2017 Final Report Summary Sheet

Grantee Information

Project Title: Web-based Decision Support Tool for Cover Crop Management Cereal Ry

Institution: University of Illinois

Primary Investigator: Coppess

NREC Project # 2017-3-360574-222 2017-3-3

Is your project on target from an IMPLEMENTATION standpoint? ☒ Yes ☐ No

If you answered "no" please explain:

Is your project on target from a BUDGET standpoint? ☐ Yes ☒ No

If you answered "no" please explain:

As discussed in the attached report, the project was transferred in May 2017 to NCSA and the agreement was not executed until July. Accordingly, expenditures have been delayed and the full amount will not be used by Feb. 28, 2018; an extension of funding is requested.

Based on what you know today, will you meet the objectives of your project on-time and on-budget? ☒ Yes ☐ No

If you answered "no" please explain:

Have you encountered any issues related to this project? ☒ Yes ☐ No

If you answered "yes" please explain: No significant problems have been experienced since moving project to NCSA and development has progressed substantially in six months.

Have you reached any conclusions related to this project that you would like to highlight? ☐ Yes ☒ No

If you answered "yes" please explain:

Have you completed any outreach activities related this project? Or do you have any activities planned? ☒ Yes ☐ No

If you answered "yes" please explain and provide details for any upcoming outreach:

Demonstrated the prototype at IL Farm Bureau annual meeting in December 2017. Met with IL Farm Bureau's SWAT team for natural resources and demonstrated the tool, will be seeking follow up meetings and work with individual farmers. We are also planning demonstration with farmers associated with IL Corn Growers Association.

Additional Notes:

See attached.

PROJECT FINAL REPORT, 2017
Grantee: Jonathan Coppess, University of Illinois
NREC Project: 2017-3-360574-222
Project Title: Web-based Decision Support Tool for Cover Crop Management
Date: February 9, 2018

The following is the final report for 2017 on the NREC project for the development of a web-based decision support tool for cover crop management.

(1) Project Management

The project was transferred from the Applied Research Institute (ARI) at the University of Illinois to the National Center for Supercomputing Applications (NCSA) in May 2017. The transfer was due to problems with sufficient programming and technical support and lack of sufficient progress. While expenditures were delayed due to the transfer, they were also delayed due to the late execution of the agreement (July 2017). Significant progress has been made, however, during the second half of 2017 (discussed below).

The following is a summary of the budget for this project based on a recent report from the University's sponsored programs office report. It covers expenditures and obligations through December 31, 2017. Because of the transfer and late date of execution, this represents approximately a half year usage of the full-year funding. The project will need to ensure that the funds remain available past February 28, 2018, and we hereby request permission to extend the funding such that it remains available for use by the project after February 28, 2018.

Item	Budget Authority	Activity	Commitments/Obligated	Available Balance
NCSA	$112,002	$29,988.02	$19,272.92	$62,741.06
ACES	$23,655.23	$13,518.28	$0.00	$10,136.95
Totals	$135,657.23	$43,506.30	$19,272.92	$72,878.01

(2) Tool Development Progress

As of the date of this report, we have a functioning prototype of the web-based decision support tool. We have demonstrated the tool in operation using a web video at the Illinois Farm Bureau annual meeting in December 2017, as well as to a team of farmer-advisors for Illinois Farm Bureau in January 2018. The full video demonstration is contained in a Powerpoint presentation that can be provided upon request, screenshots from the prototype demonstration are included below.

Beginning with the project transfer in May 2017, NCSA established a development team for this project, including full software engineering stack for handling source control (Bitbucket), bug and issue tracking (Jira), team collaboration and document tracking (Confluence), and continuous build and deployment (Bamboo). Initial steps involved creating mockup drawings of the web tool prototype based on project meeting discussions to establish a look and feel for the new tool. The team has held biweekly meetings for development progress reports and discussions, as well as other relevant updates; project management uses an Agile software development approach to continuously refine the prototype. NCSA also setup a virtual machine (VM) for the project with the following services:

- DataWolf workflow service to run DSSAT crop model as a web service, including creation of a workflow and workflow tools to get weather and soil input data for the selected CLU, execute the DSSAT model, and generate JSON data to graph the model outputs;

- Postgres with SSURGO soil database and Flask service to provide CLU for a given location. Created python tool to obtain CLU soil information from the database;

- Created python weather tool to obtain historical weather data from nearest weather station and provide the option to generate future weather data based on a selected weather pattern; and

- Necessary tools to build new versions of the DSSAT crop model.

In coordination with the technical programming and development work, members of the ACES team worked extensively on the DSSAT model so that it could be implemented in the web environment. This involved background research on the DSSAT model and capabilities, work to generate data files for soil (SSURGO), weather (Illinois State Water Survey), geolocation (Common Land Unit used by USDA), and default farm management files (cropping rotation, nutrient management, tillage, etc.).

Substantial work went into the translational effort for running DSSAT in the web environment, including the creation of default field management data files to be used by the model. Rather than require a user to enter all field management data up front, this permits a default file for the location based on average practices in the area (nitrogen rates, timing, etc.), as well as using the cropland data layer from USDA to determine cropping history in the selected field.

Beginning in the fall of 2017, development progressed to permit initial tests for simulating a rye cover crop in a specific field with historic weather data. This effort generated simulated data outputs for crop growth, nitrogen uptake, nitrogen leaching and more. Initial simulations were compared with actual data from a cover crop experiment in a field in Lexington, IL (Shalamar Armstrong's research). This provided an opportunity for initial calibration and validation of the model through which the team discovered a functional problem with DSSAT that was not properly modeling tile flow and tile nitrate loss. Subsequent efforts went into fixing the model's source code and improving DSSAT to more accurately simulate tile flow and nitrate loss. The fixes to the DSSAT model code were shared with the DSSAT modeling team (non-project) that built and maintains the open-source model and code; a significant contribution to the improvement of this model.

Development work progressed through the fall and into the winter of 2017, creating the prototype web application. The web application provides a user interface (UI) that begins with users selecting a field CLU (highlighted, figure 2) from a standard mapping feature (standard geo-location function). This field/CLU will be used in simulations, and to pull in weather, soil and other information. In the prototype, the user will then specify establishment and termination dates for a cover crop. The application simulates the cover crop growth in the field against actual weather data using the DSSAT crop model, and visualize crop model results such as carbon-nitrogen ratio, nitrate loss to tile, etc. in their web browser (see, figure 3). The current prototype uses a specific field; however, as the prototype continues to evolve, more functionality will be added to allow changing the model inputs for a farmer's specific field. Development has also established Secure Sockets Layer (SSL) certificates for the VM so all connections to the server are secure, ensuring that the data entered will be securely stored.

The completed prototype was demonstrated in December at the Illinois Farm Bureau annual meeting and an updated version in January, it is available for further demonstration. Development work in the New Year continues and includes developing the log-in capabilities (user session management) and similar features that will permit use of the simulation function by cooperative farmers. Additional development work includes

building out simulation options for weather inputs, permitting a farmer/user to simulate cover crops in actual fields under varying weather conditions (i.e., warm, cold, dry, wet conditions). This phase will provide the farmer with the ability, for example, to select a field and simulate cover crop (rye) growth in that field based on average weather conditions, or if the weather is warmer than average or colder than average, wetter or drier than average. Each of these simulations will produce visualized outputs of the cover crop in the field, nitrate scavenging, loss and carbon-to-nitrogen ratios.

In addition, based on feedback from farmers in the January meeting, we will be building out functionality that will provide farmers with a version of an "early warning system" on a growing cover crop. This would help the farmer's management decisions if, for example, a warmer and wetter winter would indicate faster growth (higher biomass) and potentially alert the farmer to the need to terminate the cover crop earlier than anticipated.

Research is also underway to refine the DSSAT model to better simulate the growth of a cereal rye cover crop. The current model estimates rye based on winter wheat growth characteristics and assumptions. A more fully developed cover crop growth model would concentrate on early growth post-establishment and growth post-dormancy, rather than an emphasis on final growth stages and seed development. For this effort, additional data will be needed from actual fields that grew cover crops during previous years and efforts are under way to get cooperation on data and results.

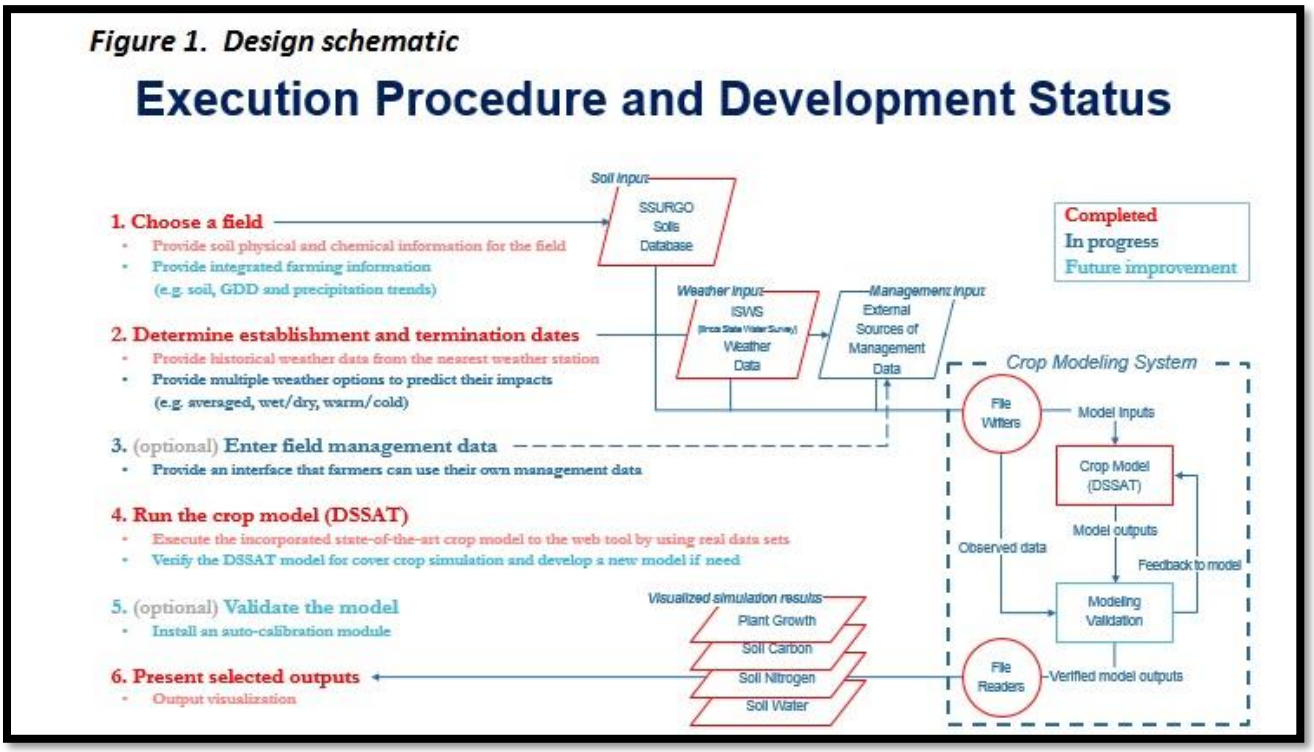

Figure 1. Design schematic

Figure 2. CLU geolocation feature

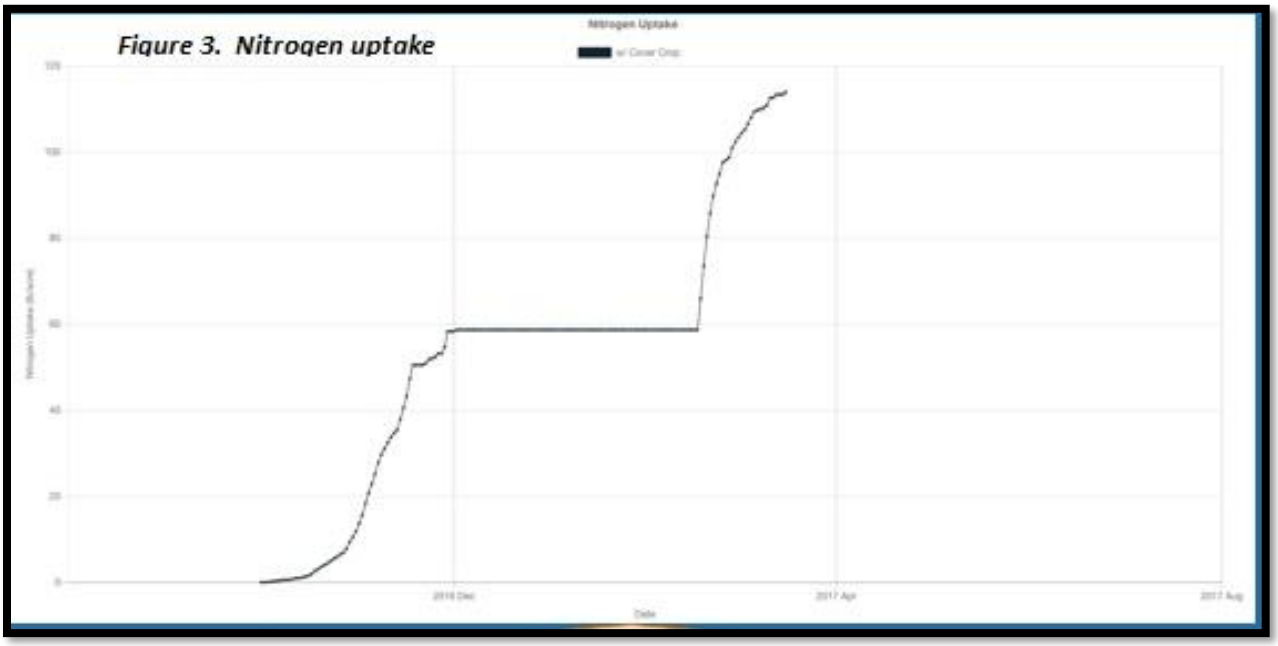

Figure 3. Nitrogen uptake

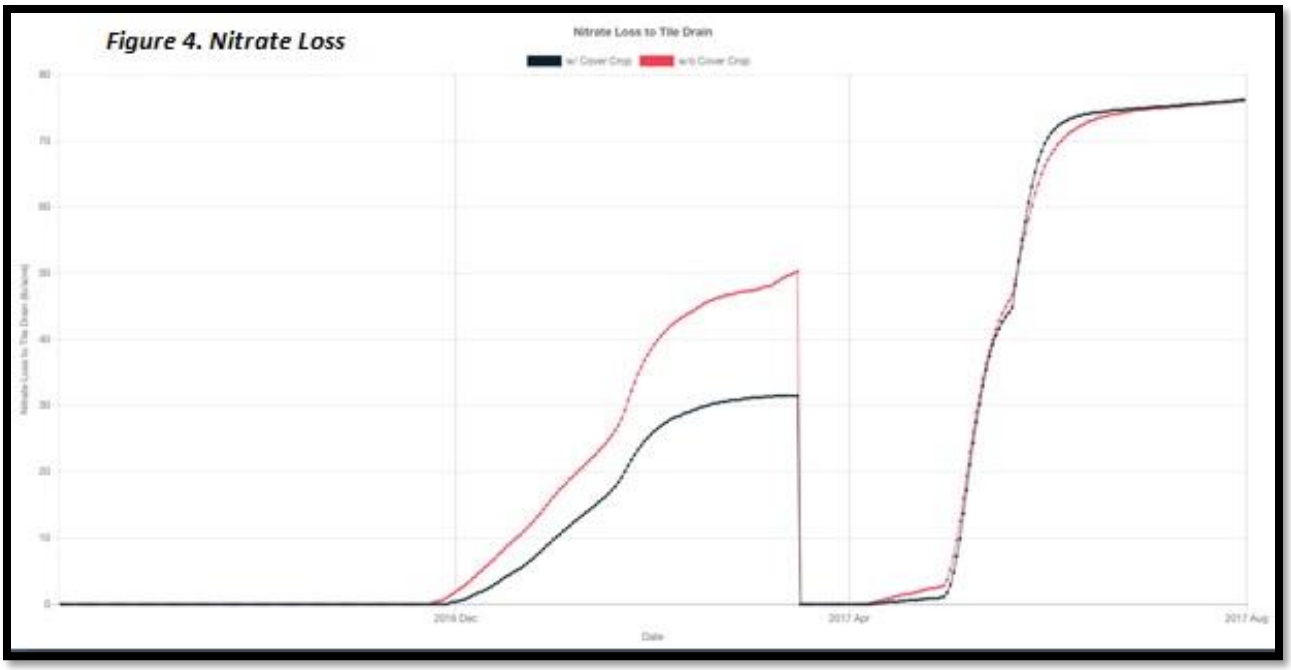
Figure 4. Nitrate Loss
Nitrate Loss to Tile Drain
w/ Cover Crop
w/o Cover Crop
2016 Dec
2017 Apr
2017 Aug
Date