UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
DALE BUMPERS SMALL FARMS RESEARCH CENTER
BOONEVILLE, ARKANSAS

The mission of the Dale Bumpers Small Farms Research Center is to develop scientific principles and technologies to enhance the profitability and sustainability of small-scale farms.

Dale Bumpers Small Farms Research Center
6883 South State Highway 23
Booneville Arkansas 72927

USDA ARS - Dale Bumpers Small Farms Research Center Research Initiative – Small Farms Technology Initiative: Bringing the Technology Revolution to Rural America

With 88% of farms in the U.S. classified as 'small farms' and less than 10% integrating agricultural technologies, there is a major opportunity to increase productivity and catalyze rural development. Previous research by USDA-ARS in Booneville and Fayetteville identified that adoption of precision agricultural technologies such as auto-guided tractors reduces over- application of nutrients and inputs by 10-20%, thus saving farmers $10.8-13.5 million annually by improving input efficiencies. Other technologies including high resolution soil maps have increased profits by 30% for small-scale commodities in Central America. However, uptake of these practices and technologies on small and beginning farms has been limited despite the increased efficiencies. Specifically, geospatial technologies use spatially explicit information to allocate precise resource amounts to production requirements. Machine-collected data, global navigation satellite systems, digital management applications, small Unpiloted Aerial Systems, satellite imagery, and associated computers and algorithms to analyze data are a few of these important innovations. Such technologies can be key to minimizing risk with real-time data, high-throughput processing for predictions, and automation for precision input applications. Research, outreach, and capacity building in this area is needed to improve rural technology transfer and agriculture-based economic growth.

The USDA-ARS DBSFRC is making strides in small farm technology innovations and applications, but research is needed for rural small-scale farmers, new developments, capacity building, and outreach. We are building on current research focused on automated tractor guidance for efficiency gains, satellite-based land observations, digital soil predictions for specific commodity production, precision inputs and digital management applications to create solutions-based approaches for data-driven decision making. The DBSFRC is striving to serve as the leader for global Small and Beginning Farm Technologies Center with the goal of improving farm operations, maximizing efficiency, and developing tools for high-tech rural jobs. With the technology revolution, cloud processing capability, and high-speed internet, rural America and underserved communities can reap benefits from the technology revolution.

Program Objectives & Approach

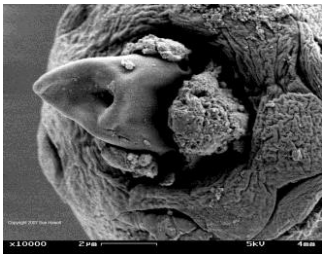
The Small Farm Technology Research Initiative is focusing on development, application, and assessment of technologies applicable for small farm systems. Small farm production systems vary from meat animal production, to specialty crops, to agroforestry, to commodity crops. The demand for technology development is great; however, the current adoption is low for small- scale and beginning farms. Although this initiative targets small and beginning farmers, these technology solutions scale to large-farm applications, hence serving the broader agriculture industry. Finally, this research initiative directly and proactively supports minorities, military veterans, Tribal farmers, and entrepreneurs in rural communities.

USDA Agricultural Research Service

Technology to improve U.S. sheep production

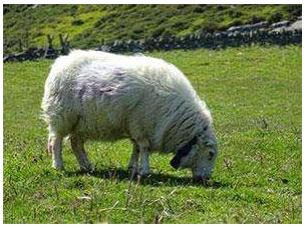
Problem

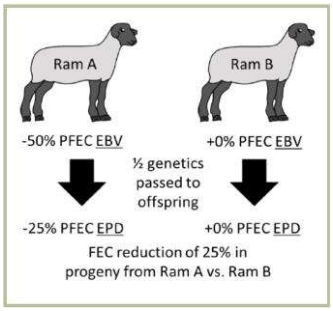
- Worm parasites cost the livestock industry billions of dollars each year. Ruminant livestock worms have become resistant to dewormers, thus alternative control needed. Genetics and behavior of animals will be key in managing worms. Parasite resistant sheep do not succumb to worm infections or need dewormer.

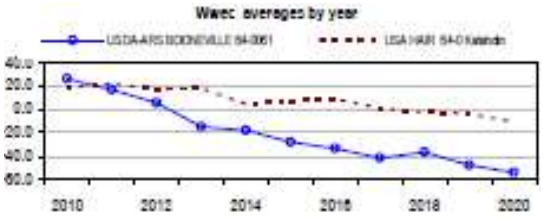


Objectives

- GPS Tracking Collars. To understand differences in grazing behavior between resistant and susceptible sheep using GPS tracking allows us to facilitate selection and manage livestock.
- Genetics/genomics databases. To select for parasite resistant sheep along with other economically important traits to eliminate need for deworming and produce more profitable sheep.





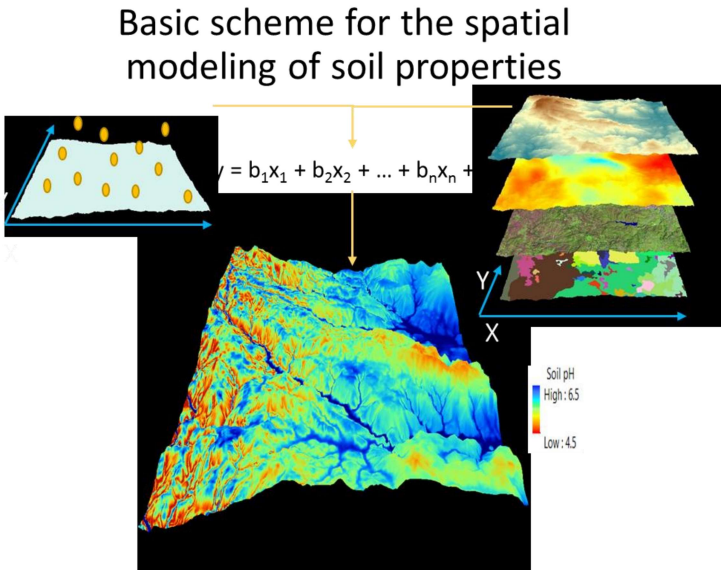


Accomplishments/Impact

- Preliminary GPS data are being analyzed that included resistant and susceptible weaned lambs.
- Increased parasite resistance in ARS and farm sheep flocks (see plot).
- Genomic enhanced estimated breeding values by the National Sheep Improvement Program (nsip.org) will be rolled out this fall which will increase accuracy of breeding values and selection responses. We established a 5000+ head reference population in collaboration with 21 farms, University of Nebraska, University of Idaho, SheepGenetics, Australia and others.

Digital soil mapping: *managing soil to manage water*

- **Overview:**
  - Digital soil mapping provides information on how soils function to a level (resolution) so that precision management can take place in real time.
  - ARS Researchers have patented this process and is used in precision agriculture platforms (this patent was purchased by the third largest seed company in the U.S.)
  - Farmers and Ministry of Agriculture in 4 countries in Central America are applying these maps for prescription management on small farms. Scientists and Farmers are finding that crop yields can increase up to 30% during drought when using these maps to manage soil to manage water.



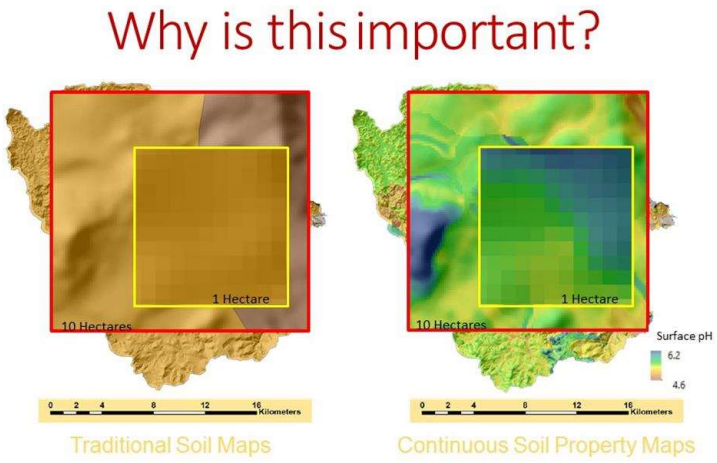
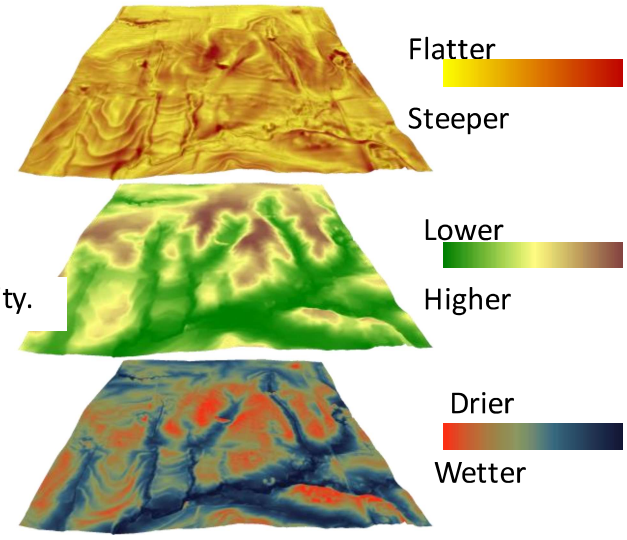


Image caption: depiction of the level of information provided for precision management by digital soil mapping. Image on the right shows soil surface pH in a 1 acre area mapped with traditional methods, with the image on the right being the same area, but with digital soil mapping. The image on the right is much higher resolution and allows for precision management of seed, fertilizer, and herbicide based on information provided in each pixel.

Digital Soil Information Produced are Being Produced on Tribal Lands for Improved Food Security

US Tribal Lands do not have detailed soil information provided to other US producers Ashworth and Owens are creating first ever continuous soil properties on tribal lands.

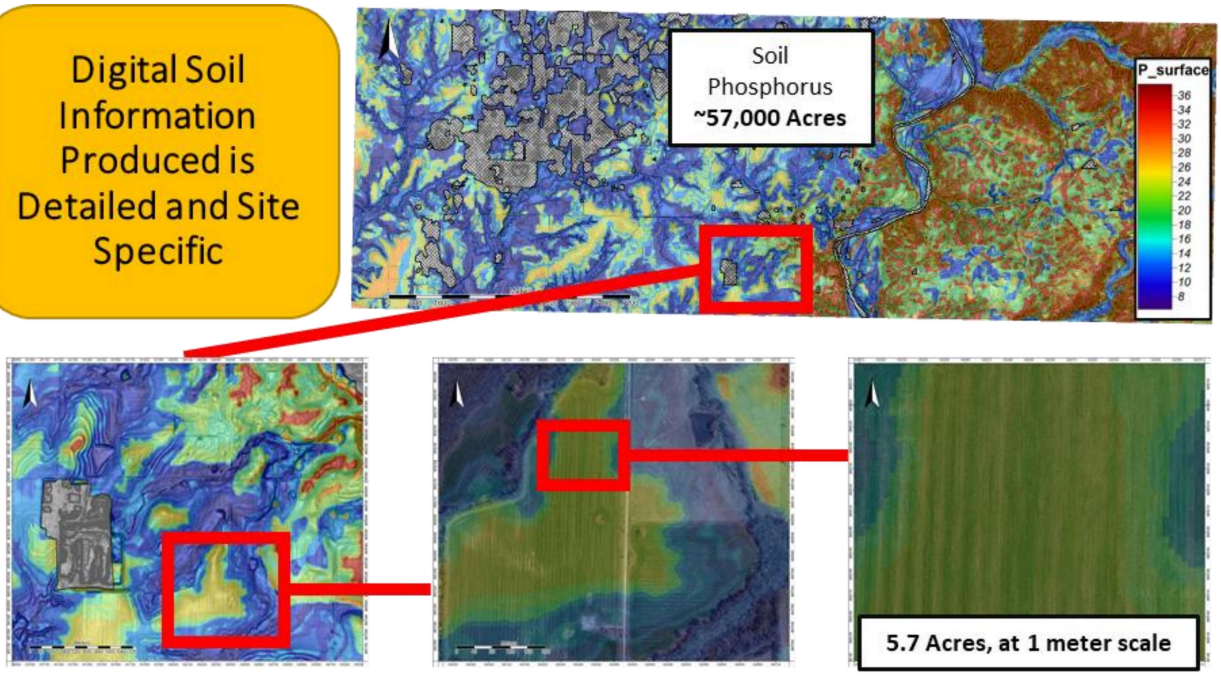
Information Related to Topography



Topography affects the soil moisture availability.

Different soils might be found across a farm of varying topography

Digital Soil Information Produced is Detailed and Site Specific



- First ever continuous soil property maps have been developed for Tribal Lands and are being used in Agricultural Resource Management Plans (57,000 acres currently).
- ARS Scientists are creating an App to house these spatially explicit soil maps so producers can pull up soil information for his/her farm in real time from a smartphone.
- Future work will focus on creating novel crop suitability models integrated with GIS soil mapping for precision soil management on U.S. Tribal Lands.

INDIGENOUS FOOD AND AGRICULTURE INITIATIVE
UNIVERSITY OF ARKANSAS

Tractor Guidance Systems

- **Overview:**
  - Tractor guidance (TG) systems use Global Navigation Satellite System (GNSS) to guide tractor paths and can result in 1-cm accuracy when applying fertilizer, seed, and herbicide, thereby resulting in precise input applications and efficiency gains.
  - Studies evaluating linkages between TG system, overlaps, input cost savings, and field terrain attributes are limited, especially on small farms.

- **Benefits of using automatic guidance systems include:**
  - Tractor guidance can reduce input use (fertilizer, seed, and fertilizer) by 10-20% and save U.S. producers $10.8-13.5 million per year by increasing equipment efficiency gains.
- **Investment cost is relatively minor but adoption of technology among small scale producers is low.**
- **Research focus:**
  - Break-even costs for this technology for small farms based on production (pasture, row and specialty crops) ranges from 50 to 100 acres.
  - Water quality and carbon savings from this technology.
  - Yield improvements based on this technology and other barriers for adoption using a decision support tool developed by ARS Scientist at Booneville and Fayetteville (decision support tool entitled "Tractor Guidance Analysis (TGA)".

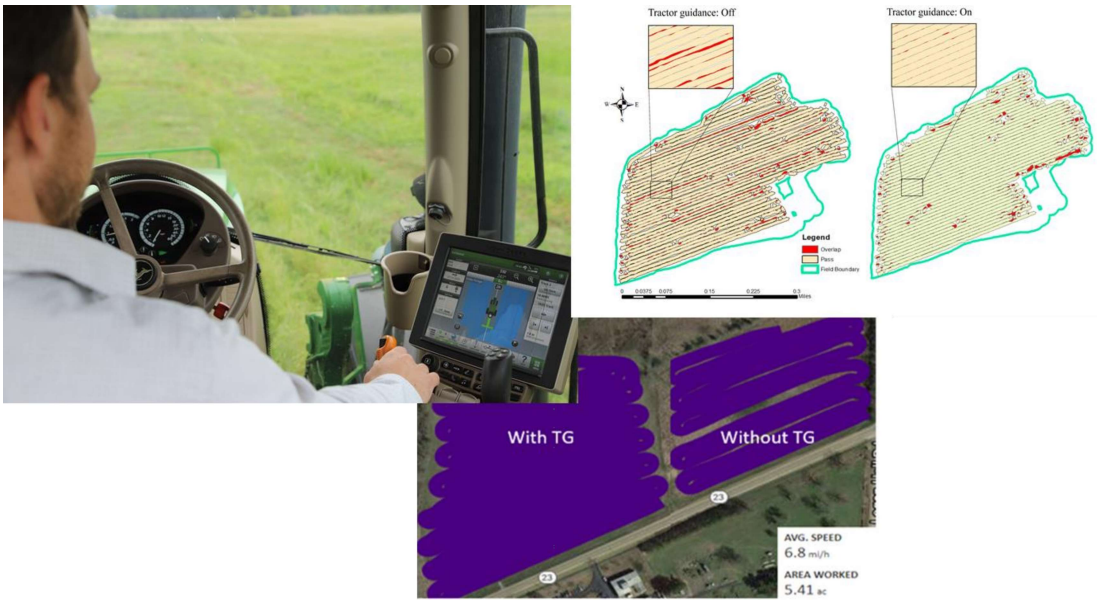


Image caption; An ARS team in Arkansas developed a method of analysis for comparing tractor-guidance systems to driving without tractor guidance. The focus of the research is to help farmers apply fertilizer, seed, and herbicide with more precision and less waste. The upper right image shows the difference in fertilizer overlap (red) when the tractor-guidance system is off (left) versus when it is on (right), thus resulting in 16% reductions in overlap. The bottom image shows an even application of fertilizer ("with TG") and more overlaps and gaps ("without TG").

Digital Soil Map and Global Position System (GPS) Cattle Tracking Application

- **Overview of coupling spatial monitoring technologies:**
  - Silvopastures combine animal and tree production into one system and can allow producers to respond to market variations through diversification, allow for reduced cattle heat stress during summer, and can store more carbon (in trees and soil).
  - ARS Researchers established an agroforestry site in 2000 at the UofA Agricultural Research and Extension Center in Fayetteville, AR. Two forages (native grass mix and orchardgrass) and two fertility rates were implemented to track grazing preference in a tree-livestock system.
  - Cattle grazing pressure was tracked with GPS tracking devices (green points below) and linked with continuous soil property maps (nutrients) and terrain features (slope, soil wetness, etc.)
  - Findings: cattle tracking shows grazing is linked to soil-water availability, which affected soil nutrients and crop growth (both trees and forage). Therefore, digital soil mapping helped explain biological responses that were observed in the field and linked soil—plants—and animal systems, as well as aided in the prediction of nutrient distribution for optimum forage and tree management.
  - Digital agriculture can help reduce inputs such as nutrients, seed, etc. in the field by predicting less productive areas which can improve economic viability in grazing systems. Scientists are using machine learning to tease apart some of these complex linkages for small farms.

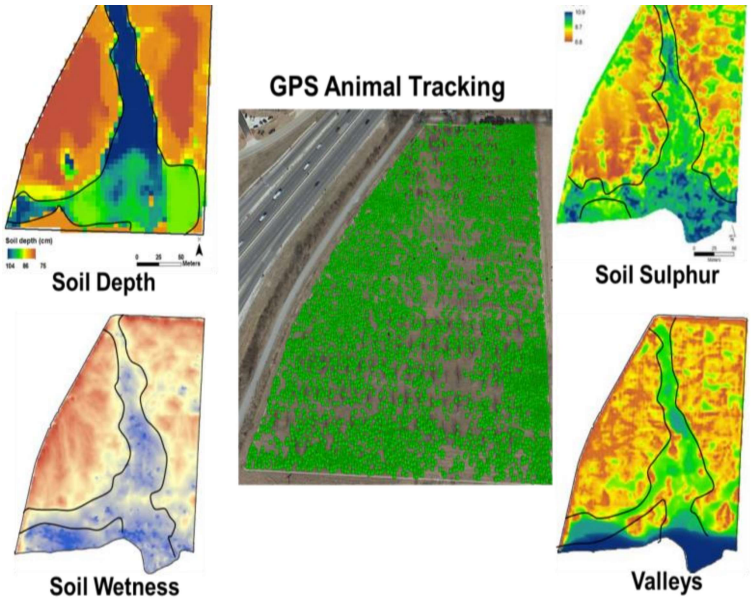


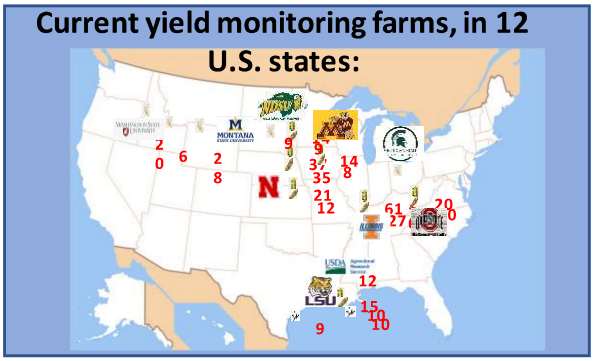
Image caption: digital soil property maps of soil wetness and nutrients are linked to cattle grazing (center image) in a 10-acre silvopastoral research site in Fayetteville, AR. Cattle tracking GPS satellite collars collect coordinates when their heads are down and grazing (green points), this is linked to plant growth, and ultimately soil properties predicted by digital soil mapping.

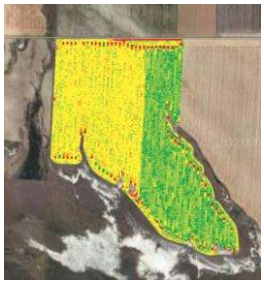
ars USDA

On Farm Experimentation: Developing an Automated Precision System Using Yield Monitoring and Soil Maps

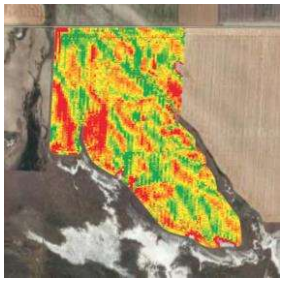
- **Project Overview:**
  - **Our multi-disciplinary team will work with a large, diverse set of farms and farmers to create a super-efficient, principally automated 'system' for on-farm precision experimentation (OFPE), the analysis of the data generated, and the practical application of that analysis to enable farmers to make data-informed input management decisions that improve both the economic and ecological sustainability of crop production, especially on small farms (see map below).**

- **Benefits of yield monitoring systems include:**
  - **Yield Monitoring is an aspect of precision agriculture that helps to provide farmers with adequate information to make educated decisions about their fields. It also allows farmers to show the effects of a change in field-management techniques (see seeding rate and yield map below), to develop nutrient strategies for their fields, and as a record of crop yield to use in securing loans or renters.**
- **Research focus:**
  - **The goal of this project is to allow NRCS to provide incentives to farmers that will increase, on a grand scale, the input use efficiency, profitability and sustainability of US crop production.**





Seeding rates



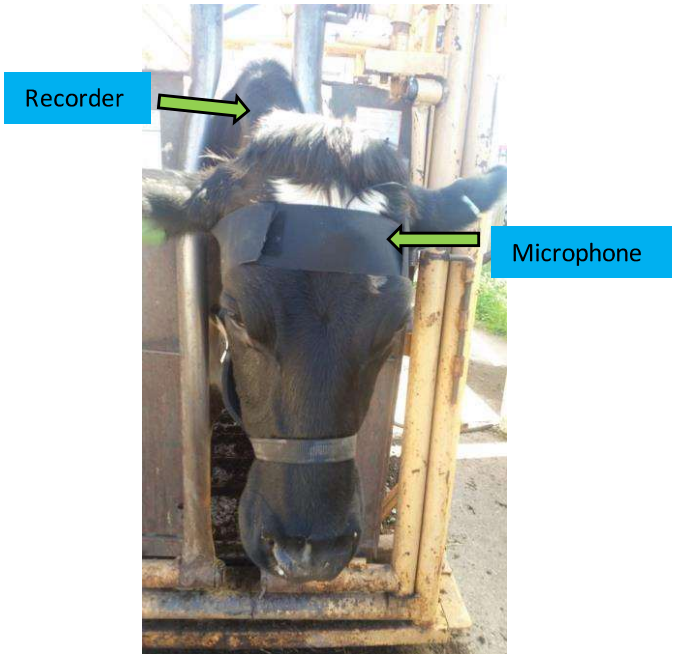
Yields

The system:

Acoustic sensors for quantifying grazing behaviors

- **Overview:**
  - Monitoring and quantifying grazing behaviors such as bites, bite rate, and when bites occur during the day, can help us understand factors affecting these behaviors and optimize them to increase cattle production and efficiency
  - Acoustic bite analysis can be correlated with rumen parameters such as pH, as shown in the figure below. Bites, intake, and bite and intake rate may also be correlated to other important variables such as forage height and biomass, temperature, precipitation, daylength, and many more variables.
  - Bites can be quantified manually or through event detection software. However, both methods are extremely time consuming. Development of machine learning or artificial intelligence methods could speed up the process, include long term data analysis, and could analyze several different variables including bite data from recorders, forage data from drones, and environmental data from weather stations.
  - Finally, the analysis of several different variables over time could lead to the development of a "smart farm" system that may send alerts to farmers from a cloud when abnormal behavior is detected. This technology will be beneficial to small farmers because automated monitoring systems will reduce labor costs and allow farmers a method for monitoring cattle remotely.

Placement for acoustic sensors



Digital recording (WAV) file

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Processing of WAV file using "Bite Detection" software

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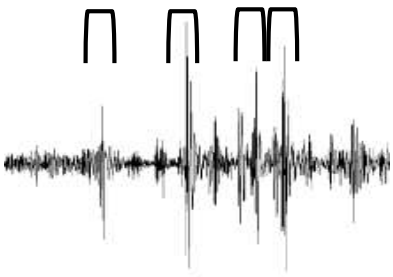

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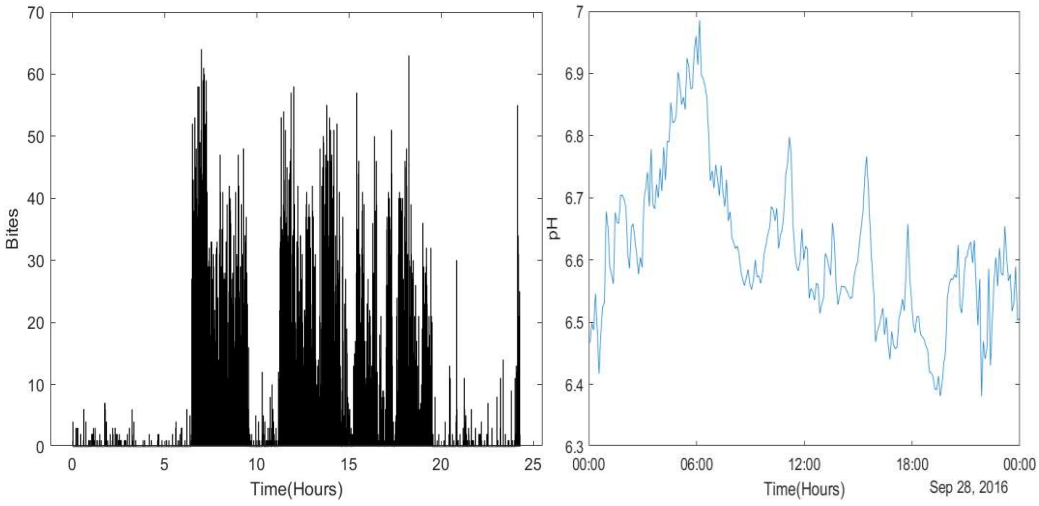
Quantify bites

What can we do with this data?



With additional sensors we can better understand the relationships between grazing behaviors and cattle intake and rumen function. These figures show the relationship between total bites and change in reticular pH, with pH decreasing when cattle are eating.

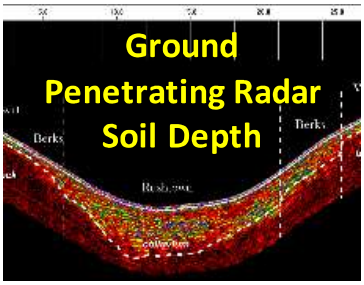
Developing Artificial Intelligence Infrastructure (AI) for increasing efficiency for On-Farm Precision Management

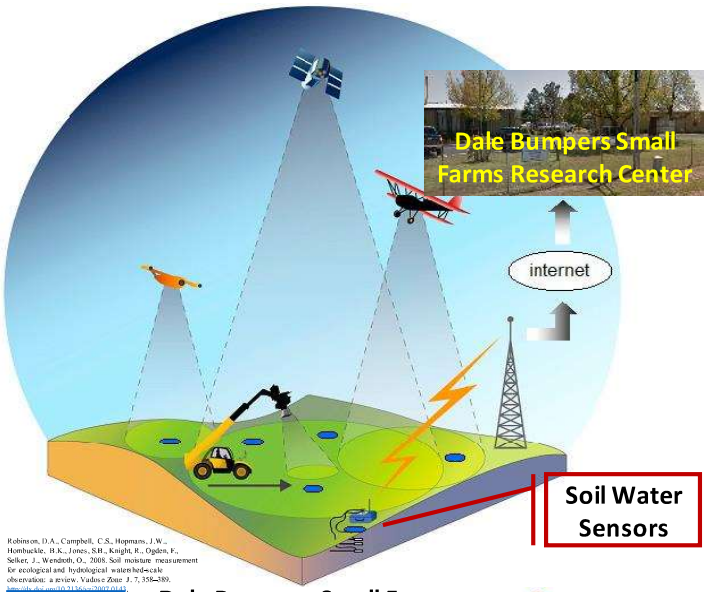
❖ Manage Systems to Manage Farms:

Farms are complex systems. Understanding and monitoring these systems increases the efficiency of farm operations and relate the performance with cost-benefit analysis, saving farmers money while reducing environmental risks.

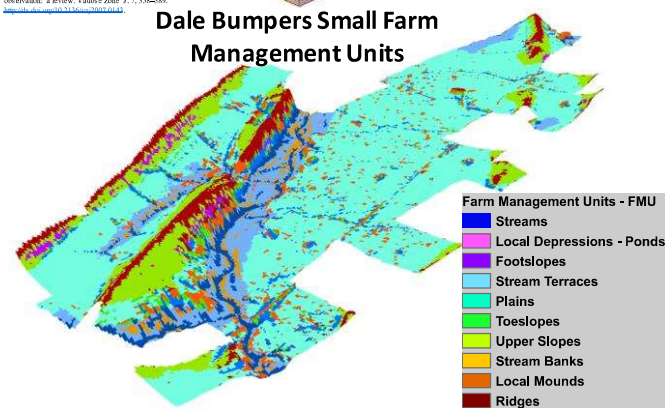
❖ Project Overview:

- ❖ Establish key components of infrastructure at farm level:
  - ❖ High resolution maps of soils and properties;
  - ❖ Sensors for monitoring soil water movement (soil moisture, water table, runoff);
  - ❖ Detailed maps of vegetation dynamics for crops, pasture and orchards using Drone;
  - ❖ Animal tracking using GPS.
- ❖ Combine key infrastructure components in a Digital Platform and utilize machine learning and artificial intelligence to understand the interactions at field level.
- ❖ Develop interactive friendly user platforms and tools for on-the-fly decision support for farms at field level (grazing, crop and animal rotations; agroforestry; water quality - hot spots, etc.,).





Dale Bumpers Small Farm Management Units



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The Dale Bumpers Small Farms Research Center is located in Booneville, AR
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