



Annual Report 2018

About The Land Institute

Since 1976, The Land Institute has worked to transform grain agriculture globally from a system of extractive domination to one of generative care. Nature is our measure and from her we are given two values that are key to a truly regenerative agriculture and to a healthy, just society in equilibrium with the earth of which it is a part: perenniality and diversity.

Our team of plant breeders and ecologists, together with collaborators on six continents, are working to develop perennial grains, pulses, and oilseed bearing plants to be grown in ecologically intensified, diverse crop mixtures. When realized, this new agricultural system promises to hold and restore soil, produce ample food, require less fossil fuels, conserve water, and mitigate and endure the impacts of climate change. In tandem, we are working to extend the insights of this new agricultural system to imaginatively and practically aid human communities to live in just relationships within an ecospheric standard.

The Land Institute is a nonprofit 501(c)(3) research and education organization funded by charitable contributions from individuals, organizations, and private foundations.

Cover: *The Land Institute's new greenhouse, just completed this year, glows pink with LED lights tuned to the red and blue wavelengths known as "photosynthetically active radiation." With all of the output going into the colors plants use most effectively, smaller lights using less electricity can be used. We expect the energy savings to pay for the cost of the lights within five years. All images: © The Land Institute 2018*



The Land Institute is rooted in the North American prairie. This powerful sense of home is what inspired our vision for building a thriving, resilient agriculture based on the structure and function of natural ecosystems, and what animates that vision today. But this local grounding is also the very thing that inspires us to reach out to other localities. So, it is fitting that some of our most exciting successes over the last year have come internationally.

In Uganda, in green fields just north of the national capital and down dusty roads in the rural, semi-arid east, something new is growing. Shoots of grain sorghum emerge from soil into which no seed has been sown for more than a year. These plants are perennials, developed by Land Institute plant breeders with guidance from Ugandan agricultural scientists and farmers. The day approaches when perennial sorghum will help empower Ugandans (particularly women, who traditionally oversee food crop production) to take control of their ecological and social destiny in a warming world.

In China, dozens of small fields of perennial rice dot the countryside in Yunnan Province in trials at research stations and farms. Ten years ago, The Land Institute provided an initial infusion of funding and crop germplasm, a spark that our Chinese collaborators have fanned into a bright flame. With their best breeding populations already competing with annual rice for yield and taste, perennial rice seems poised to take its place on the gleaming landscape of paddy rice farming. An even bigger ecological payoff lies ahead, when further research adapts perennial rice for the steep, eroding uplands of countries like Laos and Vietnam.

The Land Institute's strong connection to our local landscape inspires us to seek out global collaborators.

In Sweden, a university plant breeder in Uppsala is testing The Land Institute's Kernza® and perennial wheat for potential at high latitudes while at the same time developing her own perennial barley. Further south in Lund, a team of social scientists is helping size up the socioeconomic implications of a transition to perennial grain crops, in partnership with farmers in Sweden — and in Uganda.

In Kansas, as I write this in October, the prairie prepares for a rest, living roots deep in the soil, waiting for spring to come again. Our researchers are not resting: seed is cleaned, data is analyzed, plants are potted for the greenhouse, workshops are planned. We are on solid financial footing and our scientists have an impressive set of tools not only to do perennial grain crop breeding and ecology research in Kansas, but to inspire and support researchers around the world — 40 collaborating institutions and counting. Much work remains. With your support, we have come to this point: proof of concept that a perennial agriculture is possible. And with your support, we make perennial agriculture a reality.

Perennially,

Fred Iutzi
PRESIDENT

The Land Institute

ORGANIZATIONAL HIGHLIGHTS



Greenhouse II Project Completed

After over five years of planning, fundraising, and construction, our new greenhouse facility came into operation in the summer of 2018. Thanks to the many donor contributions and the dedicated determination of TLI staff members, Tiffany Durr and Chris Pembleton, for making this important project a reality. This building supports the growing needs of our current and new plant breeding and ecology programs.

Two New Board Members for TLI

TLI is pleased to welcome two new members to our Board of Directors. Julia Olmstead is the Mississippi River Program Officer at The McKnight Foundation. Prior to that, she was coordinator for the Farmer-Led Watershed Council Project for University of Wisconsin-Extension, where she designed, launched, and managed a multi-stakeholder agriculture water quality collaborative. The project bridged public agencies, farmers, businesses, and nonprofits, and became a regional model for voluntary, watershed-based agriculture conservation.

Ricardo Salvador, Ph.D. is director and senior scientist for the Food and Environment Program at the Union of Concerned Scientists, where he works with citizens, scientists, economists, and politicians to transition our current food system into one that grows healthy foods while employing sustainable and socially equitable practices. He was an associate professor of agronomy at Iowa State University, where he helped develop and served as the inaugural chair of the nation's first sustainable agriculture graduate program.



Kernza® Commercialization: An Inflection Point

The supply chain for Kernza® perennial grain is ever evolving as interest in the grain continues to grow. After two and a half years, we have ended our contract with Plovgh, who assisted in recruiting growers, marketing Kernza, and managing our identity preserve program and trademark licenses. The Land Institute is now searching for a new staff person to help manage the supply chain and refine our strategy for expanding production at a measured and appropriate pace.

The first limiting factor to long-term success for Kernza® is sustained and accelerated research and development of the crop and ecological cropping systems. Therefore, our commercialization strategy is to simultaneously match market demand with supply and provide visibility to the need for ongoing investment in R&D.



Incoming Interns Include International Applicants

The Land Institute's internship program saw its busiest year in terms of applicants in recent memory, with 36 applications coming in from students and postgrads hailing from universities across 19 states and seven countries. With more researchers needing assistance, we accepted one of the largest classes of interns. The first of our summer interns arrived in April, and the remaining 13 followed through mid-August. The majority were strictly Natural Systems Agriculture Interns, working side-by-side with our research staff on activities like weeding, harvesting, and soil sampling. In a new role, two were dual NSA and Ecosphere Studies Interns, spending roughly half of their time with each team.



New Programs Launch: Crop Protection Ecology and Crop Protection Genetics

In January, The Land Institute launched two new programs. Ebony Murrell, pictured at left, is our inaugural Crop Protection Ecologist. Her background is in pest ecology, community ecology, and soil-plant-insect interactions. She is interested in how diverse cropping systems can be used to improve plant defenses, boost populations of fungi and beneficial insects, and ultimately reduce pest pressure in our perennial systems. Ebony's first focus has been a thorough field assessment at multiple life stages of *Eucosma giganteana*, a moth pest of silphium, including using field collected moths to try to rear a laboratory colony for future research. She also has helped establish a few bee colonies to foster and study natural pollination.

Kathryn Turner, who was our perennial wheat post-doc, was given a three-year, renewable, PAP-funded research associate position as head of Crop Protection Genetics. Her research focuses on better understanding and controlling disease in the perennial cropping systems. She studies what pathogens are present, how important they are, and how to measure them. This initial information will help her answer other questions, such as how the genetic resistance mechanisms work, whether or under what conditions key pathogens accumulate over time in perennial grain crops, and what role these pathogens play in diverse perennial polycultures. For diseases that we identify as significant threats, she will work with breeders to reduce infection levels, largely through genetic improvements.



Perennial Rice

We now have documented progress in the development of perennial rice by our colleagues at Yunnan University in China. TLI has been supporting the perennial breeding program for the past decade, and the team, led by Prof. Hu Fengyi, now has a perennial rice variety in commercial production. This year, they published a report in the journal *Sustainability* showing that the new perennial variety yielded as well as (and sometimes better than) two popular annual varieties in 45 trials in 9 locations over several years. PR23 met with approval by farmers because it had good cooking quality, saved labor (by reducing transplanting), and helped stabilize the soil.



Leadership Changes at The Land Institute

Aubrey Streit Krug was promoted to the inaugural Director of Ecosphere Studies on April 1, 2018. She first joined TLI as a postdoctoral fellow and now has become a polished presenter of the ideas behind our research.



On July 1, 2018, Rachel Stroer's position changed from Chief Operating Officer to Chief Strategy Officer. In this role, she will continue to play a prominent role in planning and evaluating organization and perennial grain commercialization strategy. Rachel will also have more time to focus on partnerships, development, and communications.



Concurrently, Chris Pembleton was promoted to Director of Administration from Facilities and Special Projects Manager, and in that capacity took on oversight of the financial and personnel leadership duties, as well as continuing to manage facilities and infrastructure, IT, and Prairie Festival logistics.

Perennial Crops



Kernza® Perennial Grain

- Intermediate wheatgrass is being grown and marketed as Kernza® perennial grain. We have begun using the recently released genome sequence of intermediate wheatgrass to accelerate breeding by using a technique called genomic selection. With this method, we select the best plants when they are only weeks old by examining parts of their DNA. In the past year, we have experimentally tested the effectiveness of this new method and initiated another generation of selection. Early results indicate that we can at least double our rate of progress for key traits like yield and seed size using this new approach.
- We are also aiming for a breakthrough in wheatgrass breeding by introducing high impact genes directly from wheat. We now have hundreds of plants containing genetic information from wheat, and any of these could lead to critical improvements.



Perennial Legumes

- Our first cycle of selection from an alfalfa grain legume breeding nursery planted in 2017 produced seed that was larger than the majority of the 5000+ accessions/varieties from the USDA NPGS alfalfa collection. The top 5% of the 2017 alfalfa plants were selected and used in crosses to produce a new cycle of progeny that we are evaluating in 2018.
- We now have a multi-state trial comparing the performance of almost 30 alfalfa varieties with unique characteristics. Through this study we hope to 1) identify which alfalfa traits are most important and can be used as selection criteria when breeding alfalfa for Kernza+Alfalfa bicultures and 2) quantify the potential ecosystem services and changes in soil health provided by the bicultures.



Perennial Sorghum

- In January, we published on perennial sorghum experiments conducted in Uganda. These experiments were carried out by Shakirah Nakasagga for her master's thesis. In order to accelerate breeding for this crop in a region where it is showing progress, we hope to launch a perennial sorghum breeding program in Uganda, but there are no sorghum geneticist/breeders to lead the program. Therefore, in January, thanks to the generosity of a particular TLI donor, we were able to fund Ms. Nakasagga's doctoral study at Texas A&M, doing research with Dr. Seth Murray. Once she has her Ph.D., she will return to Uganda to run a perennial sorghum program.
- In partnership with social scientists from Sweden's Lund University and smallholder farmers at eight locations around Uganda, we are growing experimental perennial grain crops and mixtures, including perennial sorghum and pigeonpea. Pheonah Nabukalu and Stan Cox were in Uganda in January to help initiate the project.



Perennial Wheat

- The five-year international genotype by environment (GxE) trial was completed. In this trial, 24 researchers across four continents grew the same genetic materials in different environments to see how performance varied. The result was identification of a winter durum wheat by wheat-grass hybrid that showed greater longevity in test plots from Australia to Sweden. From progenies of this hybrid, out of hundreds of head rows, we found five uniform rows of plants that appear to be genetically stable. More than 80% of the wheat florets produced seeds, and the plants regrew excellently in the field. We will increase seed of these plants over the next year and expand the trial to more researchers internationally.
- Our molecular genetics work also continues. Some wheat or wheatgrass genes are not favorable for the performance of perennial wheat. We are sequencing 26 important genes to search for useful variations in a breeding population.
- Piyush Labhsetwar came to Prairie Festival from the University of Illinois where he was just finishing up his PhD in Biophysics and Computational Biology and made it known he was interested in working at TLI. In November, he joined us as a technician/post doc hybrid position in perennial wheat.



Perennial Sunflower (Silphium)

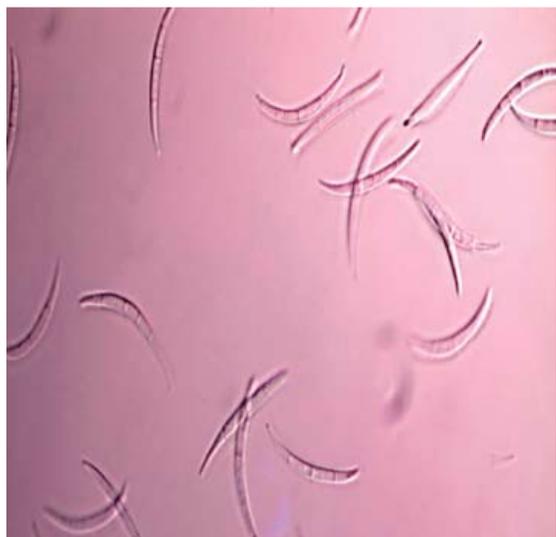
- Most of our plots this year were heavily damaged, again, by insects in the heads, stems, and crowns. However, exciting progress towards identifying the perpetrators and charting a control strategy was made by our new crop protection ecology scientists in conjunction with two USDA entomologists.
- In both Argentina and Kansas, we have demonstrated that cutting silphium stems back in the spring makes the plants bush out in a way that could improve harvestability. This discovery was made by our Argentinian colleagues Alejandra Vilela and Luciana González-Paleo. They cut plants for a different reason and then noticed that the plants became shorter and some produced fewer, larger, more uniform heads. We will need to selectively breed plants that thrive under this somewhat severe treatment, but if it continues to work it could help us achieve a more crop-like growth form and may even provide some insect control as a side benefit.
- Showing that silphium can tolerate being clipped also opens the door for several interesting intercropping opportunities. For example, a crop like winter barley could be grown while silphium is dormant and although the silphium stems will be poking up through the barley crop in June and will be snipped off by the combine harvester, that snipping may turn out to be a blessing, not a curse, for the silphium seed crop that would mature in late August or September.

Ecological Intensification



Crop Protection Ecology

- We collected data on the majority of life stages of *Eucosma giganteana*, the primary pest of silphium;
- Identified two additional insect species that are potentially serious pests of silphium: A stem-boring weevil (*Rhodobaenus tredecimpunctatus*), and a stem- and root-boring moth (*Pelochrista* sp.);
- Began a three-year study to assess establishment success and efficacy of eight summer cover crop and eight fall cover crop species inter-seeded into established Kernza®;
- Established a three-year study to assess the forage quality, pollinator resource quality, and predator habitat quality of two perennial legumes (alfalfa, sainfoin) and two perennial forbs (silphium, cup plant), compared to a nonflowering perennial (Kernza) and a native prairie mixture;
- Tracked chinch bug populations in perennial sorghum to establish an economic injury level for this pest (i.e., at what population density do chinch bugs compromise perennial sorghum yield?); and
- Hired crop protection technician Edy Chérémond, who has a master's in Biology with a focus in Ecology. Besides his general research experience, his insect (specifically bee) identification skills are a valuable asset.



Crop Protection Genetics

- Throughout the first summer of the Crop Protection Genetics program, we surveyed disease in Kernza, perennial wheat, alfalfa, clover, silphium, and sorghum plots. With each sampling, we found new symptoms and potential pathogens, but the overall disease severity was minor. There were a few significant exceptions, but there is ample opportunity for genetic improvement as our crops have not been selected for resistance to most diseases.
- We inoculated 500 Kernza plants with a toxin-producing fungus that causes *Fusarium* head blight in wheat, barley, and at low levels, in Kernza. We will predict which individuals are susceptible based on genetic sequences. After testing the accuracy of our prediction model, we can remove the most susceptible plants in the breeding program without the time and effort required to infect thousands of plants.



Soil Ecology

- Informed by work in previous years, we continued to move forward in developing approaches to intercrop Kernza® with alfalfa and other legumes in order to increase reliance on biologically-fixed nitrogen and capture other possible benefits such as greater sequestration of stable soil organic carbon and reduced emissions of the greenhouse gas nitrous oxide.
- We have planted a 16-acre Kernza-alfalfa biculture field at the Perennial Agriculture Project Field Station in Lawrence, which has equipment operated by researchers at the University of Kansas measuring the carbon balance between the atmosphere and the soil. We have also succeeded in modifying large fields of alfalfa in their second or fourth year of production, by establishing strips of Kernza which can then benefit from the nitrogen accumulated under the legume.

Ecosphere Studies



- We significantly expanded our programmatic capacity thanks to support beginning in 2018 via the New Perennials Project housed at the Rockefeller Family Fund. Our first Ecosphere Studies postdoctoral fellow transitioned to a program director role, and we hired Carl Bowden as Ecosphere Studies Associate. Increased support also fostered ongoing and emerging collaborations, growing The Land Institute's diverse network of perennial thinkers and doers.
- We began designing and carrying out work in intellectual grounding and educational workshops. Key communities for our engagement include teachers and learners, the food movement, and practitioners in the creative and healing arts. Spring program offerings included a public event with Kansas City Design Center's West Bottoms Reborn, an eco-writing course at Kansas Wesleyan University, and an Ecosphere Studies seminar with visiting scholars discussing the necessity, and possibility, of a new ecospheric economic order.

“The development of new perennial crop species is gaining momentum as a promising approach to change the fundamental nature of ecosystem processes in agriculture.”

TIM CREWS, DIRECTOR OF RESEARCH

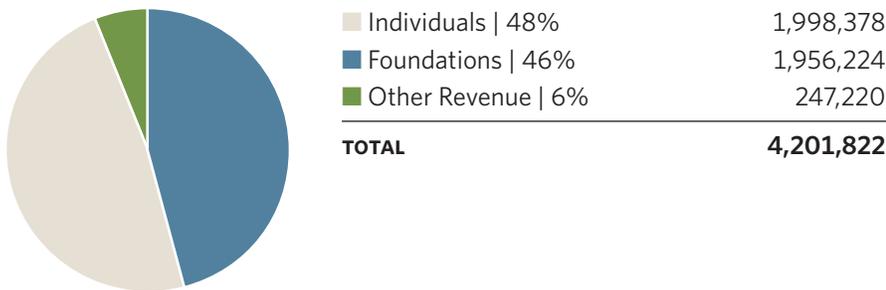


Summary Statement of Financial Position

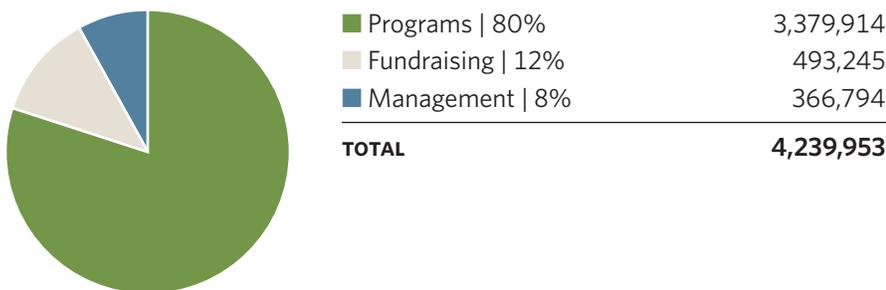
YEAR ENDED JUNE 30, 2018

	FY 2017	FY 2018
Assets	16,221,546 *	17,389,765
Liabilities	150,492	1,356,844
Net Assets	16,071,054	16,032,920

Revenue



Expenses



* The asset beginning balance for FY2017 has been restated due to two corrections made: \$775,367 for an adjustment to accumulated depreciation for the prior year and \$1,256,263 in amounts previously reported as temporarily restricted and now properly reported as unrestricted.

LEADERSHIP

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Selected Publications and Presentations

Publications

The Performance of Early-Generation Perennial Winter Cereals at 21 Sites across Four Continents | R.C. Hayes, S. Wang, M.T. Newell, K. Turner, J. Larsen, L. Gazza, J.A. Anderson, L.W. Bell, D.J. Cattani, K. Frels, E. Galassi, A.I. Morgounov, C.K. Revell, D.B. Thapa, E.J. Sacks, M. Sameri, L.J. Wade, A. Westerbergh, V. Shamanin, A. Amanov, G.D. Li | 2018 | *Sustainability*, 10(4): 1124.

Development and Evolution of an Intermediate Wheatgrass Domestication Program | L. DeHaan, M. Christians, J. Crain, J. Poland | 2018 | *Sustainability*, 10(5): 1499.

Development of Perennial Grain Sorghum | S. Cox, P. Nabukalu, A.H. Paterson, W. Kong, S. Nakasagga | 2018 | *Sustainability*, 10(1): 172.

Managing for Multifunctionality in Perennial Grain Crops | M.R. Ryan, T.E. Crews, S.W. Culman, L.R. DeHaan, R.C. Hayes, J.M. Jungers, M.G. Bakker | 2018 | *BioScience*, 68(4): 294-304.

Energy, Water and Carbon Exchange Over a Perennial Kernza Wheatgrass Crop | G. deOliveira, N.A. Brunsell, C.E. Sutherlin, T.E. Crews, L.R. DeHaan | 2018 | *Agricultural and Forestry Meteorology*, 249: 120-137.

Effect of Puccinia silphii on Yield Components and Leaf Physiology in Silphium integrifolium: Lessons for the Domestication of a Perennial Oilseed Crop | M.K. Turner, D. Ravetta, D. Van Tassel | 2018 | *Sustainability*, 10(6): 696-708.

Strategies, Advances, and Challenges in Breeding Perennial Grain Crops | T.E. Crews, D.J. Cattani | 2018 | *Sustainability*, 10(7): 2192.

Transforming Human Life on Our Home Planet, Perennially | W. Jackson, A. Streit Krug, B. Vitek, R. Jensen | 2018 | *The Ecological Citizen*, 2(1): 43-6.

Perennial Grain Legume Domestication Phase I: Criteria for Candidate Species Selection | B. Schlautman, S. Barriball, C. Ciotir, S. Herron, A.J. Miller | 2018 | *Sustainability*, 10(3): 730.

Maintaining Grain Yields of the Perennial Cereal Intermediate Wheatgrass in Monoculture V. Biculture with Alfalfa in the Upper Midwestern USA | N.E. Tautges, J.M. Jungers, L.R. DeHaan, D.L. Wyse, C.C. Sheaffer | 2018 | *The Journal of Agricultural Science*, 109(2): 462-472.

Presentations

OCTOBER 2017

The Perennial Grain Revolution Presented by Lee DeHaan | Biology Dept. Colloquium, Grinnell College | GRINNELL, IA

OCTOBER 2017

What Can Agriculture Learn from Natural Systems to Improve Drought Tolerance? Presented by Tim Crews | Colorado State University, DuPont-Pioneer Plant Sciences Symposium on Drought Tolerance in Agriculture and Natural Ecosystems | FORT COLLINS, CO

NOVEMBER 2017

Long-term Collaboration for New Crop Domestication Presented by Lee DeHaan | University and Industry Consortium Fall Meeting | MINNEAPOLIS, MN

NOVEMBER 2017

Ecosystem Science for the 21st Century Presented by Wes Jackson | Keynote address, Colorado State University International Colloquium: Ecosystem Science for the 21st Century | FORT COLLINS, CO

DECEMBER 2017

Talking Plants: Making Kin with Our Rooted Relations Presented by Aubrey Streit Krug | Conversation with Wendy Makoons Geniusz and Claire Pentecost, Garfield Park Conservatory | CHICAGO, IL

JANUARY 2018

The Solution to the 10,000 Year Old Problem of Agriculture is Now Underway Presented by Wes Jackson | Keynote presentation, Farmers and Philosophers: Towards an Ecological Civilization, Center for Process Studies | CLAREMONT, CA

MARCH 2018

Kernza® and the Promise of Perennials Presented by Rachel Stroer | Esca Bona Story Stage, Natural Products Expo West, New Hope Network | ANAHEIM, CA

APRIL 2018

Breeding Perennial Grains: the Case of Sorghum Presented by Stan Cox | DuPont-Pioneer Plant Sciences Symposium on Integrated Plant Sciences, Clemson University | CLEMSON, SC

JUNE 2018

Developing Dual-Purpose Perennial Forage and Grain Legumes Presented by Brandon Schlautman | 2018 North American Alfalfa Improvement Conference Meeting | LOGAN, UT



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SAVE THE DATE

Prairie Festival

September 27-29, 2019

Featuring some of the world's most compelling authors, thinkers, artists, and advocates focused on agriculture, the environment, science, sustainability, and social and environmental justice.