# FFAR Grant Annual Progress Report

The [Foundation for Food & Agriculture Research](#) (FFAR) builds public-private partnerships to fund bold research addressing big food and agriculture challenges. FFAR was established in the 2014 Farm Bill to increase public agriculture research investments, fill knowledge gaps and complement USDA's research agenda. FFAR's model matches federal funding from Congress with private funding, delivering a powerful return on taxpayer investment. Through collaboration and partnerships, FFAR advances actionable science benefiting farmers, consumers and the environment.

As part of the Grant Agreement, grantees must complete an Annual Progress Report. The requirement must be submitted to FFAR within 30 days after the end of each annual funding period. All questions about this form should be directed to [grants@foundationfar.org](mailto:grants@foundationfar.org).

The Annual Progress Report communicates the annual results and accomplishments of the funded grant research, including accomplishments and tentative completion of specific annual goals and objectives. Disbursement of next year's funds for this grant are contingent on the receipt and approval of the Annual Progress Report to include a programmatic and financial piece as well as availability of matching funds, if applicable.

| Grant Information | |
|---|---|
| **Project Title** | Metrics, Management and Monitoring: An Investigation of Rangeland and Pasture Soil Health and its Drivers |
| **FFAR Award** | $9.5 Million |
| **Total Award** | $19 Million |
| **Matching Funders** | Noble Research Institute, Greenacres Foundation, The Jones Family Foundation, ButcherBox |
| **Reporting Period** | 10/01/2021 – 9/30/2022 |
| **Period Budget** | Year 1 |
| **Project Director/Principal Investigator Information** | |
| **Full Name** | Isabella Cristina de Faria Maciel |
| **Grantee Organization Information** | |

| | |
|---|---|
| **Organization Name** | Noble Research Institute |
| **Address** | 2510 Sam Noble Parkway |
| | |
| **City, State Zip** | Ardmore, OK 73401 |

# General Information

**Please list the geographic location(s) – city, state, congressional district - where the work was conducted. If the work was conducted outside of the U.S., please list the city and country.**

- Ardmore, OK-4
- Beltsville, MD-5
- Burneyville, OK-4
- Cheyenne, WY-at large
- East Lansing, MI-8
- Eugene, OR-4
- Fort Collins, CO-2
- Lake City, MI-4;
- Laramie, WY at-large
- Marietta, OK-4
- Exeter, United Kingdom

**How many new jobs were created by the grant during this reporting period?**
24 in total. The breakdown is listed as follows:

- Noble Research Institute (3 in total)
    - 1 Postdoctoral Fellow
    - 1 Research Associate
    - 1 Research Assistant
- CSU (Colorado State University) (8 in total)
    - 1 Postdoctoral Fellow
    - 2 PhD Students
    - 1 Visiting Scholar
    - 4 Undergraduate Lab Assistants
- University of Wyoming (1 in total)
    - 1 Research Associate

- o   USDA-ARS HRSL (1 in total)
  - o   1 Postdoctoral Fellow
- MSU (Michigan State University) - Jenny Hodbod (2 in total)
  - o   1 PhD Student
  - o   1 Undergraduate Assistant
- MSU - Melissa McKendree (1 in total)
  - o   1 PhD Student
- MSU - Jeremiah Asher (2 in total)
  - o   2 Research Assistants
- MSU - Matt R. Raven (1 in total)
  - o   1 Postdoctoral Fellow
- MSU - Jason Rowntree (5 in total)
  - o   1 Postdoctoral Fellow
  - o   1 Graduate Student
  - o   1 Project Director
  - o   2 Undergraduate Lab Assistants

**How many jobs were maintained by the grant during this reporting period?**
17 in total. The breakdown is listed as follows:
- o   Noble Research Institute: 3
- o   CSU: 4
- o   University of Wyoming: 1
- o   USDA-ARS HRSL: 1
- o   MSU: 8

**Have there been any changes to your organization's IRS 501(c)(3) non-profit status since you were awarded the grant? If yes, please explain.**
No

# Accomplishments

**What were the goals/specific aims of the project for this reporting period? If the approved application lists milestones/target dates for important activities or phases for this reporting period, identify these milestones and dates, as well as show actual completion dates or the percentage of completion of milestone targets. (Up to 500-word limit)**

The goal of the project for this reporting period (10/01/2021 – 9/30/2022) was to initiate the project and implement experimental field sites.

The specific objectives of the project were:

- Oversee intensive monitoring sites set up and initiation in Michigan, Oklahoma, and Wyoming
- Implement experimental field sites and acquire all equipment
- Hire staff
- Undertake analysis to identify optimal tower locations that support research objectives at intensive monitoring sites
- Build and deploy 28 flux monitoring towers at intensive monitoring sites (6 in Michigan, 12 in Oklahoma, and 10 in Wyoming)
- Undertake analysis to identify the number and location of each experimental plot for water and soil health indicators at the intensive monitoring sites
- First soil core sampling (soil health indicators) at the intensive monitoring sites to compose the baseline data
- Premeasure intensive monitoring areas regarding water indicators at the intensive monitoring sites
- Establish long term monitoring (LTM) sites for the Ecological Outcomes Verification (EOV) assessments at the intensive monitoring sites to compose the baseline dataset
- Conduct short term monitoring (STM) for the EOV assessments at the intensive monitoring sites to compose the baseline data
- Recruit producers
- Team meetings
- Work with team to assemble leadership and advisory committees
- Field sampling related to remote sensing protocol every 28 days during grazing season at intensive monitoring sites

**Have any of the major goals/specific aims or milestones for this reporting period changed since the award or previous report? If so, please list the goal(s) that have changed and provide justification for the change from the approved goals. (Up to 300-word limit)**

Overall, no significant changes occurred in this reporting period. At this stage we are on track with the collection of baseline data and installation of instrumentation at the intensive monitoring sites in Michigan, Oklahoma, and Wyoming.

Regarding hiring staff, some of the students/staff have already been recruited but they have not been hired yet. They will start by the end of the year and/or beginning of 2023, so they will be included in the second year of the project.

The recruitment of producers was moved to the beginning of 2023. Michigan State University has started an Institutional Review Board (IRB) to review proposed human subject research. All human subject research must be reviewed and approved by an IRB before initiation. We are expecting to have the approval by January 2023. After that, we will be able to start recruiting producers for the distinct locations (Michigan, Oklahoma/Texas, and Wyoming/Colorado). For the next couple of months, we will prepare on-farm data collection materials and create a survey to send out, identify and recruit producers. We are expecting to start on-farm data collection in February/March 2023.

**What was accomplished under the goals/specific aims or milestones for this reporting period? For this reporting period describe: 1) major activities; 2) specific objectives; 3) significant results, including major findings, developments, or conclusions (both positive and negative); and 4) key outcomes or other achievements. Include a discussion of stated goals not met. As the project progresses, the emphasis in reporting in this section should shift from reporting activities to reporting accomplishments. In the response, emphasize the significance of the findings to the scientific field. Include approaches taken to ensure robust and unbiased results. (Up to 1,500-word limit)**

1. Major activities/specific objectives:

   - Hiring/Recruiting staff
     - One postdoctoral fellow and two researchers (associate and assistant) were hired to assist at Oklahoma's intensive site
     - One project director, one postdoctoral fellow, and one graduate student were hired to assist at Michigan's intensive site
     - One research associate was hired, and two graduate students were recruited to assist at Wyoming's intensive site
     - One postdoctoral fellow, two graduate students, one visiting scholar, and four undergraduate assistants were hired to assist with soil processing/analysis at Colorado State University (CSU)
     - Two research assistants were hired, and one postdoctoral fellow was recruited to assist with the water module at Michigan State University (MSU)

- One postdoctoral fellow was hired to assist with the Ecological outcomes Verification (EOV) samplings at MSU
- One postdoctoral fellow and one remote sensing specialist were recruited to assist with the remote sensing module at USDA-Wyoming
- One postdoctoral fellow was hired, and one research assistant was recruited to assist with the remote sensing module at USDA-Maryland
- Two postdoctoral fellows were recruited to assist with the producer social science module
- Formation of the advisory committee
  - The advisory committee was established
  - The initial meeting has been scheduled for October 31, 2022
  - Representatives from the Foundation for Food and Agriculture Research, The Jones Family Foundation, Green Acres Foundation, and Butcher Box will interact directly with the project's leadership group
  - Quarterly virtual meetings were planned to update the committee on the progress of the project
- Organization and implementation of all intensive monitoring sites
  - Leaders, staff, and students attended all intensive sites during the baseline sampling collection
- Project initiation
  - Sourced components and sensors for flux monitoring systems (COVID and war in Ukraine placed significant constraints on supply chain)
  - Initial 28 flux monitoring systems were built
  - Appropriate locations for fluxes monitoring were identified to align with wider research objectives and other environmental samplings
  - Initial 28 flux systems were installed across intensive monitoring sites in Michigan, Oklahoma, and Wyoming
  - Vegetation sampling protocol was developed in support of remote sensing validation
  - Remote data capture and management were settled to align with wider project needs
  - Protocol for EOV monitoring was established
  - Treatments based on differences in stock densities were established in each intensive monitoring site
  - Pasture Map app was set to capture grazing management in each intensive monitoring site
- Premeasure intensive monitoring areas (baseline data)

- Soil sampling campaigns of year 1 were identified at the intensive monitoring sites
- All monitoring equipment for soil moisture measurements was installed at the intensive monitoring sites
- Water infiltration measurements (saturated hydraulic conductivity) were completed at each of the intensive monitoring sites. The measurements were taken at the slope, depression, and summit of each pasture plot
- The soil moisture sensors were connected to Zentra Cloud, an online platform for collecting remote data
- Observation wells were installed at several pastures at the Lake City research facility in Michigan to detect perched water tables
- Soil samples were collected at each of the sites where soil moisture sensors were installed to measure volumetric water content of the soil
- EOV (Short Term and Long Term) was conducted by MSU's staff at Lake City Research Center – June 6-10, 2022
- EOV (Short Term and Long Term) was conducted by Noble's staff at Oklahoma intensive sites – June 27-29, 2022
- EOV (Short Term and Long Term) was conducted by Savory Institute at Wyoming intensive site – end of August 2022

- Soil samples processing
  - Soil samples processing, including weighing, drying, and 8 mm sieving has begun
  - Post-processing soil samples has been organized
  - Soil samples have been prepared for further analysis
- Data management
  - Data dictionary templates for each science team were designated to integrate data management and reporting
  - Data flows and housing were established
  - Data quality management procedures were initiated for the flux monitoring systems
  - EOV data was uploaded in excel spreadsheets
  - Remote sensing data has been uploaded in excel spreadsheets
  - Multi-year datasets for the intensive monitoring sites have been created
  - Prototype capabilities for evapotranspiration (ET) mapping over the monitoring sites using the Google Earth Engine platform have been developed and evaluated

- - Improvements to remote sensing model output over rangeland in the western United States has been identified and implemented
    - Unsupervised classifications of landcover over the three intensive sites has been developed, as well as multi-year timeseries maps of leaf area index (LAI) from 2013-2022
    - A cloud-based monitoring network at intensive monitoring sites has been established
    - Modeling needs to incorporate grazing management into MEMS2.0 has been identified
- Team meetings
    - An initial meeting among experts for early development of grazing management into the MEMS2.0 model was coordinated and executed at CSU
    - Meetings between the leadership team to discuss project needs have occurred monthly
    - Team meetings among each module to work on instrument development and project needs have been conducted
- Producer recruitment
    - Recruitment survey and requirements for producer participants has been established along with social and economic teams
    - Researchers have started talking to producers about the project – producers are part of a NC-SARE project.
    - Rancher wellbeing survey data was collected in April – June 2022 funded by SARE Rancher Wellbeing project (acting as pilot for both recruitment and social wellbeing survey in this project)
    - Survey for application in this project has been revised
- Literature review
    - Worked on the literature review and theoretical framework for economic and financial wellbeing to develop data collection instruments

- Significant results, including major findings, developments, or conclusions
    - Because we are still at the beginning of data collection, we do not yet have results from planned analyses.
    - We successfully coordinated field sampling with multiple science teams
    - We developed field sampling plans to ensure integrated measurements across several metrics (i.e., Greenhouse gases (GHG) flux, soil organic carbon (SOC), water, and plant community composition) that are each robust and overlapping on each field site

- - We identified key focus areas and data needs to implement grazing management simulations into MEMS2.0
- Key outcomes or other achievements.
  - Nothing to report at this time.

**Aside from the accomplishments outlined above, have there been any other significant impacts resulting from the work under this grant? Please describe any broader impacts such as:**

- Tools developed
  - Design data dictionaries templates
  - Begun integrating grazing into MEMS2.0
  - Developing data collection tools and a theoretical framework for economic and financial wellbeing of agricultural producers
  - Individual spreadsheets and master data spreadsheets were created to collect and store data, respectively
- Benefits to policy
  - Nothing to report
- Benefits to future research
  - Developed a sampling strategy for integrated intensive monitoring across scientific disciplines
  - Developed a robust and powerful repeated-sampling strategy for rangelands
- Benefits to food, the food system or agriculture
  - Nothing to report
- Broader economic or health benefits
  - Developing a survey to study social wellbeing of ranchers

**Describe challenges or delays encountered during the reporting period and actions or plans to resolve them. Only describe significant challenges that may impede the research and emphasize their resolution. (Up to 500-word limit)**

- All key goals have been achieved with the operational installation of flux monitoring systems at the intensive monitoring sites. The significant environmental and infrastructure differences between the sites presented differing challenges for sensor installation, but all were completed successfully and are now undergoing continuous data collection.

- Initial flux system installations in Oklahoma suffered from a fault in the power control system – this has been resolved with no significant impact on the data generation. Damage to installations in Wyoming, caused by cattle, was identified and resolved within a week of installation. Component failure of a gas analyzer in Michigan was resolved with no significant data outage.
- At Oklahoma, cattle have displaced a water sensor interrupting data collection for few days, and one sensor had problems to connect and transmit data to the Zentra cloud. Both issues were resolved with no significant impact on the data collection.

**Have there been any changes in scientific approach or reasons for change? If so, what are the changes? Remember, changes to the approved scientific approach must be pre-approved by FFAR. (Up to 500-word limit)**

In general, there have not been significant changes in scientific approach.

**What opportunities for training and professional development has the project provided during this reporting period? If the research is not intended to provide training and professional development during this period, state "Nothing to Report." For all projects reporting graduate student and/or post-doctoral participants, grantees are encouraged to describe how Individual Development Plans (IDPs) are used to help manage the training for those individuals. (Up to 500-word limit)**

- Undergraduate, graduate students, and postdoc fellows have been mentored by researchers across institutions
- Soil expert leaders provided training at each monitoring site on how to collect, process, and send samples to be analyzed
- EOV expert leaders provided training on how to perform both short term monitoring (STM) and long-term monitoring (LTM) samplings
- They have been trained in field sampling and data collection
- They have been trained in soil sampling, soil processing, and initial soil and modeling course work
- They have been trained in soil moisture sensors monitoring and measuring saturated hydraulic conductivity
- They have been meeting frequently
- They have been working on the literature review and development of the theoretical framework and data collection tools

**Please indicate the number of undergraduate and graduate students, post-doctoral scholars, or other educational components involved during this reporting period. If other education components are involved, please describe them in detail. (Up to 300-word limit)**

Post-doctoral scholar: 5
Graduate Students: 5
Undergraduate students: 7
Research associate/assistant: 6

**How have the results of this reporting period been disseminated to communities of interest? Describe how the results have been disseminated to communities of interest. Include any outreach activities that have been undertaken to reach members of communities who are not usually aware of such activities, to enhance public understanding and increase interest in learning and careers in science, technology, and the humanities. Reporting the routine dissemination of information (e.g., websites, press releases) is not required. For awards not designed to disseminate information to the public or conduct similar outreach activities, a response is not required; the grantee should write "nothing to report." A detailed response is only required for awards or award components that are designed to disseminate information to the public or conduct similar outreach activities. Note that scientific publications and sharing research sources will be reported under Information Products. (Up to 500-word limit)**

Nothing to Report.

**What do you plan to do during the next reporting period to accomplish the goals of the approved project? Briefly describe what you plan to do during the next reporting period to accomplish the project goals and objectives. Discuss efforts to ensure the approach is scientifically rigorous and results are robust and unbiased. Remember that significant changes to the approved goals and objectives and project scope require prior FFAR approval. Include any important modification to the original goals and provide justification for the change. (Up to 500-word limit)**

- Continued leadership and oversight of the project
- Continued meeting with the advisory committee
- Onboard new staff/students

- Ensure data collection is in line with the methods established at the intensive monitoring sites
- Refine the recruitment protocols
- Begin producer recruitment
- Identify participating producers (60 producers)
- Refine the theoretical framework and test data collection instruments with a subset of our pilot group of producers enrolled in the sister SARE project
- Design sampling approach on producer sites
- Identify the appropriate locations for the flux systems to be deployed at 30 extensive monitoring sites [producer sites – 10 sites in each location (Michigan, Oklahoma/Texas, Wyoming/Colorado)]
- Begin sourcing for and building the 30 flux systems for deployment at producer sites
- Implement data collection (quantitative and qualitative) on producer sites regarding social and economic modules
- Conduct both STM and LTM EOV baseline samplings on the producers' sites
- Continuing data collection for all modules at the intensive monitoring sites
- Initial data review and flux generation for the 28 flux systems at the intensive monitoring sites
- Maintenance of the 28 flux systems at the intensive monitoring sites
- Finalize metadata management plans and reporting needs for supply of data in multiple formats to enable subsequent use in model developments
- Complete soil processing for the intensive monitoring sites
- Begin soil analyses (elemental analysis, mid-IR, pH, texture, etc.)
- Evapotranspiration (ET) and leaf area index (LAI) products will be evaluated quantitatively using in-situ measurements collected at the intensive monitoring sites
- Supervised classifications will be developed using training data derived from landcover information collected during remote sensing vegetation samplings
- Grassland phenology mapping strategies will be developed using new satellite image processing techniques and ground observations
- Develop remote sensing models of biomass
- Investigate the historical record of ET, LAI, biomass, and grass phenology at each site, providing a baseline for comparison with changing conditions because of grazing management
- Data analysis
- Continuing working on the data dictionary
- Analyzing the water module data to determine if additional monitoring equipment will be needed at the intensive monitoring sites

- Start working with the modeling groups to help define data inputs and outputs, and establish next steps required to start the modeling activities

# Information Products

**Please list the type(s) of information products (e.g., scholarly publications, reports or monographs, workshop summaries or conference proceedings, video, audio, images, models software, curricula, instruments or equipment, intervention, etc.) produced during this reporting period resulting directly from the FFAR award.**

No final, quality controlled, information products have been generated at this stage – sharing of preliminary data and metadata with other project team members is being undertaken on an ad-hoc basis until fully processed data can be made available.

**Please provide a list of citations for the information products produced during this period.**

Nothing to report.

**Are there publications or manuscripts accepted for publication in a journal or other publication (e.g., book, one-time publication, and monograph) during the reporting period resulting directly from the FFAR award? If yes, please provide citation.**

Nothing to report.

**Website(s). List the URL for any internet site(s) that disseminates the research activities. A short description of each site should be provided. It is not necessary to include the publications already specified above.**

We created a project profile on the Soil Carbon Solutions Center website, which is housed at Colorado State University.

**Have inventions, patent applications, and/or licenses resulted from the award during this reporting period? If yes, indicate the invention, patent application(s), and/or license(s).**

Nothing to report.

**Are any of the information products produced during this reporting period confidential, proprietary, or subject to special license agreements? If so, please list them below and describe why they must remain confidential. Also, note if (and when) you plan to make these data publicly available in the future or if they must remain confidential indefinitely. (Up to 500-word limit)**

Nothing to report

**Beyond depositing information products in a repository, what other activities have you undertaken to ensure that others (e.g., researchers, decision makers, and the public) can easily discover and access the listed information products? What other activities have you undertaken to ensure that other can access and re-use these data in the future?**

- We have begun developing and implementing data dictionaries, which will ease data compilation and reporting across research teams
- These data dictionaries will be used to create a website for dissemination of results in later stages of the project
- Future information products will be shared at conferences, workshops, and social media channels at IWR. This may include IWR YouTube Channel, FB, Twitter, and website.

# Data Management

**During this period, did the project generate any data? Data generation includes transformation of existing data sets and data from existing resources (e.g., maps and imageries). Please list the data generated in this reporting period.**

- GIS maps containing soil types for each intensive monitoring site
- GIS maps containing point locations of the sampling sites where the data has been collected

- Grazing management (forage biomass and height) and animal performance (animal body weight) data at each intensive monitoring site
- Soil processing data (wet and dry soil weights, bulk density)
- The 28 installed flux systems are undertaking continuous measurement which will enable data processing subsequently. For each flux system this will comprise 30min mean values for Net Ecosystem Exchange; Gross Primary Productivity; Ecosystem Respiration; Latent Heat Flux; Sensible Heat Flux; Evapotranspiration; Wind Speed; Wind Direction; Air Temp; Relative Humidity; Net Radiation; Precipitation; Atmospheric Pressure; Vapor Pressure Deficit; Soil Moisture; Soil Heat Flux; Soil Temperature. This data will be processed at a later stage in the project but are dependent on measurements undertaken during the reporting period
- Soil moisture data (Tabular data of soil moisture at three depths and three locations within each experimental unit. Visual data containing charts and graphs of soil moisture)
- Saturated hydraulic conductivity data (Tabular data of infiltration rates at three locations in each experimental unit with three different infiltration measurements at each of the three locations)
- Observation of the well water depth (Tabular data of water level depth on several pastures on the Michigan Lake City research site only currently)
- Soil samples (Tabular data containing analysis of volumetric water content of soil samples)
- EOV STM and LTM data were generated at the intensive monitoring sites (STM data consists of 14 ecological indicators scored at each Soil Triangle established by CSU summated provides an Ecological Health Index. LTM data consists of number of plant species, functional groups, Shannon-Wiener Index, Ecological Health Index (EHI), Water infiltration, Haney Soil data and photos)
- Remote sensing data regarding leaf area index, visual obstruction readings and forage clipping

**If you list multiple data sets, are these data sets related? If so, please provide a short description of how they are related.**
- Maps were created during soil sampling design, using random sample placement on stratified plots within each sampling site
- Soil processing data resulted from samples that were taken at locations illustrated by the site maps
- The datasets all have common X, Y sampling locations which are also the same as the soil core sampling locations. Collectively these datasets help us understand

properties and functions of the soil as they relate to water movement, storage, and availability

- There is an overlap with flux data and water metrics
- LTM and STM data are linked by their respective EHI scores
- Ecosystem Respiration and Gross Primary Productivity are derived from Net Ecosystem Exchange. Other datasets are related through their location.

**Please provide copies of relevant metadata records to support FFAR's mission of enhancing the discoverability of FFAR funded project data and information products. Upload copies of records and a simple file inventory, if necessary, in a compressed folder.**

Metadata records will be provided once the data has been analyzed.