Final Report

NRCS Conservation Innovation Grant

PaddockTrac: A Web-based Mobile Application for Managed Grazing Systems

10/29/2021

Grantee Entity Name: Curators of the University of Missouri
Project Title: PaddockTrac: A Web-based Mobile Application for Managed Grazing Systems
Agreement Number: 69-3A75-17-277
Project Director: Dr. Robert Kallenbach
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Project Activity timeline: 8/1/2017-7/31/2021
Project End Date:7/31/2021

Summary

We completed a project that improves the efficiency by which pasture managers obtain information about their forage resources in a rotational stocking system. We developed PaddockTrac with CIG funding to focus on reducing the time needed to measure pasture growth. The time barrier is always a major concern listed by people as a reason to not measure grass growth. But the tools also reduce the time required for data management and interpretation after measuring. PaddockTrac is modeled after the Fit-Bit technology. With the atv-mounted, Blue tooth, ultrasonic sensor and mobile web-app, producers can obtain data with ease and accuracy. Then, on the grazingwedge.missouri.edu website, they can access their account and see their pasture information within minutes of uploading. These web-based outputs guide their decision making about grazing, harvesting, fertilizing, and supplementation. The tools provide a very practical mechanism to achieve adaptive management in forage/livestock systems.

Figure 1. PaddockTrac suite of pasture management tools was built like the FitBit system so popular in communities now.

In addition to the economic benefits that use of PaddockTrac confer, natural resources are better protected. Pastures grazed to proper residual height provide more biomass to reduce erosion potential. More rainfall infiltrates, and less run-off occurs, when pastures are not overgrazed. Pastures given proper rest periods can recuperate from periods of drought and show resilience to other environmental stress. By developing PaddockTrac, we provide pasture managers with technology to manage pastures for longevity and sustainability.

We worked with beef and dairy producers in Missouri for the last 4 years to build a data collection system that draws people to measure-monitor-manage forage/livestock systems on their farms. Previous technology such as Rising Plate Meters take too much time and labor in walking across fields to collect data. This ends up deterring users because of time constraints. But our PaddockTrac system was designed for use on ATVs already found on most farms to check cattle. The following EQIP producers were involved in not only evaluating the system on their farm, but they also provided good constructive criticism to improve the utility during use. We made 34 updates to the mobile phone app software over four years. It was crucial to get their input and we thank them for their honesty and frankness during this evaluation period.

i. Amy Neier
ii. Bernie Van Dalfsen
iii. Dan Mesey
iv. Daryn Koopal
v. Dennis Turner
vi. Doug Ridder
vii. Hoyt Hines
viii. James Brochtrup
ix. Jeff Schoen
x. Jeffry Scott
xi. Jim Grace
xii. Johnny Wood
xiii. Keith Koenig
xiv. Kendra Graham
xv. Michael Price
xvi. Mike Meier
xvii. Niall Murphy
xviii. Patrick Allen
xix. Rick Aufdenberg
xx. Robert Vanderen
xxi. Ron Locke
xxii. Steve Freeman

This project did not involve any testing of treatments. We made no comparisons to identify best practices. Therefore, we do not present data as results typical in other types of projects. Rather, here we present a time sequence of images to give the reader an idea of the successful developmental progress. We hope to give a figurative explanation of the journey through renovation, refinement, and recruitment. There was developmental overlap between these “Three R” phases. But they serve as structural pillars to build from.

RENOVATION-Improving the Existing Website

We start with the grazing wedge website. This site was developed in 2006 but it only accepted data by manual keyboard input. And that data would have been collected through laborious methods that included walking (many times for hours as farms increase in size). The website needed renovation to accept sensor data. CIG funding first targeted this improvement to the website.

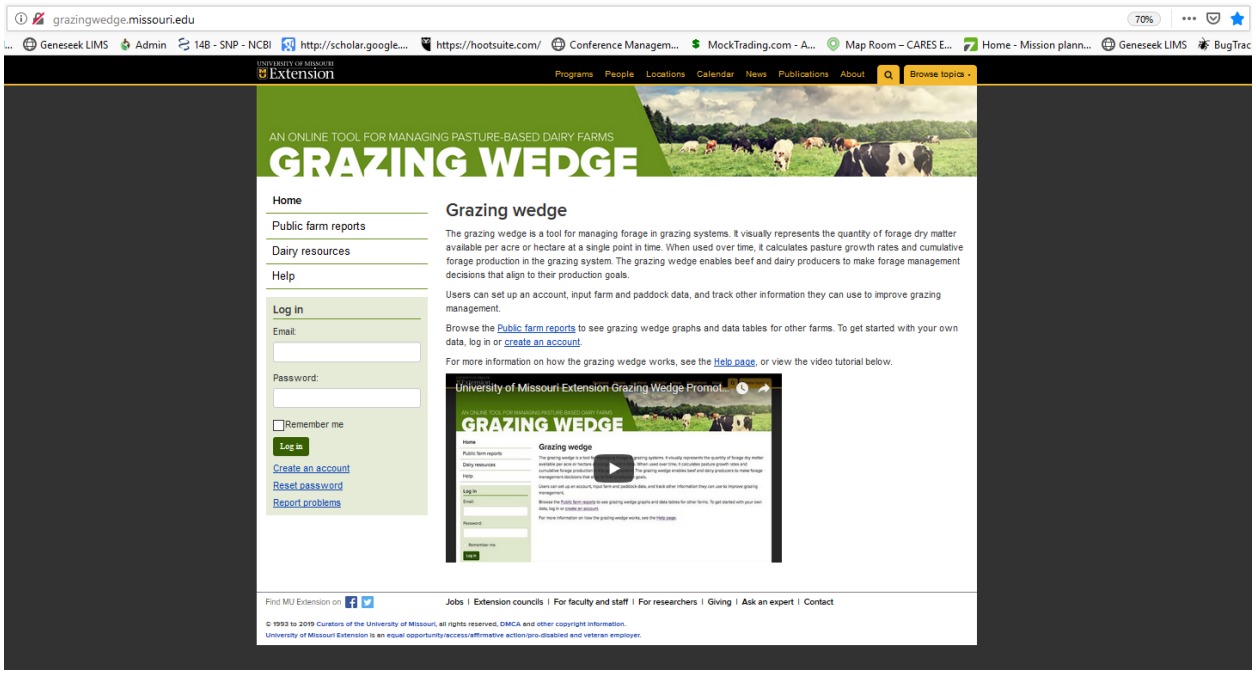


Figure 2. Grazingwedge.missouri.edu was renovated with CIG funds to handle sensor-collected data. Producers have their own private account hosted on University of Missouri Extension servers.

We also knew early on that the automation required GPS/GIS capability. Below you can see mapped polygons for a user account. The data uploaded to the website is processed by GPS location. We built the website to recognize location in the data files. In that manner, the burden for where the measurements took place was not on the producer.

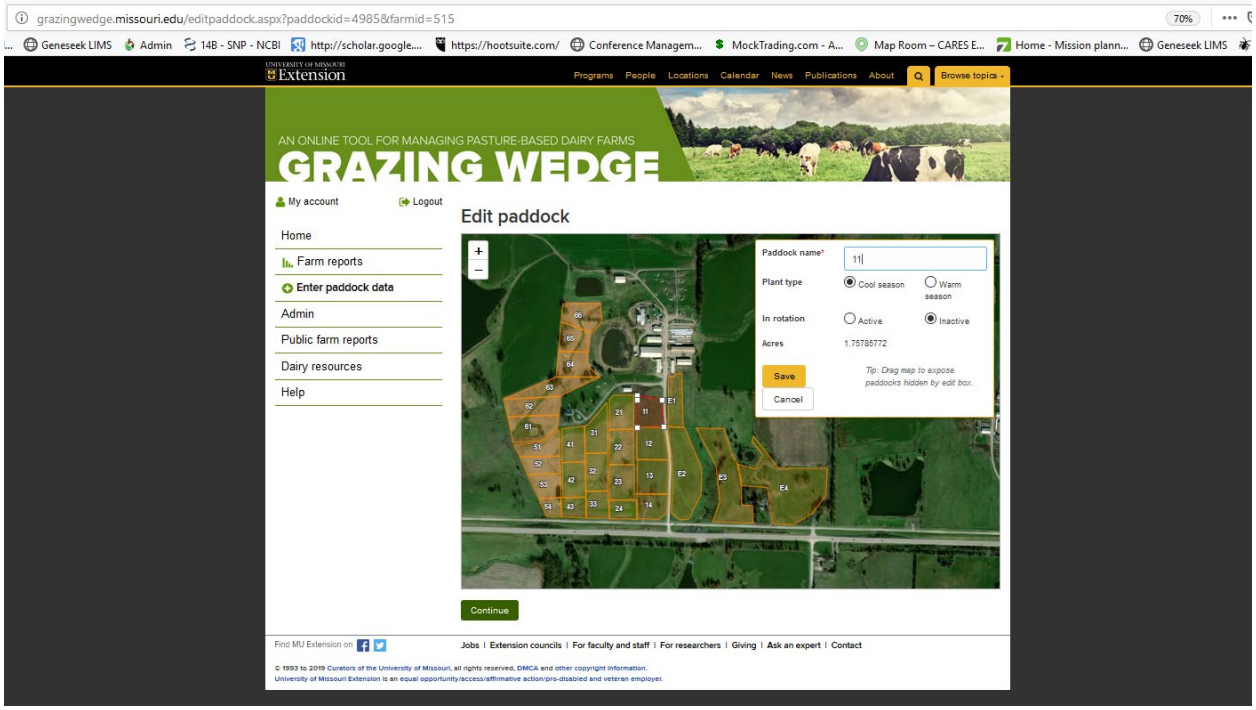


Figure 3. Grazingwedge.missouri.edu contains a GIS database to assign a location with every forage measurement. This removes the need for producers to keep track of their location while taking measurements. Mapped polygons from a farm are visible in Figure 3.

After a user collects data with the sensor and PaddockTrac app, they upload the data from the smartphone to Grazingwedge.missouri.edu. Almost instantly, our server sends an email to the user (and server administrators) so they can validate that the data was collected and transmitted properly.

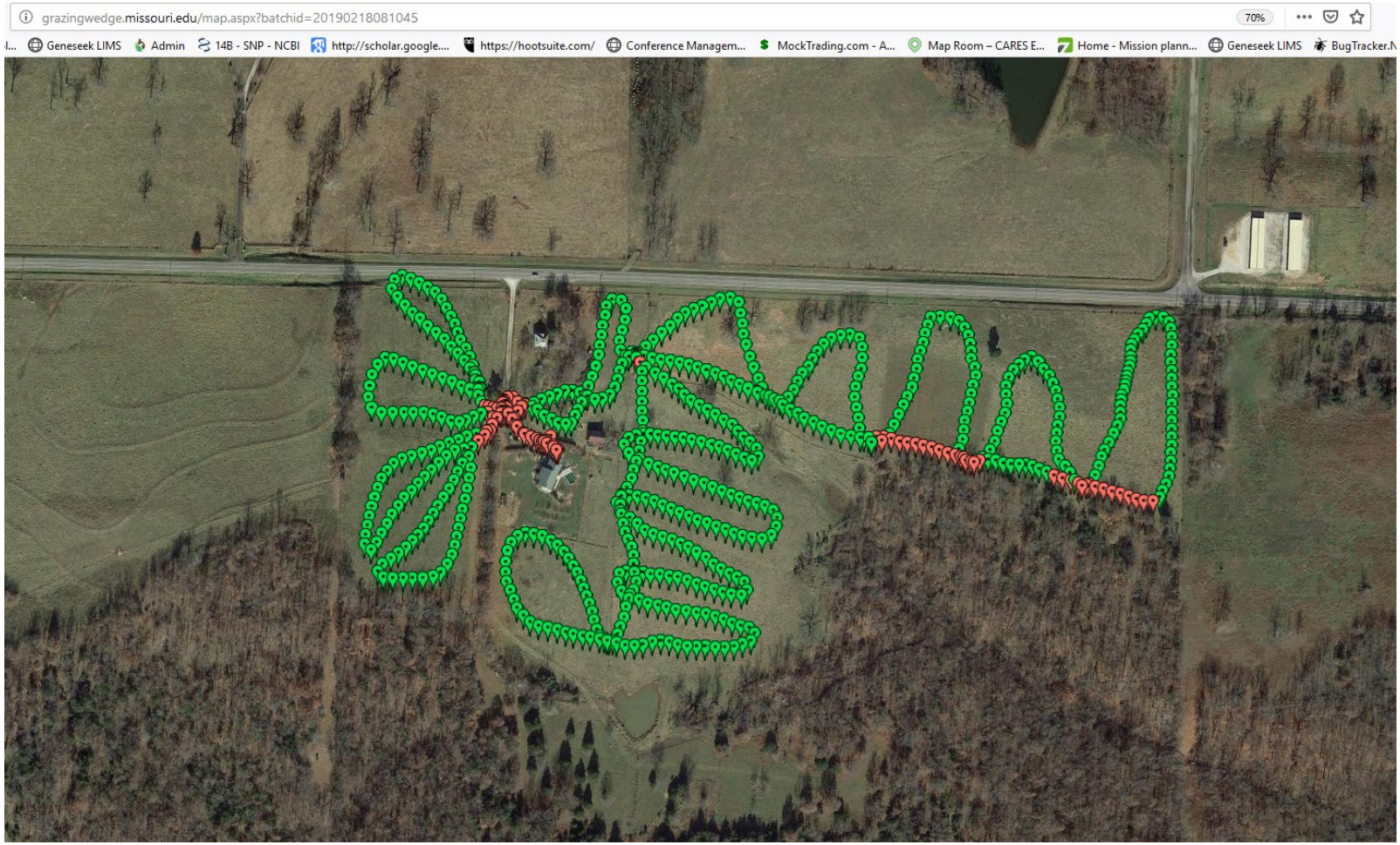


Figure 4. Validation map of account user's uploaded data showing where ATV traveled on the farm during data collection. Green dots are points that georeferenced to a mapped paddock. Red dots are excluded from the dataset because they mapped to a point outside a mapped paddock.

After completing the data collection session and seeing the validation maps, the user can login to their secure account on the website. There they will find the uploaded data ready to be processed by clicking a few menu choices.

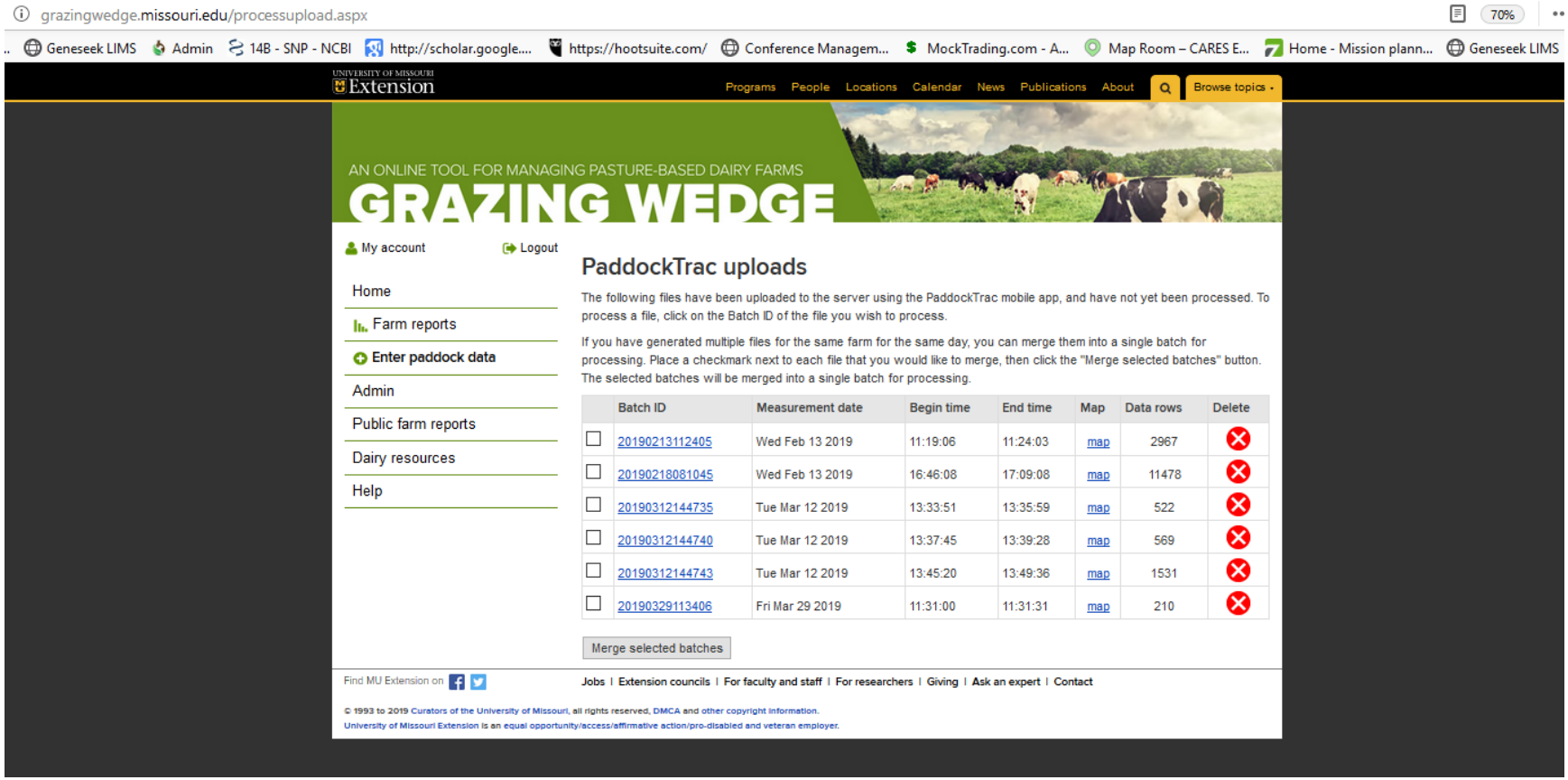


Figure 5. User account page showing new data uploaded automatically from smartphone app and ready to process into output tools.

The output graph known as a grazing wedge gives the user a figure with paddocks in the forage system arranged from highest to lowest biomass (left to right). Green bars represent paddocks where animals should be grazing for this point in time. Red bars indicate that forage is above the ideal biomass level for grazing. Often these “red bar” paddocks are intentionally allowed to grow in times of rapid forage accumulation so that silage can be harvested. Yellow bars represent paddocks that contain less forage than ideal and need rest. Users provide the parameters for too much, proper, and too low forage heights. But these can be adjusted during adaptive management.

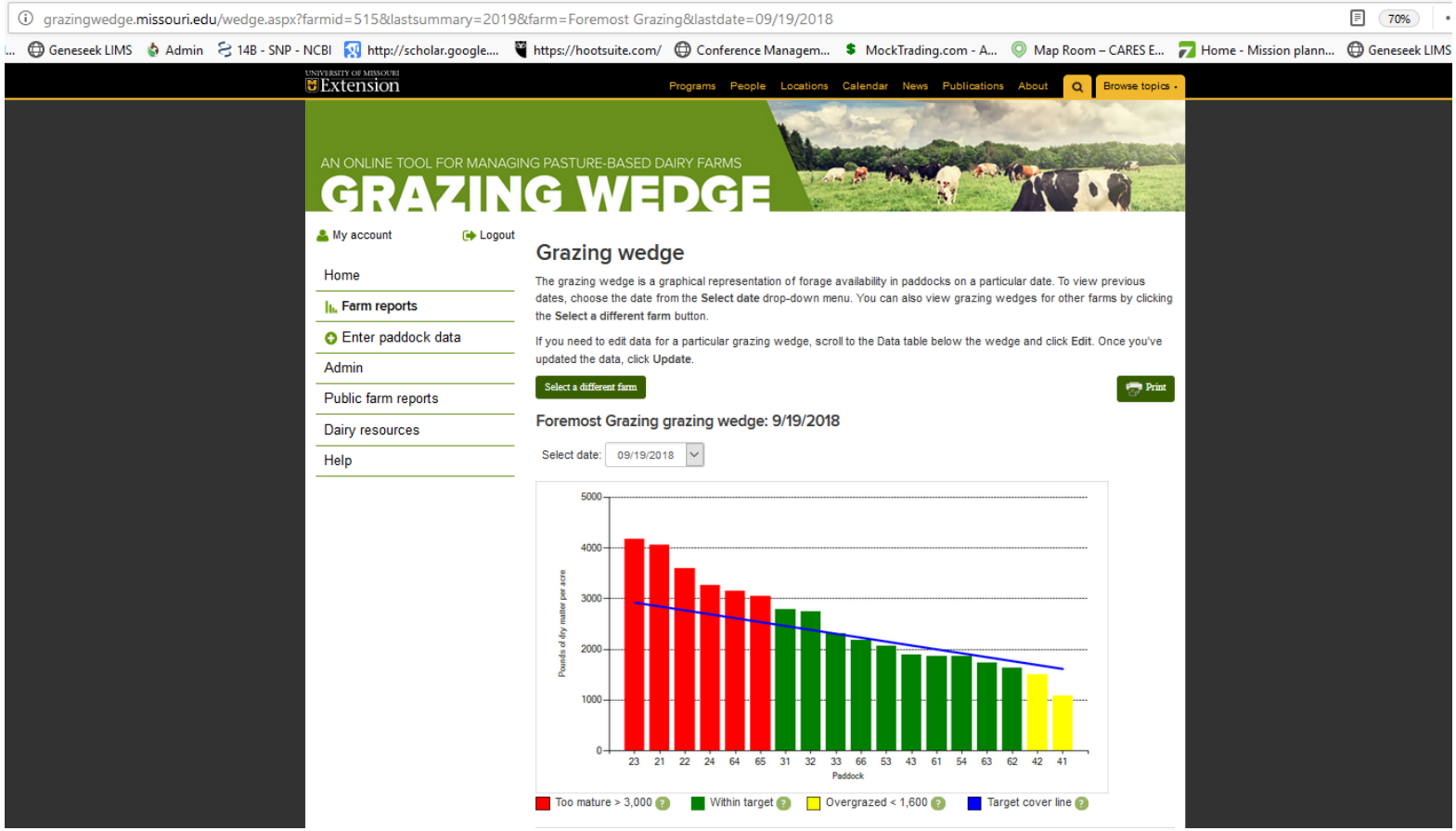


Figure 6. Grazing wedge shows the forage availability in each paddock. This information guides producer’s forage management decisions regarding which paddocks to graze or harvest and when to do so.

An added feature we thought beneficial to this improved grazing wedge website was yield mapping. Often a visual representation of “WHERE” forage yield occurred on the farm is needed, rather than just how much yield exists. CIG funding allowed us to build this utility into the website.

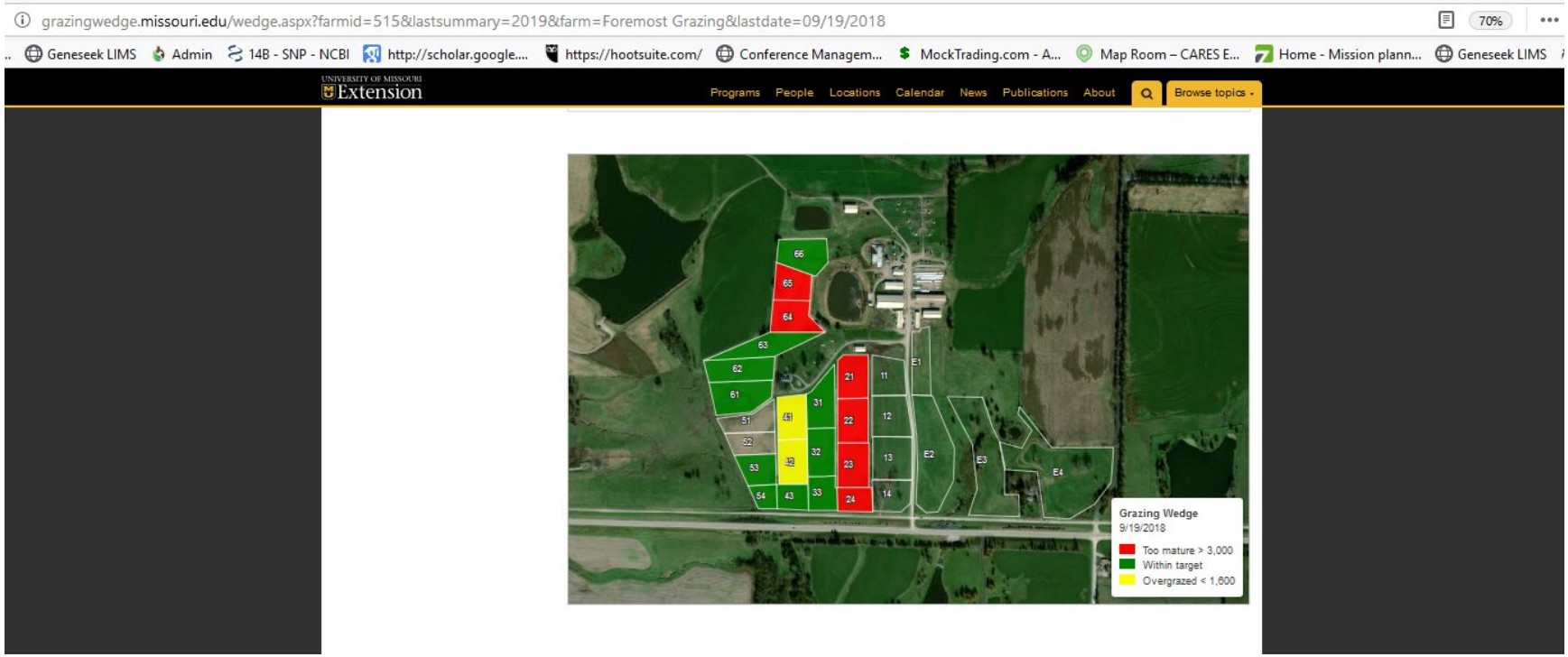


Figure 7. An improved spatial interface shows where forage resources exist on the farm.

We aimed to showcase our developments with the data collection system by highlighting progress on social media. The media give us opportunity to not only advertise but recruit collaborators to evaluate the system.

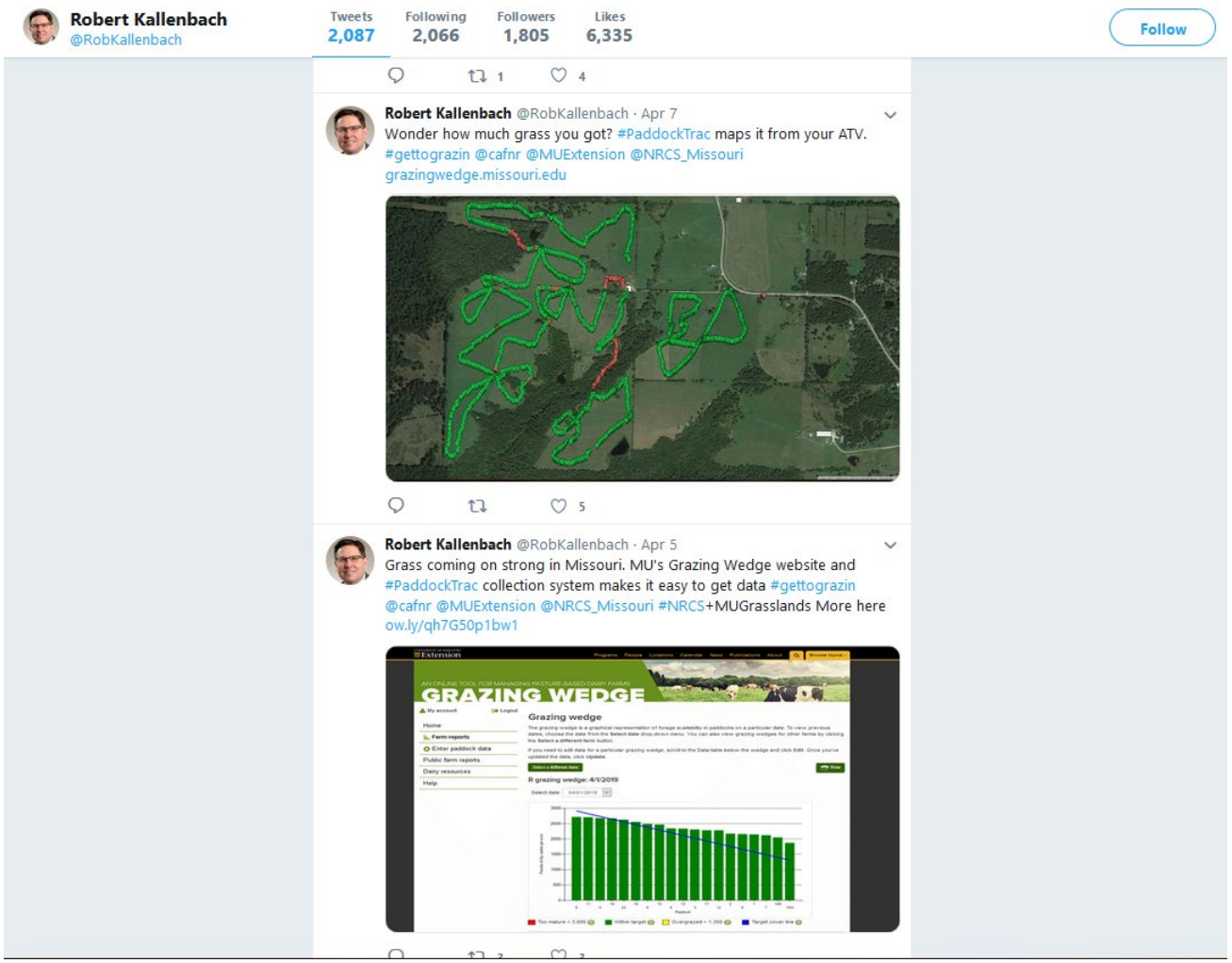
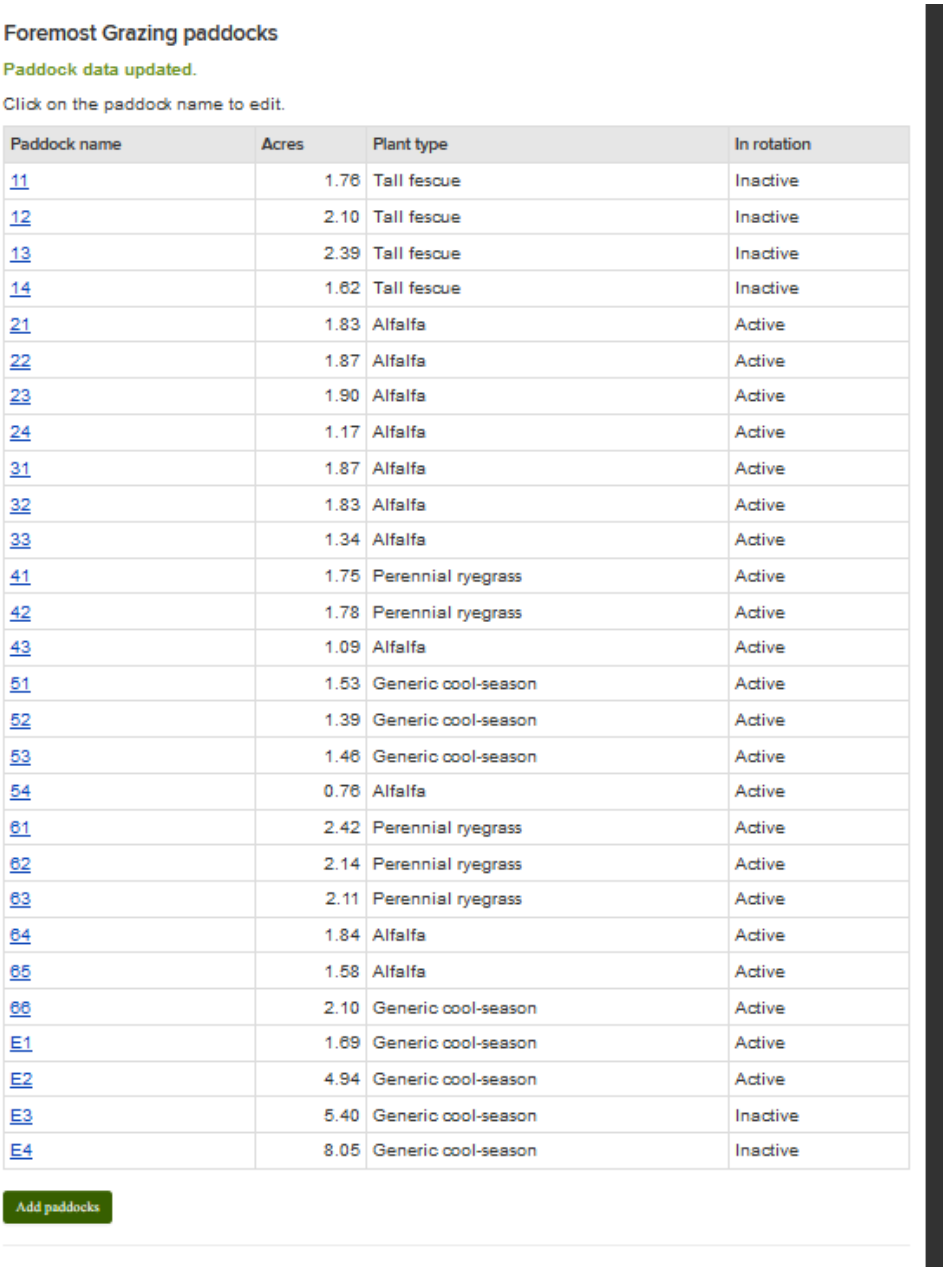


Figure 8. Social media posts allow us to inform producers with content in timely fashion.

REFINEMENT- Making PaddockTrac better

The biomass estimates given by the Grazingwedge.missouri.edu website come from equations that relate plant height to forage yield. As you can imagine, the plant species grown in a pasture, and the season of growth, both affect the height:yield relationship. In other words, 12-inch tall alfalfa has a different yield relationship than 12-inch tall tall fescue; and these change in spring, summer, and autumn. For our tool to have relevance with producers, we needed to ensure that biomass estimates were accurate. If not, producers might allocate too much or not enough forage to cows in rotational stocked systems.



Foremost Grazing paddocks

Paddock data updated.

Click on the paddock name to edit.

Paddock name	Acres	Plant type	In rotation
11	1.76	Tall fescue	Inactive
12	2.10	Tall fescue	Inactive
13	2.39	Tall fescue	Inactive
14	1.62	Tall fescue	Inactive
21	1.83	Alfalfa	Active
22	1.87	Alfalfa	Active
23	1.90	Alfalfa	Active
24	1.17	Alfalfa	Active
31	1.87	Alfalfa	Active
32	1.83	Alfalfa	Active
33	1.34	Alfalfa	Active
41	1.75	Perennial ryegrass	Active
42	1.78	Perennial ryegrass	Active
43	1.09	Alfalfa	Active
51	1.53	Generic cool-season	Active
52	1.39	Generic cool-season	Active
53	1.46	Generic cool-season	Active
54	0.76	Alfalfa	Active
61	2.42	Perennial ryegrass	Active
62	2.14	Perennial ryegrass	Active
63	2.11	Perennial ryegrass	Active
64	1.84	Alfalfa	Active
65	1.58	Alfalfa	Active
66	2.10	Generic cool-season	Active
E1	1.69	Generic cool-season	Active
E2	4.94	Generic cool-season	Active
E3	5.40	Generic cool-season	Inactive
E4	8.05	Generic cool-season	Inactive

Add paddocks

Figure 9. Screen-shot of user account on grazingwedge.missouri.edu showing that plant type is now a variable that accounts for biomass estimations. Producers can choose which species are present in their paddocks and biomass predictions are calculated accordingly

These differential equations for height:yield were found by measuring grass with the PaddockTrack sensor and then cutting the measured strip with a forage harvester. Sub-samples were retained to remove moisture such that dry matter available in the cut strip could be calculated.

Figure 10. Field work to determine relationship between forage height and mass in Perennial ryegrass. This species is less common on traditional farms across Missouri but renovated grasslands use it more frequently. The left panel shows a cut strip that was measured by the ultrasonic sensor on the ATV before and after harvesting (right panel). Samples are retained for dry matter to develop relationships between forage height and forage yield.

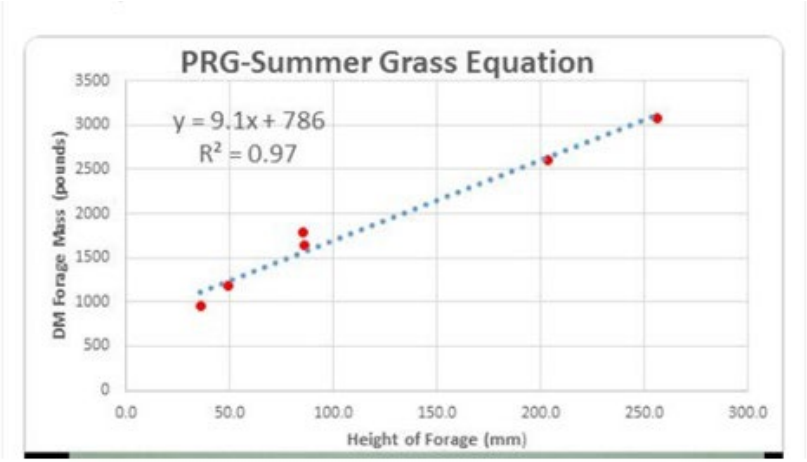


Figure 11. Calibration curve for perennial ryegrass. You can see the how the sensor gives a very accurate estimate of forage biomass from the height reading in a range of grass heights. This was incorporated into our differential species and seasonal equations on the website.

Recruitment- Making PaddockTrac Visible

We engaged with producers in a variety of settings. Farm walks and visits get the technology in front of folks in a production situation. Often, early adopters of technology are the best instruments to spread a practice.

Figure 12. A field day at University of Missouri Foremost Research Dairy during June 2019 brought approximately 50 attendees that learned about grazing management and using PaddockTrac to measure, monitor, and manage forage systems.

Extension gatherings bring a diverse audience of the general public and offer a way to engage people curious about agriculture and natural resources. At times we improvised with information presentation, as new venues were made available to us without foreknowledge of setup procedures.

Figure 13. Public interaction August 2019 at Lucas Oil Motor Speedway afforded opportunity to discuss grazing management and using PaddockTrac to measure, monitor, and manage forage systems.

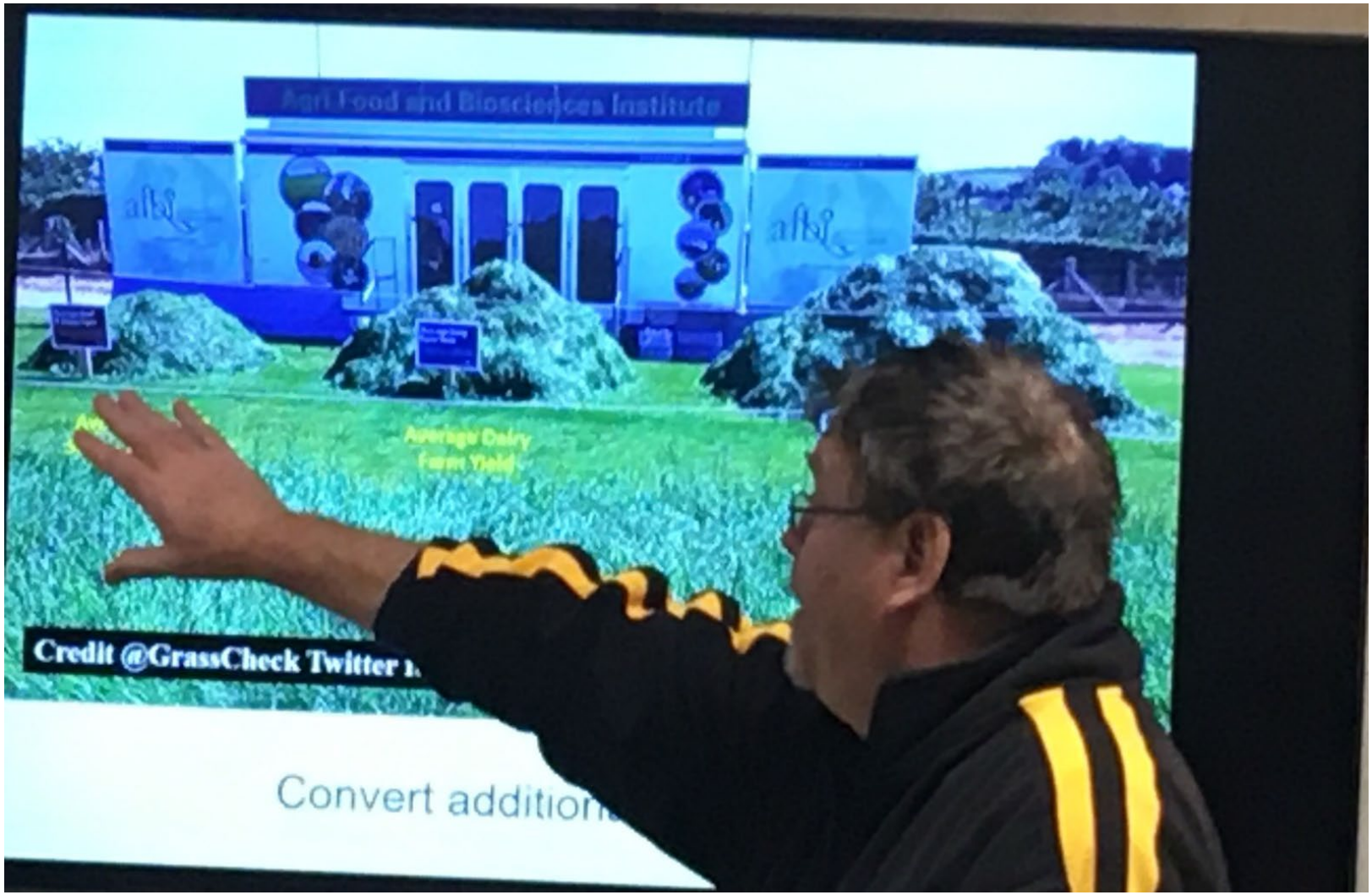


Figure 14. Stacey Hamilton explains the need for technology like PaddockTrac and management at the Missouri Dairy Expo in February 2019. Innovative tools provide a mechanism to increase forage growth on farms and support growing demand for food.

Figure 15. Large attendance at the Southwest Missouri Spring Forage Conference gave opportunity to interact with many graziers in the heart of our State's beef cattle operations.

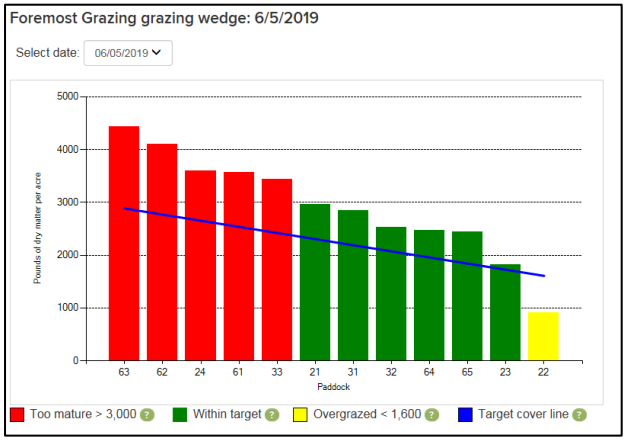
Meetings and discussions with new people seemed to pay dividends with popular press. We benefitted from new relationships in industry that recognize the need for data-driven decisions that bolster economic growth and natural resource sustainability possible with PaddockTrac.

Figure 16. Producer and industry groups share information and news articles about our work on social media platforms.

Immediately following is a tri-fold handout distributed to interested parties that attend Extension or industry functions.

Mizzou Grazing Wedge

http://grazingwedge.missouri.edu/



To learn more about increasing forage, beef, and milk production with PaddockTrac and Mizzou Grazing Wedge contact Ryan Lock (Lockt@missouri.edu) or Stacey Hamilton (Hamiltonsa@missouri.edu)

PaddockTrac App

Mizzou Grazing Wedge

Make Your Grazing Management Decisions Easier and More Reliable

Measure, Monitor, Manage

***Improve Utilization**

***Proactive not Reactive**

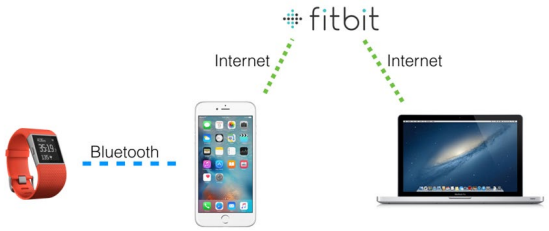
***Consistent**

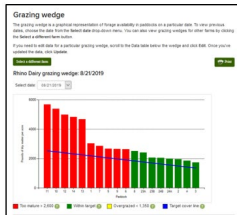
***Accurate**

***Time Saving**

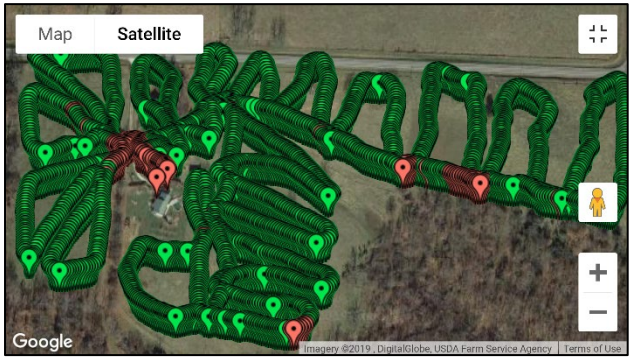
***On-the-fly reading**

*** Heights Geo-referenced**





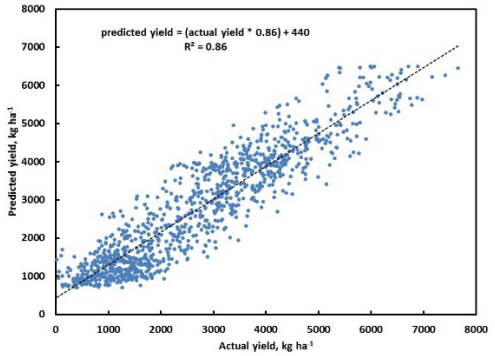
Process Similar to Fitbit



Data Referenced to GPS Location

Calibrations for Various Forages Required

Know How Much You're Feeding the Cows



Accurate and Reliable

Measure-Monitor-Manage Your Way to Profitability

Discussion of conservation impact

Overgrazing reduces longevity of pastures. With weakened pasture systems, we see soil erosion especially on the more marginal land where ruminants typically graze. Tools to manage grazing only work if they are easy and don't result in the producer having another task to perform. The functionality of PaddockTrac reduces the burden of data collection. Therefore, producers have more time to manage pastures and give grass the rest it needs to recuperate. PaddockTrac has implications in water conservation as well. Leaving proper residual heights after grazing allows for more rainfall infiltration and less runoff. Soil moisture stored in the ground helps plants stay healthy, productive, and able to accomplish their ecosystem services. We had one producer in Montana read about this system in national press and we outfitted him with the suite of tools and provided remote technical assistance in his operation. Additionally, technicians at the Jimmy Carter Plant Materials Center in Americus, GA saw the technology at the 74th SWCD conference. We sent them the hardware and they use PaddockTrac to manage grass on site. The technology has broader impacts beyond Missouri and the Midwest as evidenced by its transfer to other regions of the US.

Figure 17. Dana Larsen, NRCS Central National Technology Support Center in Ft. Worth, TX (far left) joins MU Extension and Meier family on their dairy farm where PaddockTrac helps manage grass and sustain natural resources.

Additional information relevant to this project

We have engaged our state NRCS administration on ways to implement this technology in future EQIP programs. We have a implemented a sensor unit with the Texas county, MO NRCS office and in collaboration with our University of Missouri Field Specialist in Agronomy in that region. We enjoyed preparing and delivering a recent NRCS-CIG webinar to approximately 280 attendees on October 7th. Much discussion occurred in the question-and-answer session and fruitful work is beginning to arise from those connections. We have also been awarded a cooperative agreement with our Missouri Department of Natural Resources to implement these systems on 20 more farms to demonstrate resource conservation. And we have an NRCS national cooperative agreement proposal submitted with the Dairy Grazing Apprenticeship to train underserved grazers in the upper Midwest.

We thank USDA-NRCS for investing in this CIG project. Their support furthered our ability to develop a data collection system that makes it easy to practice adaptive management in rotational stocking of pastures. On behalf of Dr. Kallenbach and his extension team we truly thank you for your investment.

Attachments to this report:

University of Missouri Grazing Wedge website

www.grazingwedge.missouri.edu

PaddockTrac android app

https://play.google.com/store/apps/details?id=edu.extension.grazingwedge

PaddockTrac Apple app store

https://apps.apple.com/us/app/paddocktrac/id1353197167

PaddockTrac marketing video

https://app.wipster.io/Review/CSJVNgD3arF-EXP32XvH8mppSPz6zLK9xvlMRdqMDXoRq88jPA