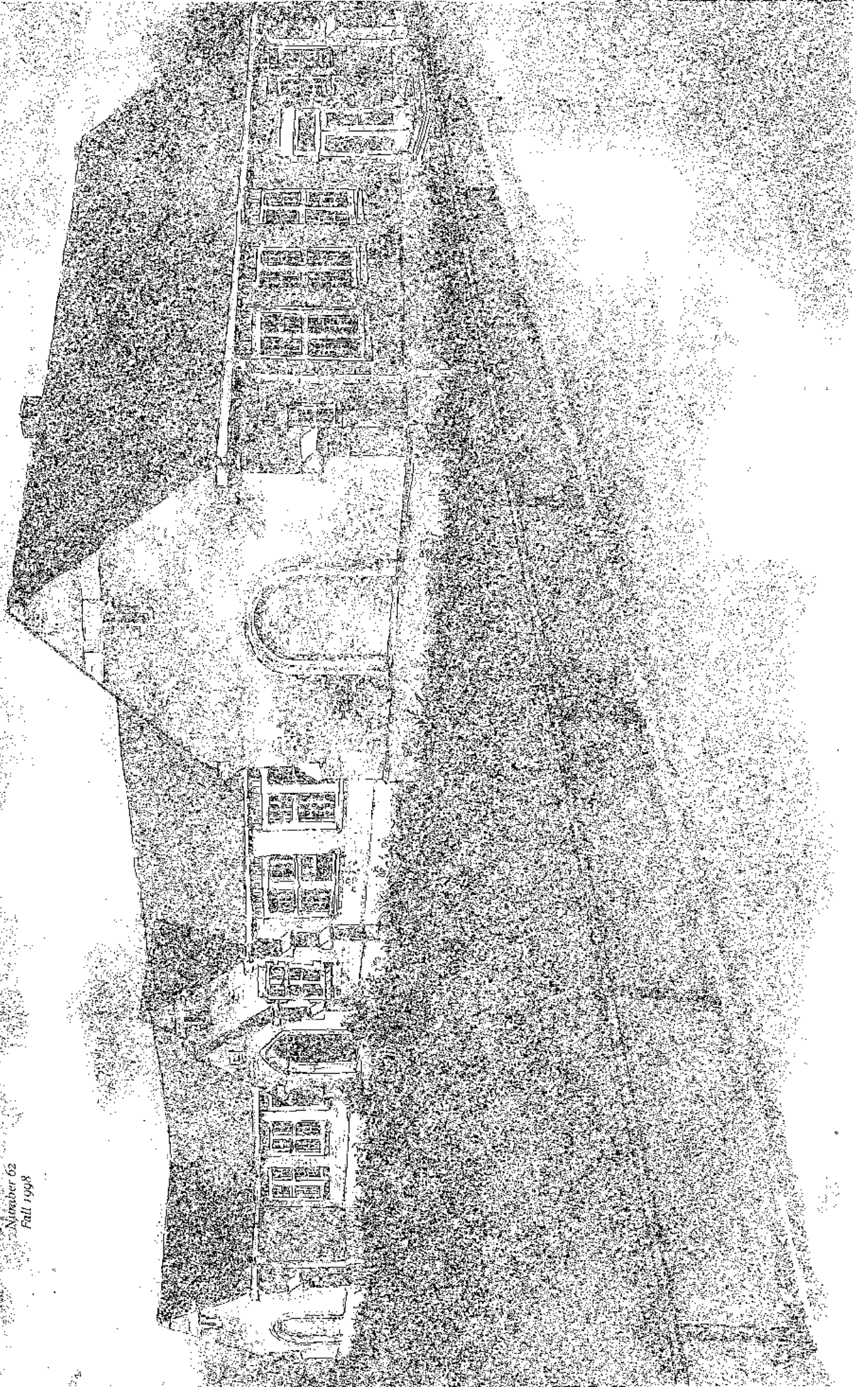


# *The Land Report*

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*Masquerading on the prairie*

### 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.*

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On the Front Cover: 1938 Schoolhouse in Matfield Green, Kansas

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## Carrying Our Work into the Next Realm

Wes Jackson

About three years ago, the Hewlett Foundation granted The Land Institute \$210,000 over three years to help us prepare for the transition to carry our work into the next realm. Last year the Dodge Foundation granted us \$100,000 for general support and to launch a graduate research fellowship program. With our publication record it has been easy to assemble a 65-member team of mostly scientific advisors. Now with their help and others we plan to set goals, plan a strategy, and develop tactics for moving this fundamentally different paradigm for agriculture and agricultural research into wider acceptance and participation. At this point, we have in mind the need to establish at least one center for Natural Systems Agriculture (NSA).

No prototype for what we are considering exists, though components are available. The Manhattan Project built a bomb that changed our relationship to the future. The space program took us to the moon and other planets and serves our communication system. The Green Revolution would seem to be closer to an example of what we have in mind, though it wrote large what industrial agriculture had already become.

I am confident that ideas on how to approach the 10,000-year-old problem OF agriculture (rather than problems IN agriculture, which are derivatives, really) will pull in hundreds of ecologists and evolutionary biologists, many of whom are frustrated because they feel that currently they are only documenters or chroniclers — forensic scientists. Most would love to work on a solution to the problem of agriculture, would love to move out of “forensic science” if they had the chance. What we are proposing provides that opportunity. We want to aggregate them all: agronomists, plant breeders, biotechnologists, ecologists, evolutionary biologists of various stripes, landscape ecologists, environmental historians, and even some biotechnologists. We now have a chance to begin to work our way out of a very old problem, a problem exacerbated during the industrial revolution, a problem that threatens to undercut the very basis of our own existence over the next half century even more rapidly than in the recent past.

Surely we can approach this problem with less of a heroic sense and more as an opportunity to roll up our sleeves and go to work on a great possibility. We can

avoid the “we must feed the world” language of the industrial hero and embrace “the world must be fed” idea, a subtle but important distinction. Given the reality of the ecological mosaic a common set of principles overrides the need to employ conventional practices. Add cultural diversity and local adaptation becomes possible with more benign ecological consequences. Given the technological array now available — much of it, of course added during the industrial revolution — it becomes possible for agriculture to become indigenous again but this time perhaps with fewer cruel anxieties than some cultures have experienced at various times in the past. What is common to the mosaic imagery informs our imagination spawning new possibilities and what is common is the evolutionary and ecological reality and the way the world has worked over the millions of years before agriculture. Since this unifying concept holds from the poles to the equator, we have a philosophical core with potential to *unite humanity* around the world in a way that industrial agriculture does not. So Natural Systems Agriculture has that distinction.

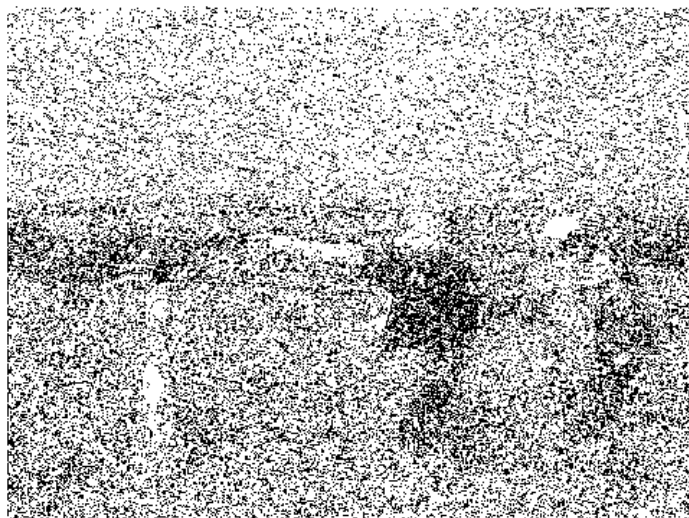
We are proposing to establish a center at The Land Institute to apply natural systems principles to the

production of food and fiber (agriculture, forestry, and fisheries). Although research to be carried out at the center is only in agriculture, our educational message is that the same natural systems principles (from ecology) apply worldwide and include forests and fisheries. The funding needed envisions a combination of research at the center and support for off-site research in collaboration with major universities and elsewhere. The offsite research would answer our research questions yet would pull in work that can be done elsewhere

where high-cost facilities already exist. This will leverage publicly supported expertise and facilities. Because work is (or could be) going on that applies to our mission, The Land Institute would serve as the center for integration of any research that can be applied to our agenda, toward the achievement of a 25-year goal to develop farmer-ready prairie mimics producing good grain yields from perennials **grown in mixtures**. Most important — that prairie mimic, with breeding specific to location, will be adaptable to grasslands around the globe.

This initial support to deliver Natural Systems Agriculture to farm fields would then serve as a prototype for institutions in other parts of the world and for forestry and fisheries besides.

In order to leverage the facilities and assets supported by public money, The Land Institute sees two categories that need to be addressed. First, the amount of funding necessary to do the job will require a budget that may or



Wes Jackson describes history of landuse near Matfield Green, Kansas

may not require a consortium of funding sources. Second, The Land Institute will need help to reach those able to assist. This help may include referrals and help in structuring the most effective ways to present the ideas.

We have three challenges to consider. We need:

- More general acceptance of the potential for melding ecology and agronomy.
- Broader public support for and understanding of the need to make a distinction between solving the 10,000-year-old problem OF agriculture compared to solving problems IN agriculture.
- To convincingly demonstrate that, when fully developed, Natural Systems Agriculture can out-compete current industrial agriculture. There are countless still-unexplored and explored but undeveloped efficiencies inherent in the integrities of natural systems. They should be allowed to contribute to crop production rather than to be swamped by chemicals and mechanical manipulation.

The proposed approach for solving the above three problems is to greatly upscale the research and education effort. The first problem to be solved, therefore, is to find the necessary funding. There is a need to fund (1) new construction, (2) research activity at the center, and (3) "pass-through" money to researchers whose work will eventually come back to directly apply to the center's research goals. Beyond research, considerable activity at the center should be devoted to education -- intensive education for graduate students and interns, and more casual education for the one-hour to half-day visitor whose time is limited to tours of research, viewing displays, videos, and taking printed materials.

I can't resist a final word in support of the placement of the center at The Land Institute here in Salina. I bring up this subject because a few friends and thoughtful critics have suggested that we should be closer to a major university. The argument is that it will be easier to attract the necessary staff where the accouterments are available which ordinarily attend universities. More positively, why not use our location as a filter for the serious applicants?

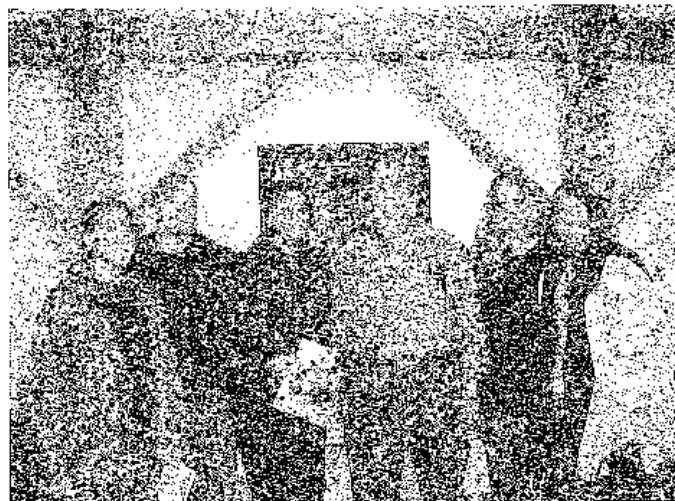
Beyond the filter justification, however, is an ecological reality that makes us perfectly positioned. We are in the land of the mixed grass. The heart of tallgrass prairie is a few miles east, short grass prairie a few miles west. The Land Institute is within an hour or so of each. Furthermore, from Saskatoon to deep in the heart of Texas the region features the four functional groups of the prairie: warm-season grasses, cool-season grasses, legumes, and members of the sunflower family. No matter whether there is drought and bitter winter or ample moisture and nearly no winter there are those four functional groups -- the groups we intend to employ in building our domestic prairies of the future. Here we are favorably positioned north-south as well as east-west. How it came to be that we are here was perhaps pure luck but here we are in the midst of one of nature's standards, a genius far wiser than any campus assembly. Here is the ecosystem featuring grasses and here are we, *Homo sapiens* who on a global basis depend on 70-80 percent of our calories from that family alone. Here we are in the midst of the largest grassland biome of the world.

## *From The Land Institute . . .*

*Kate Worster*

### *Intern Program*

Following several classes on permaculture this fall, the interns traveled to the home of Michael Almon in Lawrence, Kansas to tour his edible landscape. He has devoted a portion of his land to a small piece of restored prairie and the remainder is planted in fruit and nut trees, herbs, fruiting shrubs, and a vegetable garden. Michael's house is an old bungalow which he is renovating with energy-saving technologies and non-toxic building materials.



*Kate Worster, Terry Loecke, Claire Homitzky, Kent Whealy, Katie Goslee, and Kelley Belina*

Thanks to Iowa-native Terry Loecke, the interns had a whirlwind tour of northeast Iowa. They traveled to Seed Savers Exchange to meet with co-founder and director, Kent Whealy. Mr. Whealy gave a tour of their new Amish-constructed timberframe office which contains their library and a deep-freeze seed storage room. The interns also explored the gardens and barn where several students were extracting seeds to be saved. Nearby they hiked through Hayden Prairie, a tallgrass prairie preserve maintained by the Iowa Department of Natural Resources.

Former chief of NRCS (Natural Resource Conservation Service), Paul Johnson gave interns a tour of his home near Decorah where he and his wife Pat have a 140-acre farm with sheep, cattle, and a large vegetable garden. Pat and Paul wanted to "live deliberately," they told us, when they bought their farm. For the past 20 years they have managed to be part-time farmers while also pursuing other professions.

Tom Frantzen, member of the Practical Farmers of Iowa, met briefly with interns to describe how and why he made the dramatic switch from conventional farming (industrial-scale with large hog-confinement facilities) to certified organic. Interns also visited Laura Jackson, professor of biology at the University of Northern Iowa and her husband, Kanyar Enshayan, adjunct professor at UNI.



At the Geographical Information Systems (GIS) laboratory on Kansas State University campus in Manhattan, interns received an introduction to satellite mapping technology. Brent Brock and Greg Hoch, biologists working in the GIS lab, showed the interns how satellite images can be used to create maps with a layering of information such as soil type and vegetation cover.

## Sunshine Farm

On the first Saturday in August, 17 farmers (including, in some cases, their families) visited The Land Institute for the Third Annual Sunshine Farm Field Day. Some traveled from as far away as Lawrence, Arkansas City, and Concordia, Kansas. Marty Bender, our Sunshine Farm ecologist, Jack Worman, farm operations manager, and Claire Homitzky, grazing management intern led a farm tour and discussion. Topics ranged from renewable technologies to mixed farming (crop and animal) practices. We also referred participants to the Heartland Sustainable Agriculture Network established by the Kansas Rural Center. This annual event provides an invaluable opportunity for us to meet with our neighbors and with farmers from throughout the region. We benefit from the exposure to the farming community as they learn something about future trends in agricultural technology and energy through seeing our research.

## Visitors

Gary Anderson, of Modern Horse Logging & Lumber, LLC, Constantine, KY, visited this July to introduce us to his work. Gary brought his logging arch (a two-wheeled cart used to elevate the forward end of a log when pulling it with horses) and his chainsaw to demonstrate how to fell and pull a large tree. Jack Worman brought out two of his Percherons for the pulling.

A group of Bike-Aid 1998 participants camped at The Land Institute two nights this summer. Each year, groups ride their bikes from San Francisco to Washington D.C. raising money to support the Overseas Development Network,

making presentations about the organization's work, and learning about the work of others.

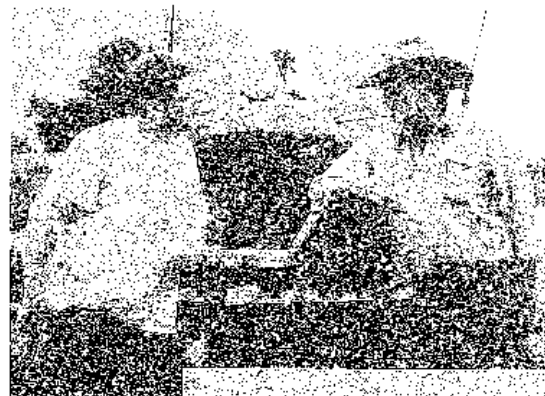
Janine Benyus, author of *Biomimicry: Innovation Inspired by Nature* (1997), spent a day with the interns and staff. She described the work of biomimickers in harnessing energy, creating stronger textiles, healing, computer technology, and commerce. A chapter in her book features The Land Institute and Natural Systems Agriculture as biomimicry in agriculture. Janine interviewed several interns and staff for her new book about choosing a place to settle and what "home" means.

Over a period of several weeks, about 300 ninth graders visited The Land Institute as part of their career class. They wanted to

learn about the kind of work involved in developing an agriculture which mimics the prairie. We increased their understanding of topics such as "prairie," "ecosystem," "perennial," and "polyculture." We also tried to help them envision Kansas when the pioneers came West by walking them through the big bluestem in our herbary. The composting toilet and solar shower, however, seemed to be the most fascinating sites during their visit.



Paul Johnson gives interns a tour of his farm



Gary Anderson and Jack Worman

Jack Worman drives his two Percherons pulling Gary Anderson's logging arch



## New Staff

Steve Renich, the son of a former Kansas Wesleyan University chemistry professor, dean, and president, knew Wes Jackson even before "The Land" added "Institute" to its name. After pursuing chemistry in college, Steve helped build a house for his sister in Kentucky. He enjoyed the experience so much that he made carpentry and house building into a 25-year career.



Steve has a rarefied perspective on our work having seen the evolution of The Land Institute throughout its history. He has enjoyed getting to know staff and interns as a landlord, as a fellow Prairieland Food Co-op member, and as a volunteer at many Prairie Festivals. Now Steve assists Sunshine Farm ecologist, Marty Bender in energy analysis, computer accounting programs, and data filing systems.



This summer we had the pleasure of getting to know Jonas Ivarson. Jonas traveled from Uppsala, Sweden, home of the Swedish University of Agricultural Sciences (SLU), to work with Sunshine Farm ecologist Marty Bender on embodied energy ("emergy") accounting. He also helped weed

research plots, take soil samples, and tend the garden. Dr. Lennart Salomonsson, director of the Unit for Ecological Agriculture at the SLU proposed this exchange after visiting us in 1991. Living at the Sunshine Farm and spending his days in the Krehbiel House and research plots, Jonas quickly became part of our community. We wish him luck finishing his agronomy degree.

## Telling the Story

Kate Worster

Solving the 10,000-year-old problem of agriculture will not be easy. One of the initial challenges is also the most time consuming — understanding and explaining the cause of the problem. We tell this story to anyone who shows interest in our work — visitors, school groups, new staff, visiting scholars — because it helps them understand our mission and why the solution to the 10,000-year-old problem requires no less than a paradigm shift.

We recently retold the story for a gathering of five graduate research fellows as part of our newest program. During a 15-day workshop in August, we met in the Matfield Green school surrounded by the Flint Hills prairie and nestled in the valley of the South Fork of the Cottonwood River. The workshop concluded with a few days in Salina so that our research fellows could meet all of the staff and view our research plots. Speakers consisted of 14 visiting scholars plus Land Institute staff. This combination provided a thorough introduction to the needs and goals behind our ongoing research in Natural Systems Agriculture (NSA).

Like any story, the one we tell has a setting and characters, a history of ideas and achievements, and sets an agenda for future action. We begin by using nature as



1998 NSA Graduate Fellows: Dan Wildy, Corey Samuels, Charles Mitchell, Dana Blumenthal, and Rob Corry

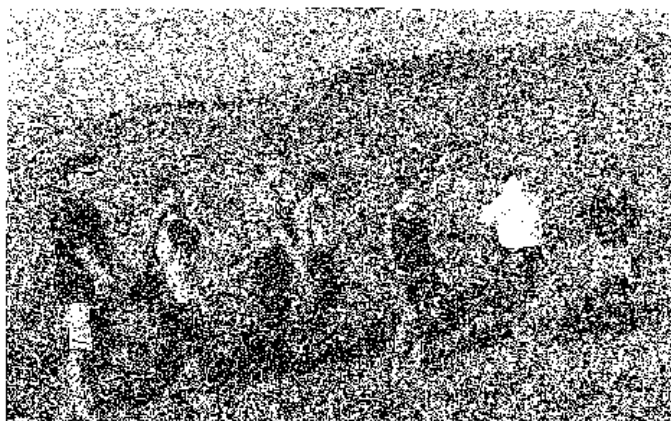
our standard. At The Land Institute we believe that by using native prairie as a model, we can create an agriculture which will sustain its own productivity. Some of the best examples of prairie that remain despite the arrival of the plow can be found in the Flint Hills. We visited the 8,616-acre Konza Prairie near Manhattan; it is one of the largest preserves of native prairie in the U.S. There we observed an abundance of wildlife and clear streams on a five-mile hike through tall and shortgrass prairie, oak savanna, and riparian ecosystems. Naturalist Valerie Wright explained many of the ecological functions we witnessed. It's important to have a vision of how the area appeared before white settlement. We also visited the more recently established Tallgrass Prairie National Preserve near Cottonwood Falls. Here we took a two-hour bus trip through the Spring Hill/Z-Bar Ranch. Next we moved indoors to discuss theory.

The philosophy behind NSA is to use nature as measure — an entirely new way of thinking about agriculture. An exciting aspect of this approach is that the idea is not restricted to the prairie. Jack Ewel, director of the Institute of Pacific Islands Forestry in Honolulu, Hawaii, presented his research mimicking early succession in deforested parts of the Costa Rican tropics. He attempts to mimic nature by replacing early succession plants with similar agriculturally productive species. His mimic is quite successful; the species thrive, protect the soil, and are resistant to insects. David Andow, associate professor of insect ecology at the University of Minnesota (see profile, page 28), presented his research in biological control of insect pests, particularly the pilot bug in relation to corn. His findings indicate that there are two primary effects of pests on corn. First is the landscape structure: he has found that corn fields located next to those of wheat and barley have more pest damage. Second is the amount of landscape disturbance: the harvest of wheat and barley cause pests to move to corn which matures later.

These examples reflect a refreshing change in the approach of some scientists. Most agricultural research, commonly funded by agribusiness, is moving increasingly towards control and manipulation of nature. We stress that an entirely different agenda is necessary. Nature can instruct us how to maintain productivity and diversity having worked out a system over billions of years. At the foundation of our strategy is the realization that human culture strongly influences the kind of science and agriculture we practice. As Donald Worster, professor of environmental history at the University of Kansas explained, science is a product of culture and metaphor has the power to shape it. He lectured on the history of ideas in ecology with particular attention to theories of evolution and ecology formed by two prominent ecologists, Henry Gleason and Frederick Clements, in the late 19th century. Clements believed that nature follows a predictable pattern and tends toward stability, while Gleason saw only competition and instability in the natural world. For Worster, this indicates that before cultural shifts occur, competing paradigms often emerge. The Gleason-Clements debate is not unlike the competing paradigms with which we are faced: the control of nature versus using nature as model. Supporters of NSA use science — especially ecology — but also history, public education, art, and tangible working examples to influence the larger culture.

The history of settlement patterns and land use are important indicators of sustainability and can inform our decisions today. Joseph Hickey, professor of anthropology at Emporia State University, and Brian

Donahue, professor of environmental history at Brandeis University, described the history of land use in the Flint Hills and New England respectively, during the workshop. These histories reflect not only the impact of agriculture on natural systems, but also how natural systems ultimately shape human community life. Professor Hickey guided us into the prairie one evening to point out sites from his book *Ghost Settlement on the Prairie: A Biography of Thurman, Kansas* (1995). Beginning in 1874, the settlers of Thurman farmed river-bottom land and did quite well in years of high rainfall. When the natural drought cycle in Kansas caught up with them, though, they found they could be much more successful as ranchers on the open plains. They shaped the landscape through agriculture, roads, and buildings, but ultimately the natural surroundings dictated settlement patterns, land use, and finally that the community be abandoned.



*Tour of Konza Prairie: Jonas Ivarson, Valerie Wright, Wes Jackson, Corey Samuels, Kelley Belina, Rob Corry, and Dana Blumenthal*

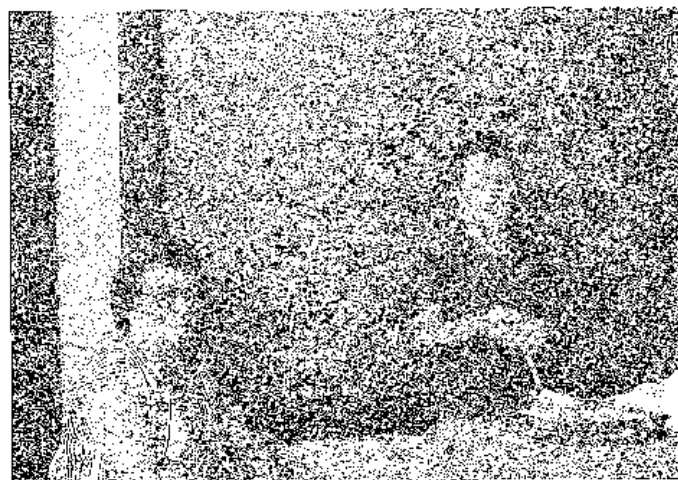
Professor Donahue, currently at work on two books *Reclaiming the Commons: Community Farming and Forestry in a New England Town* (1999) and *The Great Meadow: Husbanding the Land in Colonial Concord, Massachusetts* (2000), detailed the possibility and limits of sustainability in forests of the eastern U.S. focusing on the history of land use in Concord, Massachusetts. Like Professor Hickey, he showed how environmental

conditions are one of the strongest determinants of settlement and land use patterns. With that in mind, he suggested ways in which the eastern forests might be inhabited and maintained including common decentralized ownership, creation of continuous forested landscapes such as corridors for wildlife, and local sustainable forestry and cultivation.

After gaining a sense of how the environment shapes society, we also considered how we can willfully change society, as well. We asked: How do we encourage a cultural shift towards nature as model and increase ecological consciousness of the history of our land and resources? Bev Worster, education director for our Rural Community Studies Program, and David Orr, professor of environmental studies at Oberlin College, say the answer is education. Bev met with the fellows and discussed elements of place-based education. She is a former public school teacher and since joining The Land Institute has established a consortium of rural schools and conducted a summer teacher workshop to promote place-based education for our region.

Professor Orr is the author of several books including *Eco-Literacy* (1992) and *Earth in Mind* (1994), both of which detail his philosophy of education emphasizing hands-on experience in the outdoors so that people develop love, responsibility, and stewardship toward their

natural environment. When students go indoors, he believes these same principles can be demonstrated through "architecture as pedagogy." An example of how a building can be a learning tool and set a positive example is the new environmental studies center at Oberlin College which is a net energy exporter, uses non-hazardous building materials, and contains its own wastewater treatment facility. The center is the result of a joint effort between Orr, Oberlin students and faculty, scientists, and architects.



*Matfield Green resident Clara Jo Talkington and her grandson*

Several other characters in our story provide examples from their own lives of finding direction through consultation with nature. Pete Ferrell, Flint Hills rancher and member of the Tallgrass Prairie Beef Producers co-op, has adopted a management-intensive grazing system on his ranch near Beaumont. This strategy he says, "forces cattle to behave like bison" which both improves his rangeland health and the quality of his beef. Catherine Badgley of the University of Michigan Museum of Paleontology (see profile, page 28), described her ideas for an agriculture which simultaneously provides food and preserves biodiversity. She advocates incorporating native species into an agricultural system and allowing some places to remain uncultivated, two approaches she practices on her farm outside Ann Arbor. Finally, Gary Anderson, a horse-logger from Kentucky, questioned why we farm at all when nature can provide us with a larger and more healthy bounty if left relatively undisturbed (see Van Tassel article, page 9).

Another aspect of our philosophy is to incorporate a sense of aesthetics. The hallways of the Matfield Green school double as a gallery for Terry Evans' photos and those taken by Matfield Green residents. They are a rich collection of images from the South Fork of the Cottonwood River valley and Flint Hills. In Salina Harley Elliott, education director at the Salina Art Center, brought us his poetry, original painting, and archaeological collections from the surrounding area.

The story is an eclectic one with history, ecology, and culture woven together. It provides the necessary context for The Land Institute's own history and our emerging agenda for NSA. Wes Jackson told of the evolution of the Institute from a homesteading project with his wife

and kids to its current expanded ecological research in perennial polycultures. He concluded with an overview of NSA research. The first phase of research is to answer basic biological questions about perennial species and how those species behave in a variety of plant communities. The next phase is to develop farmer-ready prairie mimics that produce high grain yields from perennials grown in mixtures.

Work toward that end has already begun. Three scientists — Jon Piper, The Land Institute adjunct ecologist and professor of biology at Bethel College; Jim Manhart, associate professor of systemic botany at Texas A&M University; and Stephen Jones, a winter wheat breeder in the Department of Crop and Soil Science at Washington State University — described their relevant work. Jon Piper is a prairie ecologist and for 12 years as a Land Institute staff scientist conducted experiments to understand the structure of the prairie and demonstrate the feasibility of NSA. Jim Manhart described ways of using molecular biology to help domesticate native perennials for grain production (see profile, page 29). Stephen Jones presented results of his team's research to develop perennial wheat for the Palouse region of Washington State.

Part of our research is to compare the efficacy of NSA, which is not subsidized by massive fertilizers, pesticide, and fossil fuel inputs, to an agriculture based on conventional annual crops also grown without chemicals. We do this as part of our Sunshine Farm Project. Marty Bender, the Land Institute's ecologist, uses detailed accounting to determine a more accurate ecological and energetic food cost — one not supported by our national policy of cheap food and fuel. During the second week of the workshop, the fellows received a presentation by Dr. Bender and a tour of the farm.

The Dodge Fellows are an asset in forming new partnerships in Natural Systems Agriculture research. This is a small, but positive start in our effort to contend



*Courtney Smith*

with the millions of dollars from agribusiness that are channeled through large universities to fund young researchers. Now that the first year of the program is off to a positive start we are making plans for expansion in 1999. The main benefit of the program is that it allows us to financially assist

young scientists whose work we value and whom we foresee going on to become our colleagues and allies.

For more information on the fellowship see our web page [www.midkan.com/theland/](http://www.midkan.com/theland/).



## Industrial Efficiencies and Natural Systems Efficiencies

David Van Tassel

### A tale of two rice farmers

For about 30 years, two neighboring Japanese rice farmers have been keeping and comparing records. In this friendly competition, neither farmer has consistently outproduced the other. Overall, they have produced about the same amount of rice. Both farms suffer from insect pests and fungal diseases. One farmer uses the latest technology to combat insects and pests. He also uses fertilizers to boost yields. His neighbor fertilizes with compost only and avoids synthetic chemicals. How can both of these practices, the modern, industrial method and the organic, "natural" method, achieve equivalent production?

David Andow, one of the speakers at the Graduate Research Fellowship workshop this August revealed some intriguing clues that help solve this puzzle. Adding commercial fertilizer makes the rice seedlings grow quickly to form dense clumps. These plants go on to produce numerous small seed heads. The same variety of rice, grown with compost instead of fertilizer, develops more slowly and produces more sparse clumps and, therefore, fewer seed heads. However, the compost-grown rice stems and seedheads are bigger than those made by fertilizer-grown plants.

The simple act of feeding young rice heavily, in an attempt to accelerate and promote growth, leads to a series of changes in the rice field ecology that initiates a downward spiral requiring further chemical inputs. Compost-grown rice grows more slowly and evenly, but produces larger, stiffer stalks that are less susceptible to being blown over in storms. These slower-growing plants also produce fewer dead or dying leaves. The heavy foliage found in fertilized plots encourages populations of harmful insects such as plant hoppers. The problem is exacerbated by the fact that the fast-growing seedlings seem to be more sensitive to insect attack than the organically grown plants. Clipping the leaves of each kind of rice plant to simulate insect grazing showed that an equal amount of clipping resulted in a greater yield reduction in the fertilized plots. Unexpectedly, not only did plants grown with fertilizer produce fewer seeds per head when their leaves were damaged, but they proved to be much more susceptible to infection by the fungal rice blast disease.

The use of compost promotes fly populations. Flies attract and nourish spiders. Spiders help control plant-eating insects such as plant hoppers. Andow reports that plant hoppers remain in the organic fields but, unlike the situation in the conventional fields, they do not undergo population explosion epidemics. Parasitic nematodes are also "natural enemies" of pests such as the green rice leaf hopper. These beneficial nematodes, like the spiders, exist at much higher levels in the organic plots. David has found that these populations of nematodes require several years of organic farming to build up to high levels. At these levels, the nematodes are as effective as conventional pesticide usage in controlling leaf hoppers.

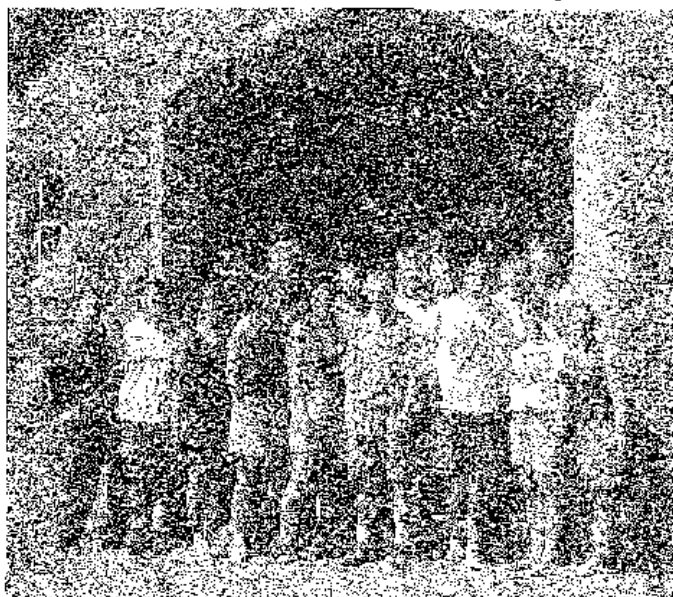
David Andow concludes that specific combinations of agricultural practices may be necessary to achieve good yields. For example, the farmer who fertilizes his rice field will probably suffer disastrous pest damage if he does not also use chemical insecticides and fungicides. The chemicals free him from tasks such as composting. This is the kind of "efficiency" we have become used to. The organic farmer also achieved consistently high yields after combining certain agricultural practices such as composting, avoiding pesticidal chemicals, and allowing water to stand in the paddy instead of using intermittent irrigation. Together this set of practices enables

vital ecosystem processes and lifecycles to function. High yields result without dependency upon industrial inputs because pests and diseases are controlled biologically. Pesticides and fertilizers are expensive both financially and ecologically. Thus, this second agricultural system is efficient in a different way from the high-input system.

### Natural systems efficiencies

If efficiency is defined as the ability to reach a certain productivity (output) with a minimum of expense and effort (input) or waste, it is clear that natural systems are extremely efficient. Industrial systems are also efficient — when cash is the only product considered or when labor is the only input that needs to be minimized. The idea that there have been evolutionary selection pressures that favor highly efficient natural systems, and that it may be possible for humans to design highly efficient systems modeled on these natural systems, has been a central tenet of the philosophy of The Land Institute.

This theme emerged repeatedly in the presentations of many of the speakers at the NSA workshop in Matfield Green (August 1998). Educators are asking how to develop curricula that encourage students to think in



*In front of the Matfield Green school. Front: Rob Corry, Melissa Arthur, Kelley Belina, Courtney Smith, Corey Samuels, Charles Mitchell, Dan Wildy, Kate Worster, Kaelyn Stiles. Back: Jonas Iverson, Wes Jackson, Dana Blumenthal, Terry Loecke, Gary Anderson, Jack Ewel, David Van Tassel*

terms of whole systems and to recognize and value ecological services. Environmental historians are looking at the historical record, which documents both failed and successful human attempts to exploit natural systems, to find clues for achieving sustainability in the future. Farmers and ranchers are beginning to model their production systems upon natural systems instead of looking only to chemicals and heavy equipment for efficiency. Scientists are documenting the ways in which natural systems are efficient and trying to understand the underlying biology. The brief examples in this article illustrate ways in which people from different disciplines and walks of life are seeking to document, explain, and participate in the efficient operation of intact natural systems.

#### **Which systems are natural?**

Those seeking to duplicate or mimic natural systems may be confounded by uncertainties over how much the current systems have been disturbed by human influences. Furthermore, natural systems are not static entities. Environmental historian Brian Donahue suggests that we ask: "What has worked in this place?" There may be more than one answer, suggesting that there is a range of systems that can be efficient in a given place. For example, his research suggests that Native Americans sustainably managed the area surrounding what is now Concord, Massachusetts through managed burns to encourage nut-bearing tree species in some spots, root-bearing swamp plants in other places, and productive blueberry patches on the hilltops. In contrast, the English settlers cleared forest and tilled the land. However, Brian suggests that in the colonial period the English-style village-based agricultural system was largely sustainable. Their method of hauling hay from the marshy river bottoms up to the barn, and spreading the manure from barns onto the fields ensured that nutrients washed downhill from the fields were returned in the form of hay and manure. Furthermore, their reliance upon animal power ensured that much land was left in perennial meadows and pastures. At least 40 percent of the original forest remained uncleared, despite population pressure, because the soils would have been unproductive without manure and the population of draft animals was limited by the amount of hay available. Furthermore, the forest was necessary for winter fuel.

The system broke down when technology freed the Concord farmers from natural limits. Imported coal eliminated the need for firewood and imported fertilizers overcame the limit to cultivation previously imposed by the need for manure. When they cut much of the remaining forest, erosion and flooding followed. Later, cheap



*Jonas Ivarson, Dan Wildy, Dana Blumenthal*

imported grain from the Midwest allowed further deviation from the careful crop rotations and nutrient cycling practices of the colonial period.

Brian Donahue's careful historical analysis reveals very important clues for designing efficient, sustainable systems in this area. It appears that the forest system in the Concord area provides a rather resilient matrix within which a range of human activities can exist. However, critical ecosystem functions may

begin to fail when the percentage of the landscape covered by forest is pushed below about 50 percent.

#### **Natural systems use nutrients efficiently**

Jack Ewel, tropical forest ecologist, has been asking for many years: "How closely do designed systems have to mimic the natural system in order to achieve efficiencies close to those of a natural system?" The cycling of minerals within a system is invisible, yet must be a highly efficient process if the system is to sustain itself. Ewel has monitored the loss of nutrients such as calcium from both natural systems and agricultural systems. While monocultures, such as corn, may be highly productive in the first year, yields typically decline due to the rapid loss of nutrients. In general, polycultures hold on to nutrients better than monocultures. Sometimes, the reasons can be dramatic. His research group found that monocultures of tropical trees were only slightly less conservative of soil nutrients than polycultures during the growing season (the wet season). However, in some monoculture plots, a single storm during the dry season could leach far more nutrients from the soil than were lost during the entire wet season. These were monocultures of a species that loses its leaves in the dry season. In contrast, the soil in the polycultures was protected from direct, heavy rain because there was always some species with plenty of leaves. Simply by maintaining constant cover through species diversity and through the domination of perennials, natural systems reduce leaching to a minimum.

#### **Natural systems are efficient in extreme conditions**

Plant taxonomist Jim Manhart's state of Texas was stricken by drought and heat this summer. Yet, while crops died and scorched, deep-rooted perennials, such as Illinois bundleflower and members of the sunflower family, growing in ditches and along railroads towered over the withered crops and flowered prolifically. Developing hardy perennial crops makes a lot of sense in this region. "Perennial crops might not beat the annuals in good years," he said, "but a modest yield is far better than zero in drought years."

#### **Natural systems efficiently control weedy species**

Agronomy graduate student Dana Blumenthal is trying to understand just why natural systems are resistant to weed invasion and whether restoring degraded systems

to a natural state could be an efficient way of reducing the need for expensive and laborious weed control programs (see article, page 20). Restoring Minnesota roadsides and other typically weedy places to prairie could close off one of the main avenues for weed dispersal. Typical agricultural weed control measures such as mowing, tilling, or spraying are self-defeating since they maintain systems in the disturbed state that invites weeds in the first place.

### **Natural systems efficiently maintain hydrological balance**

Dan Wildy, botany graduate student in Western Australia explained how the native eucalyptus forest has evolved a mechanism to efficiently collect rainfall and channel it deep into the subsoil (see article, page 18). Because the rain contains salt, the vegetation is effectively sequestering salt deep in the ground and then pumping only fresh water back up to the topsoil for use during the growing season. Replacing the natural system with annual wheat has led to ecological disaster. The wheat belt is now dotted with growing salt spoils and there is no foreseeable technological solution.

### **Natural systems are efficient producers of food**

Natural systems have been modified or destroyed since the invention of agriculture in order to achieve efficiency of a single kind: production of food, fiber, or fuel for humans. Only as we approach total domination of natural systems have we begun to understand — and value — other ecosystem functions. Having said that, it would be wrong to ignore indications that some natural systems can also be very efficient when it comes to feeding, clothing, and housing humans. Of course, this is the basis of The Land Institute's research agenda. Although our work is very long-term, we take encouragement from examples of highly productive natural systems or those which mimic natural systems.

An example of gaining food-production efficiency through mimicking natural systems comes from innovative ranchers like Land Institute board member Pete Ferrell. Pete quickly moves his cattle around his ranch, hitting each patch hard but allowing plenty of rest between grazings. This mimics the migratory grazing patterns of bison. Almost magically, this practice both improves the quality of the prairie pasture and allows Pete to stock more cattle than before. Efficiency has increased in some unexpected ways. For example, forcing the herd to move daily reduces disease and insect pest problems by breaking the pest's lifecycle. The heavy but discontinuous grazing pattern appears to result in cycles of grass root death and regrowth. The decaying roots provide channels in the soil that allow rain to infiltrate more rapidly. There are anecdotal accounts of long-dry springs reappearing as a result. In addition to producing more beef and buying less feed, Pete is beginning to see certain native wildflowers and grasses, long absent, returning to his prairie.

Finally, we have the example of Gary Anderson who set out to harvest lumber sustainably from his land in Kentucky and ended up finding that the forest produced plenty of food too. As Gary began calculating how few

trees he could cut each year and still make a living, he discovered that high-value, nutritious mushrooms were growing in profusion from the forest floor and on the stumps and limbs of trees he had cut. The chanterelles on the forest floor are the reproductive organs of mycorrhizal fungi — fungi that live symbiotically with tree roots and help the trees obtain scarce nutrients. The fungi growing on stumps and logs are essentially turning inedible wood directly into a high-protein food. While his goats feast on poison ivy in the understory of the woods, deer, squirrels, and wild turkeys grow fat on otherwise unharvestable resources. Wild fruit and nut trees in the woods are another source of nutrition and income. He reckons that his family will end up making more money on the nuts, mushrooms, and medicinal plants than on the lumber he mills.

Meanwhile, Gary's neighbors see nothing in the forest but trees and contract to have their timber clearcut by a huge commercial sawmill. Corn or other crops can be grown in the clearings, but they perform poorly in the thin soils. In order to be "efficient" the commercial loggers rely on expensive, soil-compacting heavy equipment. In order to pay the bills, a crew must log as many trees in a day as Gary Anderson reckons he will need to log in a year with his team of horses.

### **Conclusion**

The tendency for us to see nothing of value in the Kentucky forest but lumber and paper pulp reflects the predominance of industrial notions of efficiency. Yet, when we attempt to replace the forest or the prairie with a single, specialized, efficiently produced commodity, we find that we lose ecosystem functions such as soil building, nutrient retention, water infiltration and purification, nitrogen fixation, biological pest control and so forth. In order to compensate, we must now supply industrial inputs: fertilizers, herbicides, pesticides, irrigation. Suddenly the supposed efficiency of this production system is compromised, as the ratio of outputs to inputs declines. Efficiency declines further if we calculate the waste: wood scraps instead of culturing mushrooms go to fuel fires that heat no house, poison eliminates weeds before they can nourish a goat. Inexorably, nutrients leach out of the soils, and the soil itself washes into the rivers.

Environmentalists and scientists are often dismissed as sentimental and impractical. Yet, taking efficiency alone as a standard — and momentarily disregarding aesthetics and ethics — natural systems beat industrial systems. Natural systems are not simply pretty. They are doing things. Some of them are performing functions, with extreme efficiency, that are vital to our existence. A rational response? First, limit the destruction or disruption of the remaining natural systems supporting life. Second, shift research priorities from manipulating individual system components to understanding whole-system properties. Finally, over the long-term, invent ways to achieve natural system efficiencies with nature-mimicking agricultural systems.

## *Paragon*

Waning moon, waxing mind  
heavy on my back  
prairie emotion  
Sacrosanct in the land of wind and horizon

*Helianthus* before us  
volant and fantastic  
august narrative  
In the power of vantage and prophecy  
Where to face when the sun passes  
overhead royal hues  
three quarters buried the prairie  
and we walk on  
fed from above  
held from below

— Courtney Smith

## *Nature as a Model and Models of Nature*

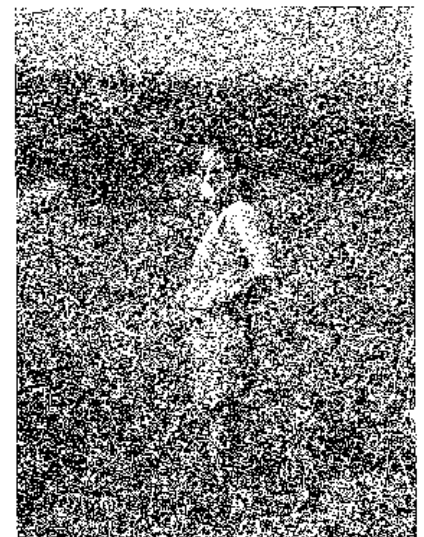
Corey Samuels, Department of Ecology and Evolutionary Biology,  
University of Tennessee

Perched at the computer in my little brick office, it is sometimes hard to imagine that I am working on applied ecological problems of agriculture and restoration ecology. I wonder, how did a Land intern who loves field work and the outdoors end up doing a Ph.D. project in computer modeling and theoretical ecology? After all, the idea of agricultural systems that use nature as a model is what first drew me to The Land Institute. I never expected that I would work to create models of nature and turn them to the task of guiding the development of Natural Systems Agriculture (NSA). That is my dissertation project. This summer, while taking part in the Dodge Fellows program, I had the chance to reconnect my work to The Land's research and to get back to the ideas and the prairie that first interested me in ecological theory.

For me, the appeal of The Land's work and the draw of ecological theory are the same. Both seek solutions that feature generality and far-reaching principles rather than fine-tuning and detail. If perennial polycultures can work in the Great Plains, the underlying principles of NSA should apply in other places too. The objective is to create a general template for a new approach to agriculture. Models of community assembly also seek generalities. They aim to uncover general rules or patterns that help us understand the process of community development. Assembly rules may help us understand what makes some species thrive and others fail when we grow perennial polycultures or restore prairie. Ultimately, they guide us in choosing which species to plant and their order of introduction.

I first learned about community assembly rules at The Land during the Visiting Scholars in Complexity program in 1994. The program featured speakers ranging from physicists to artists to philosophers. They were to consider how approaches to the study of complex systems might contribute to our research program. I have to admit, it was hard at

first not to wonder what we were doing looking to medicine and economics for clues of how to construct ecosystems. I don't think I would have experienced this kind of thinking anywhere else. Indeed, there were common themes and tools across these fairly unrelated disciplines. Most notably, solutions to dealing with complex systems are rooted in acknowledging and managing



Corey Samuels



complexity rather than overlooking it with simplifications. Ecosystems (and human bodies, and evolving works of art) are constantly changing. To understand them we need to study the process, as well as the parts, of their creation.

Far-reaching principles are impressive, but their transformation into practice is more so. The complexity workshops led to a new experiment in community assembly at The Land. Jon Piper designed it after discussions with ecologists Stuart Pimm and Jim Drake of the University of Tennessee. The field experiment is based on an assembly rule observed in computer models and laboratory experiments. The rule states that a whole community cannot be assembled using only the parts that are desired in the endpoint. There is a necessary development process where some species drop out and others colonize the system over time. It is hard to predict exactly which species will persist, but it is virtually guaranteed that we need to introduce more species than we ultimately want in order to reach a certain target state. Before the workshop we planted only the four species we hoped would comprise the perennial polyculture community endpoint (eastern gamagrass, mammoth wildrye, Illinois bundleflower, and Maximilian sunflower). In contrast, the assembly experiment is a series of plantings of different combinations of up to 16 species representing the four functional groups (warm-season grasses, cool-season grasses, legumes, and composites). We replicated the plots at two different sites in different years. Jon is now observing the process of species comings and goings in the plots to compare how different combinations function and develop over time.

The complexity program took place during my last year at The Land while I was considering my options for graduate school. Being involved in the process of planning the assembly experiment is what made me want to study theory. I wanted to learn how to use models to find simple rules that can generate research questions. There are a myriad of questions and options involved in deciding how to plant perennial polycultures. There is reason to believe that both what we plant and the order of introduction are important in determining community structure. In field experiments, even if we include what seems like "a lot" of different plots and replications, space and time are limiting. Even with the 16 species of our assembly experiment, it is impossible to try out every combination in every order. Broad rules like "plant more than what you want" are ways of boiling down the possibilities so we can devote our resources to those combinations which are most likely to be successful.

Early results from the assembly experiment at The Land indicate that the rule was a good guideline for creating polycultures that feature more of the species we want. It is striking to note that models and laboratory

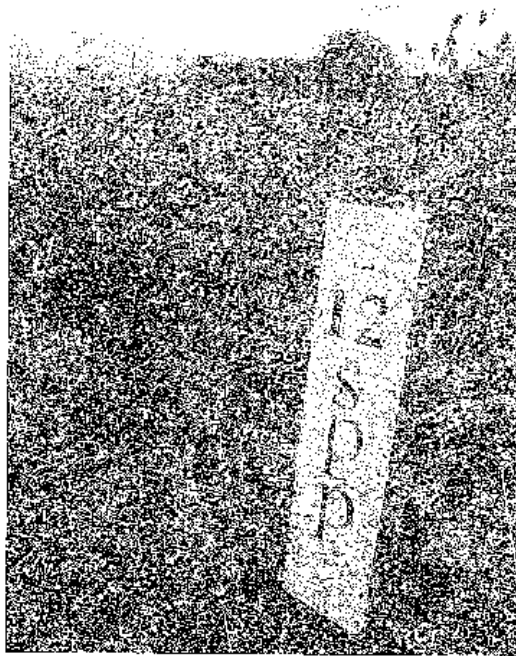
settings that had nothing to do with the prairie yielded the assembly principles of this experiment. If extremely general rules can point us toward fruitful methods, are there more specific rules that can add to the guidelines? That question is at the root of my research project. I am developing computer simulations to examine patterns in prairie community development. These models operate on the same principles as those that led to the discovery of assembly rules in the past, but incorporate features of prairie communities. The simulations include representative species from each functional group. The model functional groups are defined by differences in

growth rates and how they compete for the limiting resources nitrogen, light, and moisture.

If simulation models accurately predict what goes on in field experiments, then we can use them to generate hypotheses for future field experiments. We know that planting the same thing in different places can lead to "alternative trajectories." All that means is that in our plots at The Land, at two different sites, exactly the same combination of planted species has led to different community structures. After five years, a given mix comes to be dominated at one site by composites and by legumes at the other. What we don't know is, are these communities on their way to permanently different states, or are these merely different paths to the same outcome? If we wait long

enough, will they eventually reach the same point? Is there any way to predict what they will look like in the end? I hope that my models will help address some of these questions. It is exciting for me to think that my work might play a direct role in shaping NSA research. The Dodge Fellows program has opened the door for me to do that.

This summer I was back at The Land on two occasions, first to help with data collection on the community assembly plots and later for the Dodge Fellows workshop. Next spring and summer, I plan to spend more time there to fine tune the parameters of my computer models. Being back helped me regain a perspective on the ideas and goals that initially led me to my current graduate studies. Working in the plots, I recalled my favorite part of intern life was the banter among staff. Conversation about the wind, Salina politics, and plant taxonomy mingled with brainstorming sessions for the next generation of assembly experiments. Away from my office looking across the prairie, or in the classroom discussions at Matfield Green it's nearly impossible to forget that we're working on the problem of agriculture. It is clear to me that to model nature, I need to get out in it once in a while to reconnect. Likewise, I hope that in my career I'll always be able to find ways to reconnect with my roots at The Land Institute.



*Community assembly plot at The Land Institute*

# ***Ecological Health, Perennial Agriculture, and the Contemporary Rural Landscape: Fitting the Systems Together***

**Robert C. Corry, School of Natural Resources and Environment, University of Michigan**

## **The Need for a New Paradigm for Agriculture**

Developing a new agricultural landscape is not only a matter of selecting high yielding perennial plants to form a polyculture, but also of determining how the new agriculture fits into contemporary landscapes. Some of our present farm landscapes are ecologically healthy while others desperately need a change in the types of agriculture they support. For example, the Flint Hills of central Kansas illustrate a type of agriculture well-suited to its place — bovines grazing on native prairie vegetation. Other agricultural practices do not fit their setting; irrigated desert landscapes growing annual crops, for instance, seem very out-of-place. So in addition to using perennial agriculture systems to improve ecological health, we also need to fit them into existing rural landscapes.

The farmlands that dominate rural America don't simply produce food and fiber. They also provide valued open space, recreational opportunities, wildlife habitat, and many other social and environmental functions. Unfortunately, modern agricultural methods also have undesirable consequences. The primary non-point source polluter of lakes, rivers, and streams is agriculture. Many large-scale annual crop production and grazing activities are now more resource-depleting and chemically dependent than ever before. The scale and management practices of agriculture have an increasingly discouraging effect on the ecological health of rural areas.

The emerging field of ecosystem health provides a framework for describing landscape conditions. Measures of ecological health include stability, autonomy, and resilience. Systems that are unstable or require subsidies in energy and nutrients — like conventional, annual row crops — demonstrate reduced ecological health. At a larger scale, patterns that include a diversity of patch types improve ecological health. A diversity of patches strengthens a landscape by allowing for an increased number of relationships among ecosystems, including habitat, biogeochemical, and energy relationships. The result is a stable landscape capable of autonomy and resilience to perturbation and stress.

Agricultural lands include several different elements which often represent distinct ecosystems. A view across the rural Midwest reveals both large and small fields,

rivers, woods, wetlands, farmsteads, roads, and town settlements. These elements combine to form a pattern. Both the composition and the pattern influence ecological health. As agriculture moves toward large-scale production, landuse patterns become homogenized, decreasing ecological and visual diversity and diminishing ecological health.

At the same time that we need more diversity and complexity, the remaining vestiges of healthy ecosystems such as woodlands, wetlands, and prairies are becoming fewer, smaller, and more fragmented. Where once myriad ecosystem types prevailed, annual row-crop ecosystems are expanding. Even small patches of restored ecosystems or perennial covers would facilitate the re-introduction of important species and restore a level of ecological health.

## **Restoring Ecological Health in Rural Landscapes**

Each landscape has different levels of ecological health. Natural disturbances such as floods, droughts, fires, and storms often generate new vegetation patterns. Landscapes evolve in response to these disturbances. However, some landscapes are more resilient than others with short recovery and re-establishment periods that maintain ecological health. Other landscapes may be less resilient and require long recovery periods after disturbance. Compare the effects of periodic fire on a prairie which has thick, rich soils to that of a mountain with thin, young soils. Differences in resilience are important for determining which agricultural systems are most appropriate for improving ecological health.

Our present agricultural patterns are the result of several interacting natural and cultural forces. Geology, climate, and vegetation are striking and highly visible influences, but land surveys and ownership also influence contemporary settlement patterns. Agricultural policy, as well, continues to exert strong pressures. The agricultural landscape does not change quickly, though, and traces of historical origin are evident everywhere. We must respect these cultural patterns and the evolutionary pressures responsible for their existence. Understanding the social and ecological foundations of agricultural landscape patterns will also help us incorporate new ideas for Natural Systems Agriculture (NSA) in our contemporary designs.

Where, then, do perennial agriculture systems belong in contemporary landscapes? Ecological health may



***The Flint Hills landscape of central Kansas; agriculture suited to its place***

be an effective way of determining management needs. For example, we expect a higher level of ecological health to be associated with NSA than is currently associated with most annual row-crop fields. Of even more interest, though, is how agricultural systems affect ecological health at scales beyond the individual field. To best fit

agriculture to a diverse landscape we need to determine the ecological amplitude of the landscape and the ecological health of the agricultural system.

### **Fitting Together the Pieces of a New Landscape**

In highly stabilized areas where the ecological ability to absorb stress is high, a form of conventional agriculture may be suitable. Less resilient landscapes may require a dramatic change in management to improve their long-term ecological health. Over 380 million acres of America's cultivated cropland are highly erodible (USDA National Resources Inventory data). These soils



*A complex and diverse landscape is more ecologically healthy*

are not suited for cultivation and require a new type of agriculture.

Many highly resilient lands also need a different kind of agriculture, though. The patchy nature of land use suggests that even in a generally stable region there may be small areas of decreased resilience. Currently, however, crop management typically treats entire fields with uniform applications of fertilizers and biocides regardless of variability. With new technologies, sometimes referred to as "precision farming," it is possible to identify soil, input, and yield variability within only a few feet so that farmers can adjust for these factors continually across their fields. Where the combination results in variability that reduces net return, perennial agriculture systems may still be a better option than these increasingly precise conventional practices.

To make an informed choice, we will need to understand the ecological health inherent in native ecosystems and contemporary agriculture as well as the improvements afforded by a new perennial agriculture. Much of this information is missing. We anticipate that perennial agriculture will improve the ecological health of existing agricultural landscapes by introducing internal-nutrient cycling, species diversity, soil and water quality, and pest and disease resistance. Of course it will depend

on the composition, management, and evolution of the system. Designing this alternative allows experimentation with different compositions and patterns to approach the highest level of ecological health.

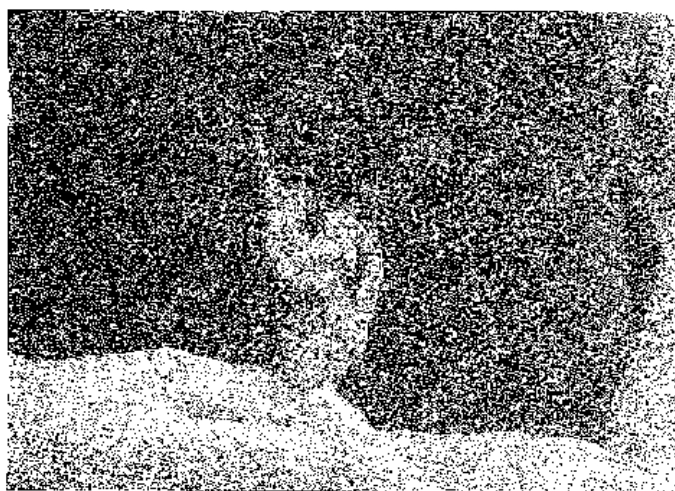
### **The Challenge of Change**

How do we realize this vision of the future agricultural landscape? If ecological health is a desired quality of society, then it should be a policy goal. Farm bill legislation and technology have historically had sweeping effects. These, along with new policy incentives should reflect our increased understanding of ecological

health. Management practices, such as the trend toward conservation over the past several decades, can likewise be encouraged to achieve greater ecological health.

Perhaps profound change will be brought about through other channels. As we continue to race toward that final drop of crude oil, we may begin to realize that a redesign of the system is not merely desirable, but that it is a matter of survival. When agriculture begins to "balance its books" with a broader view of the costs and benefits associated with production, change will be recognized as necessary for continued ecological and cultural productivity. Consequently, our future landscape will likely contain new and interesting combinations of forgotten plants and animals

whose virtues resurface in the era after oil. It will also contain some failures. What agricultural landscape does not? It is critical that we continue to learn about how landscapes demonstrate ecological health and how we can better intervene to maintain or enhance that health while still meeting our food and fiber needs. That, after all, is the joy of discovery.



*A mutant eastern gamagrass seedhead*

## ***Disease in Perennial Polyculture: Perspectives from the Prairie***

***Charles Mitchell, Department of Ecology, Evolution  
and Behavior, University of Minnesota***

Disease would often limit crop production in conventional agricultural systems were it not for the ubiquitous application of chemical control agents. In fact, disease has been a problem in agriculture since ancient times. Is there any hope that disease will be less problematic in cropping systems modeled on natural ecosystems?

To begin answering this broad question I am trying to understand the role of infectious diseases of plants in native tallgrass prairie, the natural ecosystem model for Natural Systems Agriculture (NSA) on the Great Plains. Using this approach I will address two major questions about disease in perennial polycultures: (1) How much disease will be present? and (2) How will this level of disease influence the ability of the system to produce food for people? I expect that in perennial polycultures disease will not cause the major problems it has in conventional agriculture but will still play an important role. Moreover, this role will be much more complex and difficult to define than the role of disease in conventional agriculture.

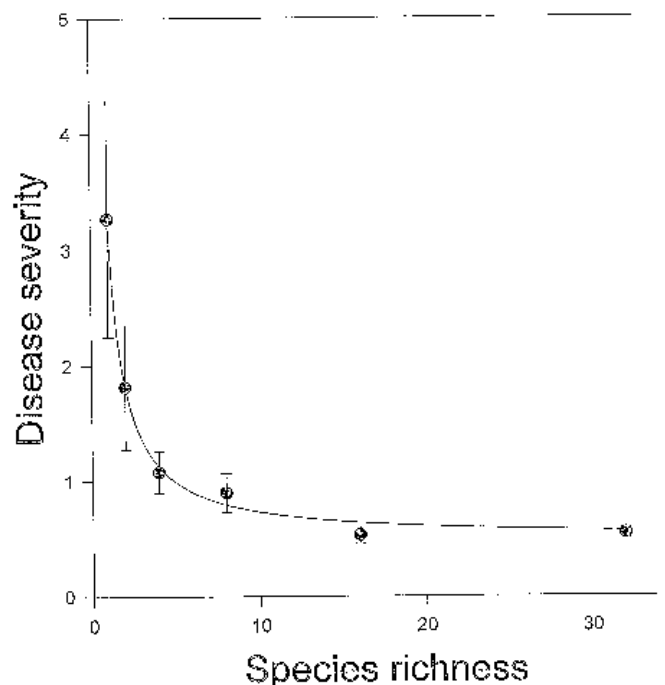
Severe outbreaks of disease are less common in native ecosystems than in conventional agricultural systems. This suggests that certain components of native ecosystems may effectively control disease levels. To address the question of "how much disease," I am investigating whether two characteristics of native prairies, high species diversity and controlled burning, may help control disease levels in NSA. To examine whether the large number of plant species found in native prairie is important in controlling disease, several collaborators and I manipulate plots of prairie to contain various numbers of plant species. I find that growing a given plant species with other species generally decreases its disease load (Fig. 1). This appears to be caused primarily by a lower density of each species; when there are more plant species in an area there tends to be less of each species. Decreased density inhibits disease spread because individuals from the same species are isolated from one another. This is somewhat analogous to the argument that some common human diseases, such as the flu, may infect less people in the summer because we tend to be inside less and not packed so closely together. Our results support an idea that is quite old but still waiting to be applied to agriculture on a large scale: growing more plant species together in polyculture reduces disease levels.

A second feature of prairie ecosystems is that they burn at least occasionally. Historically, the sources of fire were lightning strikes and Native Americans; prairie preserve land managers continue to set fires today. Fire likely reduces levels of disease on the above-ground parts

of plants because such diseases usually spread from dead leaves and stems which burn readily. I have just begun to collect data on the effects of fire frequency on disease levels. Preliminary results suggest that fire has very strong effects on disease so it may be a useful tool for disease management in NSA.

To investigate the effects of disease on production by perennial polycultures, I prevent the spread of disease into plots of prairie vegetation and measure how the ecosystem responds. Current results are preliminary but intriguing. They suggest that removing disease allows at least some plant species to increase in abundance, increasing the total plant biomass produced in the ecosystem. Therefore, the bottom line on disease in perennial polyculture may be the same as in conventional agriculture — disease decreases the ability of plants to produce biomass. However, my research suggests that the magnitude of this effect will be less in polycultures than in conventional systems.

If the effects of disease on total plant production in perennial polycultures are small, does that mean that



***Fig. 1. Decreasing disease severity as a function of an increase in species richness***

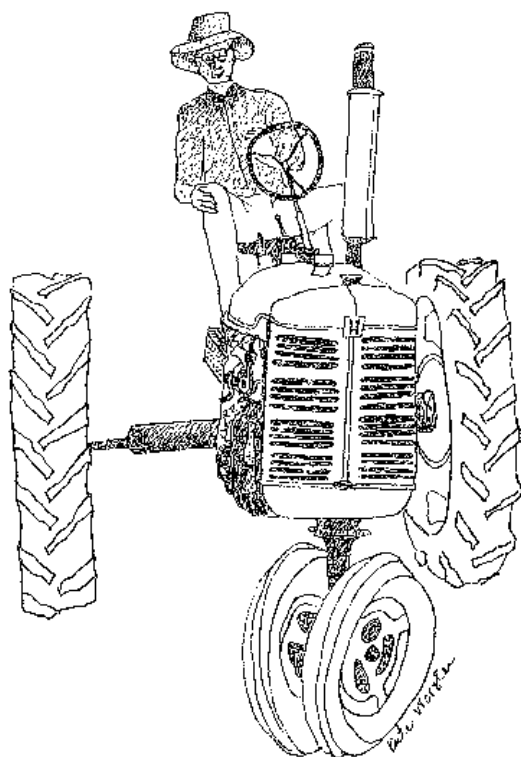
disease will not play an important role and can be ignored? Probably not. I argue that disease will still play an important but initially more subtle role due to the fundamental difference between polycultures and monocultures. In a polyculture, different crop species compete for resources such as nutrients, water, and light. Because of this, a disease that negatively influences its host species may have a positive effect on other crop species by reducing competition. Although I have not observed this effect in my experiments, Chris Mundt professor of botany and plant pathology at Oregon State University



and others have observed it in experiments with two agricultural species.

The potential for a disease of one crop species to indirectly effect other crop species has a variety of implications. First, species that are less impacted by disease may be able to compensate for species that are more impacted by disease, thus decreasing the effects of disease on total production. Second, the net effect of all diseases in the ecosystem on a given crop species may actually be positive, not negative. This would happen if a species is relatively healthy and at the same time is benefiting from the diseases of its competitors. Ultimately, this might even facilitate the persistence in perennial polycultures of some crop species that would otherwise be driven to extinction by competition from other crop species. Furthermore, although disease adds much uncertainty to predictions of crop yields in conventional agriculture, it might actually reduce variation in crop production in perennial polyculture. This would be the case if crop species that increase in abundance become more infected by disease, which drives them back down again. All of this suggests that the effects of disease on perennial polycultures will be important, but very complex.

Understanding the role of disease will be essential for effective, long-term management of perennial polycultures. Accomplishing this will require research incorporating many more variables over much longer time scales than is needed for conventional annual agriculture. But much of the battle will already be won because sudden crises where crops are completely devastated by disease should be extremely rare. Further, our current minimal understanding of the potential role of disease in perennial polycultures does not diminish the urgent need for the development and implementation of cropping systems modeled on nature.



### *The Farmer Finds A Bolt*

Dark farm barn and yard  
where halogen worklights turn  
the dust on one side of  
the faded red combine green

mid-harvest  
the machine is down.

The farmer's finger  
is invested with gravity  
as it stirs in a coffee can  
looking for the linchpin  
to his universe  
"write that down" he says  
to nothing in particular

"I not only found the  
nine sixteenth inch bolt  
I also found the nut"  
the evidence  
cradled into light

the belt will be returned  
engine repaired  
the towering fat wheel

refitted to its axle  
and he can promise wheat  
tomorrow he'll be there

worklights pool the prairie  
where farmers hang on

their coffee cans full  
of assorted bits  
of the farms of america  
are bringing in the bread

— Harley Elliott

## Natural Systems Agriculture for South-Western Australia

Dan Wildy, Department of Botany,  
University of Western Australia

Western Australia is a state one-third the size of the U.S. with a human population of two million. Most of the state is semi-arid to arid desert; relatively low numbers of sheep and cattle graze the natural "scrub" vegetation (a typical density of one cow per 150 acres). In the southwestern corner of the state, which experiences high rainfall of more than 24 inches annually, people are gradually replacing less intensive cattle and sheep grazing stations established by early settlers with orchards, vineyards, and timber plantations. This accounts for over 11 million agricultural acres — only a small portion of the state. The most significant Western Australian agricultural export is wheat and it's grown over a total of 36 million acres in the remaining semi-arid environment. Here only 11 to 24 inches of rain falls annually (Fig. 1). In addition to wheat, farmers raise barley, lucerne (alfalfa), and rapeseed in the cool winter months when the rains come. During the hot dry summer, all annual plants die and sheep graze most of the remaining vegetation — both crop residues and fallow paddocks seeded with annual pastures.

The first generation of wheatbelt landowners spent their lives clearing the open forests, woodlands, and mallee (multi-stemmed eucalypts which regenerate after fire from below-ground organs). They mistakenly associated tall

vegetation with fertile soil. Actually, the landscape was so old that the eucalypts had evolved a tall stature in spite of incredibly poor soils. Farmers found that they had removed most of the phosphorus and nitrogen in the soil after harvesting only the first few crops. As a result, they now apply large doses of nitrogen, phosphorus, and potassium with each crop so that the soils have unnaturally high levels of nutrients.

This agriculture can be highly profitable to farmers, agricultural companies, and the state, despite yields being low by world standards (because they are unirrigated crops they must be grown in winter when rain falls but light and temperature limit growth). Farmers overcome low yields by farming on a large scale with "wheat and sheep" farms ranging in size from around 3,000 to 30,000 acres. Since the farming scale is so large, land degradation often appears relatively insignificant. This partly explains why environmental devastation has gone largely unchecked for so long.

The problem with the agricultural system is that current high yields come at the expense of future high yields. There is the usual suite of problems with Western industrialized agriculture at the paddock level: high rates of soil erosion, poor nutrient uptake from lack of organic matter and biological activity, soil contamination with biocide residues and heavy metals in fertilizers, expensive fossil fuel-derived inputs, and soil compaction. At the landscape level industrial agriculture has largely removed native ecosystems, rural populations are declining, and young people are becoming disenchanted with farming.

In addition to these problems, soil and groundwater salinization now strongly threaten future productivity since most of the original woody, perennial vegetation is gone (many shires are more than 90 percent cleared). Under native vegetation, the soil stores winter rains until summer when high temperatures are favorable for growth. Plant transpiration pumps water back into the atmosphere so that the soil profile is essentially dry at the end of summer. Low concentrations of oceanic salts, naturally present in rainfall, cannot be absorbed or transpired by plants and have therefore accumulated in the soil over millennia. Even with relatively low rainfall between 20 and 80 pounds of salt are deposited on each acre every year; low rainfall means there is minimal flushing action (which removes salts from areas of higher rainfall). Consequently, many hundreds of tons of crystallized salt exist under each acre of soil. Annual crops do not use all the rain that falls during winter and, as a result, water tables rise at a rate commonly around one foot per year. The accumulating groundwater dissolves salt stored deep in the soil and carries it to the surface making the soil unfit for most biological life.

This is a problem of incredible proportions. It is estimated that one-third of the wheatbelt (12 million acres) will be affected by salinity to some degree in the next 50 years if farming practices do not change. Commonly, water tables reach the surface first in valleys, where the deepest and richest soils exist. Not only is

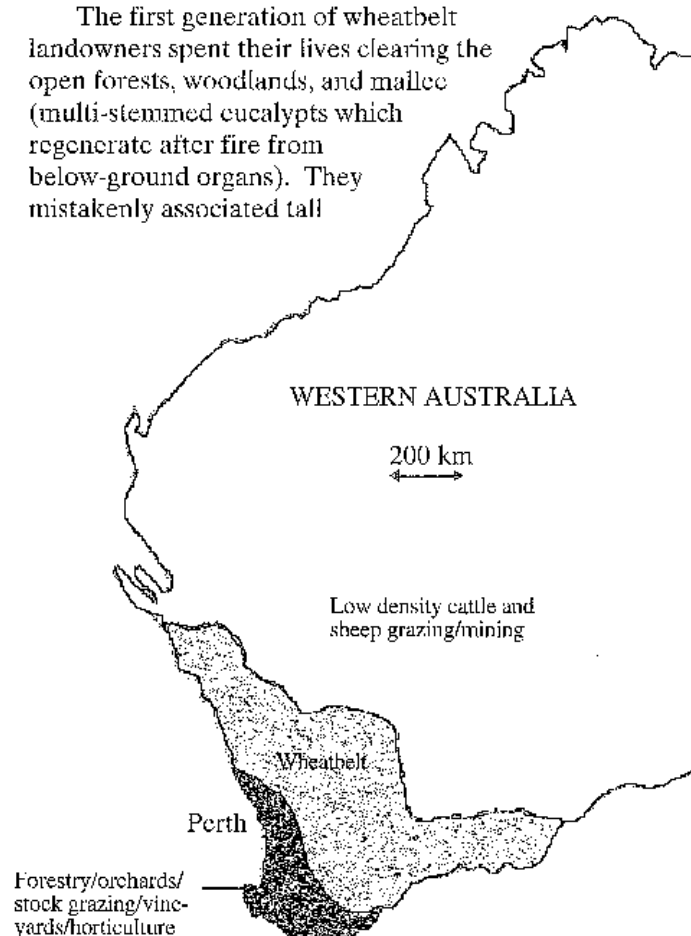


Fig. 1. The state of Western Australia showing major agricultural areas

farmland rendered useless but adjacent nature reserves are severely impacted since they are not adapted to highly saline groundwater. For example, the Fitzgerald River World Biosphere Reserve on the southern coast will be irreversibly damaged by saline groundwater from farms in the regional water catchment upstream. Many towns will be in the middle of salt lakes. Even now, it is not uncommon to walk into a pub with salt crystals on the gravel outside. If it's quiet, you can hear a bilge pumping constantly to remove saline water from the cellar. Most roads in low landscape positions need to be rebuilt on earth causeways 10 feet above the original soil level.

What can be done? Many people are working on small changes to the current agricultural system that will increase water use by crops. Alarmingly, some of the scientists most influential in addressing this problem have recently said that we'll probably have to "take it on the chin." But there are ways of reversing salinity if you don't mind breaking with the current agricultural system.

Agroforestry, where conventional cropping continues between widely spaced, contoured belts of useful trees, may halt or reverse ground-water accumulation. This may also allow other problems associated with agriculture to be addressed such as soil erosion, low biodiversity, and soil compaction. If you take the viewpoint that salinity is a readily apparent consequence of an inappropriate agricultural system, or even one of many symptoms of employing agriculture in the first place, then you can start to think about new solutions.

Aborigines lived for 40,000 years as hunter-gatherers in the wheatbelt region with little long-term damage. However, the aboriginal population was not large. A return to gathering food from the bush would likely not support the increased population in Western Australia today. Also, rehabilitation of degraded farmland to natural plant communities is difficult due to unnaturally high salinity and high soil nutrition from chemical inputs.

A more realistic goal than returning to gathering food from the bush is to redesign our food production system so that it operates by mimicking the natural processes and functions of the native ecosystems. Some of the factors that allowed the native ecosystems of the wheatbelt to persist for millennia include:

- A predominance of deep-rooted, woody, perennials.
- A predominance of summer growth, which is associated with high rates of water transpiration.
- Plants, animals, and even aborigines physiologically adapted to survive frequently occurring droughts (e.g. vegetation leaf area fluctuating with water availability; kangaroos possessing two embryos so that the larger one may be quickly aborted if food is scarce and the second raised when food is more plentiful; aborigines being able to grow big bellies of fat when food is available to supplement times when food is scarce).

- A high diversity of both species and patches of different vegetation types.
- The absence of any hard-footed or hooved animals (the introduction of which cut the soil surface crust making way for erosion and causing elevated rates of compaction).
- Nutrient cycling and a leaf litter layer which insulates soil and living matter during summer.
- Stable populations of diseases, pests, and predators.

Many of these may be incorporated into an agricultural system which, say, includes a diversity of carefully selected tree and shrub species producing food for humans or animals. Instead of excess water being a problem by raising salinity, it could be viewed as a resource which should be harvested and put to the best use for food production. Appropriate animal species could include anything from sheep and cattle to kangaroos or emus. In times of drought populations may be reduced by selling stock. Within this system there is a place for carefully selected crops, even in the form of a perennial polyculture.

Some aspects are harder to envisage than others. For example, closed nutrient cycles would rely on people living and eating food in the place where it is grown.

Fundamental issues to consider are: (i) does it matter whether you

mimic the natural ecosystem which was there or can you mimic any natural system; e.g. can you have prairie-like perennial polycultures in this landscape? (ii) To what degree do you need to mimic the original vegetation to realize the benefits of the natural system; i.e. can you have 15 plant species per acre rather than 150? Does the whole landscape need to be under a mimic for long-term stability, or can some parts still be cropped? (iii) Even if we intervened today on a massive scale with systems that mimicked the water use of native vegetation, what effect would it have on the salinization process already underway? The new vegetation can't use all the salt near the surface and there are large bodies of saline water moving slowly towards valleys where revegetation will not compensate for it.

For my Ph.D. study I am looking at the degree to which deep-rooted, woody perennials will need to be incorporated into the landscape to achieve stable hydrology. My model is the water-cycle of remaining natural vegetation. Practical questions include: Can farmers get away with adopting agroforestry into their cropping system? Will widely spaced trees use up enough water to mimic the processes in the bush? Or do they need a far greater proportion of deep-rooted woody plants? Optimistically, my work will contribute to the design of a more intelligent and practical farming system for Western Australia.

*It is not uncommon to walk into a pub with salt crystals on the gravel outside. If it's quiet, you can hear a bilge pumping constantly to remove saline water from the cellar.*

## Ecological Restoration as Weed Control

Dana Blumenthal, Department of Agronomy and  
Plant Genetics, University of Minnesota

When I explain that I study weeds, people are fond of asking "What is a weed?" This can be a very difficult question for scientists who are used to having things divided neatly into objective categories. "Weed" is most certainly not an objective category. Usually weeds are simply defined as plants growing where they're not wanted. By this definition, even a corn plant in a soybean field is a weed. Similarly, reed canary grass — an important component of many pastures and a useful plant for stabilizing disturbed soils — is considered to be one of the worst invasive weeds by practitioners of wetland conservation.

When we try to control weeds we usually start with our subjective definition and devise our control strategies from there. As a general approach this makes sense; if a plant is growing where it's not wanted, kill it. Despite centuries of improvements in our weed-killing ability, however, weeds are still with us and show no signs of going away. For this reason, it seems useful to consider whether our basic approach to controlling weeds might be flawed. Perhaps we need to go beyond simply *noting* that an unwanted plant is present and ask *why*. If we can answer this question we might learn to keep the unwanted plant from growing in the first place. Of course, it becomes more

challenging when we try to keep all potential unwanted plants from growing at once. This is the crux of the problem of weed control. I suggest that to solve it we need to return to our original question: "What is a weed?"

If weeds are simply "plants growing where they are not wanted," then they might be any sort of plant. It follows that it would be very hard to create conditions in which none of them will grow; one will thrive in the environment in which another fails. If, on the other hand, we were to add some detail to our definition, a detail that describes the attributes of plants that tend to grow where they're not wanted, we might get somewhere. That is, if weeds have certain attributes in common, we might be able to devise environments in which weeds, by and large, do poorly. Such a suggestion is ridiculous if taken as an absolute.

Weeds come in many different forms and invade almost all types of ecosystems. Nevertheless, there are good reasons to think that *most* weeds share common attributes. The weeds we are currently fighting have been selected, both at the level of the species and the level of the genotype, by many years of similar environments. We should thus be able to add detail to our definition of a weed by understanding the nature of the environments which selected them and the characteristics that have resulted from that selection. Luckily, this has already been done.

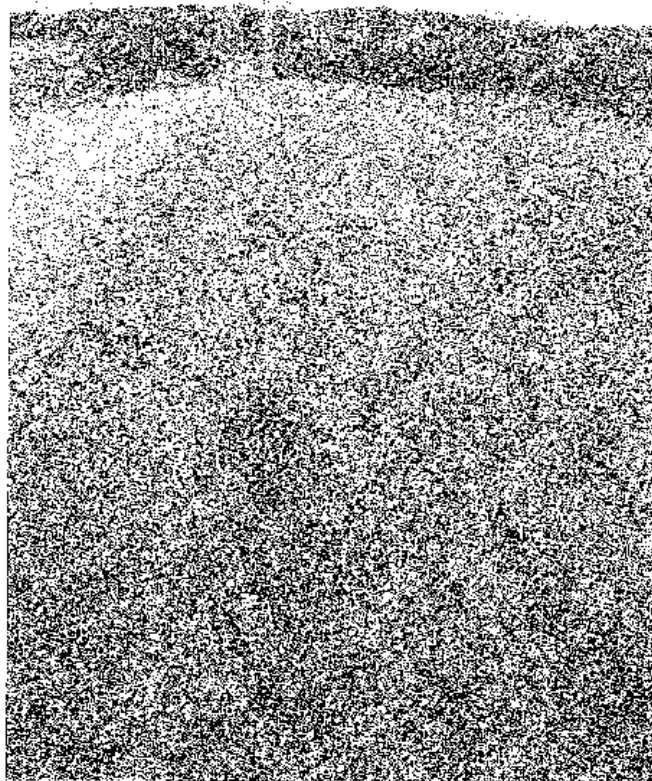
A common ecological definition of weeds is "plants that thrive in disturbed environments." This definition suggests a number of traits that help plants grow in

disturbed environments (e.g., high seed set and rapid growth). Conversely, and more importantly for the present discussion, this definition suggests a list of traits that most weeds would not be expected to have — those traits that tend to help plants growing in undisturbed environments (e.g., shade tolerance or large root systems). This second list should help us with the problem of weed control. If weeds generally don't possess certain traits, we should be able to control them by creating environments in which those traits are required. I suggest two applications.

The easiest place to control weeds should be where there are low levels of annually-recurring human disturbance. Examples include roadsides, field margins, old fields, and stream corridors. On such land, native ecosystems, or at least facsimiles thereof, can be restored. In the resulting

ecosystems plants adapted to a relative lack of disturbance will have a competitive advantage over weeds. The advantages to such a strategy, however, would go beyond weed control by contributing to a variety of conservation goals including increased habitat area for native species, corridors for wildlife, and improved water quality.

A more difficult question is how to achieve weed control in agricultural situations. In order to understand the difficulty of this problem, it is necessary to examine the restoration situation in a bit more detail. Restored ecosystems would be expected to control weeds because of their efficient use of available plant resources (some combination of light, water, and soil nutrients). If resources are unavailable because they are in use by other plants, a weed attempting to invade that ecosystem will be



Roadside near The Land Institute with a collection of native perennials



less likely to acquire the resources necessary to survive and reproduce. Efficient use of resources results from two features of native or restored ecosystems — local adaptation of native plant species and plant diversity. Native species, by virtue of selection over long periods of time, are adapted to make efficient use of the resources that are scarce in a given environment. The presence of multiple species, each adapted to a particular combination of resources, further increases the efficiency of resource use.

In most agricultural situations there are likely to be limits both to the degree of local adaptation and the degree of diversity that can be included. Thus, there are two questions bearing on whether restoration-style weed control can be achieved in agriculture. First, “*What are the limits to local adaptation and diversity within agricultural ecosystems?*” The Land Institute has shown that polycultures of grain crops can be developed that include both of these attributes. It is not yet clear, however, how much weed-control value (through local adaptation) can be retained while breeding plants for agronomically desirable traits. Nor is it clear how many species can be included in a polyculture without overly complicating planting and harvesting. The second question is “*How much weed control might be achieved with lower levels of local adaptation and diversity (relative to native ecosystems)?*” Nothing is known about this question. My guess is that substantial weed control benefits can be achieved — at least given our present array of problematic weeds. My research as a Dodge Fellow is intended to shed light on this question.

All of this hypothesizing is not to suggest that weeds can be eliminated. Diversity within the plant kingdom and rapid dispersal of plants by humans ensures that weeds will remain, though the species of weeds will change over time reflecting changes in the ecosystems that they invade. All we can do is try to move faster than the weeds. What this hypothesizing is meant to suggest is that we have an opportunity at the present time to make up ground in the race. Because we have been doing the same thing for so long — disturbing soil and planting annual crops — it should take the weeds a good while to catch up when we start doing something different.



Maximilian sunflower (*Helianthus maximiliani*)

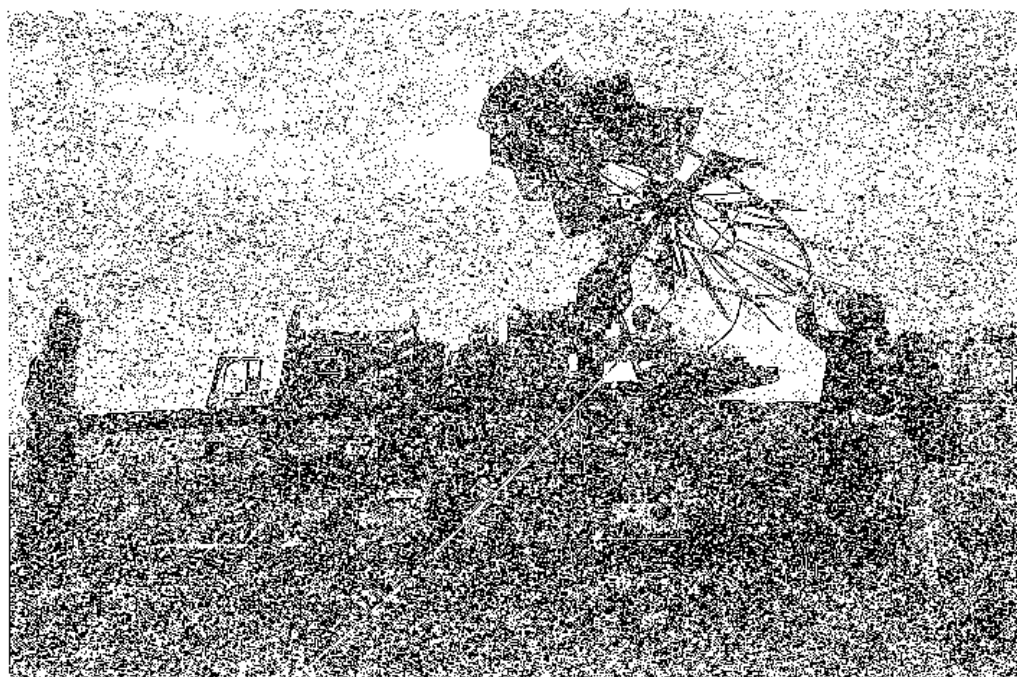
## Education in Transition

Jeff Emphfield

Education at The Land Institute is partly rooted in the distinction between agrarian and industrial values. *Agrarian* means simply “relating to the land” while *industrial* suggests manufacturing, production, human contrivance and cleverness. When something is *industrialized* it is prefabricated, mechanized, or standardized.<sup>1</sup> The agrarian mindset is based in local conditions and seasonal patterns; it’s interactive with ecosystems and community oriented. Agrarian-minded people are invested in the land, in the soil, plants, and animals of their region. The industrial mind works at highly specialized tasks and goes from one compartment of modern life to another. Consequently, agrarians have more potential for fitting into their ecological surroundings than do industrialists. The industrial mind, in order to become ecological, needs first to return to something like the agrarian mentality. But that’s not enough. Further refinement is needed through ecological awareness such as that promoted by David Orr in his books *Ecological Literacy* and *Earth in Mind*. Wes Jackson often makes this point by saying that homesteading alone is insufficient. It is the first step, though, away from industrialism. One of the great values of The Land Institute is not only that it took this first step in the 1970s but also that it has since focused on ecological refinement. Ecology sets the parameters for our agenda of mimicking nature to develop a new agriculture. One of our goals in this respect is what we call Natural Systems Agriculture or NSA.

There is a difference, though, between what The Land Institute was (which many people believe it still is) and our current focus on NSA, the Sunshine Farm, and Rural Community Studies. For instance, our intern garden, asparagus patch, photovoltaic arrays, composting toilets, solar showers, and old windmills are pursuits that grew out of the earlier period of our history. This is not to say that these projects no longer have value. On the contrary, we recognize the need for more home gardeners, small-scale niche producers, and alternative technology users. As an organization we have evolved away from these pursuits, however. It is distracting and unhealthy for a relatively small reformist organization to have too broad a focus. So instead of trying to actively address shelter, alternative energy and transportation, appropriate technology, and various aspects of personal consumption, we focus on the monolithic paradigm of agriculture. That alone is challenging enough. Beginning with grassland species inventories in 1978, our attention over the last two decades has shifted steadily towards developing NSA and away from the other earlier projects of the Institute.

As The Land Institute moves to the next logical phase in this effort, its programs must also evolve. Therefore, the board of directors, acting on a proposal by the president, recently voted unanimously to suspend the



*Wind machines symbolize the early history of the Institute*

internship program for 1999. This is a sabbatical for a program that has operated for 22 years without a break. There will likely be an abbreviated internship during the summer months to carry out research but it will have a reduced educational component. During the sabbatical, a committee of two board members, a member of the staff, and a former intern/staff member will work to develop a new program. It will try to answer the following question: If we were to redesign the education program at The Land Institute to best serve our goal of promoting NSA, what would it look like? We may find that the education program needs to evolve in the direction of the graduate student fellowship program. Certainly, through association with universities, the NSA fellows program holds more promise for getting NSA research onto the national agricultural agenda than does the intern program. Implementation of NSA will benefit from cooperation with agrarian communities but first it needs researchers. The NSA fellowship promises to strategically infuse the academic culture with young people who are poised to take on this research. Accepting this, a more important question is: As we move closer to the industrially minded academic culture, how will we safeguard our mission to unite people, land, and community?

Another consideration, of course, is the need for the kind of education that the Land Institute internship pioneered. Every year, even as similar programs have

have environmental studies programs or operating farms where students can work and learn.

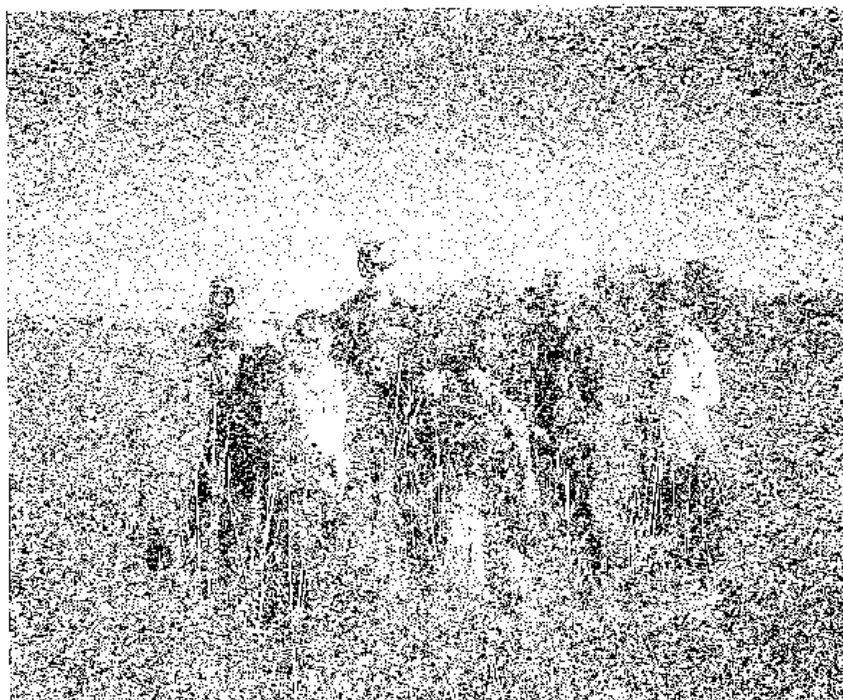
And what about everything else The Land Institute is or ever has been other than the springboard for NSA? Again, the early history of the Institute was a necessary first step leading to the current project of ecological appropriateness in agriculture, or NSA. In this early stage Wes and Dana Jackson had fairly wide-ranging interests, from food production to building shelter with recycled materials to generating power from the wind. Even though The Land Institute has grown beyond those earlier projects, many of them still have value. Likewise, the creative process of developing alternative technology,

food and energy systems, and the education associated with the Institute in the 1970s and 80s will continue to have value for every generation. For example, as in past years the fall curriculum this year addresses students' interests beyond NSA and their search for future plans. As the year draws to a close several are applying to graduate programs and others are exploring opportunities for employment. The topics they've chosen for our curriculum reflect their breadth of interests —

current agricultural research and beginning farmers, permaculture, bioregionalism, grassroots community organizing, appropriate technology and Geographic Information Systems, farm policy and the farm bill, the economics of farming, and food security. Also at the request of students, David Van Tassel is offering lectures



*Melissa Arthur, Jon Piper, and Terry Loecke identify species in a community assembly plot*



*Katie Goslee, Kaelyn Stiles, Jeff Empfield, Jen Fraulo, Kelley Belina, Claire Homitzky, Terry Loecke, Courtney Smith*

on plant biology and he and Marty Bender help lead weekly discussions of science journal articles. Students are also taking time to explore our library as well as present other topics of interest during "warm-ups."

This curriculum alone, though, is insufficient. The young person who is best prepared for responsible ecological citizenship or for creative work in NSA research should also have an education beyond the classroom. Remember that the first step Dana and Wes took at the time they founded The Land Institute was to engage their surroundings through homesteading. For years, programs at the Institute reflected that experience. Despite the evolution of our education program away from those roots, we still value capable young people who work close to the land. Consider what the people who served as interns last year are doing now. They are variously working in documents preservation, finishing a Ph.D. in philosophy at The University of Colorado, attending graduate school at Kansas State University in soil ecology, attending graduate school at Iowa State University for grassland ecology, working for ECHO which designs and promotes gardening systems for Third World nations, apprenticing on a horse-powered farm, apprenticing on an organic farm, and apprenticing on a dairy farm. Learning and manipulating theory is only part of an education. Applying theory in the physical world is needed to make an education experiential and indelible.

The Land Institute internship has directly influenced hundreds like last year's group to develop agrarian skills and to act with ecological awareness in their vocations and avocations. It has surely influenced thousands of others indirectly as well. Even as we focus on NSA for strategic reasons, we recognize that it is only part of our larger world view. Ultimately, its success depends on a culture of people who seek to live ecologically on the land.

*Agrarian* entered the English language in 1533 from the Latin *agrari-us*, pertaining to land. Initially, English speakers encountered it through the Roman's *Lex agraria* or law for dividing conquered lands. In the 18th and 19th centuries its meaning expanded to include relations or connections to cultivated land and landed property. Of particular interest for the work of The Land Institute is its Botanical meaning: "growing wild in the fields." *Industrial* came into use in 1590 with Swinburne's *Testaments*: "Of fruits, some bee *Industriall*, and some *Naturall*. By *Industriall*, I meane suche as bee sowne in the ground by mans industry, in hope...to be reaped with increase ere long." *Industry*, an English word since 1494, has come to mean a branch of systematic, habitual labor in production or manufacturing. The distinction has implications for both Natural Systems Agriculture and *Agribusiness* (c. 1955) which produces, processes, and distributes food and fiber industrially using advanced technology. *Oxford English Dictionary*, 2nd ed. (1989), s.v. "*Agrarian*," "*Agribusiness*," "*Industrial*," "*Industrialized*," and "*Industry*."

We have several suggestions for those who are interested in what our internship has traditionally provided. First, consider whether you want to be an agricultural producer or an agricultural researcher. If you're interested in research, secure admission to a graduate program and contact us about how your work can contribute to NSA. To find out more about where you can gain experience in both agricultural production and research consult the USDA's *Educational and Training Opportunities in Sustainable Agriculture*. This booklet is available from the Alternative Farming Systems Information Center, National Agricultural Library, 10301 Baltimore Blvd. Room 304, Beltsville, MD 20705-2351. Another excellent source of information on production agriculture internships is *Internships, Apprenticeships, Sustainable Curricula* available from the Appropriate Technology Transfer for Rural Areas (ATTRA), P.O. Box 3657, Fayetteville, AR 72702 or their website [www.attra.org](http://www.attra.org). Investigate your choice of potential internships closely and visit the sites, if possible, to assure a good match for your interests and abilities.

## The Life of the Soil: A World Apart

Jen Fraulo

The soil on the Sunshine Farm is heavy and brown, rock-hard in a drought, and bog-like after a big rain. These properties — color, texture, and moisture — form most people's perceptions of the soil. That the soil is filled with life is a much less familiar observation.

The soil is an extremely active realm of biological activity. Nearly everywhere, the soil abounds with microbes that exchange and reorganize the various chemical building blocks within the biological community. Visible only by microscope, a whole world of microflora and microfauna breathe, forage, and metabolize as they interact with the air, nutrients, and other organisms of the soil. There is no such thing as "sterile" soil outside of a laboratory or a chemical disaster zone. Nevertheless, I find

myself surprised to observe the unfertilized soil giving life to soybeans, sunflowers, sorghum, and alfalfa during the growing season.

The same soil supports dense experimental plots of eastern gamagrass,

mammoth wild rye, Maximilian sunflower, and Illinois bundleflower where a small portion of the Sunshine Farm's 72 acres is set aside for Natural Systems Agriculture research. In the springtime these plots look like any well-tended garden with young shoots growing neatly in straight lines. By midsummer the plants are shoulder-height, providing some of the best shade I can find from the intense heat of the cloudless prairie sky. The plots become a checkerboard jungle, ensnaring my body in tangles of foliage at every step and inviting me to pause in the cool understory. The plants scent the air around them and shelter a diversity of insect life. I am struck by the thought that all of this life has come forth from the seemingly lifeless ground, although my research into the soil of these plots should have informed my perceptions by now.

It has always been hard for me to regard the ground with the same amazement that I have had for the green things borne from it. I remember the cycles of vegetation in the part of New England where I grew up. The thick summer woods expired in a show of fireworks in the fall. Time seemed to stop when the trees stood bare, presiding silently over a black and white world. Against all expectation, green things would reemerge and

the air would again be rich with the sounds and smells of life. It has been hard for me to think of the ground other than as inert substrate in which the wondrous plants anchored themselves. I felt compelled to investigate the composition of the soil more closely; I imagined the microscope could give me x-ray vision into a handful of the unimpressive-looking material. I hoped that what I saw would help me to understand the invisible soil community. Instead, this intriguing world has remained very much a mystery to me.

The soil-building activities of micro-organisms are an active frontier of scientific inquiry. Two types of soil microbes have particularly well-known roles in sustainable agriculture: bacteria which live on the roots of legumes bring atmospheric nitrogen into the soil, and certain fungi supply phosphorous to plant roots. These mycorrhizal fungi are the focus of my independent research at The Land Institute. By examining the species diversity of mycorrhizal fungi in 25 experimental plots at the Sunshine Farm, I can compare the levels of diversity that are associated with different species of perennial plant cover.

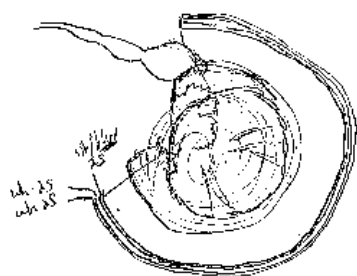
I differentiate between the many species of mycorrhizal fungi by comparing their reproductive spores under the microscope. First spores must be brought through an involved procedure so that I can mount them on microscope plates. Isolating the spores of the fungi means that at each step I eliminate additional fractions of the soil and the soil community. What begins as a small cup of soil becomes a mere few droplets of water. The water holds the spores — smooth globes which shine in the light of the microscope. Very little material remains that has any resemblance to "soil" at this point.

The dense, rich earth outside is so different from the watery slurry that I probe in the lab. I frequently interact with the soil as I am walking, planting, or weeding outside. I think about the color, texture, and moisture of the soil. I strain to imagine that the spores and nematodes I have seen under the microscope are at home here, in the field. So much for x-ray vision. The complexity of the microscopic soil community remains a challenge to my imagination.

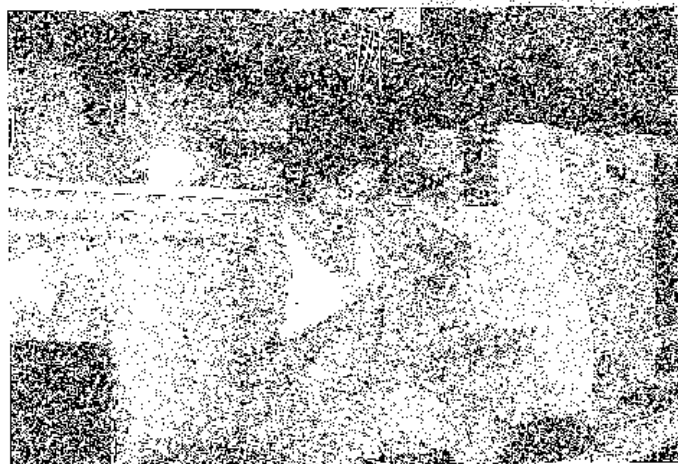
And although I am aware of the soil community, I do not automatically think of the soil being full of life. If I ever do achieve this level of understanding, it will not have been earned by making specimens in the laboratory. I suspect that the people who best understand the life of the soil are

those who use soil organisms in agriculture, working with them to improve soil health and fertility.

Organic growers know that a healthy population of soil organisms will gather nutrients, build soil, and support







*Jen Fraulo*

plant life. Although organic growers sell vegetables or grass-fed beef, they will typically tell you that their primary concern is feeding the organisms in the soil. Fertility can be produced on the farm by the intricately coordinated organismic activity in the soil. Conventional farmers use manufactured petrochemical products to alter the soil's fertility. Chemical farmers ignore the life of the soil. As consumers, our perceptions of the soil inform the kind of agriculture we support. As we work to shift our agriculture back to sustainable biological methods, it is essential that we nurture an awareness of the life and fertility in our fields beyond the chemicals that we add and the crops that we harvest.

## ***Cattle Happy***

*Claire Homitzky*

A year ago at this time the Land Institute internship program was a distant and ill-defined goal of mine; I had not yet drafted my essay of application or assembled a decent resume to that end. A few long, dreary, Manhattan-months later (winter months in New York City, if you haven't heard, are an interminable string of city-snow-gray days), I relocated to a pleasant house with a pleasant roommate in the town of Salina, Kansas.

Neither my East Coast November nor my Midwestern spring suggested the work I would soon undertake in April and through the remainder of my stay. It was late March when the eight Land Institute interns assumed one or more research projects; it was only in late March, then, that I committed myself to a small herd of Texas Longhorn beef cattle, and, I'll add, ensured my happiness for the next several months. My experiences as an intern, as a temporary Salinan, and as a "born-again" Kansan are inextricably linked to my work with these critters.

I began this work in earnest with the birth of "my" first calf by a Longhorn/Gelbvieh cross named Paintbrush. Dubbed Nike for a distinctive corporate logo gracing her forehead, this heifer calf shared her first few clammy,

spindly moments with me on a frigid April morning. From then on my days lengthened as early-morning and early-evening "calf checks" became a daily exercise and head counts the rule of thumb. Fifteen calves later the novelty of this process had diminished and the satisfying feel of routine had assumed its place.

As the spring wore on, I incorporated the herd into a rotational grazing system that plods tentatively along to this day. This system limits the grazing activity of a herd to a reduced area, often called a paddock or cell, that is delineated by one or more fences. The forage in each paddock is trampled or grazed to approximately 50 percent of its vigor before the herd is moved to another area — an adjacent paddock if I've planned well and a distant one if I have not. The time required to affect this response varies with several factors such as paddock area, herd size, and seasonal differences in rates of plant growth. There are a number of terms to describe this system, each reflecting subtle concerns including contour grazing, short-duration or time-controlled grazing, and management-intensive grazing.

As a novice to this system and to stockmanship, I am typically found standing alone and witless on the pasture trying to dissect some recent experience for a lesson. So far I have learned a handful of these lessons that may be useful to any reader interested in a career of livestock management:

- 1) *There Is No Such Thing As A Two-Person Job.* The lone and witless livestock manager must learn to do things all by herself, even when she is absolutely certain the job requires help — this includes heavy lifting! A little ingenuity and enough TOOLS will get the job done.
- 2) *Learn To Anticipate Disasters.* A nasty storm can send yearlings through fence, and roadside gates sometimes fall off their hinges. Although these things are not true all of the time they are true ENOUGH of the time to make trouble.



*Whoa, Nettie*

- 3) *Timeliness.* The livestock manager is just one part of a DYNAMIC system that does not easily accommodate another schedule. This may, at one time or another, subvert the livestock manager's other plans. Generally, it may be



Claire Homitzky and Nettie

said that livestock do not respect holidays, Sundays, or hot dates.

These lessons learned on the pasture are equaled by those learned in the greater communities of Salina and Kansas. As I became more immersed in the project, my questions concerning the cattle and their management multiplied. Looking to local knowledge on the subject, I discovered a couple of vital sources of information. The first of these is the

grazing network or "cluster group." The Flint Hills Grazers, representing members from Marion, Dickinson, Ottawa, and Saline Counties, is a network of producers who practice innovative ways of livestock management and farming. I participated in a two-day grazing school hosted by this organization that provided a mid-season review of my own management and informed all subsequent decisions. More recently the same network organized a two-day sojourn to Medicine Lodge, Kansas (Barber County) and Ardmore, Oklahoma. The field trip included a visit with a rotational grazer and a first-hand look at comprehensive research, but its greatest asset was the participants. Imagine me, a 23-year old gal who was most recently employed in the Greater Metro Area, and eight men with a median age of 50, tirelessly employed in the Great(er) Plains States. The greatest exchange of info, advice, and support (on every topic) happened in transit!

Livestock lessons may be gleaned from an arena of another sort — the country dance bar. Although I've come to realize a cowboy hat does not signify a cowhand, there are many instances when the local livestock manager can be discovered skulking in the shadows or cutting up the rug. A little clever maneuvering can lead to an engaging conversation; fortunately, most people in cattle are happy to talk cattle.

The value of personal experience, complimented by the experience of others cannot, I think, be overestimated. As the internship exhausts its autumn leg, my association with the Longhorns also comes to a close. I can't adequately express how vital the cattle project has been to my experience as a student or how important it has been to my understanding of the people and state of Kansas. I am already feeling some pangs of separation yet I suspect this brief stint as livestock manager will inform *anything* I do, particularly lessons 1-3.

## Our Work Lies Ahead

Katie Goslee

The Land Institute and its allies work to form a marriage between agriculture and ecology. As we try to incorporate questions of land use into a larger context of sustainability, others are forming a very different union. This is the marriage of agriculture to technology and big business. While this union is certainly not new, the ties that bind are growing ever stronger. Evidence lies in the increase of genetic engineering, the advent of intellectual property rights, and joint ventures between small, progressive organizations and large corporations. There are many examples that have made national news in the past few months. Although they may seem like isolated events, they actually represent a growing trend towards monopolization and industrialization.

Much of the work of biotechnology is closely related to the move towards globalization. Biotech companies promote their products as easy to control and predict. The products offer clear incentives such as increased profits and they gain widespread use, crippling farmers who do not adopt them. For instance, nearly all farmers now use hybrid seed for increased yield. As a result, farmers who choose to use heirloom varieties are less competitive in the market, although their products are no less sound. As Marty Crouch, professor of biology at Indiana University states: "biotechnology turns something that is not a commodity, and is therefore protected by invisibility, into something of monetary value to be fought over." In order to maintain high yields, biotech companies are forced to improve their products almost yearly to respond to ever-changing conditions. Thus, biotech products make it possible for agribusiness to gain control over the global market regardless of regional environmental differences.

One of the most recent and perhaps most far-reaching developments in biotechnology is the Terminator gene. It has been called the "neutron bomb of agriculture" since it prohibits plants from producing viable seeds. In essence, it allows seed companies to maintain control of crops such as rice and wheat, which are naturally self-pollinating. Normally farmers can harvest the seed from self-pollinating crops and use it the next year. In this way, poorer farmers can supply their own seed, purchasing new seed stock only every four or five years to maintain genetic diversity. With the Terminator gene, however, these farmers will be dependent on seed companies for new seed every year and will likely be put out of business. At the same time, the profits of the seed companies will greatly increase. Hope Shand of the Rural Advancement Foundation International notes that a "technology that threatens to extinguish farmer expertise in selecting seed and developing locally-adapted strains is a threat to food security and agricultural biodiversity, especially for the poor." Perhaps one of the most disturbing aspects of this technology is that it was funded in part by the USDA — our government is also part of the marriage.

While biotechnology becomes more common, some genetically engineered products are failing to live up to expectations. The September 3rd issue of *Nature* printed a

short letter entitled "Promiscuity in Transgenic Plants." The letter details a study that examined gene flow from domestic crops to their wild relatives. It compared plants which had been bred to be resistant to a particular herbicide to domestic herbicide-resistant mutant plants. The results showed that the genetically altered plants were 20 times more likely to spread the gene for herbicide resistance to the wild population than were the mutant plants. This suggests that genetically engineered plants can dramatically affect weedy populations. Similarly, insects can overcome genetic engineering. Bt cotton was bred to contain genetic resistance to the three most damaging cotton pests. In 1996, Bt cotton covered 13 percent of U.S. cotton acreage. Despite promises to the contrary, much of this land had to be sprayed to decrease pest damage. These outcomes seemed unlikely, but suggest there are many unforeseen byproducts of genetic engineering.

Generally, these failures do not receive detailed coverage in the news. In fact, some interesting patterns have emerged in the media presentation of science and technology. Journals containing supposedly objective, factual information about advances in biotechnology are much too technical for people that are not in the field, including, in many cases, scientists working in related areas. Popular news and business magazines, however, frequently offer a simplistic overview, including praise for the benefits of the technology without a straightforward description. The journals which criticize the technologies are generally harder to obtain, less well-known, and largely seen as the product of fringe groups whose ideas are not fully legitimate.

The most telling literature is that of the biotechnology companies themselves. While it is quite easy to obtain this literature, the pamphlets are often little more than advertisements. In addition, it is very difficult to find any factual information about either the benefits or the drawbacks of their products. An article in the May/June 1998 *Ecologist* describes the development of the propaganda of one biotech company. EuropaBio, an organization representing the European biotech industry, recently hired Barson Marsteller, the world's largest public relations firm, to help them improve their image. The firm advised EuropaBio to "stay quiet on risks of genetically engineered foods, as they could never win the argument, but to focus instead, on 'symbols, that elicit hope, satisfaction and caring.'"

In other instances, officials confuse public relations issues with talk of free-trade agreements. President Clinton has recently convinced Prime Minister Tony Blair to allow the use of genetically modified crops in Britain, despite consumers' disapproval with the move. Most of these crops are the products of American businesses. In our current political atmosphere, politicians have more incentive to satisfy business interests than the needs of consumers.

Another aspect of this marriage is the unwilling involvement of Third World countries, indigenous people, and traditional farmers. In a statement this summer at The International Conference on "Women in Agriculture" in

Washington, D.C., Dr. Vandana Shiva of the Research Foundation for Science, Technology and Ecology characterized this union as "biopiracy." She cited the example of centuries-old varieties of rice which have long been used as crops by indigenous people and have now been patented by a U.S. corporation. As a result of intellectual property rights, traditional farmers (often women) are forced to pay for resources they initially developed. In the meantime, organizations which originally set out to counter these technologies and methods of biopiracy are suddenly close bedfellows with biotech corporations and multinational businesses. Probably the most well known example is the recent acquisition of Seeds of Change by M&M/Mars. Another case is the proposed joint venture of the Grameen Bank with Monsanto. Both of these partnerships are ironic: a seed company devoted to genetic diversity and nutritious crops in cahoots with a candy company, and a revolutionary organization with a reputation for providing credit to "the poorest of the poor in rural Bangladesh" without collateral teaming up with the developer of Terminator technology.

Considering the overwhelming influence of biotechnology, The Land Institute faces a monumental task. As we work to develop a Center for Natural Systems

*Organizations which originally set out to counter these technologies and methods of biopiracy are suddenly close bedfellows with biotech corporations and multinational businesses.*

Agriculture and move Natural Systems Agriculture (NSA) research into the universities, we must hold true to the marriage of agriculture and ecology rather than be drawn into the prevailing marriage of agriculture and technology. It is simultaneously imperative and

seemingly impossible for NSA to avoid the grip of biotechnology. Part of its elegance is that it is not a commodity. Of course, this could change; we could some day see a trademark behind the letters NSA. If that happens, The Land Institute's agriculture and ecology will have signed the divorce papers. Currently, however, this is not our path.

The Land Institute still works to understand the larger context of the problem of agriculture and still has an awareness that the solution to this problem does not lie in big business and biotechnology. Fortunately, we are not alone in this understanding. As the move towards globalization and biotechnology accelerates, there is also an increased awareness of some of the problems that may result. The article in *Nature*, for example, gained the attention of national broadcast news. The media is beginning to respond to the need for more concrete and palatable details about the effects of biotechnology. At the same time, consumer pressures are evoking a response. Although Britain is allowing the use of genetically engineered crops, both France and Austria have banned them temporarily until more can be learned about their environmental effects. Poor public relations also affected the Grameen Bank and Monsanto causing Monsanto to withdraw their offer in the joint venture. These are just a few examples of ways in which public concern has slowed globalization. Although these examples do provide some hope, they were hard won. Further, they do not represent a complete victory for those who are working on the union of agriculture and ecology. On the contrary, our work still lies ahead.

## The Land Institute's Natural Systems Agriculture Advisory Team

Our Natural Systems Agriculture Advisory Board comprises over 65 scientists and practitioners in ecology, agriculture, and policy who are willing to endorse the potential of our work, to discuss its need and benefits to national policy, to assist in articulating its feasibility to funders, to critique the research program, and to offer suggestions as the work unfolds.

### David Andow

David is an associate professor of insect ecology at the University of Minnesota. He teaches Insect Ecology and the Ecology of Agriculture. Presently he is researching the ecology of *Orius insidiosus* (minute pirate bug) in corn and the use of *Trichogramma* (small parasitic wasp) in biological control of sweet corn pests. In his work, he is focusing on the role of landscape structure on the ecology and evolution of natural enemies, conservation and recovery of Karner blue butterfly, biotechnology science policy, ecology of insect species invasions, host plant resistance in corn, and resistance management of transgenic plants.



Before joining the entomology department at UM in 1984, David received a Ph.D. in ecology from Cornell University. In 1977 he received a Sc.B. from Brown University in biology because of his interests in food and hunger issues. In graduate school he conducted research on intercropping, specifically

looking at how weeds influenced Mexican bean beetles on black beans. He is a world authority on the effects of intercropping on insects. David conducted extensive research beginning with his post-doctoral fellowship in insect-crop interactions in rice in Japan comparing the systems of *shizen noho* (natural farming) to *kanko* (conventional/modern farming). He found that under *shizen noho*, the system of production was so different that it represented an alternative mode of production, which he calls a "management syndrome." In *shizen noho* rice growth and development is very different from conventional production, pests are suppressed without the use of pesticides, and yield is at least as great as conventional yields. David appreciates contributing to what he describes as "outstanding investigations into the functioning of natural systems in relation to agriculture and pioneering efforts to develop native plants into productive agricultural plants" at The Land Institute. "Natural Systems Agriculture will be a critical part of the future of agriculture, because without it," David says, "agriculture's future may wither on the vine."

### Catherine Badgley

Catherine has training in geology and biology with a B.A. from Radcliffe College, a M.S. degree in wildlife ecology from the Yale School of Forestry and Environmental Studies, and a Ph.D. in biology from Yale University. She is a research scientist at the Museum of Paleontology and a lecturer at the Residential College, University of Michigan. Her research concerns the ecology and paleoecology of mammals with emphasis on community ecology and biogeography. Her interests also include a wide range of environmental issues, especially sustainable agriculture. She teaches classes about the history of life, global environmental issues, and field ecology.

Catherine has done extensive work in geology and paleontology. Most of this work has been in rural Pakistan and China; she has also spent field sessions in Kenya and the western U.S. Her research publications concern the nature of long-term changes in terrestrial environments and ecological diversity of mammals. The field work has also been a good introduction to the diversity of agricultural systems and rural cultures around the world today.

In the winter of 1998, Catherine and University of Michigan colleague James Walker organized an honors seminar, "Agriculture in the Age of Ecology," taught by Wes Jackson and Don Worster. Catherine is developing a field-based course for the spring of 1999 about agriculture, ecology, and rural communities in southern Michigan.

Catherine and her husband Gerald Smith live on a farm of 110 acres located about 20 miles west of Ann Arbor. They plow with draft horses, milk a Jersey cow, keep a few chickens and two beehives, and tend a large vegetable garden. Much of the farmland is managed to support local wildlife, including several families of sandhill cranes.





## Jim Manhart

Jim is currently associate professor of systemic botany at Texas A&M University in College Station. Before taking this position in 1988 he earned a Ph.D. from the University of Georgia in botany and had a two-year position at the University of Michigan as a National Science Foundation Research Fellow. He earned both a B.S. and an M.S. from Kansas State University.

His master's thesis involved an investigation of the effects of nitrate on nitrogen fixation levels in legumes. For his Ph.D. dissertation at the University of Georgia, Jim explored the systematic relationships of several sections of the genus *Carex* based on the chemistry of flavonoids (compounds in plants which absorb visible light), chromosome counts, and achene (small, dry fruit) micromorphology. As a post-doctoral student he began work on molecular systematics, particularly concerning the use of molecular and structural characters to increase our understanding of the phylogenetic relationships of green algae and land plants. Members of the group of charophytes (a class of green algae) have been under debate as the closest relative to land plants.

While he has done considerable work characterizing the chloroplast genome, he is also interested in mapping nuclear genomes using molecular genetic markers. These markers, Jim believes, are also useful in population genetic studies. Of particular interest to him are native prairie plants with potential uses in a perennial polyculture or in prairie restoration. He has begun work on *Desmanthus illinoensis* (Illinois bundleflower) and has an interest in *Silphium* (genus which includes cup plant and compass plant).

Jim currently has two graduate students one of whom is working on a genus of tropical trees and the other on members of the genus *Senecio*.



Bob White?

The low-morning sun threatens  
to bake us all  
evenly, steadily, mercilessly.  
I watch through windows, helpless.  
It crosses the sky.  
Mud puddles shrivel and crack.  
Heat seeps into crevices  
finds us in classrooms, hallways, and basements  
invades, stifles, chokes.

Bob White?

Blows the wind.  
Hot air provides no relief  
picks up dust and drops it  
rustles through the trees  
promises compromise and then laughs  
steals the remaining drops of moisture  
twists and turns, evil, dry.

Bob White?

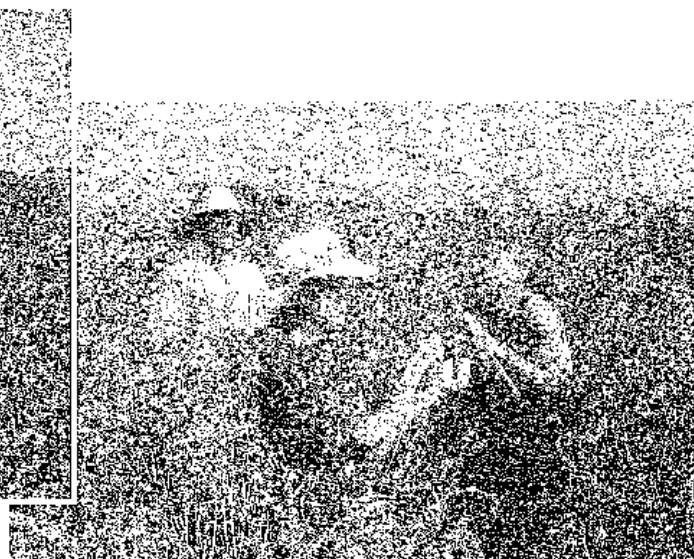
The clouds roll  
creep silently, swiftly  
huge, dark, flat clouds.  
Ominous grapes divide the sky  
predicting fear, intensity, and culmination.  
Cold. Immediate. Final. Anvil.  
The prairie howls  
trees groan, bend, ache, and moan.

Bob White?

— Kaelyn Stiles



Kelley Belina, David Van Tassel, and Courtney Smith



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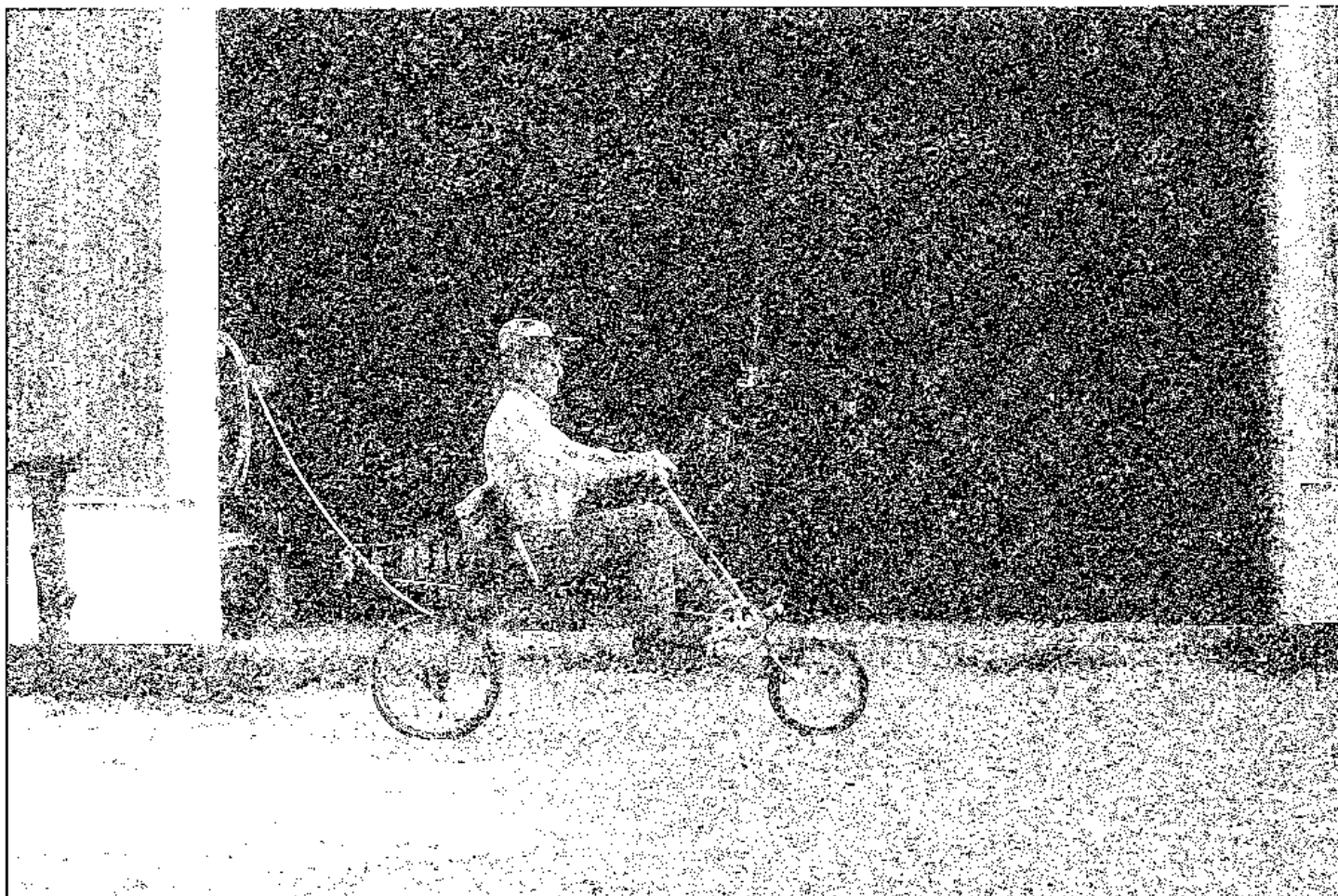
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