



Quarterly Progress Report

**Regenerating America's Working Landscapes
to Enhance Natural Resources and Public Goods
through Perennial Groundcover**

Report No. 19 | Feb. 1, 2026 - Apr. 30, 2026

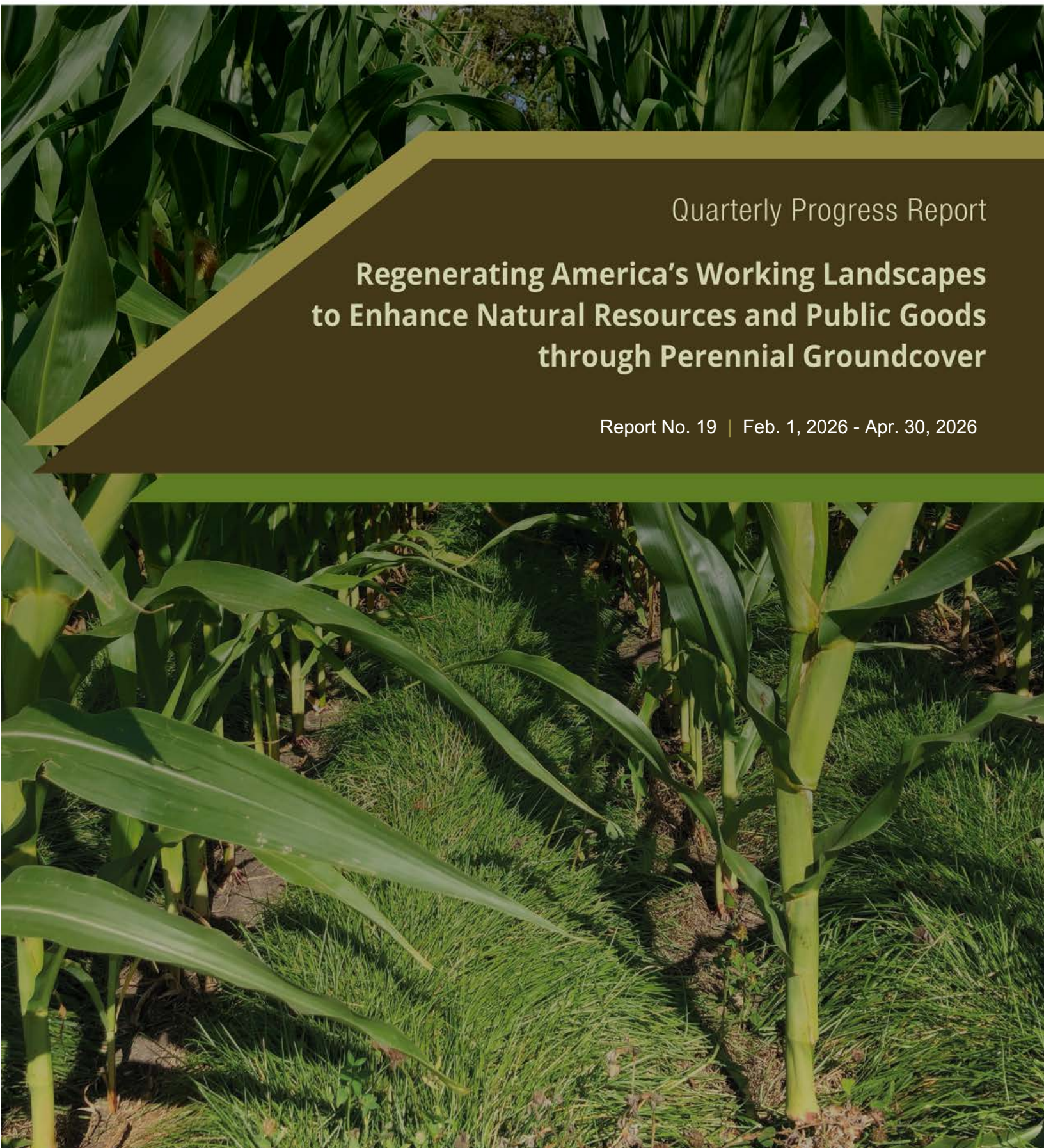


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Exhibits

- Exhibit 1. 2026 Undergraduate Research Experience

For more information, visit the RegenPGC website at <http://www.regenpgc.org/>. Previous RegenPGC Progress Reports are available at <https://www.regenpgc.org/resources/reports/>.

Acknowledgment

Regenerating America's Working Landscapes to Enhance Natural Resources and Public Goods through Perennial Groundcover (RegenPGC) is supported by Agriculture and Food Research Initiative Competitive Grant No. 2021-68012-35923 from the USDA National Institute of Food and Agriculture. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the U.S. Department of Agriculture.

Legal Notice

This RegenPGC project quarterly report was prepared by Iowa State University (ISU) and RegenPGC research colleagues from Corteva, Inc. (Corteva), Kansas State University (KSU), The Land Institute (TLI), University of Kentucky (UK), University of Missouri (UM), and University of Wisconsin-Madison (UW-Madison) in the course of performing research supported by Agriculture and Food Research Initiative Competitive Grant No. 2021-68012-35923 from the USDA National Institute of Food and Agriculture (USDA-NIFA).

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Abstract

Achieving the SAS program goal of transforming the U.S. agricultural system to sustainably increase production by 40% requires large-scale production agriculture across multiple crops to profoundly change its bare-soil winter-fallow practices. These conventional practices negatively impact soil health and natural resources conservation – the pillars of agricultural systems sustainability. A scalable solution to this challenge is the implementation of perennial groundcover (PGC) cropping systems, which use an ecologically complementary, permanent groundcover in fields where annual cash crops are grown. This transformative approach to large-scale agricultural production increases the duration and extent of groundcover on cropland, enhancing resiliency and improving the quality of water, air, and soil. Working closely with farmers, NGOs, and industry stakeholders, this project will develop and refine PGC approaches enabling high-yielding row-crop production while improving soil and water quality, providing large increases in the availability of lignocellulosic feedstocks, and preserving or increasing farm income. This project will develop best management practices for growing crops and suppressing weeds with PGC, develop improved crop and groundcover genetics, develop appropriate soil and nutrient management practices, quantify the environmental impacts, and determine the policy and socioeconomic implications of the adoption of PGC approaches. Knowledge gained through this project will be used to educate a new generation of undergraduate and graduate students who recognize the opportunities to enhance agriculture using PGCs. We will provide a multi-pronged extension effort using a combination of hands-on field days, farmer meetings, and online resources to educate practitioners about the opportunities and challenges of the system.

REGENERATING AMERICA'S WORKING LANDSCAPES TO ENHANCE NATURAL RESOURCES AND PUBLIC GOODS THROUGH PERENNIAL GROUND COVER (REGENPGC)

AFRI Competitive Grant No. 2021-68012-35923

Year 5 –3rd Quarter Project Activities

February 1, 2026 – April 30, 2026

PROJECT ADMINISTRATION AND GOVERNANCE

1. Planned Activities

- Continue regular meetings with CoPds groups and ad hoc meetings with individual CoPds.
- Finalize No-Cost Extension (NCE) plans: Solicit budgets and specific goals; communicate requirements; and submit to NIFA.

2. Actual Accomplishments

A. Meetings

- **Stakeholder Advisory Board Meetings.** Met with the Stakeholder Advisory Board for SAB-12 to discuss No Cost Extension (NCE) details, project timeline, and major goals for the NCE year.
- **Theme Leader Meetings.** At this stage of the project, the meetings are generally one-on-one.
- **Co-PD Meetings.** All-CoPD meeting 22 focused on NCE updates and on the 11 major goals for the final 15 months of the project. The Cafés have continued to be a near-weekly informal CoPD meeting ground.
- **RegenPGC Café.** The Cafés continue to be highly attended and with significant engagement among participants, with eight total meetings during this quarter.

B. Project Leadership

- **Project Governance**
 - The Project Director and Deputy Director meet regularly.

- Continued to regularly meet with the data manager re: pipeline efforts and Zenodo
- Did several 1:1 meetings with CoPDs re budget plans and NCE
- Worked with the CoPD Erin Haramoto on a PGC-focused session proposal for the Fall 2026 CANVAS meeting
- **Research, Fieldwork, and Data Stewardship**
 - Traveled to the field to place detachment pads across 18 treatments
 - Worked on funding and finalizing the herbicide study with two contractors. This was done in coordination with the *Research and Development* and *Commercialization* Theme Leaders
 - Participated in multiple discussions with Objective 5. *Socioeconomic Impacts and Policy* RMA leaders on their data needs
 - Met regularly with the project Data Manager on archival processes (Zenodo)
- **Scholarship and Policy**
 - Worked on two papers with Objective 4. *Ecosystem Services and Modeling* Leadership Team:
 - A PGC policy paper
 - A PGC intensity paper
- **Mentorship, Teaching, and Training**
 - Guided a graduate student on multiple project manuscripts, including field-trial results and a new risk-characterization effort.
 - Guided the new Obj 4. *Ecosystem Services and Modeling* student on modeling perennial groundcover in the ALMANAC model.
 - Held 10 meetings with *Undergraduate Research Assistants* (UGRA) on RegenPGC projects involving bucket studies of water impacts of perennial groundcover (PGC) (See Exhibit 1. 2026 Undergraduate Research Experience).
 - Conceived and organized the "*How to Look at Plots*" event for graduate students (led by CoPDs Dan Andersen and Ken Moore).
 - Worked with the Education Theme Leader on the short-course vision.

- Guest lectured on RegenPGC for Iowa State University *Agronomy 3900X (Cover Crops)*.



Photo 2. RegenPGC "How to Look at Plots" Field Teaching Event (Raj Raman)

- **Team Building, Hiring, and Onboarding**

- Onboarded four new team members across two events.
- Hired two new summer 2026 UGRAs for continuity with existing UGRA efforts.

3. Plans for Next Quarter

- The NCE will be drafted and submitted to NIFA.
- The café program will continue.

4. Publications, Presentations, Stakeholder Engagement, and Submitted Proposals

- **Presentation**

- Raman, D. Raj. (2026). *Perennial Groundcover Approaches to Pressing Conservation Challenges: The RegenPGC Story*. AGRON 3900X, Iowa State University.

- **Stakeholder Engagement**

- Prepared a report for the Midwest cover crop meeting.
- Presented the RegenPGC vision, progress, and challenges to the Iowa State University Agriculture & Natural Resources extension crops team. [Raman, D. Raj & Andersen, Daniel S. (2026, March 31). *Perennial Groundcover Approaches to Pressing Conservation Challenges — A RegenPGC Status Update for ANR Extension Crops Team* [Extension presentation]. Iowa State University ANR Extension, Ames, IA, United States].
- Update for a local farmer/conservation leader.

THEME 1. RESEARCH AND DEVELOPMENT

The cross-cutting Research and Development Theme focuses on establishing organizational structures for data management and modes of communication among the research teams and individual participants – the foundation of integrated research. **Brandon Schlautman** (The Land Institute) leads this theme. Gabriel Jesus (The Land Institute) works with Dr. Schlautman.

1. Planned Activities

- Finalize modeling and inference related to the scalability of PGC suppression practices using the *Liberty* (glufosinate) herbicide and initiate preparation and submission of a peer-reviewed manuscript.
- Continue expanding and refining the synthesis of on-farm trial datasets, with a focus on developing comparative analyses across sites and identifying key drivers of system performance and variability.
- Advance modeling of PGC image datasets to improve estimation of PGC intensity and recovery dynamics, including validation of model outputs across locations and integration with agronomic datasets.
- Refine and document standardized data pipelines for ongoing and future data collection, curation, and analysis to support long-term scalability and cross-site comparability.

2. Actual Accomplishments

- Modeling efforts related to the scalability of PGC suppression practices progressed substantially during this quarter. In addition to *Liberty* (glufosinate), analyses were expanded to include *Sharpen* (saflufenacil) and *Gramoxone* (paraquat) as potential suppression tools. Analytical frameworks were refined to facilitate comparison among suppression strategies and to evaluate operational feasibility across diverse management

and environmental conditions. Results are being synthesized to support manuscript development and inform future experimental design and management recommendations.

- Curation and synthesis of on-farm trial datasets continued throughout the quarter, with an emphasis on integrating datasets across locations to evaluate system performance under diverse management and environmental conditions. Progress was made toward comparative analyses designed to identify key drivers of PGC performance, suppression efficacy, persistence, and overall system stability across sites.
- Modeling of PGC image datasets advanced during this reporting period. Efforts focused on improving estimation of PGC intensity and recovery dynamics through refinement of image-derived metrics and validation across multiple locations. Additional progress was made toward integration of image-based outputs with agronomic datasets to improve interpretation of treatment responses and support cross-site comparisons.
- Standardized data pipelines for data collection, curation, and analysis were further refined and documented. These efforts improved reproducibility, streamlined integration of datasets from multiple locations, and supported development of workflows intended to enhance long-term scalability and cross-site comparability.
- Weekly RegenPGC Café meetings continued throughout the quarter, maintaining strong communication across research teams. These meetings supported coordination of data analysis efforts, troubleshooting of methodological challenges, and continued integration across project objectives.

3. Explanation of Variance

None noted.

4. Plans for Next Quarter

- Finalize the comparative analyses of *Liberty* (glufosinate), *Sharpen* (saflufenacil), and *Gramoxone* (paraquat) suppression strategies, and incorporate the findings into the manuscript preparation and future experimental planning.
- Continue expanding and refining the synthesis of on-farm trial datasets, with a focus on identifying key drivers of system performance, suppression efficacy, persistence, and variability across environments and management systems.
- Conduct further work on the advance modeling of the PGC image datasets to further improve estimation of PGC intensity and recovery dynamics, including validation of model outputs across locations and integration with agronomic datasets.

- Complete the preparation of a comprehensive analysis evaluating the onset, extent, and consistency of summer dormancy in *Poa bulbosa* across experimental varieties, locations, and herbicide suppression treatments. Data from multiple research sites and years will be synthesized to assess dormancy dynamics, suppression response, and long-term persistence under perennial ground cover management systems. Results will be compiled into a report intended to support discussions with *USDA Risk Management Agency* (RMA) stakeholders regarding the agronomic risk profile of perennial ground cover systems.
- Refine and document standardized data pipelines for ongoing and future data collection, curation, and analysis to support long-term scalability and cross-site comparability.

5. Publications, Presentations, Stakeholder Engagement, and Submitted Proposals

None this quarter.

THEME 2. EXTENSION

This cross-cutting theme extends the project's reach by developing a robust platform to share science-based knowledge, existing and potential commercial opportunities, and policy recommendations to an expanded set of stakeholders. Dan Andersen (Iowa State University) leads this theme.

Our comprehensive extension education efforts, which are geared towards ensuring and strengthening PGC adoption, target five stakeholder groups:

- Extension educators
- Farmers
- Technical service providers and crop advisers
- The scientific community
- The general public

1. Research Progress and Preliminary Outcomes

- We calibrated RUSLE2-style equations to correlate soil detachment measurements on the Nashua PGC plots to estimated erosion. Results suggest a 60% reduction in soil erosion at this location and demonstrate that the RUSLE2 framework can be modified to make meaningfully accurate erosion estimates.

- We measured cover crop biomass and found that the RHb this year generated as much cover crop biomass (0.25 ton/acre) as the cereal rye drilled after corn and soybean harvest (0.25 ton/acre), but had less biomass than a cover crop interseeded into standing corn at the end of August.

2. Overall Impact

Our work has shown that we can achieve solid RHb ground coverage and obtain biomass coverage similar to that of a standard cereal rye management system.

3. Explanation of Variance

None noted.

4. Upcoming Programming and Planning

We are working through a plan for a webinar series in August 2026 and field day(s) in September 2026.

5. Publications, Presentations, Stakeholder Engagement, and Submitted Proposals

Raman, D. Raj & Andersen, Daniel S. (2026, March 31). *Perennial Groundcover Approaches to Pressing Conservation Challenges — A RegenPGC Status Update for ANR Extension Crops Team* [Extension presentation]. Iowa State University ANR Extension, Ames, IA, United States

THEME 3. EDUCATION

The cross-cutting Education Theme coordinates educational efforts that impact students from pre-college through undergraduate and graduate levels at multiple institutions. The aim of each educational program is tailored to the audience. The Educational Theme Coordinator and the project Objective Leaders will ensure that these programs are not siloed, providing rich, cross-disciplinary training and engagement opportunities for undergraduate and graduate students to meet the workforce education and training requirements for successfully adopting PGC production systems.

Ken Moore (ISU) leads this theme, with **Maureen Griffin** (ISU, focusing on REU and RET), **Dennis Miller** (independent contractor, focusing on FFA), and **Maya Hayslett** (ISU, focusing on 4-H) serving as collaborators.

1. Instructional Development (Moore)

Development of instructional materials related to the science and practice behind PGC systems for use at all levels of instruction.

A. Planned Activities

Development of instructional materials will continue. Modules will be shared in the project's Teams directory as they become available.

B. Actual Accomplishments

The development of instructional materials is ongoing, and materials are being posted to the shared Teams directory as they become available.

C. Explanation of Variance

No variance encountered.

D. Plans for Next Quarter

Development of instructional materials will continue. Modules will be shared in the Teams directory as they are finalized.

2. Undergraduate REU Program (Griffin)

Undergraduate interns who will participate in a coordinated summer research experience.

A. REU Planned Activities

We planned to accomplish the following during the quarter:

- The final professional learning day will take place on February 7, 2026. All REUs are participating in this event via Zoom with the RETs. Also, the final SToM takes place on January 13, 2026. Recruitment for both the hosting labs and participants for the summer of 2026 is underway. The recruitment window closes on March 20, 2026, and final decisions for participants will be made by March 31, 2026. Planning for the 2026 professional learning is ongoing.

B. REU Actual Accomplishments

All activities described above were accomplished over the course of the quarter.

C. REU Explanation of Variance

No variance encountered. We completed all planned activities.

D. REU Plans for Next Quarter

A cohort of five undergraduate students, three funded by RegenPGC, will participate in a coordinated summer research experience from June 8-31, 2026. Major activities will include program onboarding, mentored laboratory research, weekly professional development sessions, collaborative cohort events, and final research presentations.

3. Research Experience for Teachers

A. RET Planned Activities

We planned to accomplish the following during the quarter:

- Final professional learning day takes place on February 7, 2026. All RETs are participating in this event via Zoom with the RETs. Also, the final SToM takes place on January 13, 2026. Recruitment for both the hosting labs and participants for the summer of 2026 is underway. The recruitment window closes on March 20, 2026, and final decisions for participants will be made by March 31, 2026. Planning for the 2026 professional learning is ongoing.

B. RET Actual Accomplishments

All activities described above were accomplished over the course of the quarter.

C. RET Explanation of Variance

No variance encountered.

D. RET Plans for Next Quarter

A cohort of 18 middle and high school teachers (none funded by RegenPGC) will participate in a Research Experience for Teachers (RET) program from June 17 - 31, 2026. Major activities will include program onboarding, mentored laboratory research, weekly professional development sessions, classroom application planning, and final presentations.

4. Undergraduate Internship Program (Moore)

We have discontinued the project due to insufficient interest among undergraduate students working in the project CoPDs' labs.

5. Graduate Student Community (Moore)

A. Planned Activities

The Graduate Education Community will continue weekly meetings throughout the spring semester. Students will participate in the RegenPGC Café and attend professional development workshops.

B. Actual Accomplishments

The RegenPGC Café / Graduate Student Seminar was the primary community activity for the quarter. A Spring PGC Assessment Field Day was held at the Sorenson Research Farm on April 24, 2026. Most local students attended to interact with Co-Pds about how to evaluate PGC and assess its potential to hinder early corn establishment.

2025 REU participants Kylie Buchholz and Alex Haus presented posters at Wartburg College's RICE Day, detailing their summer 2025 experiences.

- **Haus, Alex, Franklin da Silva, Rickiel, Galland, Patrick, & Moore, Kenneth J.** (2026, April 9). *How Perennial Groundcover Affects Maize Growth: Exploring Shade Avoidance Responses* [Poster presentation]. Rice Day, Wartburg College, Waverly, IA, United States. <https://www.regenpgc.org/wp-content/uploads/2026/03/RegenPGC-Poster-Template-med-QR.pdf>
- **Buchholz, Kylie, Krumm, Cameron, Fei, Shhuizhang, & Galland, Patrick.** (2026, April 9). *The Effect of PGC Species and Suppression Method on Maize Growth and Development* [Poster presentation]. Rice Day, Wartburg College, Waverly, IA, United States.

C. Explanation of Variance

No variance encountered.

D. Plans for Next Quarter

The Graduate Education Community will be busy finalizing their field research and writing about the results. No formal community activities are planned for the summer.

6. FFA and 4H Programs (Hayslett & Miller)

Training for county 4-H and youth staff on the lessons will be provided for Iowa State University Extension and Outreach (ISUEO) Region 20 on February 3, 2026, and for ISUEO Region 19 on March 19, 2026. Maya Hayslett will continue to work with 4-H State Staff on lesson publication.

E. Actual Accomplishments (Hayslett)

The February 3, 2026, training was accomplished as planned. The March 19, 2026, training was canceled due to low enrollment. An event was added due to county staff

interest. On April 22, 60 youth participated in activities for the Jefferson County Earth Day program. (Miller) The FFA subtask program has been completed.

F. Explanation of Variance

The March 19, 2026, training was canceled due to low enrollment. An event was added at the request of county staff.

G. Plans for Next Quarter

Three youth events are scheduled for next quarter: 1) the Kirkwood STEAM Institute in Johnson County on May 7, 2) the Shelby County Conservation Day on May 12, and 3) the Trail of Iowa Corn in Adair County on May 14. Lesson plans will be published by the end of the quarter.

H. Publications, Presentations, Stakeholder Engagement, and Submitted Proposals

None this quarter.

THEME 4. COMMERCIALIZATION

Sara Lira (Corteva Agrisciences) leads this theme.

Our goals are to work with Project Director Raj Raman and Deputy Director Anne Kinzel to engage stakeholders by establishing a Stakeholder Advisory Board (SAB) and a Farmer/Landowner Advisory Group (FLAG). We specifically will:

- Establish on-farm trials and conduct field days with producers to gain input and advice on how to make PGC approaches more practical, reliable, and profitable.
- Engage the ag sector commercial entities in research partnerships and further identification of investment and development opportunities.

1. Plans for Next Quarter

We are continuing the following work:

- Completing the 2026 herbicide trial protocol.
- Finalizing the data quality controls prior to upload to the Zenodo database

2. Publications, Presentations, Stakeholder Engagement, and Submitted Proposals

None this quarter.

OBJECTIVE 1. CROP ECOLOGY AND MANAGEMENT

This objective focuses on developing and testing best management practices for cash crop establishment in PGC systems and managing the transition from current practices. Objective 1 will improve PGC economics by tuning and integrating groundcover and cash crop management, thereby reducing risk. The primary goal is to elucidate key mechanisms related to a) cash crop and PGC interference, b) early cash crop growth and development in PGC systems, and c) pest dynamics.

Erin Haramoto (University of Kentucky) and Scott Flynn (Corteva Agrisciences) lead this objective. Collaborators include Lucas Borrás (Corteva Agrisciences), Susana Goggi (ISU), Ken Moore (ISU), and José Rotundo (Corteva Agrisciences). Hallie Sandeen (UK) and Kiera Searcy (UK) are the graduate students (Master's) involved in this objective.

1. Planned Activities

A. Kentucky

- We will continue working on publications from Hallie Sandeen's and Kiera Searcy's theses.
- Kiera Searcy will submit her Master's thesis to the graduate school.

B. Iowa

- We will acquire material resources for the remaining experiments.
- The final field season for evaluating short-stature corn performance in PGC will begin at the same location, with changes to randomizations for Year 2.
- Areas for establishment studies will be identified, field preparations will take place, and initial plantings will occur.

2. Actual accomplishments

A. Kentucky

- Kiera Searcy submitted her Master's thesis to the graduate school; she is officially a May 2026 University of Kentucky graduate (*Kentucky Bluegrass (Poa Pratensis L.) as a Perennial Groundcover: Establishment and Weed Management in Corn*).
- CoPD Haramoto continued working on publications from the Sandeen and Searcy theses.

- CoPd Haramoto submitted a proposal for a Special Session on PGC to the 2026 CANVAS annual meeting, which was accepted.

B. Iowa

- Material resources (seed, fertilizer, and chemicals) were acquired for the remaining experiments.
- The final field season of evaluating short-stature corn performance in PGC was planted in the same location as the 2025 plots, with changes made to randomizations for Year 2.

3. Explanation of Variance

A. Kentucky

None noted.

B. Iowa

Reconsideration of the time frames needed to complete the establishment experiments has led to pulling them from the 2026 portfolio of field research.

4. Plans for Next Quarter

A. Kentucky

We will submit one publication from Hallie Sandeen's thesis and one publication from Kiera Searcy's thesis.

B. Iowa

We will continue data collection from the short-stature corn experiment and continue processing the data to produce publication manuscripts by graduate students.

5. Publications, Presentations, Stakeholder Engagement, Awards, and Submitted Proposals

A. Publications

- **Searcy, Kiera S.** (2026). *Kentucky Bluegrass (*Poa Pratensis* L.) as a Perennial Groundcover: Establishment and Weed Management in Corn* [Master's thesis, University of Kentucky]. https://uknowledge.uky.edu/pss_etds/204/ (<https://doi.org/10.13023/etd.2026.13b>)

- **Galland, Patrick D., Dutter, Cole R., Chen, Allen, Moore, Kenneth J., Fei, Shui-Zhang.** (2026), Summer-dormant, perennial groundcover has minimal effect on plant-available nutrients and no effect on maize yield. *Agronomy Journal*, 118, e70333. <https://doi.org/10.1002/agj2.70333>. OPEN ACCESS.

OBJECTIVE 2. PLANT BREEDING AND GENETICS

This objective focuses on PGC cropping system optimization by screening for superior groundcovers and maize hybrids that minimize competition as each occupies its own temporal or spatial niche. This can enhance PGC's economic viability through yield improvements and reduced management requirements, while also increasing ecosystem impacts through reduced chemical inputs. Our work will also enable the design of novel breeding strategies and the development of dedicated breeding programs for PGC hybrids and varieties.

Shuizhang Fei (ISU) and Thomas Lübberstedt (ISU) lead this objective, and Brandon Schlautman (TLI) and Sara Lira (Corteva Agriscience) serve as collaborators. Yu Ru Chen serves as a PostDoc Scholar, and current graduate students are Memis Bilgici (Lübberstedt Group), Prathyusha Cheguri (Fei Group), Cameron Krumm (Fei Group), and Vipul Kumar (Fei Group).

SHUIZHANG FEI GROUP

1. Current Activities

Graduate students Pratyusha Cheguri, Cameron Krumm, and Vipul Kumar have focused on data analysis and on preparing manuscripts for publication.

2. Awards, Publications, Presentations, Stakeholder Engagement, Submitted Proposals

Kumar, Vipul, & Fei, Shui-zhang. (2026, March 25). *Vernalization Response and Freezing Tolerance of Poa secunda, a Promising Perennial Groundcover* [Poster presentation, Abstract]. Raymond F. Baker Plant Breeding Symposium, Department of Agronomy, Iowa State University, IA, USA. https://www.regenpgc.org/wp-content/uploads/2026/06/2026-06-04-Kumar_Vipul_Poster_FINAL.pdf

LÜBBERSTEDT LAB

1. Actual Accomplishments

A. Academic Publications

The Lübberstedt Lab published a paper title *Trends in stomatal density and size in maize hybrids representing 100 years of long-term breeding for yield.*¹ To the best of our knowledge, this is the first crop-focused study to show century-scale changes in stomatal traits associated with long-term maize breeding for yield.

Modern hybrids had higher stomatal density but lower total stomatal pore area than historical hybrids. Across 27 Pioneer hybrids, stomatal density was negatively correlated with stomatal size, length, width, and leaf area. Over the past 100 years, the total stomatal pore area on leaves decreased, while stomatal density increased as leaf area declined, revealing a connection between these two patterns. Total stomatal pore area was negatively correlated with release-year atmospheric CO₂ concentration and temperature anomaly (°C) over the past century.

B. Presentations

Graduate student Memiş Bilgici presented one scientific talk and three posters at the 2026 Maize Genetics Meeting, held February 26-March 1, 2026, at the Maritim Hotel Köln in Cologne, Germany. The Maize Genetics Meeting brings together researchers from around the world to share advances in maize genetics, genomics, breeding, and crop improvement. Additionally, Memiş Bilgici also delivered a talk at the Corn Breeding Research Meeting, a pre-conference event held February 24-26, 2026, at the same location. His presentations highlighted research connected to RegenPGC, maize breeding for perennial ground cover systems, and controlled-environment phenotyping. Memiş's participation at these professional meetings was supported through Maize Genetic Co., the RegenPGC project, the Francis and Beatriz Castro Mar Graduate Scholarship, and the K. J. Frey Chair in Agronomy funding.

In a related study, we are preparing a manuscript, *Shade avoidance responses in seedlings of maize hybrids representing 100 years of breeding history*, that will focus on shade avoidance and stomatal traits in ERA maize hybrids.

C. Current Activities

We are also analyzing and synthesizing results from three years of field trials on perennial ground cover crops in maize, including conventional systems, RHB-*Poa bulbosa*, and Kentucky bluegrass.

¹ Bilgici, Memiş, Ebrahimi, Elnaz, Prada de Miranda, Leticia, Lira, Sara, Borrás, Lucas, Young, Thomas, Yavuz, Recep, Moore, Kenneth J., Dixon, Philip, & Lübberstedt, Thomas. (2025). Trends in stomatal density and size in maize hybrids spanning 100 years of long-term yield breeding. *Front. Plant Sci.*, 17:1829321. <https://doi.org/10.3389/fpls.2026.1829321>

A major objective of this work is to determine whether a dedicated maize breeding program is needed for production systems using perennial ground cover crops, such as *Poa bulbosa*. We are preparing a manuscript titled “*Do perennial groundcover systems need dedicated maize breeding? Evidence from three years of hybrids evaluation regarding ranking stability and prediction in conventional and living-groundcover environments*”. PostDoc researcher Yu-Ru Chen, who is leading the analysis and writing of the manuscript, found that BS39-derived doubled-haploid (DH) testcross hybrids out-yielded commercial check hybrids under the perennial ground cover (PGC) system, and were not inferior to commercial checks under the conventional system.

These superior testcrosses could only be identified through yield analyses conducted within PGC field trials. They would not have been distinguished from conventional-system evaluation alone, underscoring the importance of incorporating PGC environments directly into maize breeding pipelines if maize production under perennial ground cover is to be scaled up. Across the three years of field trials, the genotype $\times$ environment (G $\times$ E) interaction was statistically significant, whereas the genotype $\times$ planting system (G $\times$ PS) interaction was not, indicating that maize genotypic responses were shaped primarily by year-to-year weather variation rather than by the planting system per se. From a breeding standpoint, this implies that without direct yield evaluation in PGC environments, conventional-system data alone are insufficient to reliably select maize hybrids well-suited to PGC production.

2. Awards, Publications, Presentations, Stakeholder Engagement, and Submitted Proposals

- Bilgici, Memiş. (2026, February 25-26). *4-Trends in stomatal density and size in maize hybrids representing 100 years of long-term breeding for yield* [Meeting presentation]. 2026 Corn Breeding Research Meeting, Cologne, Germany.
- Bilgici, Memiş. (2026, February 27 – March 2). *Trends in stomatal density and size in maize hybrids representing 100 years of long-term breeding for yield* [Meeting & poster presentation]. 68th Annual Maize Genetics Meeting, Cologne, Germany.
- Bilgici, Memiş. (2026, February 27 – March 2). *Do we need dedicated maize varieties for perennial groundcover systems?* [Poster presentation]. 68th Annual Maize Genetics Meeting, Cologne, Germany.
- Bilgici, Memiş. (2026, February 27 – March 2). *Stable phenotypic shade-avoidance responses to low red/far-red ratio and shifting resource-use strategies in maize hybrids representing 100 years of long-term breeding for yield* [Poster presentation]. 68th Annual Maize Genetics Meeting, Cologne, Germany.

OBJECTIVE 3. SOIL HEALTH AND NUTRIENT MANAGEMENT

This objective focuses on comparing soil health improvement and nutrient retention between perennial ground cover (PGC) and conventional cover crop systems, and on generating data to help frame expectations for PGC's environmental and economic outcomes.

Morgan P. Davis (Missouri) and Marshall McDaniel (ISU) lead this objective, and Daniel Andersen (ISU), Raj Raman (ISU), and Richard Roth (ISU) serve as collaborators. Current graduate students are Philip Ekow Rockson (ISU) and Alioune Diopp (ISU).

1. Actual Accomplishments

- Graduate student Malcom St Cyr is currently finishing his master's thesis (*Avoiding bare Soil – Can perennial ground cover intercropping systems replace traditional cover crops?*). His defense is set for late April 2026.
- Graduate student Philip Rockson is continuing his research in preparation for completing his Ph.D. studies.

2. Explanation of Variance

None noted.

3. Plans for Next Quarter

- Only some soil analyses are left for intensive soil and root sampling. These should be finished by October 2026
- Graduate student Malcom St Cyr will have completed his Master's defense.

4. Awards, Publications, Presentations, Stakeholder Engagement, and Submitted Proposals

- **Submitted Manuscripts**
 - **Eness, Maxwell, E., Dutter, Cole R., York, L.M., & McDaniel, Marshall, D.** (2026). Root distribution and competition between maize and perennial groundcovers (e.g., living mulch). *Submitted to New Phytologist*
 - **Mendis, S.S., Davis, M.P., Ansari, J., McDaniel, Marshall D., & Flater, J.** (2026). Comparing soil nitrous oxide fluxes from in-field optical feedback – cavity enhanced absorption spectroscopy to laboratory gas chromatography. *Submitted soon.*
- **Accepted Manuscripts**

McDaniel, Marshall, D., Dutter, Cole R., Eness, Maxwell, Cecil, A., Miller, B.A., & Modestou, Modestos. (2026). A minimally destructive method for 2-dimensional soil and root mapping in row crops. *Plant & Soil - Accepted*.

- **Stakeholder Engagement**

Raman, D.Raj & Rockson, Philip. (2026, March 12). *Evaluating manure application and cover crop planting timing to maximize water, quality benefits in corn* [Virtual field day]. Iowa Learning Farms & Iowa Nutrient Research Center, Iowa State University, Ames, Iowa, United States. <https://www.iowalearningfarms.org/events/manure-cover-crop-virtual-field-day?rq=Rockson>.

OBJECTIVE 4. ECOSYSTEM SERVICES AND MODELING

This Objective focuses on quantifying the provision of ecosystem services derived from PGC implementation. We consider a wide range of ecosystem services, including improved water quality, flood and drought mitigation, protection against soil erosion, carbon sequestration, and biofuel feedstock and/or fodder provision. Quantification is crucial to incentivize farmers for ecosystem services. **Amy Kaleita-Forbes** (ISU) and **Rob Anex** (University of Wisconsin-Madison) lead this Objective. In the fall of 2025, the Objective team will add graduate student **Ralph Danquah-Acquah** (Kaleita).

1. Quantify Decreased Flood Risk and Improved Drought Resiliency Compared to Conventional Cropping Systems

A. Planned Activities

- Complete paired EPIC and ALMANAC runs under the validated rainfall series and expanded diagnostics using soil water components and daily stress outputs.
- Begin plot-level validation as field datasets become available.

B. Actual Accomplishments

- Extended ALMANAC and EPIC simulations through 2025 to align with available field datasets.
- Updated ALMANAC management schedules and ran timing to improve alignment with field operations.
- Reviewed management effects on runoff and other water balance components as part of revised scenario checks.

- Built a workflow tool to manage EPIC and ALMANAC runs, store outputs, and support quick scenario comparisons.

C. Explanation of Variance

EPIC topography inputs were a bottleneck early in the period because the interface overwrote slope and slope length settings. This was addressed by the workflow tool, which supports safe editing of topography inputs and reliable execution without losing those settings.

D. Plans for Next Quarter

Continue paired EPIC and ALMANAC comparisons under consistent inputs, focusing on runoff and water balance diagnostics under revised management.

2. Quantify PGC Impacts on Water Quality

A. Planned Activities

- Obtain and organize erosion pad data and field operation records for the Iowa State University Northeast Research and Demonstration Farm (Nashua, IA) (<https://farms.cals.iastate.edu/project/northeast-research-and-demonstration-farm>).
- Define a defensible comparison approach for observed versus modeled erosion.

B. Actual Accomplishments

- Received 2024 and 2025 erosion pad datasets, reviewed data quality, and began cleaning the 2025 dataset due to known errors.
- Rebuilt the ALMANAC setup to match the 2024 field operation dates after identifying a mismatch in how the no-cover treatment had been represented.
- Recalibrated ALMANAC erosion outputs toward 2024 erosion pad observations and ran performance checks (RMSE, NSE, R2, PBIAS).
- Documented the sediment measurement and interpretation question and began a data-quality review to resolve unexpected magnitudes in the erosion pad series.

C. Explanation of Variance

Our initial interpretation assumed the difference reflected detachment versus modeled transported erosion. After discussion, we concluded that sediment transport still contributes to what reaches the erosion pads, so the mismatch is more likely due to data-quality issues or measurement or processing inconsistencies in the erosion pad datasets.

Work shifted toward cleaning, verifying, and reconciling the field data before final model evaluation.

D. Plans for Next Quarter

- Complete cleaning and verification of the erosion pad datasets, and confirm field operation records for the evaluation periods.
- Identify and document the source of the erosion pad inconsistencies and apply corrections or filters as needed for defensible analysis.
- Re-run the model evaluation after the corrected erosion pad dataset is finalized, and continue erosion calibration while keeping annual totals in realistic ranges.

3. Quantify PGC Ecosystem Service Sustainability Indicators and Compare them with Conventional Systems

A. Planned Activities

Improve groundcover representation for RHb and strengthen the basis for LAI calibration using field image information.

B. Actual Accomplishments

- Established RHb in ALMANAC and checked LAI, rooting depth, and summer dormancy behavior.
- Worked with Dr. Jim Kiniry on summer dormancy and senescence representation, including compiling and testing an alternative executable and advancing a summer senescence representation that does not rely on a harvest-only proxy.
- Ran RHb simulations under different PHU and dormancy values for target years to support validation and calibration.
- Organized and annotated RHb field image sets, resolved timestamp issues, and prepared the images for consistent interpretation of seasonal cover patterns.
- Refined the visual rating approach so it reflects both greenness and canopy occupancy, then prepared to compare image-derived seasonal patterns with simulated RHb patterns.

C. Explanation of Variance

Image preparation required manual timestamp cross-checking, and some images had limited strip visibility, which increased preparation time.

D. Plans for Next Quarter

Complete image-based seasonal pattern extraction and compare against RHb simulations to refine PHU, dormancy, and suppression timing.

4. Publications, Presentations, Stakeholder Engagement, and Submitted Proposals

None at this time.

OBJECTIVE 5: SOCIOECONOMIC IMPACTS AND POLICY

This objective evaluates the conditions under which the proposed practices are economically sustainable for farmers and input suppliers within the PGC supply chain, while also enhancing well-being for farmers and consumers. It integrates these practices by examining how PGC aligns with existing policy frameworks. Essentially, the objective combines information from other objectives and evaluates the overall value proposition for different versions of PGC. Keri Jacobs (University of Missouri) leads this objective, with Amani E. Elobeid (ISU) and Cynthia A. Bartel (ISU) serving as collaborators. Our overall team direction focuses on continuing data discussions, finalizing the data, and communicating it to the Data Management Team.

1. Evaluate the Economic Feasibility of PGC Systems for Maize Producers

A. Planned Activities

- Finalize and submit the unpriced benefits manuscript to an environmental or land-use economics journal
- Finalize and submit the policy paper that discusses a roadmap for administratively developing USDA support to de-risk conservation program adoption, with a case study of perennial groundcover systems under the USDA SAS CAP RegenPGC grant.
- Present for USDA SARE *Farming Matters* on perennial intercropping; The segment is a national feature piece for USDA.²
- Complete the interview with *Hoard's Dairyman* on preparation for World Dairy Expo Virtual Farm Tour 2026, including an overview of on-farm research for perennial intercropping systems.

² "Farming Matters" is a YouTube series produced by the USDA's NCRSARE video team which features farmers, ranchers, educators, and researchers sharing the stories of their sustainable agriculture research. See <https://www.youtube.com/@NCRSAREvideo> to learn more.

B. Actual Accomplishments

- Finalized and submitted the policy paper on the roadmap for administratively developing USDA support to de-risk conservation program adoption, with a case study of perennial groundcover systems under the USDA SAS CAP RegenPGC grant. The paper is under review at the *Journal of Soil and Water Conservation*.
- Finalized and submitted a paper to guide policy development on the standardization of metrics for BMP development. The article finished on quantifying groundcover intensity for PGC metrics standardization to advance system development (paper still in review). Bartel, C. A., Moore, K. J., Andersen, D. S., Raman, D. R. 202_. Quantifying and characterizing groundcover “intensity” in perennial groundcover (PGC) systems. In review at *Agronomy Journal*.
- The unpriced benefits manuscript is being finished for submission to an environmental or land-use economics journal.
- We presented to USDA SARE’s “*Farming Matters*” show on perennial intercropping. The segment is a national feature piece for USDA. The segment is being edited.
- The interview with *Hoard’s Dairyman* is being prepared for the *World Dairy Expo Virtual Farm Tour 2026*, including an overview of on-farm research for perennial intercropping systems.

C. Plans for Next Quarter

- Proof papers for publication.
- Continue engagement with USDA RMA, FSA, and NRCS for program development. Prioritize farmer outreach on prices and the impact of prices on conservation practice adoption.
- Begin the education module with an overview of federal farm policy with perennial groundcover as a case study.
- Identify next policy products.

2. Evaluate the Market and Aggregate Welfare Effects of PGC Approaches

A. Planned Activities

Update the model results with field-trial data on yield and cost impacts (if available), and prepare a new manuscript based on the updated results.

B. Actual Accomplishments

- Received a revise-and-resubmit decision from *Applied Economic Perspectives and Policy* for the manuscript "Integrating Perennial Groundcover in Corn and Soybean Acres: Impacts on U.S. Agriculture".
- Published an online article on the global production and trade impacts of PGC in the *Agricultural Policy Review* online.

C. Plans for Next Quarter

- Obtain field trial data on yield and cost impacts of PGC adoption generated through other grant objectives, incorporate these data into the model, and prepare a new manuscript based on these results.
- Complete the revision and resubmit the amended manuscript to *Applied Economic Perspectives and Policy (AEPP)*.

3. Explore the Role of Input Supply Agribusinesses in the PGC Supply Chain

A. Planned Activities

Seek alternative analyses to complement the project.

B. Actual Accomplishments

Work remains in progress.

C. Plans for Next Quarter

One option for this piece is to document the activities and investments currently underway or planned by private industry, especially focused on ag cooperatives, that are farm-facing or intended to incentivize or support farm-level adoption of PGC systems.

4. Explanation of Variance

We did not submit the unpriced benefits paper this quarter, but we should be able to submit it in the next quarter.

5. Publications, Presentations, Ag Press, Stakeholder Engagement, and Submitted Proposals

• Publications

Dahal, Sagar, & Elobeid, Amani. 2026. *Perennial Groundcover and the Future of US Corn Production: Market and Policy Implications from a Global Land-Use Perspective.*

Agricultural Policy Review, Winter 2026. Center for Agricultural & Rural Development, Iowa State University. <https://agpolicyreview.card.iastate.edu/winter-2026/perennial-groundcover-and-future-us-corn-production-market-and-policy-implications>

- **Agriculture Press**

- Presented for USDA SARE *Farming Matters* on perennial intercropping; the segment is a national feature piece for USDA; segment is being edited (March 11, 2026).
- Prepared an interview with *Hoard's Dairyman* regarding preparations for the *World Dairy Expo Virtual Farm Tour 2025*, including an overview of on-farm research on perennial intercropping systems.

- **Stakeholder Engagement**

Farmer outreach on prices and the impact of prices on conservation practice adoption.

- Continued engagement with stakeholder groups re: PGC

PROJECT EVALUATION

Dr. Heather Dantzker is the RegenPGC External Evaluator. PD Raman and Deputy Director Kinzel meet with Dr. Dantzker regularly to review her work and plan future evaluation activities. Our goal is to use these activities to fine-tune the RegenPGC team's performance.

1. Planned Activities

- Participate in RegenPGC leadership calls (Co-PD and SAB) and evaluation calls with the project director and deputy director, as scheduled..
- Participate in RegenPGC Friday Cafés as scheduled to gather information on integrated project findings, activities, and outputs
- Ongoing monitoring/review/analysis of project progress and milestones in relation to the main project logic model.
- Evaluation planning, including planned data collections, analysis, and any formative and summative reporting across project objectives and themes for the remainder of the project (Feb 2026 – July 2026 and any NCE year activities, if applicable).

2. Actual Accomplishments

- Participated in RegenPGC leadership calls (Co-PD and SAB) and evaluation calls with the project director and deputy director, as scheduled.
- Ongoing monitoring/review/analysis of project progress and milestones in relation to the main project logic model.

3. Explanation of Variance

Planning for final evaluation data collections and reporting is postponed to Q4 due to the approval of the NCE.

4. Plans for Next Quarter

- Participate in RegenPGC leadership calls (Co-PD and SAB) and evaluation calls with the project director and deputy director, as scheduled.
- Ongoing monitoring/review/analysis of project progress and milestones in relation to the main project logic model and integrated analysis.
- Final evaluation planning into NCE year.

5. Publications, Presentations, Stakeholder Engagement, and Proposals Submitted

None this quarter.

2026 RegenPGC Undergraduate Research

Four students, (1) **Hailey Knox** (Junior, Biological Systems Engineering); (2) **Liam Perreault** (Sophomore, Agricultural Engineering); (3) **Colton Zupke** (Sophomore, Agricultural Engineering); and (4) **Caroline Edsen** (Freshman, Biological Systems Engineering) have been engaged in Undergraduate Research projects under the supervision of RegenPGC Project Director Dr. Raj Raman. All were recruited based on Dr. Raman's experiences with them in ABE 1600, which he has taught ~25 times since coming to ISU 20 years ago — and which has proven to be an excellent way of identifying students interested in (and capable of) doing high-quality undergraduate research.

The students have been working with Dr. Dan Andersen (Regen CoPd) and Dr. Raj Raman (Regen PD) since the fall semester of 2025, on RegenPGC-relevant projects. In addition to their lab work, they participated in weekly meetings where they presented to one another and discussed challenges. Since January 2026, each student has been working on building a paper suitable for entry into the K. K. Barnes student paper competition hosted by the ASABE.

Hailey Knox is working on a project titled *Impact of annual and perennial cover crops on soil detachment in corn/soybean systems — results from a 2-year study in northeastern Iowa*. She has been focusing on using field data from the NERF plots that RegenPGC graduate student Philip Rockson has been studying, under the guidance of Drs. Andersen and Raman, as well as with CoPd Dr. Ken Moore. Hailey has been analyzing erosion-pat data and using the data to inform selecting the correct "C" parameter value in the RUSLE2 model for erosion prediction. This work will help better predict how PGC systems can reduce erosion.

Liam Perrault is working on a project titled *Impacts of tillage and residue on water balance of soils — a bucket study in central Iowa*. He filled 39 5-gal buckets with soil, seeded them with multiple cover crops, including two promising perennial groundcover species, and has been weighing these weekly to monitor water gains and losses. This work was initiated by RegenPGC PhD student Philip Rockson through a competitive grant that he secured. The work will help understand how different suppression/termination dates impact soil-water relations in these systems.

Colton Zupke is working on a project titled *Implementation and calibration of instrumentation for a bucket water-balance experiment*. Colton has programmed a datalogger to collect real-time soil moisture data from the buckets described in Liam Perrault's experiment. He has recently completed the validation stage, which included creating calibration curves for the 13 sensors. Again, this work will help understand how different suppression/termination dates impact soil-water relations in these systems.

Caroline Edsen is working on a project entitled *Modelling the impact of crop-growth-zone width and leaf height on lower leaf of corn in perennial groundcover (PGC) systems*. She has been working closely with Dr. Raman to revise a model that describes the intensity of light reflected



Exhibit 1

from groundcover (green) vs. soil (brown) in PGC systems. Her work shows how plant height impacts the relative brown/green fraction and gives guidance on the timing of PGC suppression needed to avoid shade-avoidance-responses.



The long-term goal of this project is to develop and de-risk a transformative method for increasing groundcover on working landscapes, thereby realizing urgently-needed environmental benefits. Our vision is to develop a perennial cover-cropping system that requires less labor, provides equal or more ecosystem benefits, and increases resiliency while having an overall economic profile that is equivalent to, or better than conventional row-crop practices.

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