

Kernza®CAP

Year Two Annual Report

Prepared December 2022



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Photo Credit: Prabin Bajgain

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For more information, visit www.kernza.org/kernzacap

YEAR TWO TIMELINE

SEPTEMBER 2021

- Research trials planted
- Baseline soil samples collected at research station trials

OCTOBER 2021

- KernzaCAP collaborators gather virtually for the year 1 all-hands meeting
- Lysimeters installed at research station trials to measure water quality
- Genetic data from cycles 3 and 4 deposited in the Kansas State University database

NOVEMBER 2021

- Next Gen Crops: Clean Water and Prosperous Farms education & policy webinar
- Information sessions on steward ownership lay the foundation for the Kernza Stewards Alliance

DECEMBER 2021

- First beta testing of "Kernza in Context" education modules

JANUARY 2022

- Protocols for data collection during the 2022 field season planned and written

FEBRUARY 2022

- Second KernzaCAP Advisory Committee meeting
- KernzaCAP lunchtime seminar series launches with a panel discussion on carbon markets

MARCH 2022

- Perennial Promise Growers Cooperative and researchers meet in Dundas, MN
- Strategic planning for the Kernza Stewards Alliance begins
- High School Teacher Advisory Group first convenes under the guidance of the "Kernza in Context" education team

APRIL 2022

- Kernza Conference in Salina, Kansas
- Policy presentation to Mississippi River Network's policy working group

MAY 2022

- Social Network Analysis launched
- Kernza timeline project begins to document Kernza's history



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YEAR TWO TIMELINE

JUNE 2022

- Extension cohort comes together for their first meeting
- Soil health samples collected for agronomy and environmental quality research

JULY 2022

- Presentation at the NRCS Central Region Agronomists meeting
- KernzaCAP partners host field days throughout the Midwest

AUGUST 2022

- Grain and biomass harvest of Kernza field trials

SEPTEMBER 2022

- Water samples analyzed for environmental quality research
- Year 2 annual reporting and budget review



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Kernza®CAP year two by the numbers

2

educational sessions on steward ownership lay the foundation for the Kernza Stewards Alliance

48

Kernza products on the market



11

Extension educators participating in the KernzaCAP Extension cohort

6

field days and workshops hosted by KernzaCAP collaborators

11

lessons in the "Kernza in Context" educational curriculum distributed to 60 teachers and researchers for beta testing

36

hours of direct stakeholder input during Kernza Stewards Alliance strategic planning process

7

monthly seminars hosted to encourage cross-project integration



3

policy outreach & education events hosted by KernzaCAP collaborators

428

water samples analyzed

281

people reached by the Social Network Analysis with a 54% response rate



65

attendees at the first annual KernzaCAP all-hands meeting

20

interviews conducted and over 100 people involved in developing a timeline and history for Kernza

700+

lysimeter samples collected to measure water quality

356

soil samples taken for research and analysis of soil health and nitrogen cycling

2

large modeling projects initiated on greenhouse gas emissions and water quality

568

IWG plots sampled to calculate grain and biomass yields

358,608

square feet of research ground fertilized for research trials

3

on-farm trials established

19

variety candidates in trials; 6 new candidates will enter trials in 2023



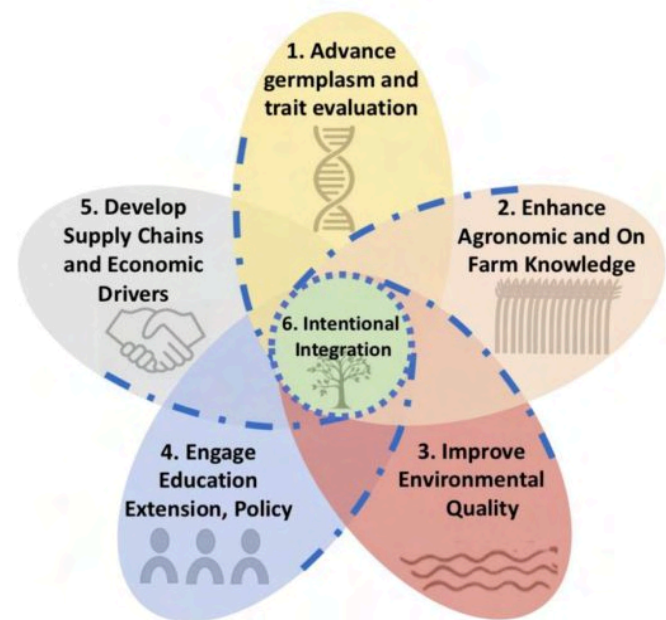
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Project Overview

One of humanity's most urgent challenges is to provide food, feed, and fiber for a global population of 10 billion by 2050. This challenge is compounded by the fact that the world's current annual-based cropping systems are deteriorating the natural resource base necessary for agricultural productivity. In contrast, perennial crops can improve agricultural sustainability because their extensive root systems reduce soil erosion, nutrient runoff, and pesticide requirements while simultaneously increasing farmer incomes due to decreased annual inputs and costs. The domestication of the world's first commercial-scale perennial grain crop (intermediate wheatgrass) is underway in the US, trade named "Kernza®". This project is leveraging and expanding a strong network of researchers, educators, farmers, businesses, non-profit leaders, and others to launch a perennial grain crop enterprise based on Kernza.

KernzaCAP was funded by the U.S. Department of Agriculture National Institute of Food and Agriculture (USDA NIFA) in 2020 and runs through August 2025. This project currently supports over 90 researchers, graduate students, business leaders, nonprofit professionals, and farmers across nine states (Appendix A). Collaborators are organized into six objective teams:

1. Advance germplasm & trait evaluation
2. Enhance agronomic & on-farm knowledge
3. Improve environmental quality
4. Engage education, extension, & policy
5. Develop supply chains & economic drivers
6. Intentional integration



Collectively, KernzaCAP aims to activate transformational change in agriculture that improves the environment and rural prosperity. Outcomes will include Kernza variety candidates for various regions of the US; best agronomic recommendations for optimizing yield, profitability, and environmental quality; expanded acreage in ecologically sensitive areas to protect drinking water from nitrate contamination; new Kernza supply chains and products; and an education and extension portfolio of tools and events to educate a broad range of students, agriculture professionals, and the public.

This report summarizes activities and outcomes from year two of KernzaCAP (September 2021 through September 2022).

"It's thrilling to see all the progress made toward the project objectives this year. We achieved some major milestones that set our team up for continuing to develop and deploy this new crop onto the landscape and into the marketplace."

-KernzaCAP Project Director Dr. Jake Jungers

Project Organization & Management

In year two of the project, the management team continued to meet weekly to ensure smooth grant operations and project management. The Coordinating Team, made up of the project management team and co-leads of each objective team (Figure 1), met bi-weekly to encourage integration across teams and provide high-level thinking and decision making for the project.

The 17-person Advisory Committee (Appendix A) is made up of individuals from nine states and three countries. The Advisory Committee convened in February 2022 to advise on a publication outlining the conceptual and philosophical framework of Kernza development. Advisory Committee members were also invited to the annual all-hands meeting and the KernzaCAP monthly lunchtime seminar series.

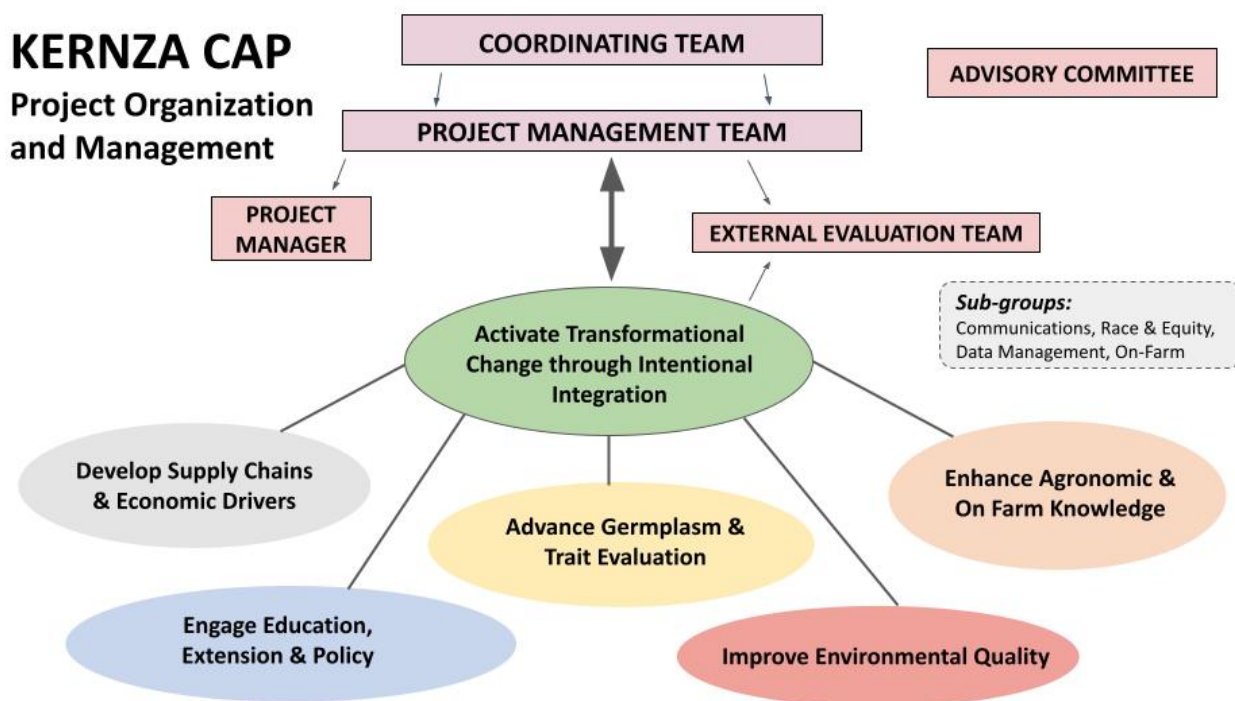


Figure 1: Project organization chart

The first annual all-hands meeting was hosted on October 29, 2021 with 65 collaborators participating virtually. The second all-hands meeting was hosted on October 24, 2022 with 75 collaborators participating virtually (Appendix B). The all-hands meetings provide an annual opportunity for conversation, reflection, and updates across objective teams, which is critical to meet our integration goals.

A data management subgroup met weekly to set up systems for data collection and analysis. The subgroup created protocols and templates for all field collection activities and distributed them to all research sites to ensure consistent data collection.

Collaborators continued to use the reporting system designed in year one to track progress and outcomes across objective teams. All collaborators have access to a project CV and are responsible for adding their work to the CV on a regular basis. Annually, subaward institutions and objective team co-leads fill out a report that the project manager compiles and submits to USDA. Annual reporting also includes budget checks with objective teams and subaward institutions to ensure spending remains on track.

Project collaborators have access to a private Google Site with quick links to important documents and a project calendar. This internal site also links to the project's Google Drive, which hosts all project documents and objective team folders and allows team members to easily upload, share, and review documents.

To communicate with external stakeholders interested in the project, KernzaCAP sends a quarterly newsletter through MailChimp that had an audience of 180 at the end of year two. This newsletter provides project updates, collaborator introductions, and media stories highlighting Kernza. Newsletters are archived online and can be accessed on the project website (www.kernza.org/kernzacap), which is regularly updated to reflect progress.



Germplasm & Trait Evaluation

Advance intermediate wheatgrass (IWG) germplasm and trait evaluation for improving yield, economic viability, and ecosystem services as a perennial grain crop.

Team members

- Dr. James Anderson (co-lead) - University of Minnesota
- Dr. George Annor (co-lead) - University of Minnesota
- Dr. Prabin Bajgain (co-lead) - University of Minnesota
- Dr. Lee DeHaan (co-lead) - The Land Institute
- Dr. Jared Crain - Kansas State University
- Dr. Pam Ismail - University of Minnesota

Team objectives

Objective 1: Improve IWG breeding populations and release varieties adapted to specific regions of the United States.

The breeding team continues to develop future Kernza varieties with improved agronomic traits including grain yield, seed size, plant height, resistance to shattering, and free threshing.

The University of Minnesota Kernza breeding program phenotyped the fifth cycle breeding population at two locations (St. Paul, MN and Lamberton, MN) during the summer of 2022. Based on thousands of measurements of plant height, plant health, grain yield, and seed size, the plant breeding team selected 46 intermediate wheatgrass plants as parents of new synthetic varieties. These 46 plants were cloned and transplanted in the field in fall 2022 and will be used to obtain grain for eight candidate varieties in 2023.



Variety trial planted in St. Paul, MN. Photo credit: Prabin Bajgain

The new breeding population, Cycle 6, was also established at St. Paul, MN and Lamberton, MN in August 2022. The Cycle 6 population includes 1,008 plants, an 80% increase in population size relative to Cycle 5. A larger population will allow the breeders to select the ideal and superior individuals which will be used in population advancement as well as creation of future varieties.

A new variety trial was initiated that included synthetic variety candidates from three different cohorts (MN16XX, MN18XX, MN19XX) and MN-Clearwater. Trials were established in St. Paul, MN and Lamberton, MN and will likely be expanded in 2023 to new locations. Information from this trial will determine which variety will be released and commercially available to farmers in the next few years.

Objective 2: Develop a low cost genotyping approach that leverages recently completed IWG genome sequencing to genotype larger breeding populations.

The team had good success in skim-sequencing (whole genome sequencing of plants at less than 1X coverage, currently targeting 0.1X or less). Imputing the data, or predicting genomic regions that were not sequenced, presented a challenge. To overcome this, the team focused on an existing population of Kernza-Carthlicum amphiploids (40 unique crosses total). These are wide crosses between intermediate wheatgrass (IWG) and a tetraploid wheat. The resulting embryo has a single (haploid) copy of both IWG and wheat. The genome constitution is doubled with colchicine to create a

homozygous plant that contains both IWG and wheat chromosomes. The team will sequence 20 of the IWG parent plants of the amphiploids and 20 of the resultant Kernza-Carthlicum crosses at 15-20X coverage. The 20 unique amphiploids will provide 20 sequenced haplotypes, from which the team can bioinformatically infer the remaining haplotype of each parent. This will provide a



A synthetic crossing block in St. Paul, MN. A crossing block is typically comprised of 10 top-performing individuals replicated 4-5 times and will give rise to a new candidate variety. Photo credit: Prabin Bajgain

reference panel of 40 haplotypes of current breeding material with which to impute low coverage skim-sequencing data. This method is essentially how imputation in humans and other animals is carried out and has a high accuracy rate. The team will deep sequence the 40 plants.

Objective 3: Expand database of genotyped plants and associated phenotypes to improve accuracy of genomic selection models and increase breeding efficiency.

The University of Minnesota Kernza breeding program deposited genotypic and phenotypic data from breeding cycles 3 and 4 in the Kansas State University database during October 2021. Cycle 5 data will be deposited in the coming year. This database also hosts data generated by The Land Institute's Kernza breeding program from Cycle 5 (prior to 2015) to the present cycle in 2022. The large number of measured phenotypes and genetic data provide a substantial resource for developing genomic selection methods. This database also serves as a backup in case of local data loss or corruption at either breeding programs.



Dr. Prabin Bajgain, co-lead of the germplasm & trait evaluation team, presents at the Kernza Meeting in Salina, Kansas. Photo credit: The Land Institute

Objective 4: Evaluate breeding germplasm for the nutritional quality and storage stability of IWG ingredients and food products.

Populations that will be analyzed for this objective were established in Fall 2021, harvested in Summer 2022, and provided to the research team in Fall 2022. Analysis will begin in 2023 after the grain is cleaned.



Samples of extruded Kernza produced by the food science team were shared at the annual Kernza meeting in Salina, Kansas. Photo credit: The Land Institute

Objective 5: Explore the impact of breeding on root architecture and subsequent effects on ecosystem services.

The team installed rhizotron tubes next to 150 plants of the University of Minnesota's Cycle 6 breeding population in St. Paul, MN. Data collection will commence in Spring 2023 and analysis will occur after obtaining root images.



Kernza at the University of Minnesota's St. Paul campus.

Agronomy & On-Farm Knowledge

Enhance agronomic and on-farm knowledge of IWG grain production systems.

Team members

- Dr. Valentin Picasso (co-lead) - University of Wisconsin, Madison
- Dr. Nicole Tautges (co-lead) - Michael Fields Agricultural Institute
- Dr. Andrea Basche - University of Nebraska, Lincoln
- Dr. Steve Culman - The Ohio State University
- Dr. Julie Dawson - University of Wisconsin, Madison
- Dr. Leonardo Deiss - The Ohio State University
- Carmen Fernholz - A-Frame Farm
- Dr. Audrey Kalil - North Dakota State University
- Dr. Priscila Pinto - University of Wisconsin, Madison
- Dorothy and John Priske - Fountain Prairie Farm
- Dr. Dave Stoltenberg - University of Wisconsin, Madison
- Dr. Jake Jungers - University of Minnesota

On-farm partners

- Whilden Hughes - W. Hughes Farms, Wisconsin
- Dustin Johnsrud - Johnsrud Farms, North Dakota
- Kurt Kimber - Kimber Farms, Minnesota
- Luke Peterson - A-Frame Farm, Minnesota

Team objectives

Objective 1: Evaluate variety candidates and their response to growing conditions and agronomic practices across the United States.

The team planned and implemented a Genotype by Environment by Management (GEM) trial to explore how genotypes managed in identified environments interact (Figure 2).

Four Kernza breeding lines that are top candidates for variety release later in the project were selected for planting. Two of the lines were selected for significant gains in seed size and, by extension, grain yields. One line was selected for significantly improved threshability (higher proportion of grains threshed from the hull during harvest operations), and one line displayed uniquely high rhizome production (“highly rhizomatous”). These four breeding lines are being compared to the industry standard variety at each site (MN-Clearwater or C5).

The trial was established and replicated at six research sites with collaborating institutions in Wisconsin, Minnesota, Kansas, Ohio, and Nebraska in September/October 2021. The experiment is evaluating row spacing and legume intercropping effects on growth, yield, and yield longevity in the four breeding lines. The team used narrow row spacings of 12 inches and wide row spacings of 24 inches, and legume intercropping treatments with red clover or alfalfa planted between the 24 inch rows of Kernza.

Data collection commenced in November 2021 with stand counts to evaluate establishment and early seedling vigor. Weed counts and stand counts were performed again in spring 2022. Lodging, growth stage, and plant height measurements were collected throughout the growing season and prior to harvest. Grain and biomass was dried and weighed after harvest in August 2022. Remaining biomass was cleared by mowing and baling off to encourage regrowth. Post-harvest regrowth has already commenced and the team will repeat observations over the next year.

GEM Trial (Genetics x Environment x Management)

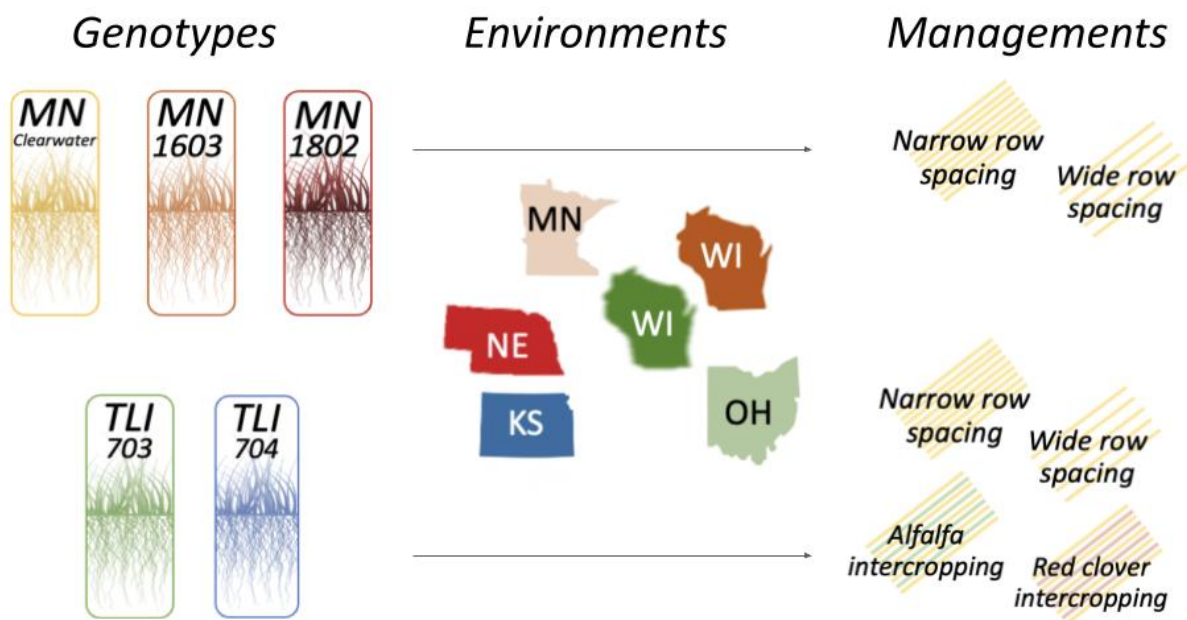


Figure 2: Diagram of the Genotype x Environment x Management experiment.
Credit: Priscila Pinto

Objective 2: Optimize nitrogen (N), phosphorus (P) and potassium (K) management for Kernza grain and forage production across US environments.

The team planned and implemented a fertility trial to study different fertilizer management practices for Kernza compared with annual cropping systems of corn and soy (Figure 3). The experiment features 12 treatments, replicated four times in six locations (the same locations as the GEM trial). The treatments include different nitrogen application rates, timing, and source, and different phosphorus and potassium rates. This experiment will provide needed fertilizer recommendations for Kernza farmers.

Trials at the different experiment sites were replicated as closely as possible in terms of plot size, management operations, and timing of activities. The selected treatments allow the team to answer the following research questions:

1. What rate of nitrogen application (between 0 and 160 pounds of nitrogen per acre) applied in spring maximizes grain yields and minimizes nitrate loss?
2. What timing of nitrogen application (fall, spring, or split) maximizes yields and minimizes nitrate loss?
3. Are annual applications of phosphorus and potassium necessary to maintain high grain yields?
4. How do conventional and organic sources of fertility compare, in terms of ability to maximize and sustain grain yields while minimizing nitrate losses?

FER Trial (Fertility)

Fertilizer application

- N 40 lbs/acre
- P 50 lbs/acre
- K 150 lbs/acre

Experiment addressed

- R N rate
- T N timing
- S N source
- PK PK

Locations

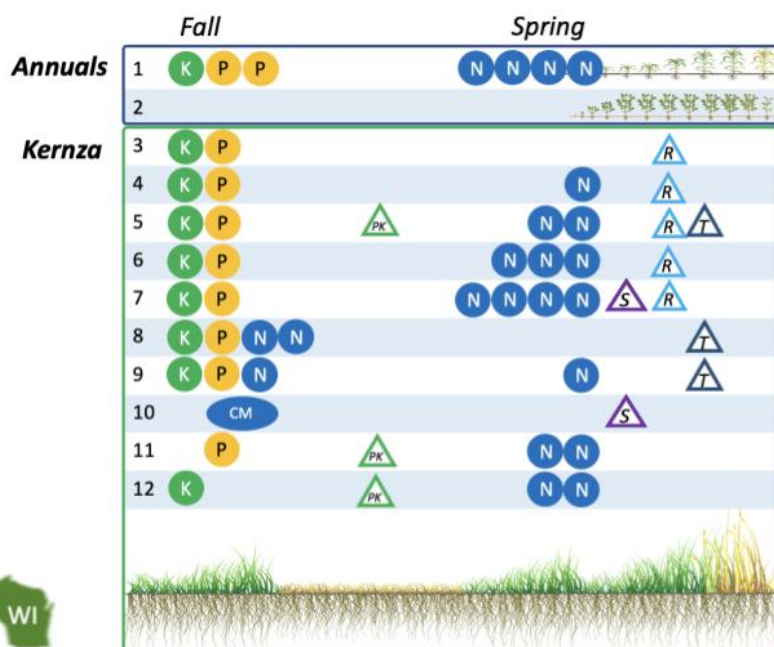


Figure 3: Diagram of the fertility trial. Credit: Priscila Pinto

The team established the trials at all sites in September/October of 2021 and applied fall fertilizer applications in October 2021. Weeds were controlled via herbicide application at all sites to maintain Kernza crop vitality. Data collected include baseline soil samples in September 2021; stand and weed counts in October/November 2021; weed ratings in spring 2022; growth stage observations throughout summer 2022; lodging, growth stage, and height measurements prior to harvest in August 2022; and grain and biomass production after harvest in August 2022.

Remaining biomass was cleared by mowing and baling off to encourage regrowth. Post-harvest regrowth has already commenced and the team will repeat observations over the next year. Preliminary results will be generated over the winter.

For both trials in objectives 1 and 2 (GEM and fertility), researchers at all sites contributed to protocols to encourage uniformity across sites. Management operations and records were documented online in the project's shared cloud storage. Data entry and backup is ongoing.



The University of Nebraska-Lincoln team finished harvesting the fertility trial on July 27, 2022. Photo credit: Roberta Rebesquini

Clearing Kernza fertility trial plots with a small plot combine after harvest samples were collected at the Ohio site.



Objective 3: Conduct participatory on-farm research to leverage grower experience and knowledge to inform research strategies and address regionally specific management practices to support the grower's network.

Agronomy team members worked with four farmers (Kurt Kimber and Luke Peterson in Minnesota, Whilden Hughes in Wisconsin, and Dustin Johnsrud in North Dakota) to plant four on-farm Kernza trials with two treatments mimicking treatments in the fertility trial (objective 2). Each farmer selected at least two other treatments that involve different aspects of fertilization to test on their farms, including intercropping, sulfur fertilization, and companion planting.

Farmers and researchers participated in planning calls over Zoom throughout the summer. Treatments of interest were devised for each farmer and maps were designed to coordinate decision making and research questions among the broader research team.

Farmers received seed in September 2021 that they then planted and fertilized (two sites organic and two sites conventional). Farmers applied fertilizers in fall and spring and planted legume intercrops as relevant to each site's study design. Soil samples were collected in June 2022 at each site at two depth increments. These samples will be used to track soil fertility status and soil carbon changes over time. Grain and biomass production was evaluated by plant collection and harvest performed in August 2022, which was all dried and weighed. Remaining biomass was cleared off by combining or mowing to enable healthy regrowth.

"Probably the most important moment occurred when the group decided to meet every other week for one hour throughout the project. These meetings have been indispensable for making key management and research decisions, and have included many debates over logistics, ability of all sites to conduct activities uniformly, quality of data, and suitability for publication down the road. Regular meetings have allowed us to achieve consensus and personal investment in the project and the team, and the engagement of all researchers taking part has been incredible."

-Agronomy & On-Farm Knowledge co-lead Dr. Nicole Tautges



Kernza grain and forage harvest at the University of Wisconsin-Madison with sickle knives, scissors, and quadrats. Photo credit: Priscila Pinto

Environmental Quality

Measure the environmental outcomes and benefits of IWG production systems for strategic deployment across the US.

Team members

- Dr. Jessica Gutknecht (co-lead) - University of Minnesota
- Alyssa Hartman (co-lead) - Artisan Grain Collaborative
- Dr. Nathaniel Brunsell - University of Kansas
- Dr. Tomás Cassani - The Land Institute
- Dr. Tim Crews - The Land Institute
- Emily Elder - University of Kansas
- Gurparteet Singh - University of Minnesota
- Jared Trost - United States Geological Survey

Team objectives

Objective 1: Quantify the potential of Kernza to improve water quality through a combination of empirical measurements and modeling on plot and landscape scale measurements.

The environmental quality team used the same plots as the agronomy team's fertility trial to measure soil moisture and water quality outcomes. Layering these experiments will show how environmental outcomes are impacted when Kernza is managed in different ways for fertility.

Lysimeters were installed at all sites in September 2021. Throughout the growing season, lysimeter data was collected every two weeks from all six sites in Wisconsin, Minnesota, Kansas, Ohio, and Nebraska. Data will be analyzed in early 2023, and the same data collection activities will be repeated next year.

The team at The Land Institute developed an automated camera system (right) to efficiently monitor surface runoff. The solar-powered system has a sensor that's triggered by moisture, which prompts a camera to turn on. Two of these camera systems will be deployed per site in 2023, providing data on water movement in Kernza compared to annual cropping systems. Data will be used to improve hydrologic models and water quality assessments.





The Land Institute team also developed a novel 20” ring method of continuous water infiltration measurement in the fertility trial lysimeter plots (left). This large ring method will give more robust data across row and interrow spaces and hopefully decrease the in-field variability that is commonly associated with infiltration measurements. This method development includes both the equipment and the written protocol for measurement. These rings will be deployed in 2023 for 1-2 rounds of measurement.

Graduate student Gurpartee Singh and United States Geological Survey partner Jared Trost are beginning to optimize the coupled APEX and MODFLOW models, which are intended for agricultural water use and groundwater modeling, respectively. By combining them, scientific understanding of Kernza’s cropland water movement will increase in a way that also provides practical information to project partners about how to improve groundwater quality in Kernza systems.

Objective 2: Quantify the potential of Kernza to reduce GHG emissions by synthesizing field observations with biophysical, predictive models in relation to cropping practices and climate forcings.

A graduate student at the University of Kansas has been working on parameterization and verification of the NOAH-MP land surface model, which will be utilized to assess the water and carbon dynamics across treatments and in relation to climate perturbations. Models such as NOAH-MP have been well established for annual row crops but not for perennial grains like Kernza. The first step is to parameterize and validate the model using data from eddy covariance towers to measure greenhouse gas emissions in Kernza. There is an eddy covariance tower at The Land Institute in Salina, KS, and two at the University of Kansas. These will provide valuable data for model development and assessment.

Objective 3: Quantify soil health changes under Kernza cropping systems, including soil physical characteristics, as potential drivers of other ecosystem services.

The environmental quality team worked closely with the agronomy team to sample soil in the fertility trial at peak plant growth in June 2022. Soil samples were taken at 0-20 cm depth, with the shallowest depth matching 2021 baseline sampling. The team is using these soil samples to analyze a suite of soil health measurements. N mineralization was also measured in the fertility

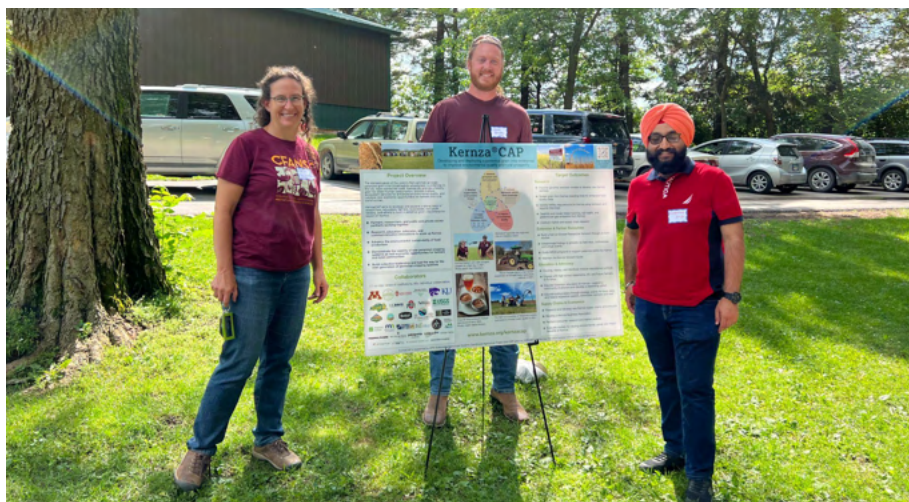
trial soil health plots and in six of the GEM experimental treatments. The team now has 2021 and 2022 baseline soil chemistry data from all sites. Analysis of N mineralization samples, yield, and plant growth are being analyzed in partnership with the agronomy team. An experimental design/baseline analysis of these variables is being developed for a first year manuscript from the fertility trial.



PhD student Gurparteeet Singh collects soil moisture data at the University of Minnesota, left.



A lysimeter in a “business as usual” comparison plot, right.



Environmental Quality team co-lead Dr. Jessica Gutknecht presents a KernzaCAP poster at a field day in July 2022 with graduate students James Bowden and Gurparteeet Singh.

Education, Extension, & Policy

Engage education, extension, and policy to deploy IWG production and support perennial crops.

Team members

- Constance Carlson (co-lead) - Forever Green Initiative, University of Minnesota
- Erin Meier (co-lead) - Green Lands Blue Waters
- Dr. Aubrey Streit Krug (co-lead) - The Land Institute
- Dr. Cynthia Bartel - C. Bartel Inc.
- Dr. Michael Bell - University of Wisconsin, Madison
- Whitney Clark - Friends of the Mississippi River
- Dr. Steve Culman - Ohio State University
- Maura Curry - Land Stewardship Project
- Dr. Clair Keene - North Dakota State University
- Jonathan Kilpatrick - Sustainable Farming Association of Minnesota
- Peter LaFontaine - Friends of the Mississippi River
- Shona Langseth - Land Stewardship Project
- Dr. Diane Mayerfeld - University of Wisconsin, Madison
- Steve Morse - Minnesota Environmental Partnership
- Lydia Nicholson - The Land Institute
- Trevor Russell - Friends of the Mississippi River
- Hannah Stoll - University of Minnesota
- Claire Wineman - The Land Institute
- Lucinda Winter - Sustainable Farming Association of Minnesota

Team objectives

Objective 1: Develop, deploy, and distribute modular educational curricula targeted at students and teachers from middle school through graduate level education.

The education team drafted 11 lessons in the “Kernza in Context” curriculum. These lessons were developed in collaboration with six high school teachers from Kansas and Minnesota who provided perspective and feedback through site visit interviews and high school teacher advisory group meetings. Six advisory group meetings were held, focusing on four main topics. Graduate students from the University of Minnesota and University of Wyoming helped create content by drawing from their own research on genetics, water and soil quality, and experimental design.

Lessons are designed to stand alone but can also be taught together to build modules and convey broader contextual concepts associated with Kernza and perennial agriculture. The team used Data Nuggets for select lessons to enable students to explore real-world Kernza research.

From datanuggets.org: “Data Nuggets are free classroom activities, co-designed by scientists and teachers, designed to bring contemporary research and authentic data into the classroom. Data Nuggets feature a scientist role model and the story of what inspired their research. In a Data Nugget activity, students are guided through the entire process of science, including identifying hypotheses and predictions, visualizing and interpreting data, supporting claims using data as evidence, and asking their own questions for future research.”

60 educators received the lessons for beta testing, which will happen in year 3 of the project. Current lesson topics are:

1. Deep Roots in Soil
2. Growing Grains
3. Kernza and Intercropping
4. Kernza and Soil Carbon
5. Kernza and Water Quality
6. Kernza Ecosystem Services
7. Meeting Perennials
8. Understanding Genotypes & Phenotypes
9. What is a Grain
10. Kernza for Dual Use
11. Environmental Photostory



Lydia Nicholson, left, & Claire Wineman, right, present on the “Kernza in Context” curriculum at the Kernza meeting in Salina, KS. Photo credit: The Land Institute

Objective 2: Develop Extension capacity and technical assistance for farmers.

This objective aims to develop the role of Extension in the future of perennial agriculture, using Kernza as the blueprint crop. In year 2, the team designed and launched a cohort experience for Extension educators to learn about Kernza research, production, ecosystem services, and market development. Planning began in early 2022 with a series of monthly meetings to define goals, processes, and activities for the Extension cohort. These include attending field days and virtual seminars, reviewing publications, and participating in facilitated dialogues with their Extension counterparts. These peer-to-peer dialogues will deepen knowledge about perennial-based agricultural systems, identify resource and experience gaps, and spur cohort participants to serve as a resource to their Extension colleagues about Kernza and perennial agriculture.

The cohort is made up of 11 Extension educators from North Dakota, Minnesota, Wisconsin, and Kansas. A kickoff meeting was hosted in June 2022, during which a yearlong schedule of experiences was shared. Throughout the summer, cohort members were encouraged to attend



Kernza field days across the region and report back on their experiences via a shared Google folder. The cohort reconvened in September 2022 to engage in peer learning about what they learned and experienced and to identify additional resources and tools that they need to learn more about Kernza.

Participants at the Kimber Farms field day look at a combine used to harvest Kernza.

Objective 3: Develop an IWG Grower-Researcher Network focused on current IWG growers linked with established markets.

KernzaCAP collaborators hosted six Kernza field days in summer 2022. These events attracted over 200 attendees to learn about Kernza, including growers, researchers, Extension educators, policymakers, food industry representatives, processors and consumers. The team attended, supported, and promoted many more Kernza field days not sponsored by KernzaCAP to disseminate information and learnings from this project.



*Growers and researchers participate in a conversation at the annual Kernza meeting in Salina, KS.
Photo credit: Constance Carlson*

Other activities to answer key questions and foster connections between growers and researchers included podcasts, grower calls, and conferences. This work heavily overlaps with existing work happening through the University of Minnesota’s Forever Green Initiative, The Land Institute, and other institutional partners.

A project space was established on the online CitSci platform to capture grower questions and spark dialogue and connections. The current plan is for the platform to be available initially to licensed Kernza growers and will operate similar to a Slack channel. A draft launch plan has been created that will require outreach to growers and researchers to both curate the platform and encourage use.

Objective 4: Raise awareness and deepen the understanding about the transformative power of perennials with public decision makers.

On November 5, 2021, the policy team hosted a webinar titled “*Next-Gen Crops: Clean Water & Prosperous Farms.*” Co-sponsored by the Healing Our Waters coalition and the Forever Green Partnership, this two-hour webinar aimed to educate members of the environmental NGO sector on the subject of “continuous living cover” (CLC) agriculture, with Kernza as the key component. The webinar attracted 80 attendees and was recorded and widely distributed to organizations across the country after the event.



80 individuals attended the policy and education webinar “Next-Gen Crops: Clean Water & Prosperous Farms.”

During the 2022 Minnesota state legislative session, KernzaCAP collaborators and other partners successfully advocated for new appropriations for Kernza research & development and the establishment of a state grant program to aid in the expansion of businesses that will be key to growing acreage planted to continuous living cover crops including Kernza. These appropriations included \$1.26 million in additional base funding for the University of Minnesota Forever Green Initiative and one-time appropriations from the Environment & Natural Resources Trust Fund of \$763,000 for the Forever Green Initiative and \$500,000 for value chain development (VCD) grants.



Farmers Carmen Fernholz and Luke Peterson speak at a field day at A-Frame Farm in July 2022. Photo credit: Jessica Gutknecht

Objective 5: Construct a national framework for IWG adoption opportunities through state and federal conservation programs.

The policy team continues to contact and engage NRCS staff and partners in Minnesota, North Dakota, Wisconsin, and Kansas, exploring program points of entry and current opportunities that include updating technical notes and practice standards.

In early 2022, USDA announced that perennial grains were formally adopted into the NRCS Conservation Stewardship Program Practice E328O, creating a new enhancement for incorporating perennial grains into conservation crop rotations. This new national standard opens doors for potential cost-share opportunities for farmers and provides a new baseline for increasing adoption of Kernza through more CSP and EQIP practices.

With this new enhancement, the NRCS Central Region agronomists consortium requested a briefing from Kernza researchers and farmers on July 18, 2022. KernzaCAP policy lead Dr. Cynthia Bartel, KernzaCAP project director Dr. Jacob Jungers, and farmers Carmen Fernholz

and Trenton Bohling presented, providing a baseline of information on fundamental agronomic and best management practices for growing Kernza, economic opportunities and existing challenges, and farmer interest and adoption barriers.

The policy team engaged the USDA Risk Management Agency (RMA) to identify viable insurance products for Kernza-producing varieties of intermediate wheatgrass. Potential risk management products will be informed by data over additional growing seasons. Viable possibilities include a pilot program to launch risk management products near identified centers of Kernza production.

“Our experiences creating educational materials to introduce high school students to Kernza taught us that the general public lacks baseline knowledge about food systems and agriculture, highlighting the need for accessible learning materials for a wide variety of audiences as a vehicle for exposing people to the idea of a new crop and the many facets of that process.”

-Education, Extension, & Policy co-lead Dr. Aubrey Streit Krug



KernzaCAP collaborators Dr. Jake Jungers, Dr. Jessica Gutknecht, James Bowden, Dr. Prabin Bajgain, and Colin Cureton at a field day in Madison, MN in July 2022

Supply Chains & Economics

Develop supply chains and economic drivers for Kernza.

Team members

- Colin Cureton (co-lead) - Forever Green Initiative, University of Minnesota
- Dr. Tessa Peters (co-lead) - The Land Institute
- Christopher Abbott - Perennial Pantry
- Christie Biddle - Patagonia Provisions
- Gwenael Engelskirchen - University of California, Davis
- Tannie Eshenaur - Minnesota Department of Health
- Alex Heilman - Perennial Promise Growers Cooperative
- Dr. Gail Feenstra - University of California, Davis
- Dr. Nicholas Jordan - Forever Green Initiative, University of Minnesota
- Andrew Leach - Forever Green Initiative, University of Minnesota
- Peter Miller - Sustain-a-Grain
- Ben Penner - Penner Farms
- Tracy Singleton - Birchwood Cafe
- Sophia Skelly - The Land Institute
- Chris Wiegert - Healthy Food Ingredients

Team objectives

Objective 1: Develop a Kernza Business Association to be the voice for Kernza industry partners in a broader Kernza Consortium.

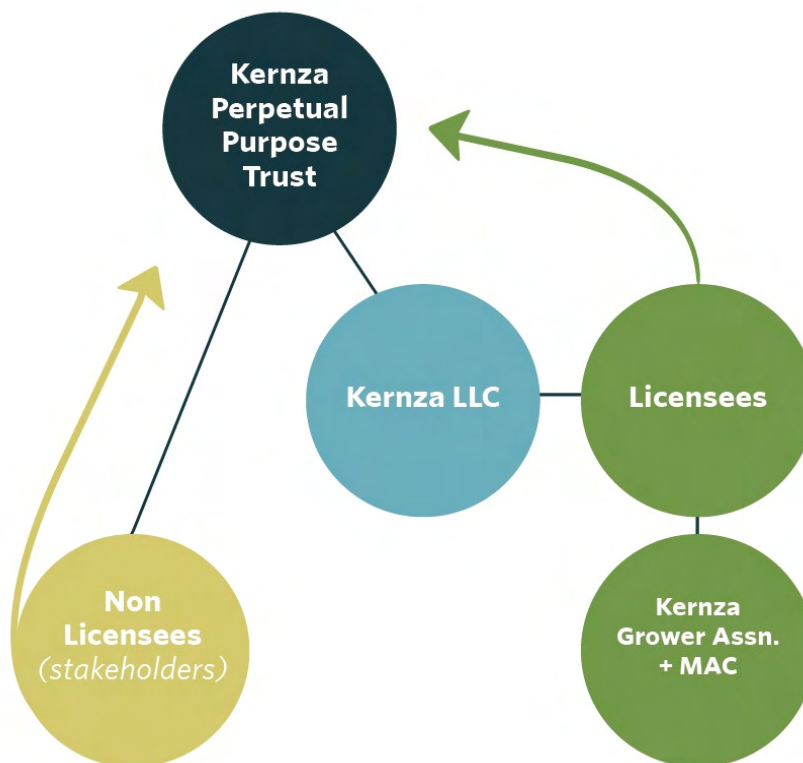
Foundational strategic planning began to build the Kernza Stewards Alliance. This organization will ultimately manage the Kernza trademark, advance the growth of the industry, and help streamline communication along the supply chain. The strategic planning process, led by Terra Soma, resulted in drafts of a governance model; a revenue model; an equity framework; and mission, vision, and values.

MISSION: Guiding and growing Kernza's future together.

VISION: Vibrant ecosystems, vital economies, and healthy people through perennial grains.

VALUES: Innovation, Urgency, Equity, Collaboration, Effectiveness, Longevity

The Kernza Stewards Alliance is envisioned as a perpetual purpose trust which will allow for shared ownership and governance of the intellectual property (the Kernza trademark) that creates boundaries around the commodity and how it is stewarded on the landscape and in the marketplace. Steward ownership empowers stakeholders involved in the day-to-day production activities in decision making and profit sharing for the organization. This is different from typical shareholder models that prioritize investors who are often external to business activities and focused on profit maximization only. One potential model for the governance structure is shown below. In the coming year, the team will work to develop bylaws and identify next steps for legal incorporation.



A potential model for the governance structure of the Kernza Stewards Alliance

Objective 2: Perform foundational consumer research and market analysis to determine Kernza's profitability for producers, supply chain actors, and end-users.

The first comprehensive Kernza supply review was undertaken in 2021 to determine: 1) the number of Kernza growers and their fields' locations, 2) the number of acres of Kernza planted, 3) barriers to successful field establishment, 4) the amount of grain harvested, and 5) the amount of grain available to the marketplace. This review will be repeated annually to help the team understand how the industry is changing and growing.

KernzaCAP collaborators Sustain-a-Grain, Healthy Food Ingredients, the Perennial Promise Growers Cooperative, and Ben Penner have begun conducting initial market research with their own supplies of grain and have shared initial successes. Successes include adding Kernza to new brewing and distilling applications that require less processing and achieve a lower price point than finished flour applications. KernzaCAP collaborator Perennial Pantry launched a new marketing method that mimics the model of Community Supported Agriculture. Their “Perennial Share” allows investment by individual consumers up-front for pantry staples including perennial grains. Inflation and processing price increases have led to a slowing of the marketplace, especially for larger market partners who are competing with commodity grains on the global scale.

A nation-wide demand review will be undertaken in year 3 to develop a nuanced understanding of barriers to adoption for market partners.



*Supply Chains & Economics team co-lead Dr. Tessa Peters (right) at a field day in Kansas.
Photo credit: The Land Institute*

Objective 3: Research, develop, and solidify Kernza supply chains and markets.

The team continued management of the Kernza trademark (currently administered by The Land Institute) and vetted 104 new grower applications. Regional value-based supply chains have advanced with 48 products using Kernza, up from 25 a year ago.

A supply review provided information to produce the first comprehensive data report on Kernza, published by The Land Institute. The report includes information on acres planted and harvested, where and how farmers are growing the grain, and more. The report reflects 2021 data; another review is currently underway to gather 2022 data.

The team worked with licensed Kernza seed sources and current and prospective growers to identify a projected 2022 seed shortage. Intensive cross-region and cross-sector engagement helped avert this shortage by identifying two methods for increasing seed supply. First, The Land Institute opted to release five new varieties that are all improved from previous germplasm rather than choosing only one. Second, the team worked with the Minnesota Crop Improvement Association to inspect additional fields to ensure that those harvests could be sold as seed in

accordance with the Identity Preserved Program. Maintaining connectivity with partners to meet the needs of the emerging market was possible due to the team funded by this grant.

Objective 4: Evaluate models for valuing and promoting the diverse environmental, social, and health benefits of Kernza.

Dialogue started with internal and external stakeholders on ecosystem service valuation models, which will continue into later years of the project.

"If our efforts are successful, new and additional needs will rapidly emerge and we will have to incorporate new businesses and commercialization needs into these types of projects."

-Supply Chains & Economics co-lead Colin Cureton



Nick Gardner of Perennial Pantry, left, shares Kernza products at a field day in July 2022.

KernzaCAP project director Dr. Jake Jungers presents about KernzaCAP at a Perennial Promise Growers Cooperative meeting in March 2022.



Integration

Activate transformational change through intentional integration.

Team members

- Dr. Jacob Jungers (co-lead) - University of Minnesota
- Aaron Reser (co-lead) - Green Lands Blue Waters
- Dr. Tessa Peters (co-lead) - The Land Institute
- Tara Ritter (co-lead) - University of Minnesota
- Dr. Aubrey Streit Krug (co-lead) - The Land Institute
- Greta Landis - University of Wisconsin-Madison
- Amber Mase - University of Wisconsin-Madison
- Erin Meier - Green Lands Blue Waters
- Evelyn Reilly - University of Minnesota
- Sophia Skelly - The Land Institute
- Co-leads of all other objective teams participate on the integration team

Team objectives

Objective 1: Project-wide integration and activity tracking through the design of our objectives and engagement with our project partner network.

The team continued to hone and use the project infrastructure built in year 1, including an internal collaborator website and a public-facing website, internal and external newsletters, and a structure for reporting activities and outcomes. Throughout the year, the project management team met weekly, the Coordinating Team met bi-weekly, the Advisory Committee met in February 2022, and over 75 collaborators came together in October 2022 for the second annual all-hands meeting (Appendix B). These tools and meetings are the foundation for communication and integration across KernzaCAP collaborators and the broader Kernza network.

Objective 2: Co-create and actualize a Kernza Consortium to serve as a multi-stakeholder leadership body.

Kernza leadership continues to develop through the Kernza Stewards Alliance, farmer leadership including the Perennial Promise Growers Co-op, the Forever Green Partnership, and other collaborative entities. The KernzaCAP team is in communication with all of these entities and continues to explore what needs exist for shared leadership for Kernza.

The developing Kernza Stewards Alliance has clear paths of engagement for Kernza licensees. The integration team is working on ways for non-licensees to engage in the Kernza Stewards

Alliance and in Kernza leadership more broadly. A contract with the agency Terra Soma will help define these roles in 2023.

Objective 3: Lead the way for the next generation of perennial cropping systems.

The team facilitated a series of reflection conversations throughout the year to capture learnings that will inform a model for future perennial crops. The annual all-hands meeting featured breakout groups that brainstormed top milestones and lessons learned in specific topic areas. These learnings, along with written answers on annual reporting forms, are being collected to inform a model for future perennial crops that will be published at the end of the grant.

A timeline of Kernza history will be released in early 2023 to create a shared understanding of what has made Kernza successful to date. The timeline was developed with feedback from all project collaborators. A narrative history is underway with expected publication in 2023.



The beginnings of the Kernza timeline are displayed at the Kernza meeting in Salina, KS.

The evaluation team at University of Wisconsin-Madison designed and launched a Social Network Analysis (Appendix C), which captured information on the Kernza network. We will replicate the Social Network Analysis in year 5 to understand how the network has changed and grown, and will apply these findings to the model for future perennial crops.

Objective 4: Catalyze new network reach and effectiveness through accessible data and shared learnings.

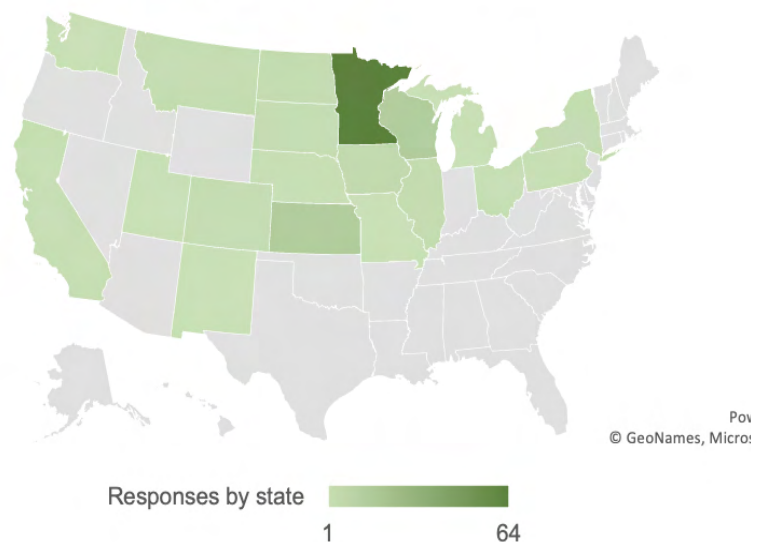
The project's data management subgroup developed protocols and data collection templates for all field activities. Each site collected data according to the protocols and uploaded it to their provided templates to ensure consistency for data analysis.

The team continues to promote the project’s data sharing and co-authorship policy to ensure equity in authorship and track manuscripts across the project. The project’s website (www.kernza.org/kernzacap) is regularly updated to reflect progress and an external newsletter through Mailchimp is sent quarterly to an audience of 180 to share learnings.

Objective 5: Evaluate for impact, systems change and emergent learning.

The evaluation team at University of Wisconsin-Madison designed and launched a Social Network Analysis (Appendix C). The survey was sent to 281 people and had a 54% response rate. The purpose of the survey was to identify key characteristics of the network of individuals currently involved in Kernza development, marketing, and education, and learn more about how they exchange information. Results highlighted where people in the network are located, how they get their information about Kernza, who their most important contacts are, and key events that have helped move Kernza forward. The Social Network Analysis will be repeated in year 5 to measure the impact of the network and how it has changed and grown.

130 survey respondents work at organizations in the United States, the majority of which are in Minnesota (64), Kansas (14), and Wisconsin (14).



The evaluation team helped design and lead reflection conversations to capture learnings that will inform a model for future perennial crops. These conversations happened at Coordinating Team meetings and the annual all-hands meeting in October 2022. Team functioning questions were part of the all-hands meeting evaluation, offering a space for grant collaborators to provide feedback to inform better cohesion, awareness, and grant-wide effectiveness.

Race & equity subgroup:

The project’s race and equity subgroup aims to better incorporate justice, equity, diversity and inclusion into the project. The purpose of the race and equity work in this project is to expand perennial agriculture in a way that is fair, inclusive, and benefits all people and communities equitably. The subgroup identified four ways, based on activities that are already embedded within the project, to pursue this work:

- Empower individual learning and development amongst KernzaCAP project collaborators
- Build mutually beneficial, long-term relationships beyond the current white-dominant networks
- Leverage project resources, processes and decisions we have at hand
- Reflect and report openly on our process and results

There have been seven subgroup meetings. Meetings have focused on expanding the Advisory Committee to include a broader range of perspectives, drafting a race and equity framework (Appendix D), informing the project's shared values and principles, writing a coordinated USDA comment, and discussing strategy and intentionality within relationship building.

A hiring resources toolkit was created and shared with project collaborators. It includes example candidate evaluations, interview questions, and job descriptions to encourage equity in recruiting and hiring practices. In year 3, the toolkit will be expanded to include resources on building an inclusive culture in labs and research environments.



The October 2022 all-hands meeting (Appendix B) featured a race and equity session focused on accountability and reporting openly. This work will continue throughout the grant.

Two members of the KernzaCAP race & equity subgroup attended a training from Soul Fire Farm on Uprooting Racism in the Food System.

"The integrative focus of this project is key to developing and launching a new crop. While progress can be made in isolated teams, coordination across disciplines is necessary for the greatest impact. KernzaCAP collaborators learned how to coordinate field trials closely across sites (matching layouts, inputs, field preparation, timing, etc.), plan for management of experiments over time, collaborate with growers and businesses to approach market planning, and understand the priorities unique to early Kernza adopters. This type of integrative communication and planning is what makes this project unique and what will help us create a model for future perennial cropping systems."

-KernzaCAP Project Manager Tara Ritter

Products

Peer reviewed publications

1. José G. Franco, Marisol T. Berti, John H. Grabber, John R. Hendrickson, Christine C. Nieman, Priscila Pinto, David Van Tassel, and Valentín D. Picasso. 2021. Ecological Intensification of Food Production by Integrating Forages. *Agronomy* 2021, 11, 2580. <https://doi.org/10.3390/agronomy11122580>

Presentations

2. Jungers, J. M. 2022. KernzaCAP: A model for developing and deploying a new sustainable crop enterprise. University of Minnesota Applied Plant Sciences Graduate Program Seminar. Virtual. Feb. 7, 2022.
3. Gutknecht, J.M. 2022. Kernza-CAP, creating a model for environmentally friendly food systems. Horticulture department seminar. Virtual. April 23, 2022.
4. A. Hartman. Q&A session during Fermentation Fest Grain & Graze panel with 25 attendees featured a discussion about KernzaCAP, Perennial Promise Growers Cooperative, and other project stakeholders. September 25, 2021.
5. Jungers, J. M. On-farm trials for secondary and post-secondary education. Minnesota Association of Agricultural Educators. St. Cloud, MN. January 21, 2022.
6. Fernholz, C. and Skelly, S. Kernza round table discussion. Midwest Organic & Sustainable Education Service (MOSES) Annual Conference. February 26, 2022.
7. Reilly, E. Kernza®: A profitable, perennial approach to reducing nitrate leaching. Nitrate Reduction Solutions in Groundwater Workshop. Zoom Webinar hosted by Environmental Protection Agency Regions 3, 5, 7. March 8, 2022.
8. Picasso, V. Sustainable food production systems. Seminar for Nelson Institute for Environmental Studies seminar at UW-Madison. April 28, 2022.
9. Tautges, N. and Hughes, W. Kernza Updates & the Perennial Promise Growers Coop. OGRAIN annual meeting, Madison, WI. January 29, 2022.
10. Tautges, N. Introduction to Kernza. Land Stewardship Summit, East Troy, WI. June 22, 2022.
11. Bajgain, P. Diversifying the Agroecosystem. University of Minnesota Southwest Research and Outreach Center, Lamberton, MN. September 14, 2022.
12. Bajgain, P. Advances in Harvesting, Processing and Marketing. A-Frame Farm, Madison, MN. July 7, 2022.
13. Gutknecht, J.M. Perennial grain systems as a pathway to improved soil functioning and climate resiliency. Seminar for Pacific Northwest National Laboratories Environmental and Molecular Sciences Laboratory (EMSL). Virtual. September 29, 2022.

Podcasts

14. Anderson, K. and Jungers, J. featured on the Land Stewardship Project's podcast, episode 259: Kernza's Stress Test. September 27, 2021.
<https://landstewardshipproject.org/podcast/ear-to-the-ground-no-259-kernzas-stress-test>
15. Tautges, N. and Picasso, V. featured on Clean Wisconsin's podcast, episode 20: Kernza Crunch: Racing to Develop the World's First Perennial Grain Crop. August 31, 2022.
<https://www.cleanwisconsin.org/kernza-crunch-racing-to-develop-the-worlds-first-perennial-grain-crop/>

Policy

16. Practice Standard to include Kernza in conservation programs. Developed according to the MN Department of Agriculture Template.
17. Advocates Regional Briefing. Zoom webinar for policy advocates exploring Kernza and other Continuous Living Cover crops. November 5, 2021.
<https://www.youtube.com/watch?v=sV0e8KbmUY4&t=1s>
18. Jungers, J. and Bartel, C. Presentation at the NRCS Central Region agronomists meeting. July 18, 2022. <https://nrscs.app.box.com/s/gn0dh0et3adqa3jgnk83426u0vs4y9j9>

Education

19. Cureton, C. and Penner, B. Guest co-teaching in Dr. Hikaru Peterson's Food Marketing Economics class. University of Minnesota. November 23, 2021.
20. Gutknecht, J. Beta-tested the "Meet Kernza" educational module. UMN Environmental Science, Policy, and Management Environmental Soil Biology course. November 2021.
21. Jungers, J. Beta-tested the "Meet Kernza" educational module, UMN Agronomy Crops, Environment, and Society course. November 2021.
22. "Kernza in Context" monthly newsletter launched with updates from the education team. Launched August 2022.
23. "Kernza in Context" pamphlet. Created and disseminated at the annual Kernza Conference to share educational modules and strategy.
24. "Deep Roots in Soil" educational module developed for the "Kernza in Context" curriculum.
25. "Growing Grains" educational module developed for the "Kernza in Context" curriculum.
26. "Kernza and Intercropping" educational module developed for the "Kernza in Context" curriculum.
27. "Kernza and Soil Carbon" educational module developed for the "Kernza in Context" curriculum.
28. "Kernza and Water Quality" educational module developed for the "Kernza in Context" curriculum.
29. "Kernza Ecosystem Services" educational module developed for the "Kernza in Context"

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- curriculum.
 - 30. "Meeting Perennials" educational module developed for the "Kernza in Context" curriculum.
 - 31. "Understanding Genotypes and Phenotypes" educational module developed for the "Kernza in Context" curriculum.
 - 32. "What is a Grain" educational module developed for the "Kernza in Context" curriculum.
 - 33. "Kernza for Dual Use" educational module developed for the "Kernza in Context" curriculum.
 - 34. "Environmental Photostory" educational module developed for the "Kernza in Context" curriculum.

Field Days

- 35. Cave Tour and Kernza Field Day hosted by the Land Stewardship Project. Mauston, MN, July 6, 2022.
- 36. Kernza Field Tour at Hughes Farm Field Day. Janesville, WI. July 27, 2022.
- 37. Kernza Field Tour at Stute Farm Field Day. East Troy, WI. August 4, 2022.
- 38. Kernza Field Day and Product Showcase at A-Frame Farm. Madison, MN. July 9, 2022.
- 39. Kernza Field Day at Kimber Farms. Farmington, MN. July 21, 2022.
- 40. 2022 Kernza Field Days press release. <https://kernza.org/wp-content/uploads/2022-Field-Day-Press-Release-4.pdf>

Commercialization

- 41. Kernza Stewards Alliance - mission, vision, and values
- 42. Kernza Stewards Alliance - revenue model
- 43. Kernza Stewards Alliance - equity framework
- 44. Kernza Stewards Alliance - governance model
- 45. Kernza perennial grain early commercialization timeline. Timeline outlines efforts from the 1980s through 2020.
- 46. 2021 planting and harvest data compiled based on a survey of 52 growers who have trademark licenses to grow and sell Kernza.

Project Tools

- 47. KernzaCAP monthly lunchtime seminar series. February 2022 featured a panel of 4 presenters discussing carbon markets and Kernza.
- 48. KernzaCAP monthly lunchtime seminar series. March 2022 featured an agronomic research update. https://mediaspace.umn.edu/playlist/dedicated/1_vkhx2tck/1_4g4ciesj
- 49. KernzaCAP monthly lunchtime seminar series. May 2022 featured an update on free threshing. https://mediaspace.umn.edu/playlist/dedicated/1_vkhx2tck/1_pt63gmox

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50. KernzaCAP monthly lunchtime seminar series. June 2022 featured Perennial Pantry and their product development process.
https://mediaspace.umn.edu/playlist/dedicated/1_vkhx2tck/1_t39akanl
 51. KernzaCAP monthly lunchtime seminar series. August 2022 featured a food science update on Kernza extrusion, puffing, and distillation.
https://mediaspace.umn.edu/playlist/dedicated/1_vkhx2tck/1_io280jv4
 52. KernzaCAP quarterly newsletter, sent to an audience of 180. Archive of past newsletters:
<https://kernza.org/field-notes/?category=kernza-cap-newsletter>
 53. KernzaCAP promotional video, produced by University of Minnesota.
<https://www.youtube.com/watch?v=itYRKclDowI>
 54. KernzaCAP Year One Annual Report. Outlines the project's efforts from September 2021 - August 2022. <https://kernza.org/wp-content/uploads/KernzaCAP-Year-One-Annual-Report-compressed.pdf>
 55. Social Network Analysis. Survey created in partnership with the University of Wisconsin-Madison evaluation team to measure the reach and impact of the Kernza network. Survey sent to 281 Kernza stakeholders with a 54% response rate.
 56. Equitable hiring resources toolkit created and distributed to encourage equity in hiring processes.

Protocols

57. 2022 grain harvest protocol. Informs the agronomy and environmental quality teams' data collection efforts.
58. 2022 corn and soybean harvest protocol. Informs the agronomy and environmental quality teams' data collection efforts.
59. 2022 spring nitrogen application protocol. Informs the agronomy and environmental quality teams' data collection efforts.
60. 2022 forage harvest protocol. Informs the agronomy and environmental quality teams' data collection efforts.
61. 2022 growth staging protocol. Informs the agronomy and environmental quality teams' data collection efforts.
62. 2022 lodging score protocol. Informs the agronomy and environmental quality teams' data collection efforts.
63. 2022 plant counts protocol. Informs the agronomy and environmental quality teams' data collection efforts.
64. 2022 weed surveys protocol. Informs the agronomy and environmental quality teams' data collection efforts.

Appendix A: Collaborator List & Advisory Committee

Collaborator list

- Christopher Abbott, Co-Founder, Perennial Pantry
- Jim Anderson, Professor, University of Minnesota
- George Annor, Assistant Professor, University of Minnesota
- Prabin Bajgain, Research Assistant Professor, University of Minnesota
- Cynthia Bartel, Principal, C. Bartel Inc.
- Andrea Basche, Assistant Professor, University of Nebraska-Lincoln
- Michael Bell, Professor, University of Wisconsin-Madison
- Christie Biddle, Supply Chain Manager, Patagonia Provisions
- Nathaniel Brunsell, Professor, University of Kansas
- Tomás Cassani, Postdoctoral Researcher, The Land Institute
- Whitney Clark, Executive Director, Friends of the Mississippi River
- Jared Crain, Postdoctoral Fellow, Kansas State University
- Tim Crews, Director of Ecological Intensification, The Land Institute
- Steve Culman, Professor, Washington State University
- Colin Cureton, Director of Adoption and Scaling, UMN Forever Green Initiative
- Maura Curry, Soil Health Organizer, Land Stewardship Project
- Julie Dawson, Associate Professor, University of Wisconsin-Madison
- Lee DeHaan, Lead Scientist, The Land Institute
- Leonardo Deiss, Research Assistant Professor, The Ohio State University
- Emily Elder, Masters Student, University of Kansas
- Gwenael Engelskirchen, Sustainable Supply Chain Analyst, University of California-Davis
- Tannie Eshenaur, Planning Director, Minnesota Department of Health
- Jessica Gutknecht, Associate Professor, University of Minnesota
- Alyssa Hartman, Executive Director, Artisan Grain Collaborative
- Alex Heilman, Marketing Contractor, Perennial Promise Growers Cooperative
- Whilden Hughes, Farmer, W. Hughes Farms
- Pam (Baraem) Ismail, Professor, University of Minnesota
- Dustin Johnsrud, Farmer, Johnsrud Farms
- Nicholas Jordan, Professor, University of Minnesota, Forever Green Initiative
- Jacob Jungers, Assistant Professor, University of Minnesota
- Audrey Kalil, Plant Pathologist, North Dakota State University
- Clair Keene, Extension Specialist, Cropping Systems, North Dakota State University
- Jonathan Kilpatrick, Soil Health Specialist, Sustainable Farming Association
- Kurt Kimber, Farmer, Kimber Farms
- Tammy Kimbler, Director of Communications, The Land Institute
- Peter LaFontaine, Agricultural Policy Manager, Friends of the Mississippi River
- Greta Landis, Evaluation Specialist, University of Wisconsin-Madison
- Shona Langseth, Co-Director of Soil Health, Land Stewardship Project
- Andrew Leach, Sustainable Commercialization Associate, Forever Green Initiative
- Amber Mase, Evaluation Specialist, University of Wisconsin-Madison
- Diane Mayerfeld, Sustainable Agriculture Coordinator, Extension, UW-Madison
- Erin Meier, Director, Green Lands Blue Waters

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- Peter Miller, Chief Operating Officer, Sustain-a-Grain
 - Steve Morse, Executive Director, Minnesota Environmental Partnership
 - Sienna Nesser, Commercialization Research Specialist, Forever Green Initiative
 - Lydia Nicholson, Post-Baccalaureate Researcher, The Land Institute
 - Ben Penner, Farmer, Penner Farms
 - Tessa Peters, Commercialization Manager, The Land Institute
 - Luke Peterson, Farmer, Peterson Farms
 - Valentin Picasso, Assistant Professor, University of Wisconsin-Madison
 - Priscila Pinto, Postdoctoral Researcher, University of Wisconsin-Madison
 - Samuel Pratsch, Evaluation Specialist, University of Wisconsin-Madison
 - Dorothy and John Priske, Farmers, Fountain Prairie Farm
 - Evelyn Reilly, Research Project Assistant, KernzaCAP and Green Lands Blue Waters
 - Aaron Reser, Associate Director, Green Lands Blue Waters
 - Tara Ritter, KernzaCAP Project Manager, University of Minnesota
 - Trevor Russell, Water Program Director, Friends of the Mississippi River
 - Coleman Selfridge, Masters Student, University of Minnesota
 - Gurparteet Singh, PhD Student, University of Minnesota
 - Tracy Singleton, Owner, Birchwood Café
 - Sophia Skelly, Research Technician, The Land Institute
 - Hannah Stoll, Graduate Research Assistant, University of Minnesota
 - Dave Stoltenberg, Professor, University of Wisconsin-Madison
 - Aubrey Streit Krug, Director of Ecosphere Studies, The Land Institute
 - Nicole Tautges, Agroecologist, Michael Fields Agricultural Institute
 - Jared Trost, Hydrologist, USGS, Upper Midwest Water Science Center
 - Chris Wiegert, Chief Soil Health and Sustainability Officer, Healthy Food Ingredients
 - Claire Wineman, Post-Baccalaureate Researcher, The Land Institute

Advisory committee

- Liz Carlisle, Assistant Professor, University of California-Santa Barbara
- Constance Carlson, Assistant Statewide Director, UMN RSDPs
- Christophe David, Executive Director, ISARA
- Lydia English, Strategic Initiatives Coordinator, Practical Farmers of Iowa
- Carmen Fernholz, Farmer, A-Frame Farms
- Laura Hansen, Retired Research and Development lead, General Mills
- Mitch Hunter, Associate Director, Forever Green Initiative
- Bonnie Keeler, Assistant Professor, University of Minnesota
- Emily Luscombe, Natural Resources Director, Intertribal Agriculture Council
- Juli Obudzinski, Policy Consultant, Independent Consultant
- Korede Olugbenle, PhD Student, University of Wisconsin-Madison
- Hikaru Peterson, Professor, University of Minnesota
- Matt Ryan, Associate Professor, Cornell University
- Craig Sheaffer, Professor, University of Minnesota
- Rachel Stroer, President, The Land Institute
- Omar Tesdell, Associate Professor, Birzeit University
- Peggy Wagoner, Retired Project Leader, Rodale Institute

Appendix B: Year 2 All-Hands Meeting Agenda

Year 2 All-Hands Meeting Agenda

Monday, October 24, 2022 // 10am-3pm central

10:00-10:15 - Welcome

10:15-12:00 - Objective Team & Project Updates

- Germplasm and trait evaluation
- Agronomy and on-farm knowledge
- Environmental quality
- Education, extension, and policy
- Supply chains and economics
- Integration
- Full project updates

12:00-12:30 - Race & Equity Self Evaluation & Reporting Openly

We will report openly on what we have accomplished so far and where we can do better.

Breakout groups will discuss how we can better leverage existing tools and resources.

12:30-1:15 - Break

1:15-2:00 - Keynote

Aubrey Streit Krug (The Land Institute) and Omar Tesdell (Birzeit University) will discuss their ongoing research into the biogeography of intermediate wheatgrass.

2:00-2:45 - Kernza Milestones & Model for Future Perennial Crops

We will spend time in breakout groups reflecting on building a model for future perennial crops.

Groups will identify top milestones in their topic area and discuss what worked and what didn't in reaching those milestones. Please review the Kernza timeline as preparation for this session.

- Communications and messaging
- Policy
- Commercialization and product development
- Managing seed supply and varietal licensing
- Grower support
- Education and extension
- Transdisciplinary research

2:45-3:00 - Closing

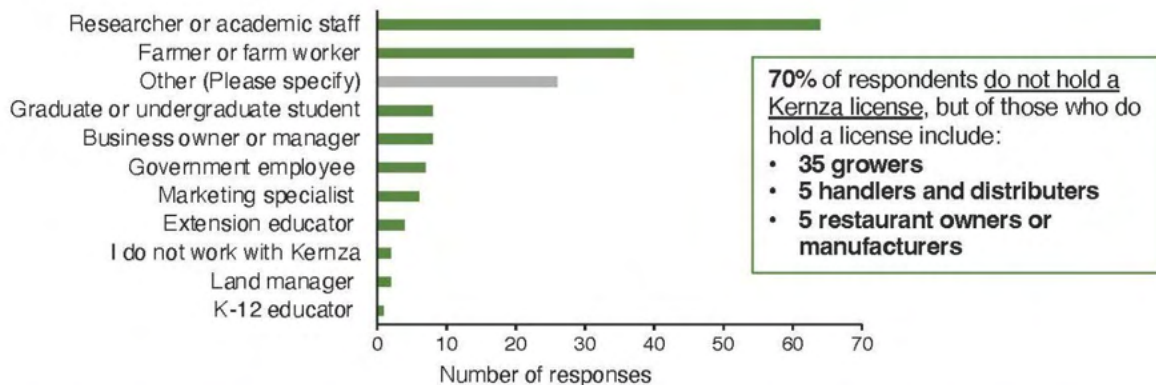
Appendix C: Social Network Analysis Overview

Kernza® CAP Social Network Analysis

In June of 2022, the Kernza® CAP team distributed a survey to project contacts. The purpose of the survey was to identify key characteristics of the network of individuals currently involved in Kernza development, marketing, and education, and learn more about how they exchange information. The survey was distributed by email to 281 people, and 151 responded for a 53.7% response rate. Below is a draft summary of their responses. Questions? Contact greta.landis@wisc.edu and amber.mase@wisc.edu

Who is part of the Kernza Network?

Most survey responses came from **researchers or academics** (64), **farmers and farm workers** (37), and individuals who described their work role as “**other**” (26), which included roles like nonprofit educators and advocates (13), city employees and community leaders (5), retail managers, chefs, and brewers (4), landowners (2), and advisors (2). Distribution of all categories below:

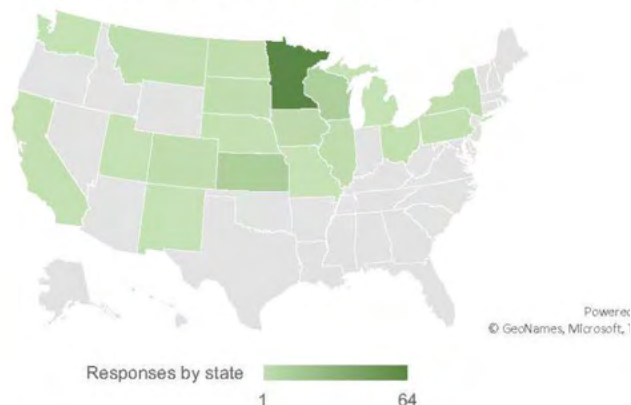


Where are they located?

The institutions and organizations below are affiliated with respondents' most important Kernza-related contacts (total mentions for each organization are in parentheses):

- **University of Minnesota** (153)
- **The Land Institute** (88)
- **Forever Green Initiative** (29)
- **University of Wisconsin-Madison** (22)
- Perennial Promise Grower Coop (12)
- Green Lands Blue Waters (10)
- U.S. Department of Agriculture (7)
- Agricultural Utilization Research Institute (7)
- Sustain-a-Grain (7)
- Michael Fields Agricultural Institute (6)
- Ohio State University (3)
- North Dakota State University (3)
- South Dakota State University (1)
- **Individual farmers and businesses** (31)

130 survey respondents work at organizations in the United States, the majority of which are in **Minnesota** (64), **Kansas** (14), and **Wisconsin** (14).



20 individuals work at internationally, at organizations in Canada (5) and European countries (12), and Palestine, Kazakhstan, and Argentina.

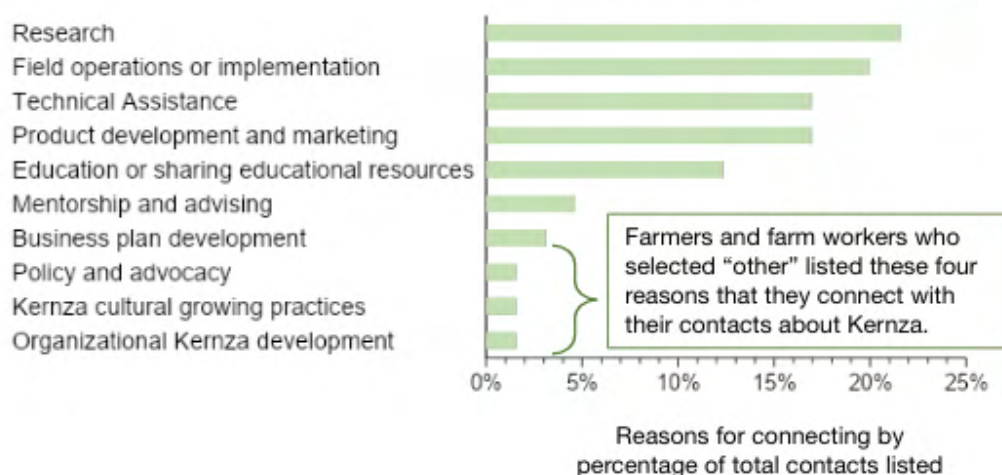
How does the network communicate and connect?

The way that individuals in the network connect with their Kernza-related contacts varied significantly by organizational roles. Percentages below were calculated by the number of total listed contacts provided by survey respondents.

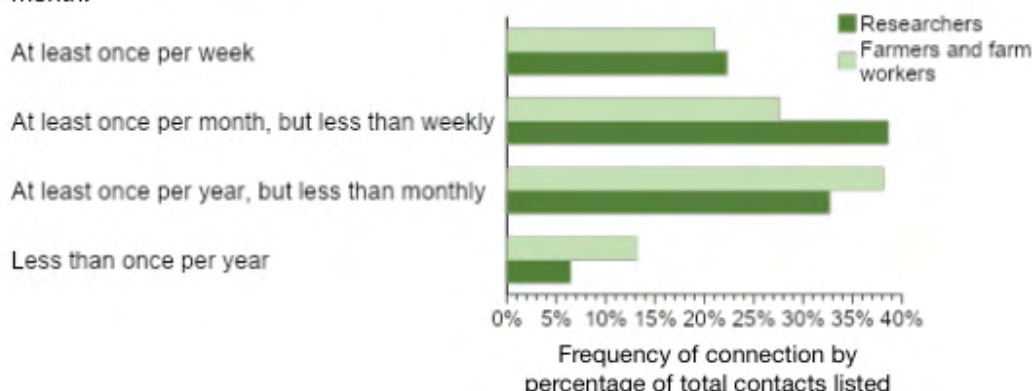
Researchers and academic staff primarily connect with their most important contacts about research. Of all contacts listed by this group, **65% connect for research-related activities**, followed by education or sharing educational resources (11%), mentorship or advising (5%), and field operations or implementation (5%).

Survey respondents that identified as **farmers and farm workers** had a wider range of connections—they primarily connect with their most important contacts about **research** (22%), **field operations or implementation** (22%), **technical assistance** (17%), and **product development and marketing** (17%).

How farmers and farm workers connect with their key contacts about Kernza

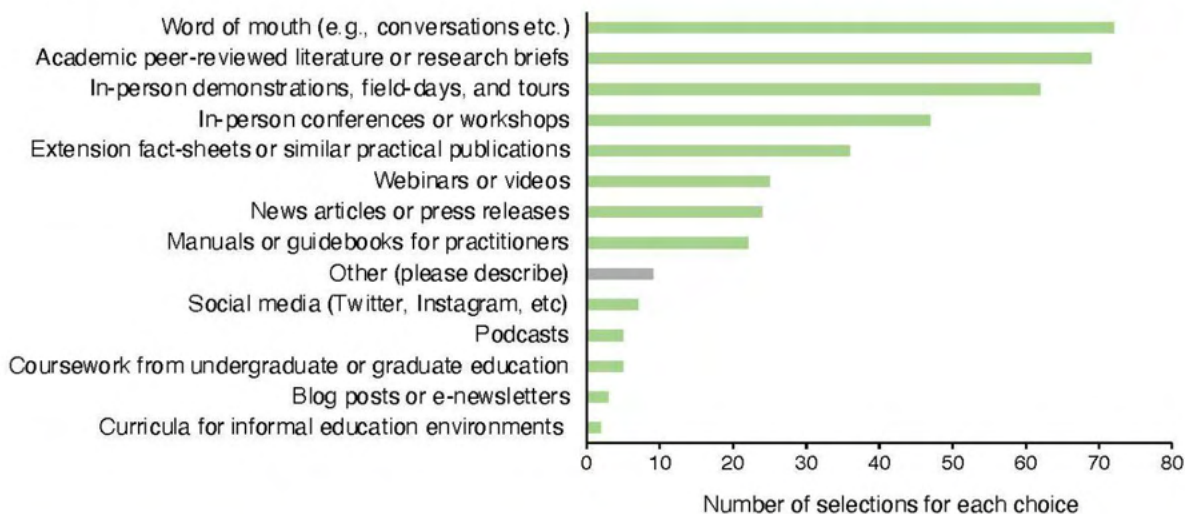


The **frequency** with which individuals connect with their contacts also varied slightly by these two groups. Farmers and farm workers had slightly more important contacts that they connect with infrequently (less than once per year), while researchers have more contacts that they connect with weekly and at least once per month.

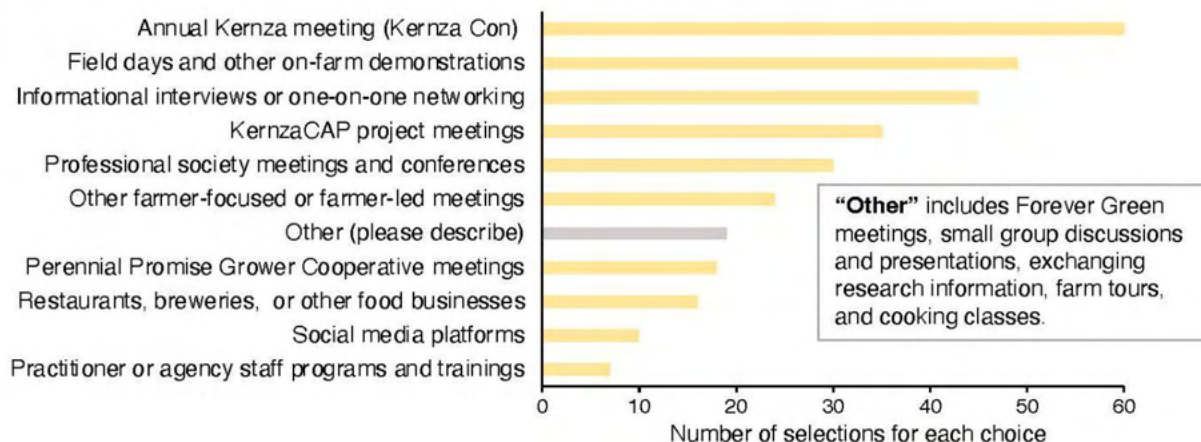


Where does the network get their information about Kernza?

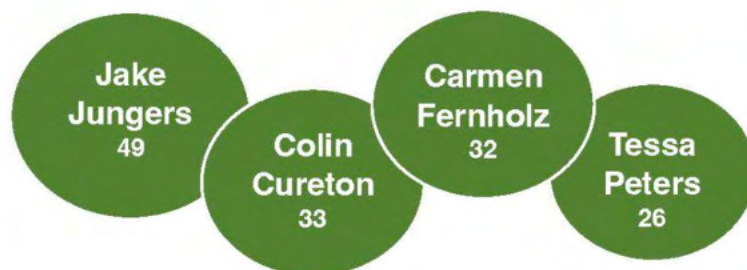
Most important sources of information about Kernza: **word of mouth** (e.g., conversations with colleagues, advisors, and other farmers) (72), **academic literature** (69), and **in-person demonstrations** (62). Respondents who chose “**other**” described Forever Green lab meetings, content from The Land Institute, and direct contact from collaborators. Distribution of selections below (survey respondents could select up to three):



In addition, the network identified the most valuable ways or places where they connect with colleagues over Kernza. Distribution of selections below (survey respondents could select up to three):



Survey respondents were asked to list up to 5 of their most important Kernza-related contacts, or colleagues, collaborators, neighbors, mentors, with whom they exchange information about Kernza. These four individuals were mentioned most frequently across all responses.



Which key events, people or resources have helped move Kernza from an idea to on-the-ground acres?

The analysis of open-ended responses is ongoing, but the broad themes that came from this question included specific activities related to **technical assistance**, **marketing**, and **media coverage** that boosted Kernza development and adoption. The network also referenced particular events and programs including **Kernza Con**, the **Lund Conference on Perennial Grains**, gatherings at **The Land Institute**, and the **Minnesota State Fair**, as well as key partnerships between industry and public research institutions. Sample responses referring to key people, events, activities, and contextual factors below:

Activities and Partnerships:

- **Legal definition** of the grain and trademark incorporation;
- **Marketing success** of Kernza beer, working with Patagonia Provisions, Perennial Pantry, and other groups;
- **Tracking acres** in production;
- **Gap filling measures** like intellectual property assistance, finding milling partners and distributing grain, and technical assistance answering calls from early growers;
- University of Minnesota's Forever Green Initiative;
- **Press coverage**, including the Nation Magazine and a PBS special

Contextual factors:

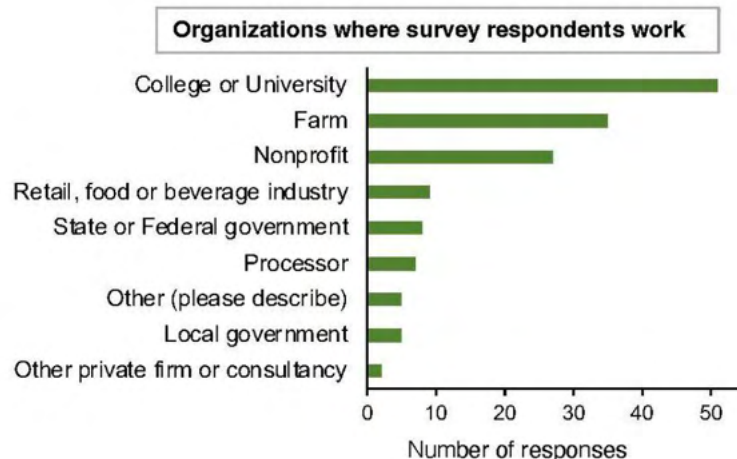
- growing interest in mitigating **climate change**
- **nitrate pollution** in soil and drinking water
- support for "**no till**" practices
- **low crop prices**
- **supportive policy** for research, technical assistance, and implementation.

People and key roles:

- Aaron Reser
- Carmen Fernholz
- Colin Cureton
- Connie Carlson
- Craig Sheaffer
- Don Wyse
- Early adopter farmers (Jack Erisman)
- Jake Jungers
- Laura Hanson and Jerry Lynch (General Mills)
- Lee Dehaan
- Matt Ryan
- Peggy Wagoner
- Tessa Peters
- Wes Jackson
- Valentin Picasso
- Staff at The Land Institute

Identities and demographics of the network:

The majority of survey responses came from individuals who are **college educated (89%)** and identify their race as **white (76%)** and their gender as **male (57%)**. They primarily work at **colleges or universities**, **farms**, or **nonprofit organizations**. Most are between the ages of 31-60, with the largest age group in the range of **31-40 years old**. Distribution of organizations and racial demographics below:



Racial distribution of survey responses

- White 76%
- Prefer not to answer 11%
- Asian (5%)
- Black or African American (3%)
- Hispanic or Latinx (2%)
- Middle Eastern or North African (1%)
- American Indian or Alaska Native (1%)
- Other (please describe) 1%
- Pacific Islander or Native Hawaiian (0%)

Appendix D: Race & Equity Framework

Framework for weaving race & equity work through Kernza®CAP

This is a working internal document for KernzaCAP project collaborators. It was initially developed based on conversations within the race-equity subgroup and we expect it to continue to grow and evolve. Feedback is always welcome.

The KernzaCAP grant aims to improve the environmental sustainability of food production and demonstrate the viability of new perennial crops as real economic opportunities for farmers and rural communities. The purpose of our race and equity work in this project is to expand perennial agriculture in a way that is fair, inclusive, and benefits all people and communities equitably. A first step in this process is inspiring and challenging ourselves to understand how and why to engage race and equity in this project and beyond.

We see four ways, based on activities that are already embedded within this project, to pursue this work. These four ways of weaving race & equity work through KernzaCAP are distinct but connected.

1. Empower individual learning and development amongst KernzaCAP project collaborators

- Why we do it: to grow as researchers, practitioners and human beings, with the explicit goal of equipping ourselves with enough knowledge and understanding to be effective agents of change towards equitable systems; to create shared understandings of history, present and privilege in the white-culture-dominated fields of agriculture and conservation.
- What it looks like: individuals across the project supported in engaging with educational resources, inquiry tools, and opportunities for reflection and practice.
- What it results in: individual learning outcomes (new knowledge, positive behavior change, increased self-efficacy or motivation, etc.) and application of that learning into some grant activities, as measured by the evaluation team.

2. Build mutually beneficial, long-term relationships beyond the current white-dominant networks

- Why we do it: to care for and broaden the social connective fabric our work depends on
- What it looks like: individuals across the project putting relationship building into practice; sustaining good collaborative relationships through project work; responding to inquiries and doing outreach to identify and seek out underrepresented voices and new perspectives, places, organizations, and audiences to engage.

-
- What it results in: increased capacity to initiate, deepen, and tend to relationships, within and beyond the current project team; wider and stronger network of relationships for broader impact and future work, as measured by the evaluation team.

3. Leverage project resources, processes and decisions we have at hand

- Why we do it: to put our learning and values about equity into practice.
- What it looks like: building and using hiring resources and/or other toolkits; challenge ourselves to recognize where equity-related decisions are made (such as through advisory board, hiring, shaping of new systems and structures, event planning, messages we forward through curriculum modules, etc.) and making wise choices in those forums.
- What it results in: more just and fair distribution of resources and access to opportunities through this project, as measured by the evaluation team.

4. Reflect and report openly on our process and results

- Why we do it: to figure out and communicate what we're learning and translate and apply it beyond this project.
- What it looks like: ongoing communications work; baseline evaluation, identify core values and implicit assumptions of our theory of change, identify key metrics to track related to race/equity; ongoing formative or developmental evaluation about what is being un/learned or changed through the project process; summative evaluation to document results and implications.
- What it results in: improved model for equitable perennial grain crop development, as measured by the evaluation team