Grazinglands Research Laboratory

RESEARCH REPORTS 2017

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
GRAZINGLANDS RESEARCH LABORATORY
7207 WEST CHEYENNE STREET
EL RENO, OK 73036
1-888-608-2727
https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

Welcome to the Grazinglands Research Laboratory's 2017 Field Day!

The Grazinglands Research Laboratory (GRL) develops and delivers technologies, management strategies, and planning tools to evaluate and manage economic and environmental risks for integrated-crop-forage-livestock systems under variable climate, energy and market conditions. This research mission leverages diverse partnerships with federal, state, and local stakeholders.

Our research is organized in interactive and complementary Units focused on **Great Plains Agroclimate and Natural Resources** and **Forage and Livestock Production.** Additionally, the GRL leads the Southern Plains (SP) site of the Long-Term Agroecosystem Research Network (LTAR) and USDA's Southern Plains Climate Hub. Our objectives are to bridge gaps between farm management goals and goals that are shared across farms and communities using off-location research watersheds and the 6,700 ac GRL as outdoor laboratories; and develop techniques to enhance ecological function, resource-use efficiency, and sustainability of livestock production in the Southern Plains.

The laboratory assets and facilities include farm-scale pastures for evaluation of improved warm- and cool-season grasses, 1,000 ac. of wheat, and 3,000 ac. of tallgrass prairie; experimental beef cattle herds and extensive forage and animal research infrastructure; research greenhouses and laboratories for analysis of soil, plant, forage quality, and livestock fecal and blood characteristics; and climate, hydrology, remote sensing, and modeling research capacity.

Today's Field Day has been structured to share findings from our research that is conducted to address the ever changing challenges facing today's agriculture. Additionally, we will feature information about the GRL partnership with the BlueSTEM AgriLearning Center that is helping students, teachers, and families gain a better understanding of research and agriculture.

We hope you re-kindle old friendships, get to know our new research scientists, and go home with information that is useful to you!

Jean L. Steiner, Laboratory Director
and Research Leader

Great Plains Agroclimate and
Natural Resources Unit

Prasanna Gowda
Research Leader

Forage and Livestock
Production Research Unit

Page intentionally left blank

Grazinglands Research Laboratory

Mission: To develop and deliver technologies, management strategies, and planning tools to evaluate and manage economic and environmental risks for integrated-crop-forage-livestock systems under variable climate, energy, and market conditions.

Jean L. Steiner	Laboratory Director
Susan Eisenhour	Program Support Assistant
Brylee Vandiver	Office Automation Clerk
Eilene Gibbens	Administrative Officer
Wendy Leimbach	Administrative Support Assistant
Jack Robbins	Office Automation Clerk
Clendon Tucker	Station Operations Manager
Deryl Nelson	Agricultural Research Science Technician
Troy Gibbens	Maintenance Worker
In Recruitment	Facilities Maintenance
Steven Hudson	Automotive Mechanic
Logan Curtis	Student Worker
Dennis Wallin	Information Technology (IT) Specialist
Jason Jacobs	Information Technology (IT) Specialist

Great Plains Agroclimate and Natural Resources Research Unit

Projects and Objectives:

Towards Resilient Agricultural Systems to Enhance Water Availability, Quality, and Other Ecosystem Services under Changing Climate and Land Use.

- Quantify states, fluxes, and cycling of water, carbon, and hydrologic constituents within the soil-plant-hydrologic-atmospheric systems of selected landscapes, watersheds, and agricultural systems of the Southern Great Plains.
- Develop tools and techniques for the selection, placement, and evaluation of conservation and agricultural practices.
- As part of the LTAR network, use the Little Washita River/Fort Cobb Reservoir Experimental Watersheds to support research to sustain or enhance agricultural production and environmental quality.

Uncertainty of Future Water Availability Due to Climate Change and Impacts on the Long Term Sustainability and Resilience of Agricultural Lands in the Southern Great Plains.

- Develop new and enhance existing model components and methods to estimate long term trends, variations, and uncertainty in future water availability due to climate change.
- Determine the impacts of future variation or change in water availability on erosion, crop productivity, and resilience and sustainability of managed agricultural lands.
- Develop long-range planning information for policy makers, environmental organizations, and conservation planners on potential future water availability, cropland productivity, and water and soil conservation options that would maintain or increase the resilience and sustainability of agricultural lands.
- Through the Southern Plains Climate Hub, develop science-based, region-specific information and technologies for agricultural and natural resource managers which enable climate-smart decision-making and transfer the information and technologies to users.

Jean L. Steiner, Research Leader	Soil Science, Agroclimatology
Stephen Teet	Support Biologist – LTAR Coordinator
Brekke Peterson Munks	Research Associate (Soil Biology and Ecology)
Lauren Hanna	Student Worker
Cooper Sadowsky	Student Worker
Jorge Guzman, OU Post Doc	Modeling Complex Systems
Administrators Research Associate	Ecologist – in recruitment.
Jurgen Garbrecht, Lead Scientist	Hydrologic Engineer
Phillip Busteed	Support Hydrologist
Rabi Gyawali	Research Associate (Agricultural Engineer)
Daniel Moriasi, Lead Scientist	Research Hydrologist
Alan Verser	Hydrologic Technician
Haile Tadesse	Physical Science Technician/OEM
Amanda Nelson	Research Associate (Research Hydrologist)/OEM
Mansour Talebizadeh	Research Associate (Research Hydrologist)/OEM
Maci Harjo	Student Worker
Patrick Starks	Soil Scientist
Veronica Hall	Physical Science Technician
Danielle Walker	Student Worker
John Zhang	Research Hydrologist
Mark Smith	Hydrologic Technician
Soil Scientist (Biology)	In Recruitment
David Brown	Climate Hub Director
Caitlin Rottler	Climate Hub Fellow
Clay and Sarah Pope, CSP LLC	Climate Hub Coordinators

Forage and Livestock Production Research Unit

Projects and Objectives:

Integrated Forage Systems for Food and Energy Production in the Southern Great Plains

- Compare effects of different systems of intensive grazing on plant communities and soil properties of tallgrass prairie, and responses to applied management.
- Develop improved cool-season grasses that utilize water and nutrients efficiently.
- Identify forage species and management practices, including legume crops, that promote efficient resource use and increase year-round forage availability.
- Determine how SP forage-livestock systems interact with plants, soils, and climate with respect to C and N cycling, especially greenhouse gases.
- Define influences of Eastern redcedar on soil conditions of abandoned cropland and develop restoration practices for brushy native prairie.
- Provide decision-support tools for evaluating climatic risks and ecologic and economic outcomes of different production and conservation practices and strategies.

Improving the Efficiency and Sustainability of Diversified Forage-Based Livestock Production Systems

- Compare effects of different systems of intensive grazing on plant communities and soil properties of tallgrass prairie, and responses to applied management.
- Determine how Southern Plains forage-livestock systems interact with plants, soils, and climate with respect to C and N cycling, especially greenhouse gases.
- Evaluate efficient ruminant genotypes, feed intake, and nutrient-use efficiency of cattle fed varying proportions of forage and grain.

- Increase marketing options through methods to produce farm-finished beef.
- Provide decision-support tools for evaluating climatic risks and ecologic and economic outcomes of different production and conservation practices and strategies.

Prasanna Gowda, Research Leader	Soil Scientist
Jeff Weik	Biological Science Technician
Jesse DuPont	Chemist and Safety Officer, LTAR
Dorrie Parrott	Veterinarian
Kathie Wynn	Biological Science Technician
Pradeep Wagle	Research Associate (Ecologist)
Pradip Adhikari	Research Associate (Environmental Scientist)
Tanka Kandel	Research Associate (Agronomist)
Colton Flynn	Student Worker
Alicyn Harjo	Student Worker
Nisha Srinivas	Student Worker
Sophia Wilks	Student Worker
Kenneth Turner, Lead Scientist	Research Animal Scientist
Cindy Coy	Biological Science Lab Technician (Plants)
Craig Mittelstaedt	Agricultural Science Technician
Vacant	Agronomist (in recruitment)
Vacant	Plant Physiologist
Bryan Kindiger	Plant Geneticist
Steve Hamann	Agricultural Science Technician
James Neel	Research Animal Scientist
Scott Schmidt	Biological Science Technician
Neil Fobes	Agricultural Science Research Technician
Jacob Kastl	Animal Caretaker
Shane Russell	Animal Caretaker
Brian Northup	Ecologist
Kory Bollinger	Biological Science Technician
Delmar Shantz	Biological Science Technician
Kwyn Bollinger	Student Worker

Page intentionally left blank

Great Plains Agriculture and Natural Resources Research Unit

Forage and Livestock Production Research Unit

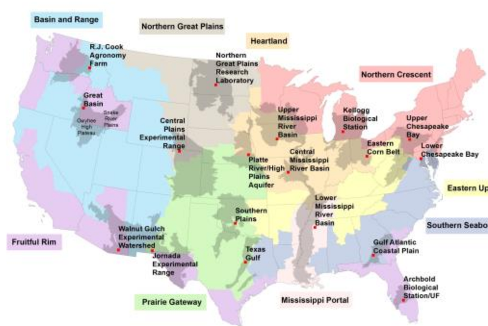
Education and Outreach

Long-Term Agroecosystem Research (LTAR)

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Agriculture faces tremendous challenges in providing a stable and affordable food supply; bioenergy production; protection of water, air, soil, and biological resources; and maintenance of rural economic vitality in the face of growing world population variable and changing climate, and competition for limited natural resources. Meeting the needs of future populations will require production of more food, fiber, and fuel from agricultural lands while protecting and sustaining environmental quality. The ability of US agriculture to adapt to changing demographic, economic, environmental, and climatic conditions while sustaining agricultural production and ecosystem services into the future is the focus of the Long Term Agro-Ecosystem Research (LTAR) network.

Objective: The LTAR network conducts long-term, trans-disciplinary research across major regions of the US to enhance sustainable intensification of agro-ecosystems and elucidate potential tradeoffs in alternative production strategies. The Southern Plains LTAR will focus primarily on forage-based beef production that links dual-purpose wheat, native prairie systems, and a variety of other pasture and forage crops. Such mixed land-use systems dominate the Southern Plains landscape and provide the largest farm-gate returns in the region. The grazing phases of the beef cattle life cycle - cow-calf, stocker, heifer replacement – will be the primary focus of the research.

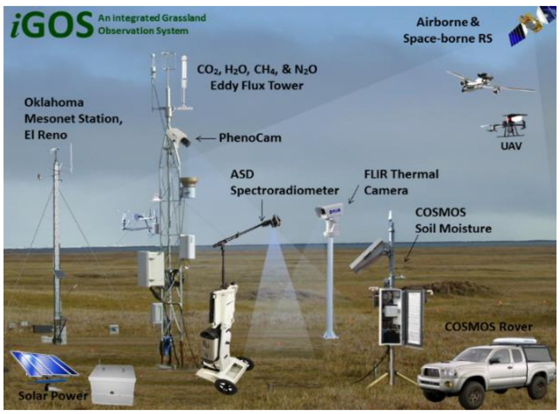


Map showing the LTAR sites within their farm resource regions.

What we are doing: The LTAR network will draw upon historical long-term data and rely upon cross-site research and common geographically-scalable databases to deliver knowledge and applications to address challenges related to productivity, climate variability and change, agricultural conservation and environmental quality, and socioeconomic ties to productivity, climate, and environment. The LTAR network strategy includes site based research, a Common Experiment that contrasts a "business as usual" versus an aspirational system that enhances productivity and ecosystem services that are relevant to each specific site. Delivery of long-term, standardized publicly-available data is a core element of the LTAR network. The Southern Plains common experiment will contrast conventionally-tilled graze-out wheat with no-till wheat-canola rotations (see p. 75 for further information). Two fields will have integrated cropland observation systems (iCOS) as illustrated below.

In addition, we will conduct research at two iGOS fields, one a native prairie pasture and one an Old World Bluestem pasture.

A variety of associated studies will address management of native prairie grazing, tillage-cover crop-fertilizer dynamics, soil microbiological processes, and nutrient use efficiency of beef cattle. Field and modeling assessment of climate variability and change, hydrologic processes, and soil moisture dynamics will span across the agroecosystems being assessed.



Summary: The Grazinglands Research Laboratory leads the Southern Plains site of the LTAR network. A goal of the LTAR network is to apply research results to solve critical challenges facing agriculture. The LTAR scientific foundation builds from a mixture of data from on-going networked science, new cross-site experiments, and long-term historical measurements. This foundational science approach is expected to lead to: 1) new technologies and management practices that address key problems facing agricultural production and natural resource conservation; 2) new knowledge of processes and systems central to US agriculture; 3) improved models that apply data, technologies and/or knowledge to characterize how agriculture meets multiple goals at regional, national and global scales; and 4) data sets that are globally accessible for scientific analyses.

Partners: University of Oklahoma, Oklahoma State University, Kansas State University, Texas AgriLife at Overton, and others.

Contact Persons:
Dr. Jean L. Steiner (Jean.Steiner@ars.usda.gov)
Dr. Prasanna Gowda (Prasanna.Gowda@ars.usda.gov)
Dr. Patrick J. Starks (Pat.Starks@ars.usda.gov)
Dr. Jurgen Garbrecht (Jurgen.Garbrecht@ars.usda.gov)
Dr. Daniel Moriasi (Daniel.Moriasi@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036
Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

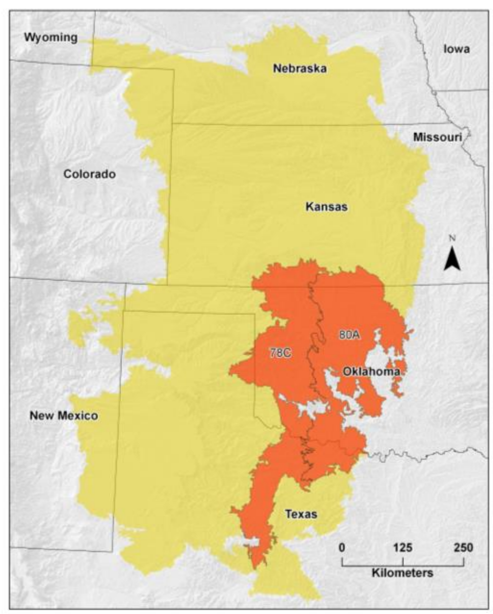
United States Department of Agriculture
Agricultural Research Service

Resilient Beef-Forage Systems: The NIFA-AFRI-CAP Partnership

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Beef produced on pasture and rangeland forages and dual-purpose winter wheat in the Southern Plains (SP: Texas, Oklahoma, and Kansas) provides a significant portion of the nation's red meat while contributing greatly to farm income in the region. However, beef production and farm income in the SP fluctuate wildly because of large climate variability. The 2010/2014 drought, terminated by some of the most extreme precipitation events on record, in loss of billions of dollars in the agriculture sector, raises questions about vulnerability and resilience of this important food supply system. What are future magnitudes of climate variability and change in the SGP? What are the most vulnerable aspects of the region's beef-grazing enterprises? How resilient are these enterprises to likely changes in climate, land use and markets? What management practices and technology innovations would strengthen the resilience and reduce carbon, nitrogen, and water footprints of these production systems? What are the tradeoffs between beef production and maintaining ecosystem services, both essential to meet needs of an increasing human population?

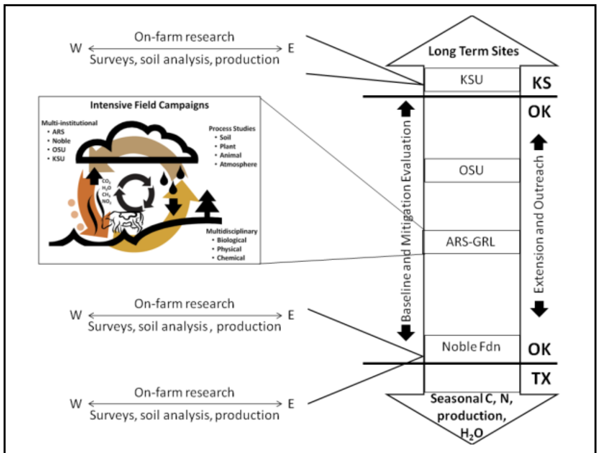
Objective: Our **long-term goals** are: 1) to better understand vulnerability and enhance resilience of SGP beef-grazing systems through introduction of diversified forages, improved management, multiple marketing options, strategic drought planning, and improved decision support systems for evaluation of alternative options; and 2) to safeguard and strengthen production and ecosystem services while mitigating greenhouse gas emissions in the SGP. Additional goals are:



The Southern Great Plains highlighting

- To build capacity and strengthen collaboration to empower and enable research and extension at a higher level of integration.
- To understand, monitor and forecast dynamics of beef–grazing production systems; and balance and safeguard the sustainability of beef production and ecosystem services.
- To provide timely and accurate information, decision support tools, management practices and technologies that will assist and empower producers to employ risk- and evidence- based information in their decision-making.
- To train and educate the next generation of ranchers, farmers and researchers to collectively address challenges due to climate variability, land use change and market dynamics.

What we are doing: A collaborative team of research and extension specialists from Kansas State University, the Agricultural Research Service at El Reno and Bushland, Texas University of Oklahoma, Tarleton State University Oklahoma State University, and The Samuel R. Roberts Foundation are conduct experiments at multiple scales to develop new knowledge and evaluate improved plant materials, animal efficiencies, and production practices; develop and apply improved models to understand how the systems may respond to varying climate and economic drivers; and link research closely with extension programs aimed to address producer needs and consumer preferences as related to beef production practices and products. The partnership leverages internal resources with external funding provided from 2013 to 2018 by the USDA-National Institute for Food and Agriculture (NIFA) as a Coordinated Agricultural Project in Climate Variability and Change. Baseline sampling across a network of long-term research sites has been collected since 2014 and intensive field campaigns began in 2014. In 2016, we partnered with the USDA Southern Plains Climate Hub to initiate a network of on-farm research focused on managing for improved soil health.



Coordinated research and extension at multiple scales

Summary: The project will advance adaptation of beef production systems to climate variability. In addition, improved management offers potential for mitigation of enteric methane emissions through improved forage quality and soil nitrous oxide emissions through improved nutrient management. Sustainable cow-calf and stocker cattle production systems and ecosystem services is essential for the regional economy and society at large. Information systems and decision support tools from the project can also be used in other parts of the world, where beef-grazing systems provide food and ecosystem services to billions of people.

Acknowledgement: This Partnership is led by Kansas State University and is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number 2013-69002-23146. For more information: www.greatplainsgrazing.org

---

Contact Persons:
Dr. Jean L. Steiner (Jean.Steiner@ars.usda.gov)
Dr. Prasanna Gowda (Prasanna. Gowda@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036
Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Climate Change, Decision Opportunities for Agriculture, and User Expectations

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

What is climate change?

Climate change is a change in the statistical distribution of weather patterns over an extended period of time. Climate change also refers to a change in average weather conditions, or in the variation of weather around longer-term average conditions.

How does climate change affect agriculture?

Most agronomists believe that place-based agricultural production will be primarily affected by climate variability and extreme events, and not so much by gradual trends in global climate patterns. Climate change affects crops differently across regions and uncertainties are large.

What are tactical and strategic decisions in climate change?

Tactical decision information has lead times of a month, season, or year. Sources of tactical decision information include short-term weather forecasts and seasonal climate outlooks. Climate change, as defined above, does not provide short term tactical decision information.

Climate change information is at a decadal to century time-scale and suited for strategic decision making. Agricultural issues that typically benefit from climate change information include management for long term sustainable agricultural production, investments in infrastructure development, and development of conservation programs for future climatic conditions. Sources of climate change information include climate projections with lead times of decades to centuries. The use of climate change information by agricultural producers is generally limited due to the long lead time and time spans needed to produce actionable information.

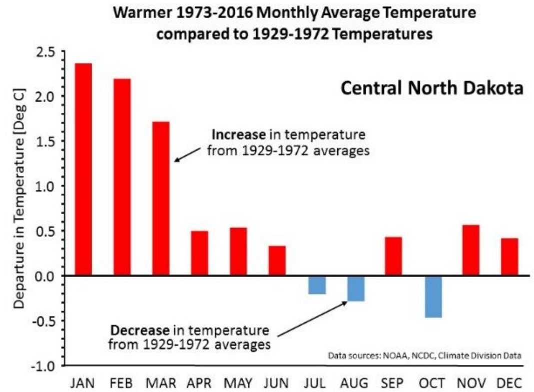
What are the uncertainties and risks in utilizing climate change information?

Climate change projections are associated with uncertainties and risk as to which future climate change scenario will be realized, which agronomic adaptation options are suitable for that scenario, and the cost and profitability of any projected production system. These considerations provide the basis for development of practical risk assessments. Different climate change scenarios alter the choice between different agronomic options to managing risk. Some uncertainty aspects may be irreducible and decision-makers will have to take action under significant uncertainty. Land managers, conservationists, water resources planners, and policy makers are more likely to be users of climate change projection information.

What examples exist of agricultural adaptation to climate change?

Climate change has already been occurring for over half a century and present-time climate change information has proven suitable for certain decision-making.

In the northern United States and southern Canada, the growing season has been warmer over the last few decades which impacts the length and timing of the season. Such climate change information provides adaptation opportunities to producers which results in more productive pastures, increased grazing capacity, and larger livestock herds. Additional producer intervention may arise from climate change related increased pests and diseases, competition from weeds, pathogens, soil erosion, and soil degradation.



Increased frequency of extreme precipitation events in the central and northeastern United States is another example of climate change information suitable for producer decision making. One-day very heavy precipitation has increased up to 70% since 1958 in that region. Agricultural producers adapting to climate change would benefit from implementing more effective soil conservation practices to offset the additional soil erosion.

How should climate change information be delivered to agricultural audiences?

Skepticism about the value of climate change for agricultural management is often an issue of information delivery and format, trust in the messenger, and unrealistic expectations for the tactical value of climate change information. Where possible, messages about climate change should be conveyed through trusted information brokers such as extension agents and crop advisors, rather than government scientists. Given the technical considerations of climate change information and the time frame at which climate information is strategically useful, agricultural producers are likely to be more open to and recognize the importance of adaptation to climate change for their production system when the information is expressed in agriculturally relevant terminology. For example, an increase in frequency in extreme precipitation events could be communicated as a previously experienced extreme event occurring every 5 years as compared to previously every 10 years without climate change. This information can subsequently be tied to the need to review and adjust soil conservation practices and crop insurance coverage. In addition, agricultural information brokers need to be better informed about the limitations of both seasonal climate forecasts as well as climate change-scale projections, including issues of probabilistic versus deterministic information and geographic scale.

Contact Persons:

Dr. David Brown (David.Brown@ars.usda.gov)
Dr. Jean Steiner (Jean.Steiner@ars.usda.gov)
Dr. Jurgen Garbrecht (Jurgen.Garbrecht@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036
Telephone: (405) 262-5291
FAX: (405) 262-0133

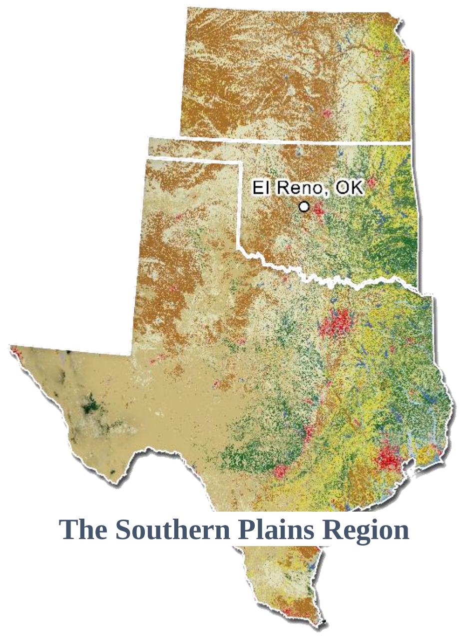
https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Southern Plains Climate Hub

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Agricultural production in the Southern Great Plains is challenged not just by long-term changes in the climate system but also by the impacts of increasing variability in day-to-day weather. Highly variable weather has been a benchmark of life and agriculture in the region since long before the states of Texas, Kansas, and Oklahoma were formed; coping successfully with the impacts of droughts, fires, floods, and other extreme events has long been a point of pride for agricultural producers in this region. Over the last two decades, however, an increasing frequency of extreme events has created a more challenging environment for producers and land managers. Agricultural systems are being repeatedly stressed, with increased risk to a wide range of economic enterprises. Given robust projections for increased warming over the coming decades, the impacts of extreme events in this region can be expected to continue and intensify. It is therefore critical that USDA and ARS facilitate the development of agricultural management options that will be resilient and productive under both increasingly variable weather and a changing climate.



The Southern Plains Region

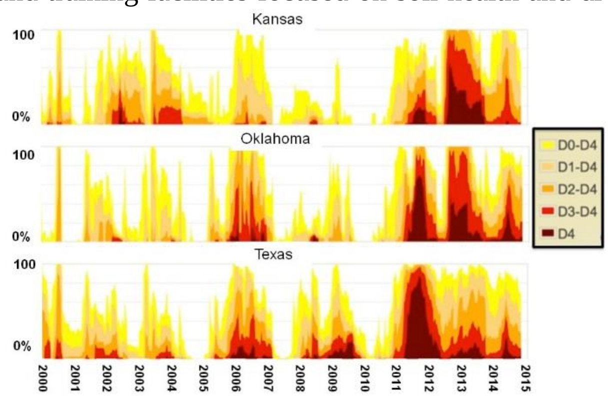
Objective: The Southern Plains Climate Hub, part of the ARS Grazinglands Research Laboratory, is a collaborative effort across USDA agencies. The Climate Hub works with a wide variety of partners to develop and deliver science-based, region-specific information and technologies to agricultural and natural resource managers that enable climate-informed decision-making, and to provide access to assistance to implement those decisions.

What we are doing: The Climate Hub provides outreach, education, and extension to farmers, ranchers, forest landowners, and rural communities on science-based risk management through critical partners such as land grant universities, Cooperative Extension, USDA service centers, and via public/private partnerships. We engage in user-inspired science and assess the vulnerabilities of and impacts to agricultural producers from weather and climate stressors. We facilitate the transfer and translation of science to producers and producer organizations through workshops and other regional events, and support regional implementation of USDA and ARS agency initiatives.

We have worked with Redlands Community College, the USDA Natural Resource Conservation Service (NRCS), and other government and private sector partners on a series of seminars and field days designed to educate farmers, ranchers, and other landowners on land-management strategies designed to help production agriculture better adapt to extreme weather events such as droughts and floods.

We have partnered with Texas Tech University and Texas A&M University's Cattle and Climate Coordinated Agriculture Project (CAP) to analyze communication tools for extension agents and USDA and partner personnel to increase their understanding of climate science and patterns in the Southern Plains as it affects livestock systems in the region.

Healthy soils provide one of the primary opportunities for agricultural adaptation to variable weather and changing climate in the Southern Great Plains, and we have engaged partners in efforts focusing on farm level demonstrations of these practices. These include the development of demonstration farms and training facilities focused on soil health and diversified cropping systems; for example, we have facilitated, in partnership with NRCS, two Native American tribal demonstration farms on land owned by the Cheyenne and Arapaho Nation and the Choctaw Nation of Oklahoma. We also are working with NRCS and Prairie View A&M on the establishment of a demonstration farm on their school land in southeast Texas. We have worked with Oklahoma 4-H, Texas 4-H, and private sector partners to establish soil health achievement awards and we are working with NRCS and the Soil Carbon Coalition to create a soil health curriculum supplement for agriculture education and FFA in the region.



http://droughtmonitor.unl.edu/MapsAndData/WeeklyComparison.aspx

We facilitate key interagency partnerships with other climate service provider organizations in the region, such as the Department of Interior's South Central Climate Science Center (CSC) and the Department of Commerce's Southern Climate Impacts Planning Program (SCIPP). These partnerships focus on science, such as contributions to the National Climate Assessment; outreach, including grant writing workshops for Tribes and participation in working groups to identify training needs and curriculum requirements; and communications, such as a joint newsletter currently in development. The Climate Hub is also designing a new website which will be released in the summer of 2017.

Key Partners: DOI South Central Climate Science Center, NOAA Southern Climate Impacts Planning Program, USFWS Great Plains and Gulf Coast Prairie Landscape Conservation Cooperatives, University of Oklahoma, Texas A&M University, Texas Tech University, Kansas State University, Oklahoma State University, National Drought Mitigation Center, Redlands Community College, Prairie View A&M University, Oklahoma Association of Conservation Districts, Texas Water Development Board, National Agroforestry Center

---

Project Contact Persons:
Dr. David Brown - Hub Director
david.brown@ars.usda.gov
Mr. Clay Pope: CSP, LCC - Hub Coordinator
claypope@gmail.com
Ms. Sarah Pope: CSP, LCC - Hub Coordinator
sarahmariepope@gmail.com
Dr. Caitlin Rottler - Hub Fellow
caitlin.rottler@ars.usda.gov
Mr. Jason Jacobs - Technical Specialist
jason.jacobs@ars.usda.gov

Dr. Jean L. Steiner - Lab Director
jean.steiner@ars.usda.gov

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036
Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.climatehubs.oce.usda.gov/southernplains

United States Department of Agriculture
Agricultural Research Service
Southern Plains Climate Hub

How Does Agricultural Management for Soil Health in the Southern Plains Impact a Suite of Soil Health Indicators?

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Background: Producers across the Southern Plains are expected to experience a number of impacts on their operations as a result of climate change, including more variable and extreme precipitation events, higher seasonal and annual temperatures, and more prolonged and intense droughts. One possible way of buffering systems against these expected changes is to promote soil health, as healthy soils are less likely to erode, have a higher water-holding capacity, and dry more slowly than unhealthy soils. A number of producers across the Southern Plains employ practices with a specific emphasis on soil health. Many of these are designed to reduce the amount of soil disturbance and promote the return of organic matter to the soil.

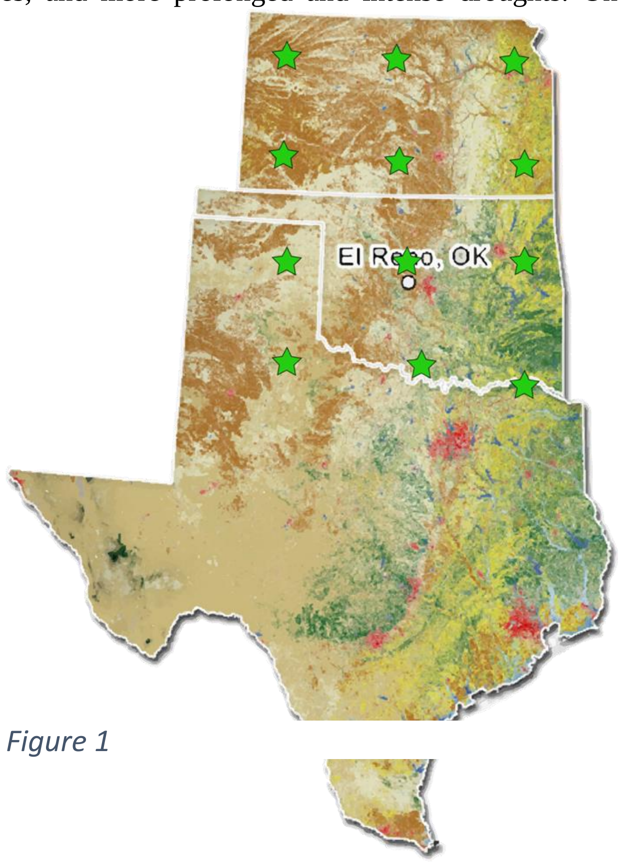


Figure 1

There is some evidence that these soil health management practices (SHMPs) do have a positive effect on soil health, but these effects have not been quantified using a standard method across the Southern Plains, and they have not been compared extensively to sustainably managed conventional systems. Wide variation in soil types along with pronounced temperature and precipitation gradients across the region further complicate and limit the realm of inference of results from any one producer or location. A better understanding of the effects of SHMPs at the region-wide scale is important to both scientists and producers working within the context of climate change and adaptation of regional agricultural production in order to improve resilience.

Objective: The objective of this study is to determine how soil health management practices such as no-till and the use of diverse cover crops affect a suite of soil health practices across the southern plains region of the United States.

Research Questions:

I. How do soils associated with SHMPs and Conventional Management (CM) differ with regards to physical, chemical, and biological soil health indicators?

   a.) How does soil structure associated with SHMPs compare to that associated with CM?
   b.) How do soil microbial communities associated with SHMPs and CM differ?
   c.) How do chemical properties of soil associated SHMPs and CM differ?

II. To what extent do SHMPs accomplish their goal of improving or conserving soil health across the Southern Plains when compared to sustainable traditional management?

What we're doing: We have identified twelve sites (Figure 1) from northern Kansas to northern Texas. At each site, we are coordinating with local producers to collect soil samples (Figure 2) from pairs of fields consisting of one SHMP field and one CM field, which we will then analyze for a suite of characteristics that are commonly used to indicate soil health. These include texture and bulk density (physical); percent organic matter and microbial community characteristics (biological); and percent carbon, percent nitrogen, pH, and electrical conductivity (chemical).

Figure 2

This study's paired design allows us to compare soils that have experienced very similar environmental conditions, reducing the likelihood that these same factors will have a disproportionately large impact on our results. We use paired statistical tests to identify where differences between management practices exist, and additional analyses to show the primary drivers of these differences and spatially relevant trends.

This work is being sponsored by USDA's Southern Plains Climate Hub, which is based at the Grazinglands Research Laboratory. The Hub's mission includes developing and delivering science-based, region-specific information and technologies to agricultural and natural resource managers that enable climate-informed decision-making, and the results of this project will be made available to producers throughout the region as part of Hub outreach and stakeholder engagement activities.

Project Contact Persons:
Dr. Caitlin Rottler - Hub Fellow
Caitlin.Rottler@ars.usda.gov
Dr. David Brown - Hub Director
David.Brown@ars.usda.gov
Dr. Jean L. Steiner - Lab Director
jean.steiner@ars.usda.gov
Clay & Sarah Pope: CSP, LLC - Hub Coordinators

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036
Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.climatehubs.oce.usda.gov/southernplains

United States Department of Agriculture
Agricultural Research Service

Adaptation of Soil Conservation Practices under Uncertain Precipitation and Air Temperature Projections: Proposed Research

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Winter wheat crops in the southern Great Plains have the potential of producing high soil erosion rates especially during the summer-fallow season. It is of concern to the conservation community that the current soil and water conservation efforts, based largely on climate observations and agronomic practices of the past century, may not keep pace with anticipated impacts of climatic change, especially under increased frequency of more extreme rainfall events. Changes in air temperature, precipitation, and frequency of extreme rainfall events are projected to stress agricultural soil and water resources over the next several decades. Challenges include an increase in production risks affecting crop yield and management and maintaining soil conservation within tolerable soil erosion limits. As such, it is critical to evaluate the impacts of future climate change on soil erosion to develop adaptive soil conservation strategies that maintain high crop yield. This knowledge will help maintain effective, competitive, sustainable, and environmentally responsible agricultural systems under changing climatic conditions.

Objective: Evaluate field-scale effects of future precipitation and air temperature projections on soil erosion and crop yield, and review adaptation options for soil conservation practices and associated winter wheat crop yields in central Oklahoma.

What we will do: We will use computer simulation of hydrologic processes, plant growth, and soil erosion to optimize the effectiveness of alternative conservation practices and agronomic crop management. To maximize crop yield it is necessary to assess anticipated future increases in soil erosion rates from winter wheat fields.

Proposed evaluation:

Soil erosion rates and crop yields under a variety of combinations of climate change scenarios, climate projections, tillage practices, and summer cover crops will be simulated.

The analyses will include the combination of the following climate and soil erosion models:

- 3 climate change scenarios: low, medium, and high greenhouse gas concentrations
- 15 different climate projections
- 4 tillage practices: conventional, conservation, minimum till, no-till
- winter wheat and two summer cover crop: fallow, sorghum, sudan grass

Synthetic daily weather, soil erosion, and crop yield will be simulated by SYNTOR and Water Erosion Prediction Project (WEPP) computer programs. Potential daily weather and soil erosion outcomes will be simulated to capture the uncertainty associated with future weather realizations. The soil erosion rates of each combination will be grouped and characterized by a statistical distribution. The distribution characteristics will be used to assess and rank the effectiveness of the various management combinations to maintain soil erosion at tolerable levels.

Expected outcomes:

This research will result in the following outcomes:

- Identify promising combinations of conservation tillage system(s) and summer cover crops to offset the anticipated increase in soil erosion rates due to climate change while maintaining high crop yield.
- Provide information on the uncertainty of achieving the desired reduction in projected soil erosions rates and maintaining current crop yields.
- Determine the long term sustainability of selected tillage-cover crop combination and crop yield.

Contact Persons:

Dr. Jurgen Garbrecht (Jurgen.Garbrecht@ars.usda.gov)
Dr. John Zhang (John.Zhang@ars.usda.gov)
Dr. Jean Steiner (Jean.Steiner@ars.usda.gov)
Dr. Rabi Gyawali (Rabi.Gyawali@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Tailoring Climate Change Information to Facilitate Agriculture Decision Making

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Resource management agencies seek to incorporate climate change information into long term infra-structure investments and adaptation planning to reduce climate change risks and vulnerabilities. In order to make such infra-structure investments or formulate adaptation policies in response to climate change, resource managers/decision makers require both “useful” and “actionable” information regarding future climate change and variability. Global Climate Models (GCMs) and Regional Climate Models (RCMs) are the best tools available to generate future climate projections. Arguably, these tools are necessary, but insufficient for impact assessments which require linking bottom up vulnerability assessment with multiple sources of climate information. Given the multitude of plausible projections of future climate, the computational and analytic requirements for assessing climate change impacts often deters analysts from identifying the climate hazards, further confounding the decision making process. Herein, we develop and demonstrate approaches to mitigate computational burden of climate change analyses, and ways to integrate the state-of-art climate information from future climate projections in the context of Agriculture decision making (ADM).

Objective: The objectives of this study are: (i) to develop approaches to reduce the computational burden of climate change analyses and integrate climate change information in ADM; (ii) use downscaled CMIP 5 GCM projections to select climate realizations to efficiently explore wide range of climate projects relevant for ADM; (iii) identify the subjectivity underlying climate model scenario selection and associated agricultural impact sensitivities.

What we are doing: Climate projections representing GCMs and future greenhouse gas emission scenarios are being analyzed. Future transient and period based changes relative to a baseline historic period are being evaluated. Analysis using inter and intra-model variability, weather generator, ensemble approach, period change methods are being carried out with a decision centric perspective. A decision centric climate risk assessment approach is being developed using multiple sources of climate information.

Expected Outcomes: To efficiently explore the range of climate change risk in the context of ADM, we argue that the primary approach to assessing climate change impacts, only through GCMs to estimate impact variables, is far from complete. It is critical to incorporate both "science centric" and "decision centric" approaches for GCM application is agricultural impact assessments.

Climate information, at its face value, may not directly benefit agricultural decision horizons that span 1 – 5 years. However, long term engineering decisions, e.g. Infra-structure design/investments, flood control, land use planning, and reservoir operations are influenced by climate change and inherently shape short-term agricultural decision horizons.

The gulf between the "climate scientists" and farmers in terms of relevant knowledge is large. There is a great need for participatory approaches among climate scientists, farmers, farm business analysts, and agricultural scientists within farming systems research to serve as a conduit to farmers regarding impacts of, and adaptation to, climate change.

Contact Persons:

Dr. Rabi Gyawali (Rabi.Gyawali@ars.usda.gov)
Dr. Jurgen Garbrecht (Jurgen.Garbrecht@ars.usda.gov)
Dr. Prasanna Gowda (Prasanna.Gowda@ars.usda.gov)
Dr. Jean Steiner (Jean.Steiner@ars.usda.gov)
Dr. David Brown (David.Brown@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Evaluation of Downscaled Daily Precipitation for Field Scale Hydrologic Applications

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Recent dissemination of statistically downscaled Global Circulation Model climate projections are commonly used to investigate climate change impacts. Landscape and environmental features affected by anticipated climate change include air quality, flood control, water quantity, water quality, agricultural crop production, soil erosion, adaptive planning, and ecosystem management.

Simulation of hydrologic, agronomic, and conservation activities require reliable representation of precipitation characteristics, in particular wet-day/dry-day sequences, as well as physically meaningful and realistic precipitation distributions. Monthly precipitation projections representing various climate change scenarios have been available for over a decade. More recently, Bias Corrected Constructed Analogue (BCCA) daily precipitation projections have been developed.

In this study, the accuracy and appropriateness of BCCA precipitation projections for field-scale hydrologic applications was examined for central Oklahoma climatic conditions.

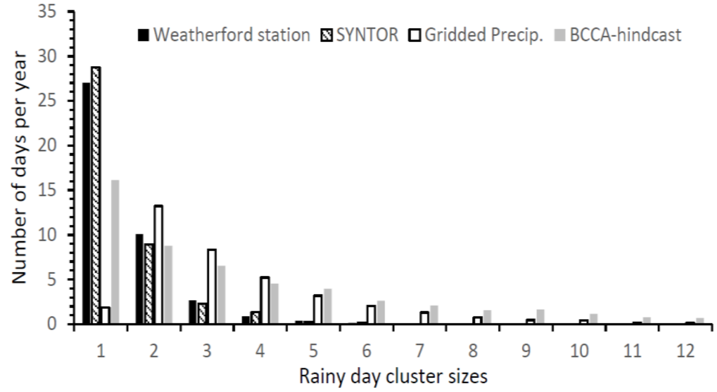
Objectives: (1) to review the ability of BCCA daily precipitation hind-casts to replicate wet-day and dry-day sequences of locally observed daily precipitation; and (2) to demonstrate that statistical downscaling based on a synthetic weather generator can replicate number of rainy days, amount of rain on a rainy day, rainy-day cluster distribution, and wet-dry/dry-wet day sequences of observed daily precipitation.

What we did: We evaluated the BCCA daily precipitation hind-cast time-series to determine their suitability to study daily soil moisture dynamics at the field-scale for central Oklahoma climatic conditions.

Three daily precipitation data sets were considered in this evaluation: (i) the 1961-1999 BCCA precipitation projections for a 12 km grid in central Oklahoma; (ii) the 1961-1999 spatially interpolated daily precipitation data used in the BCCA downscaling procedure; (iii) the 1961-1999 observed daily precipitation observations at the Weatherford COOP weather station located within the 12 km grid of the BCCA projections.

Results: Results showed that BCCA daily precipitation hind-casts compared to observations display (i) a large number of rainfall days; (ii) a smaller rainfall amount on rainy days; (iii) a high clustering of consecutive rainy days; and (iv) a high probability of a wet day following a wet or dry day.

These shortcomings may impact field-scale hydrologic investigations by leading to higher infiltration amounts and lower surface runoff volumes.



Given the aforementioned shortcomings, caution is advised to end-users to use BCCA daily precipitation products judiciously- particularly for field-scale hydrologic applications that require reproducing sequential rainfall patterns. Statistical downscaling based on stochastically generated weather reproduced daily observed daily precipitation patterns.

Contact Persons:

Dr. Rabi Gyawali (Rabi.Gyawali@ars.usda.gov)
Dr. Jurgen Garbrecht (Jurgen.Garbrecht@ars.usda.gov)
Dr. John Zhang (John. Zhang @ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

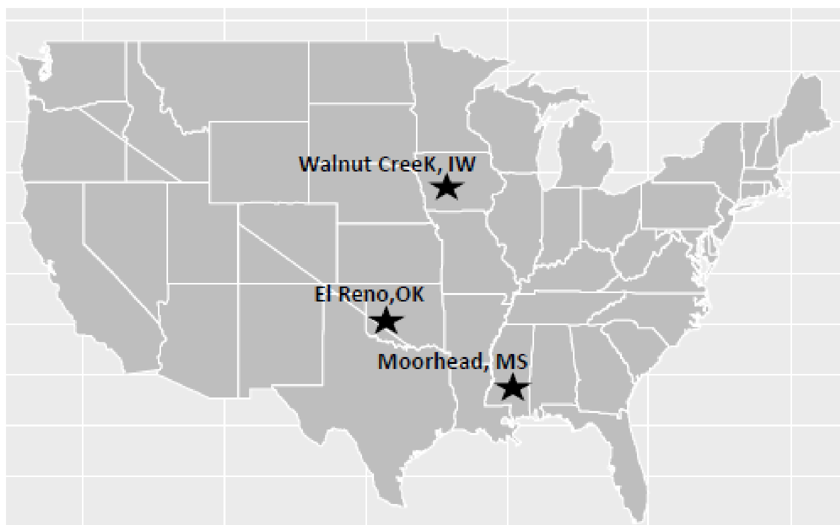
https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Application of the State-of-Art Rainfall Disaggregation Model and Assessment of Rainfall Properties

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Precipitation time-series at sub-daily time scales are important because they support detailed assessment of a wide range of applications, including studies of soil carbon storage, soil productivity, soil moisture dynamics, plant growth modeling, etc. However, sub-daily precipitation records are typically limited. Precipitation data are mostly available at daily or coarser time-steps. Of the 25,000 daily recording precipitation stations in the entire United States, only 8,000 stations record hourly data.



Furthermore, observed hourly records are available for relatively short time periods and often impaired by missing data and record keeping inconsistencies.

Rainfall disaggregation techniques address the constraint of data availability by generating finer temporal resolution rainfall time-series. Several disaggregation methods of varied complexity have been used for the enhancement of data records. However, the challenge remains to preserve the statistics of observed sub-daily series in model simulations to the extent possible.

We assessed the state-of-art rainfall disaggregation model HyetosMinute, which enables rainfall sequences to be generated at sub-daily time-scales. The model was applied in Southern plain stations of the United States at El Reno, OK, Ames, IW, and Moorhead, MS using 15 years of observed hourly and daily precipitation records from 2000-2015.

The reliability of disaggregation model, issues in temporal disaggregation, and representation of observed rainfall could be used to interpret the design storms of hydrological systems under current and future climate change conditions.

Objective: The objectives of this study were: (1) to evaluate the stability of parameters within HyetosMinute model over 5-, 10-, and 15-years at the aforementioned locations based on 15 years of continuous hourly data from 2001-2015; 2) to evaluate HyetosMinute disaggregation model ability to represent rainfall sequencing at three geographic locations, El Reno, OK; Ames, IW; Moorhead, using the properties that are included in the fitting procedure..

What we did: We used observed hourly and daily precipitation time series of a record length of 15 years (2000-2015), pertaining to El Reno, OK; Moorhead, MS; Ames, IW, to estimate parameter inputs to the disaggregation model HyetosMinute. The disaggregation scheme based on the mathematical formulation of estimated parameters was applied to daily rainfall data to obtain hourly time-series. Next, we evaluated HyetosMinute disaggregation model ability to represent rainfall sequencing at the above three geographic locations using analytical equations, cumulative distributive functions (CDFs), and cluster analysis.

Results: The comparison of the observed and model generated disaggregated data indicated the appropriateness of the model estimates at the study locations. Contrary to the general expectation that longer time series of hourly data would yield robust parameter estimates, the parameters obtained from 5-, 10- and 15- year windows of observed hourly data at El Reno, Ames and Moorhead stations were similar and within a range of 13.1%. The clustering analysis suggested that the HyetosMinute disaggregation may not reflect the sequencing characteristics of larger storm events with high precipitation intensity and duration. Thus, caution is advised when using HyetosMinute rainfall disaggregation while considering extreme events for hydrologic investigations.

Contact Persons:

Dr. Rabi Gyawali (Rabi.Gyawali@ars.usda.gov)
Dr. Jurgen Garbrecht (Jurgen.Garbrecht@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

High Density, Short Duration Grazing Impacts on Native Prairie Soil and Vegetation

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: The Great Plains is one of largest expanses of prairie ecosystems in the world. Prairies, particularly tall grass prairies, have been predominantly converted to other land uses. The remaining prairie ecosystems can be productive for livestock grazing and provide numerous benefits of high carbon soils and sink for atmospheric carbon, clean water, and diverse habitat for avian, terrestrial, and aquatic species. Resource concerns on Great Plains native grazing lands include invasion of brushy species (e.g., Eastern redcedar, mesquite); low productivity land (e.g., highly eroded, former cropland returned to grassland after Dust Bowl and droughts in 1950s); and unstable stream networks (bank failure, gully erosion, headcuts) that may be associated with livestock traffic and loss of vegetative cover near steams. Grazing management systems need to be developed to address these concerns.

Objective: Determine if the impacts of short duration, intensive grazing (mob grazing) on soil and plant properties is comparable to that observed in continuous and rotational grazing.

What we are doing: Continuous and rotational grazing trials were established in native prairie pastures in 2009, with two replicates of each treatment (Fig. 1). One herd of cows is assigned to each continuous or rotational replicate. Exclosures are used to establish subplots within the continuous treatments (Pastures Ca and Cb, Fig. 1) to examine impacts of high stock density on vegetation and soil characteristics. Each site has a 1 acre and a 0.5 acre exclosure to provide different stocking densities.

Over a 3-day period each year, the 25-cow herds assigned to Pastures Ca and Cb are confined into a 1 acre subplot for 24 hours, returned to the continuous paddock overnight, and then confined into a 0.5 acre subplot for 24 hours. In 2017, this was the equivalent of 21, 782 lbs/acre stocking density for the 1acre plot and 43,565 lbs/ac for the smaller plot.

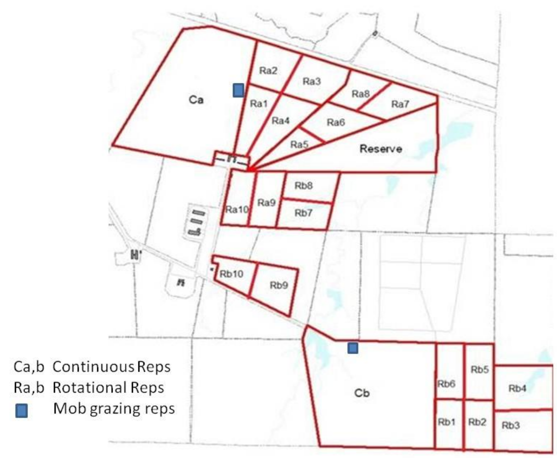


Fig. 1 Plot map for native prairie grazing study

Land Health Indicators of system performance

Vegetation indicators include biomass, basal area of perennial grasses and bare ground, and litter. Remote sensing methods will be applied in the future to determine greenness index over time and forage quality over time and space.

Productivity indicators include grazing days per unit area, body condition index, calving rate, and weaning weight.

Soil indicators include carbon and nutrient dynamics (**In collaboration with Dr. Alan Franzluebbers, USDA-ARS, Raleigh, NC**), aggregate stability, and aggregate size distribution. In the future, phospholipid fatty acid profile, soil respiration, soil greenhouse gas emissions, and infiltration will be determined.

Baseline soil samples were collected from each paddock in 2009 and again in 2012. Treatment effects on soil respiration and soil microbial biomass are shown at right (Fig. 2).

Sampling is planned in fall of 2017 to evaluate the longer-term treatment effects on soil, vegetation, and productivity indicators for the 2009-2017 period.

(See associated fact sheets enclosed herein that describe fluxes of nitrogen and phosphorus as a function of grazing management and location within pastures.)

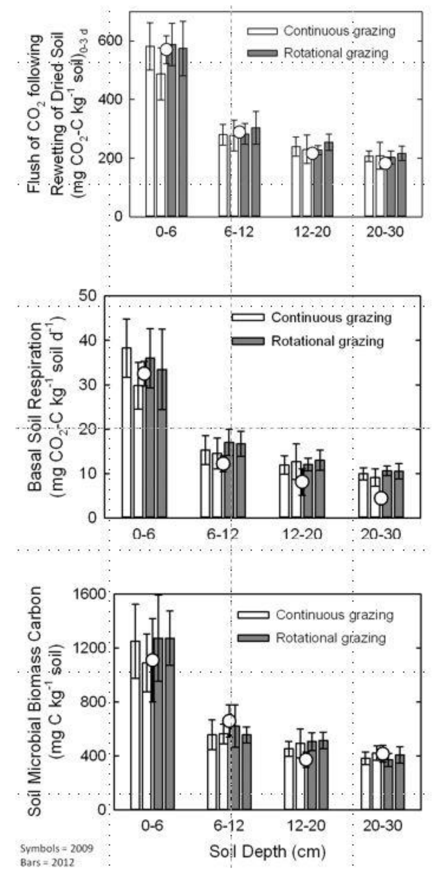


Fig. 2 Effect of 4 years of rotational and continuous grazing on soil (data from A. Franzluebbers.)

Contact Persons:

Dr. Patrick Starks (Patrick.Starks@ars.usda.gov)
Dr. Jean Steiner (Jean.Steiner@ars.usda.gov)
Dr. James Neel (Jim.Neel@ars.usda.gov)
Dr. Brian Northup (Brian.Northup@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Soil Nitrogen and Phosphorus Flux from Cattle Excreta Part I: Comparing Three Forms of Grazing Management

Grazinglands Research Laboratory, El Reno, OK May 2017

Rationale: Large pastures managed with beef cattle that continuously graze year round typically develop areas where overgrazing is evident. Overgrazing often results from cattle consistently re-grazing areas by selecting immature and more nutritious forage plants in these areas. Forages in the ungrazed areas of pastures become mature and less nutritious for grazing cattle. Dividing large pastures into smaller paddocks and rotating cattle among paddocks can result in more uniform grazing and utilization of forages and more even distribution of nutrients from urine and feces in paddocks. Feces and urine recycled to pastures by grazing cattle provide important sources of both nitrogen and phosphorus. Limited research has been done in regards as to how different grazing managements may influence the fluxes of these nutrients in the native pasture soils.

Objective: To determine if the flux of nitrogen and phosphorus in soils of native pasture differed among three systems of grazing management: continuous, rotational, and short-term mob grazing by cow/calf pairs.

What We Did: Cow/calf pairs were managed year-round on continuous and rotational paddocks and in 24-hour grazing bouts on 0.5 and 1.0 acre paddocks beginning in 2009. Rotational pastures were allowed 120 to 180 day rest periods between grazing bouts, while the mob-grazed pastures were grazed once per year. Numbers of animals applied were: 18 cow/calf pairs on 148 acres (150 lb of cow/ac) for continuous grazing; 25 cow/calf pairs on 190 acres in 10 paddocks (165 lb of cow/acre) for rotational; and 25 cows for 24 hours one time per year on the 0.5 and 1.0 acre pastures in mid-August. In spring 2015, transects were laid out from the water source to pasture centers in sets of the pastures under the different forms of management. Pairs of anion and cation probes were inserted vertically into the soil at 0-3 in and 3-6 in depths. The probes were left in place for 2 weeks, then removed and nitrate and phosphorus fluxes determined.

Preliminary Findings--after six years:

- All forms of grazing management resulted in hot spots of nutrient flux of varying degrees in soils after 6 years of applied grazing regimes.
- Continuous stocked pastures had more uniform distribution of nitrate flux (top panel of figure). Pastures managed under the other forms of grazing showed hot spots in nitrate flux; location of hot spots within pastures under different management systems was not consistent.
- Rotationally-grazed pastures had hot spots near water tanks; mob-grazed pastures had hot spots at center of pastures (PC) and 70% of distance between tanks and PC.

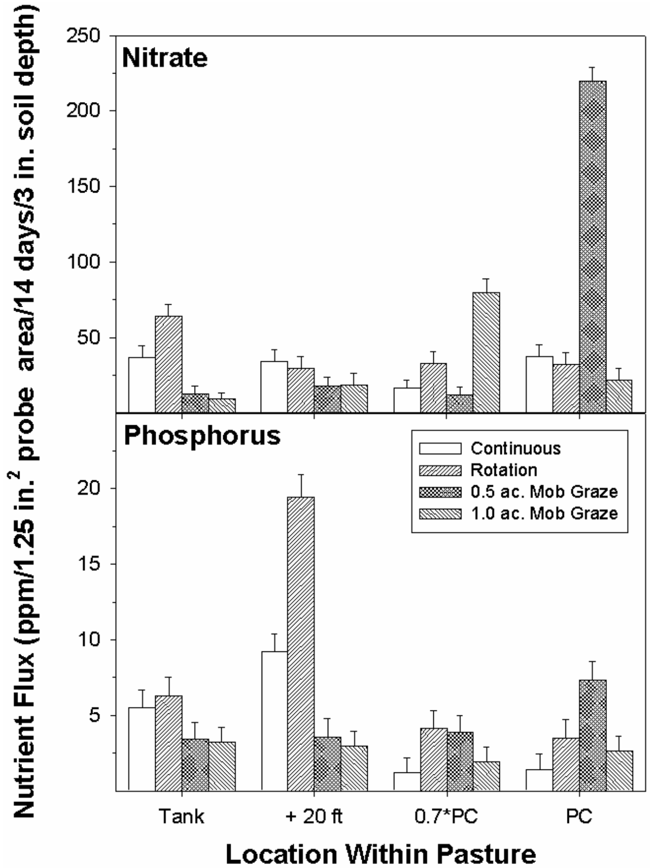
▪ Continuous and rotationally grazed pastures had hot spots in phosphorus flux close to water tanks, compared to pasture centers (bottom panel, figure at right).

▪ Mob-grazed, 0.5 acre pastures had hot spots in phosphorus flux near pasture centers.

▪ Hot spots in flux of both nutrients noted in response to rotational and mob grazing occurred after long rest periods from grazing; 6.5 months for rotation, 7.5 months for mob grazed. (Continuous pastures were grazed by cattle year round without rest periods.)

▪ Such results indicate that 6 years of applied management did not prevent development of point source nutrient concentrations that can affect quality of ground or surface water. Some grazing systems may make it more difficult to identify the location of such potential pollutants.

▪ Additional measurements are being collected to determine if the distribution patterns in nutrient flux within the rotational and mob grazed pastures occur immediately after grazing of pastures.



Contact Persons:

Dr. Patrick J. Starks (Patrick.Starks@ars.usda.gov)
Dr. Kennneth Turner (Ken.Turner@ars.usda.gov)
Dr. Brian K. Northup (Brian.Northup@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Soil Nitrogen and Phosphorus Flux from Cattle Excreta Part II: Spatial Distribution in Continuous and Rotationally Grazed Systems

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

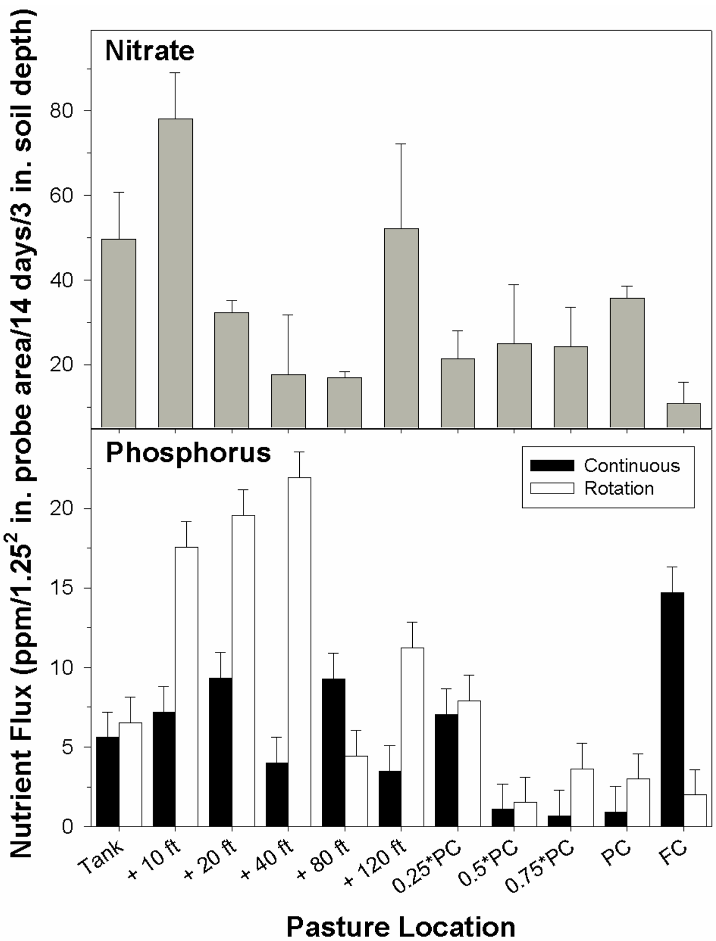
Rationale: Large pastures managed with beef cattle that continuously graze year round typically develop areas where overgrazing is evident. Overgrazing often results from cattle consistently re-grazing areas by selecting immature and more nutritious forage plants in these areas. Forages in the ungrazed areas of the pasture become mature and less nutritious for grazing cattle. Dividing large pastures into smaller paddocks and rotating cattle among paddocks can result in more uniform grazing and utilization of forages and more even distribution of nutrients from urine and feces in paddocks. Feces and urine recycled to pastures by grazing cattle provide important sources of both nitrogen and phosphorus. Limited research has been done comparing the spatial distribution of the fluxes of nitrates and phosphorus in continuously and rotationally grazed systems.

Objective: To compare the spatial distribution of the fluxes of nitrates and phosphorus in paddocks that are grazed year round to fluxes of nitrates and phosphorus in paddocks that are rotationally grazed.

What We Did: Cow/calf pairs were managed year-round on continuous and rotational paddocks beginning in 2009, while rotational pastures were allowed 120 to 180 days of rest between grazing bouts. Numbers of animals applied were: 18 cow/calf pairs on 148 acres (150 lb of cow/acre) for continuous grazing and 25 cow/calf pairs on 190 acres in 10 paddocks (165 lb of cow/acre) for the rotational system. In Spring 2015, transects were laid out from the water source to pasture centers in sets of pastures under the two management treatments. Pairs of anion and cation probes were installed vertically into the soil at 0-3 inch and 3-6 inch depths. The probes were left in place for 2 weeks and then removed and nitrate and phosphorus fluxes determined. Fluxes from the two depths at a given location in the pasture were averaged to represent the 0-6 inch soil layer.

Preliminary Findings—after six years:

- Both forms of pasture management apparently resulted in hot spots of nutrient flux in soils.
- No effects related to grazing treatment could be determined in nitrate flux; indicates that both continuous and rotational grazing had similar effects on level and distribution of nitrate flux within large pastures (top panel of figure).
- Hot spots in nitrate flux close to tanks (tank and 10 ft. from tank), and 120 ft. from water tanks.



- Phosphorus flux was affected by both grazing treatment and location in pastures (bottom panel, figure at right).
- Rotational grazed pastures had hot spots in P flux 10 to 40, and 120 ft., from water tanks.
- Continuous grazed pastures had higher P flux at 20 and 80 ft. from tanks and at far corners (FC) from tanks.
- Lower and more consistent P flux from near pasture centers (PC) to 50 to 75% of distance from tanks to PC under both grazing systems.
- Hot spots in nutrient flux in response to rotational grazing occurred after $6^{1/2}$ months of rest from grazing; hot spots in continuous pastures occurred under year round grazing.
- Such results indicate that after 6 years, both forms of grazing management generated high levels of nutrient flux within both similar and different areas of pastures. However, the pastures in this study were large, so hot spots in nutrient flux could also be due to local variation in soil fertility.
- Additional measurements are being collected to determine if the above distribution patterns in nutrient flux are similar to times immediately after the rotational pastures have been grazed.

Contact Persons:

Dr. Patrick J. Starks (Patrick.Starks@ars.usda.gov)
Dr. Kenneth Turner (Ken.Turner@ars.usda.gov)
Dr. Brian K. Northup (Brian.Northup@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

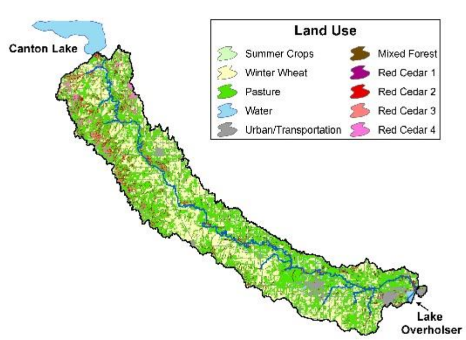
Impact of Eastern Redcedar on Water Resources

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Eastern redcedar (*Juniperus virginiana*, L.) is an aggressive native woody shrub/tree that has encroached upon millions of acres of grassland in the central and southern Great Plains. It decreases rangeland forage production, and has been implicated in reducing stream flow and groundwater recharge. Little is known concerning the impacts of increasing redcedar density and areal coverage on local and regional water budgets through transpiration (Tr) and canopy interception (CI) of precipitation.

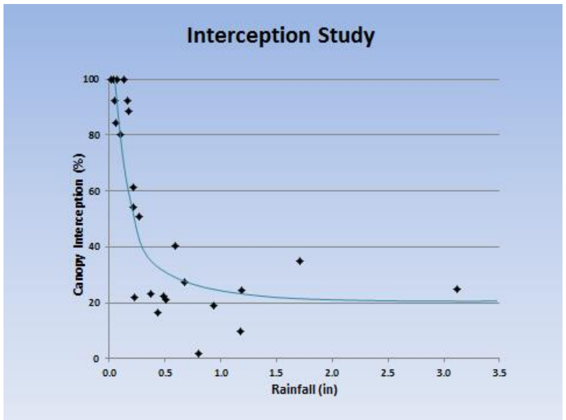
Objective: We had two objectives: 1) measure canopy interception and evapotranspiration of two size classes of redcedars, and 2) use this information along with other data to assess the impact of increasing density and aerial expansion of redcedars on surface runoff.

What we did: We measured both CI and Tr at two locations, for two large and two small redcedars. CI is calculated as: CI = GP – TF – SF. Gross precipitation (GP) is the total amount of precipitation that falls within the vertically projected canopy area of a given redcedar, and was calculated from precipitation measurements and vertically projected canopy area. Tr was measured using sap flux sensors. Both CI and Tr were measured over a two-year period.

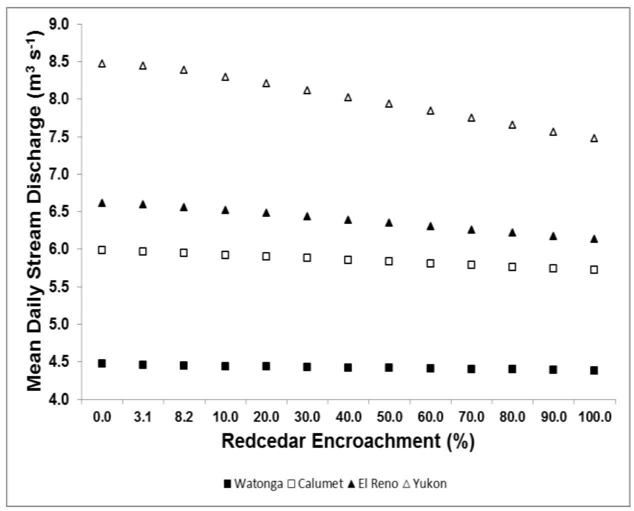


Our measurements of CI and Tr were used in combination with other measurements in the Soil and Water Assessment Tool (SWAT). In this study, we modeled the effects of increasing redcedar coverage and density on the central reach of the North Canadian River basin between Lake Canton and Lake Overholser, located in central Oklahoma. (The North Canadian River supplies about 25% of Oklahoma City's water supply.)

What we found: Redcedar canopies were found to intercept 100% of precipitation for events ≤ 0.09 in (2.4 mm) and 50% of precipitation under about 0.25 in (6.4 mm). Redcedar canopies reduce annual precipitation received at the surface by about 33%, and as much as 39% in the western portion of the state. The amount of water transpired by a given redcedar will be a function of tree size, atmospheric demand, and available soil water. One of the large redcedars in our study transpired 87 gal d^{-1} (331 L d^{-1}) for one day in May 2012, but averaged 35 gal d^{-1} (132 L d^{-1}) over the study period. The smaller redcedars transpired from 0.2 to 0.6 gal d^{-1} (0.8 to 2.2 L d^{-1}). These data imply that CI, coupled with Tr rates as large as or larger than native grasses and with year-round Tr, increases in redcedar density and areal coverage could affect local water resources (e.g. reducing infiltration, runoff, and ground water recharge rates).



To the right you can see the modeled reductions in runoff at four USGS stream gages as a function of increasing redcedar density encroachment. Our simulations suggested that if all grasslands in the central reach of the North Canadian River were replaced by redcedar, the simulated reduction in stream discharge would equal 112% of current municipal water demand and 89% of the projected 2060 demand. However, a more realistic conversion of 20% of grassland to redcedar would, according to our simulations, reduce stream discharge by an amount of water equivalent to ≈ 27% of the current water demand, or ≈ 21% of the projected 2060 demand. Our model simulations suggest that encroachment of redcedar into grasslands could have a detrimental effect on stream discharge, which could impact water availability on populations further downstream.



Contact Persons:

Dr. Patrick Starks (Patrick.starks@ars.usda.gov)
Dr. Daniel Moriasi (Daniel.moriasi@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

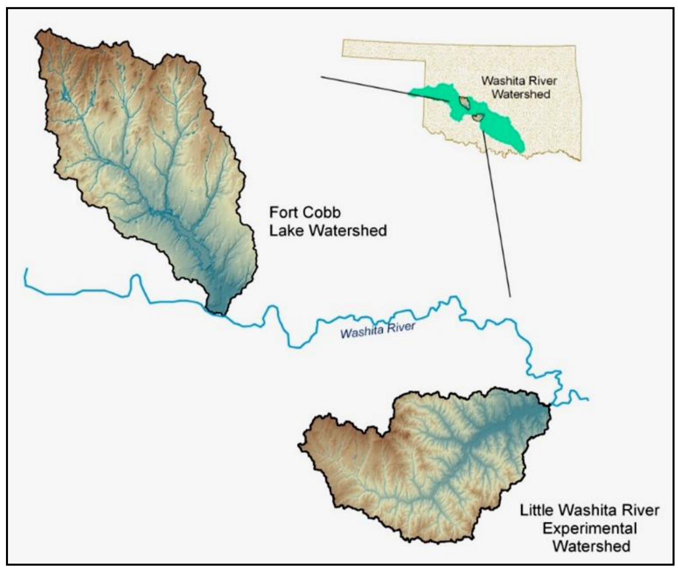
https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

Soil Water Content Measurement Network(s)

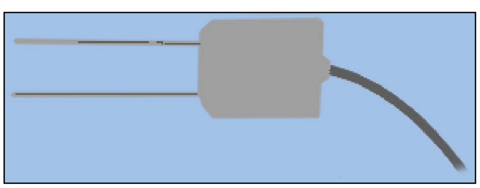
Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

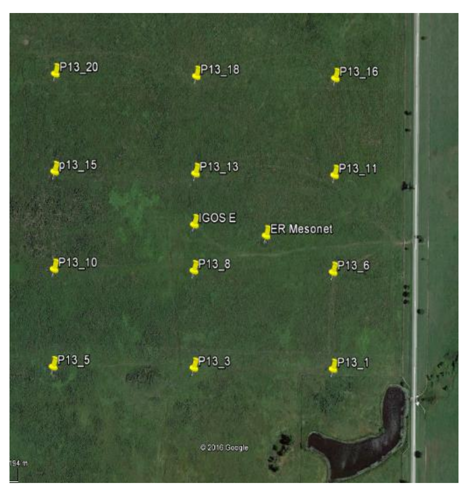
Rationale: Soil water accounts for only about 0.0001% of the total water on earth, yet it is a key component in describing the transfer and distribution of mass and energy between the land surface and atmosphere—thus, of major importance to the field of meteorology; it partitions rainfall into runoff and infiltration—thus, of primary importance to the field of hydrology; and it exerts major influences on forage and crop productivity—thus, of critical importance to the agricultural production and research communities.

Objective: Establish soil water content measurement networks to support on-going, long-term watershed scale hydrologic research and to address research goals connected with ARS' newly established Long-term Agro-ecosystem Research network.



What we are doing: We previously established a network of meteorological stations on both the 610 km^2 Little Washita River Experimental Watershed (LWREW) and the 800 km^2 Fort Cobb Reservoir Experimental Watershed (FCREW) in southwestern Oklahoma. The data from these sites are used in modeling exercises to evaluate the effectiveness of conservation practices. Additionally, they are being used by NASA and other research agencies to develop and test new satellite soil moisture sensors and algorithms. We recently established a smaller network of similar sensors on the GRL laboratory grounds to monitor soil moisture dynamics of both pastures and croplands to determine best management practices to conserve water and increase water use efficiency of plants. The GRL, LWREW, and FCREW soil water networks incorporate point-based sensors (see above). To the right is an example of the station layout.





Additionally, we are testing and calibrating a new soil moisture sensor (COSMOS – Cosmic-ray Soil Moisture Observing System) that provides field-scale footprint estimates of soil water content. This sensor uses the interaction of naturally occurring cosmic rays with hydrogen (soil water being the largest pool of hydrogen) to estimate soil water content. The method uses an above-ground sensor (above left) and we have installed four of these on the GRL property (3 locations are shown above right and are co-located with our Integrated Grassland/Cropland Observing Systems).

Contact Persons:

Jean L. Steiner (jean.steiner@ars.usda.gov)
Patrick J. Starks (Patrick.starks@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Conservation Effects Assessment Project (CEAP)

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Agriculture is the dominant land use in the Great Plains, cropland and grazingland management has a large effect on the region's streams, rivers, lakes, and groundwater. The USDA spends about $5 billion per year on agricultural conservation programs in order to help producers and land owners implement good conservation practices and systems on their land. However, the conservation programs have not had a monitoring component to determine the effectiveness of the conservation practices and program. Therefore, in 2003, the Natural Resources Conservation Service entered into partnership with ARS and many other partners to help quantify the environmental benefits and cost effectiveness of agricultural conservation.

Objective: Conduct watershed scale assessments of conservation practices in the Fort Cobb Reservoir Experimental Watershed (FCREW) and the Little Washita River Experimental Watershed (LWREW).

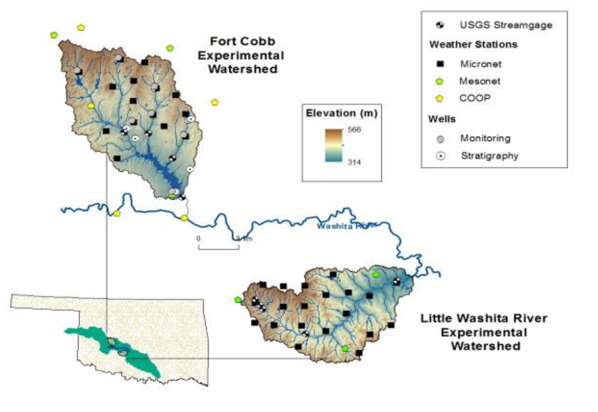
What we are doing and studying: 1) Collecting data for research studies, 2) Effects of land use and climate changes, and conservation on sediment, nitrogen and phosphorus transport within the watersheds, 3) Surface water quality, groundwater quality and quantity, riparian and channel conditions, and soil quality, 4) Determination of optimal timing and placement of a suite of conservation practices on the land surface and stream channels to minimize negative impacts on water quality and quantity, 5) Determination of projected climate and a suite of conservation practices to mitigate against the negative impacts.

Outcomes:

- Management impacts soil and vegetation over years to decades, soil properties and vegetation have an immediate influence on hydrologic processes, and hydrology influences fate and transport of nutrients, chemicals, and organisms at the watershed and field scales.

- ARS researchers and collaborators published a collection of data and research papers describing long-term research (1961 to present) in the Upper Washita River basin of Oklahoma. This living history of research is presented to engage collaborative scientists across institutions and disciplines in further researcher related to water resources.

- Modeling results showed that high spatial precipitation data resolution had a significant and positive impact on the accuracy of simulated model outputs, suggesting that the use of high spatial and temporal rainfall resolution precipitation datasets provides more realistic modeling outcomes.



Watershed-scale research is conducted in the Fort Cobb Reservoir and Little Washita River Experimental Watersheds to quantify environmental benefits of agricultural conservation implementation

- Large differences in the simulated surface runoff and deep aquifer recharge values due to soils dataset resolution were noted, suggesting that significant differences in simulated soil hydrology affect simulated water quality components such as sediments and nutrients. Significant differences in simulated sediment and/or nutrient fluxes could lead to significantly different outcomes in terms of the impacts of a given conservation practice for studies like the Conservation Effects Assessment Project.

- Effective riparian practices have potential to significantly reduce sediment delivery to water bodies within the CEAP watersheds.

- Studies are underway to determine the impact of projected climate change on water quantity and quality and conservation practices to mitigate the negative impacts. Additional studies on streambank instability are ongoing through a collaborative effort funded by USDA NIFA.

Contact Persons:

Dr. Daniel Moriasi (Daniel.Moriasi@ars.usda.gov)
Dr. Patrick Starks (Pat.Starks@ars.usda.gov)
Dr. Jean Steiner (Jean.Steiner@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036
Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

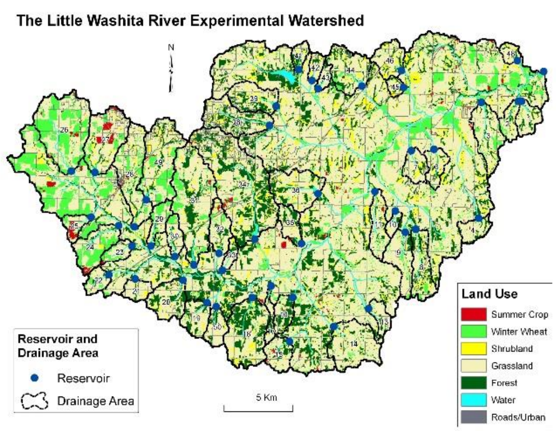
United States Department of Agriculture
Agricultural Research Service

Reservoir Sedimentation Research

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: The quantity and quality of water in streams, rivers, and lakes depends on land use, land management, and climate. However**,** few studies have been conducted in mixed agricultural land use watersheds to investigate the effects of land use and climate variability on reservoir sedimentation and associated water quality concerns. This is due in part to short lengths of hydrological records, the relatively high natural variability of most hydrological systems, difficulties in controlling land-use changes in real catchments, and the challenges involved in extrapolating or generalizing results from such studies to other systems.

The Little Washita Experimental watershed (LWREW) has over 60 years of hydrologic records and contains 45 flood-retarding reservoirs distributed in varying cropland, rangeland, and forest land settings. Ongoing research addresses many of the complicating factors noted above.



Objective: Quantify the interactive effects of land cover, land management, and climate on reservoir sedimentation.

What we did: We selected twelve sub-watersheds (four grass, four cropland, four shrub/forest) of the 45 USDA-funded flood control reservoirs in LWREW to evaluate impacts of contrasting land use/management in the contributing areas above the reservoirs on sediment delivery to the reservoirs. We also performed bathymetric surveys using a multi-frequency acoustic profiling system and collected reservoir sediment core samples. The core samples were analyzed to determine bulk density soil texture. Analyses using pollen markers are being carried out to correlate results with climate and land use. Chemical analyses will be conducted on the cores and will provide information to NRCS and other agencies and may relate to renovation or remediation issues connected with these types of reservoirs.

Anticipated Products:

- Sediment thickness map of reservoir (Fig. 1); sediment bulk density (Fig. 2) and texture; age dating using pollen markers for cores from each of the surveyed reservoirs
- Long-term average annual reservoir sedimentation rates and contributing factors.

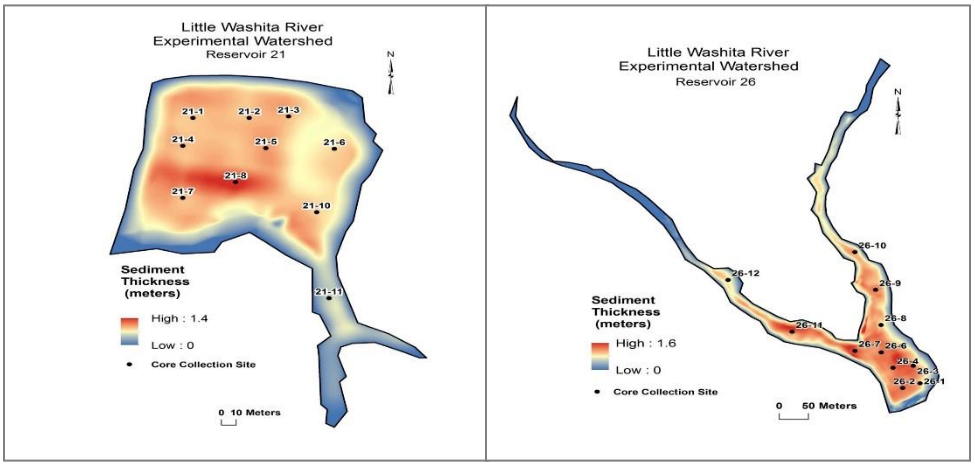


Fig 1. Location of sediment cores for Reservoirs 21 and 26.

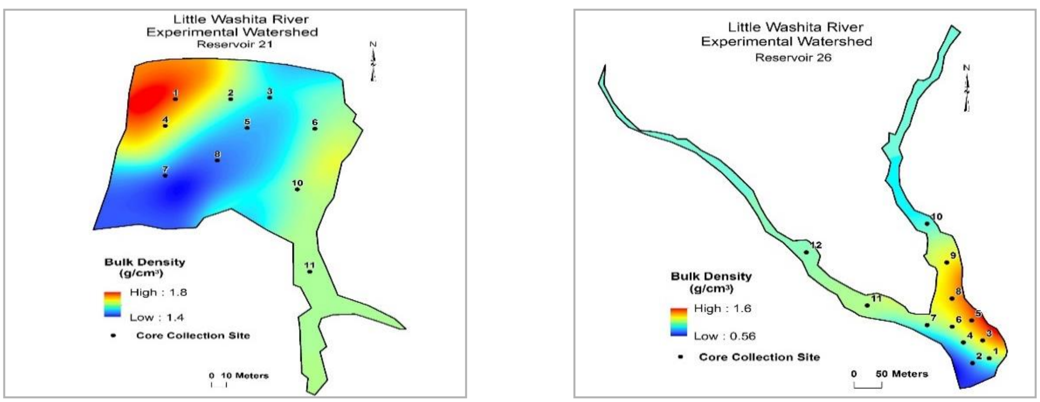


Fig 2. Spatial variability of bulk density for specific depth for Reservoirs 21 and 26

Contact Persons:

Dr. Daniel Moriasi (Daniel.Moriasi@ars.usda.gov)
Alan Verser (Alan.Verser@ars.usda.gov)
Dr. Patrick Starks (Patrick.Starks@ars.usda.gov)
H. Skibstead (hollieskibstead@gmail.com)
Dr. Jean Steiner (Jean.Steiner@ars.usda.gov)
Maci Harjo (maciharjo@yahoo.com)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036
Telephone: (405) 262-5291
FAX: (405) 262-0133
https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Development of Guidelines for Calibration and Validation of Hydrologic and Water Quality Models

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Hydrologic and water quality models are increasingly used to evaluate the impacts of climate, land use, and land and crop management practices on quantity and quality of land and water resources. Calibration and validation of these models are necessary before using them in research and/or real-world applications in order to increase trustworthiness of simulation results.

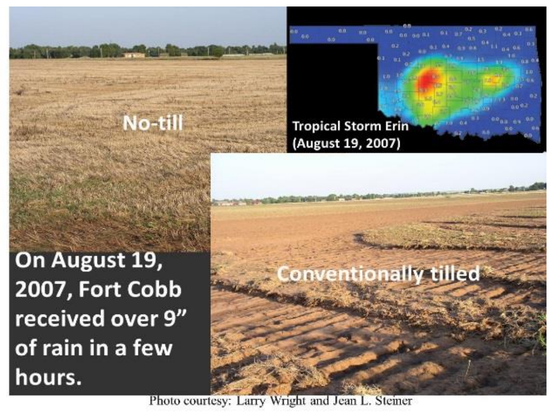


Photo courtesy: Larry Wright and Jean L. Steiner

Universally accepted guidelines for model calibration and validation offer many published benefits to the modeling community, for example 1) consistent reports of model application capabilities, which results in increased credibility of modeling studies, and 2) improved assessment and comparison of different models applied on the same study area or the same model(s) applied in different areas. However, no universally accepted procedures or guidelines for calibration and validation currently exist in the literature.

Objective: Develop universally accepted guidelines for calibration and validation of hydrologic and water quality models.

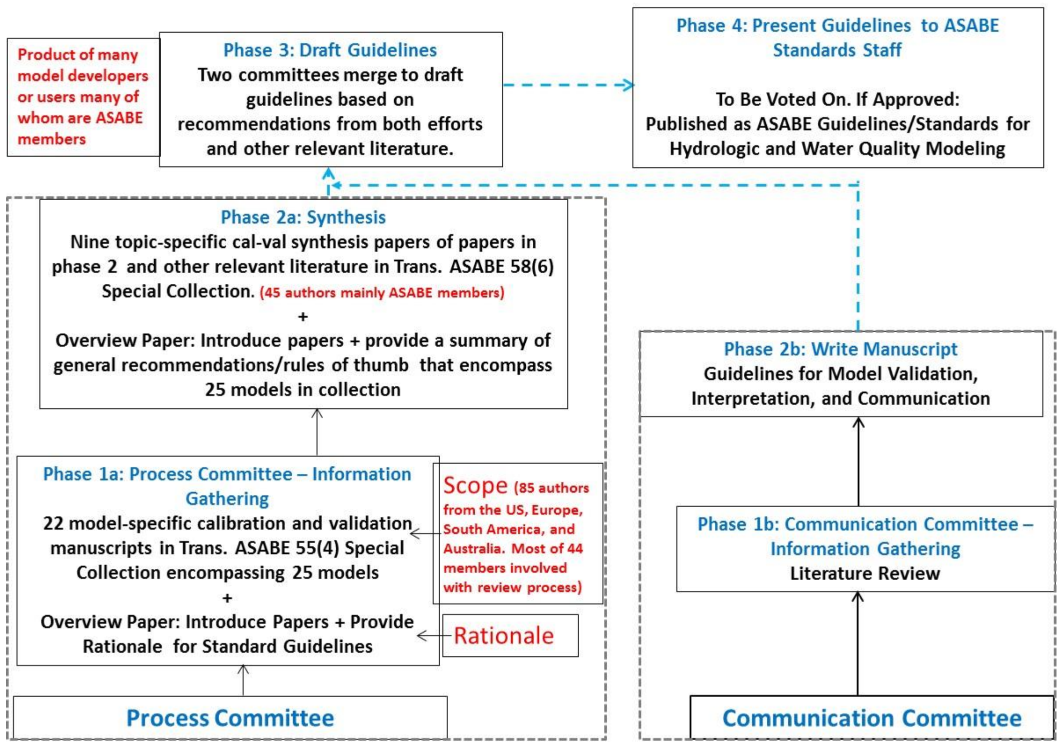
What we have done: In 2010, two committees (each led by a USDA ARS scientist) were established by the American Society of Biological and Agricultural Engineers (ASABE) with the goal of developing calibration, validation, evaluation guidelines, and documentation and reporting for hydrologic and water quality models. This multi-year process consisted of several phases as summarized below.

Summary of development activities and progress:

- 2012 Model-specific Special Collection: 22 papers covering 25 models and an introductory paper were published in Trans. ASABE 55(4): a total of 85 authors from the US, Europe, South America, and Australia were involved.
- 2015 Synthesis Special Collection: Nine research articles covering key topics related to calibration and validation of H/WQ models were published in Trans. ASABE 58(6). These include: terminology, hydrologic processes and model representation, spatial and temporal scales, model parameterization, C/V strategies, sensitivity, uncertainty, performance measures and criteria, and documentation and reporting. The main product is general recommendations/rules of thumb that encompass 25 models in 2012 special collection.

- Topic-specific recommendations from the synthesis special collection and the communication subcommittee article will contribute to the discussion surrounding potential development of topic-specific ASABE engineering practices or standards for model calibration and validation (http://www.asabe.org/media/226610/2016_04_20_x621_pr.pdf).

Framework for Development of Guidelines for Hydrologic and Water Quality Modeling



Contact Persons:

Dr. Daniel Moriasi (Daniel.Moriasi@ars.usda.gov)
Dr. Jorge Guzman (jorge.guzman@ou.edu
Dr. Rebecca Zeckoski (rzeckoski@zeckoski.net)
Dr. Dharmendra Saraswat (saraswat@purdue.edu)
Dr. Jeffrey Arnold (Jeff.Arnold@ars.usda.gov)
Dr. Yongping Yuan (yuan.yongping@epa.gov)
Dr. Claire Baffaut (Claire.Baffaut@ars.usda.gov)
Dr. Bruce Wilson (wilson@umn.edu)
Dr. Robert Malone (Rob.Malone@ars.usda.gov)
Dr. Adel Shirmohammadi (ashirmo@umd.edu)
Dr. Prasad Daggupati (pdaggupa@uoguelph.ca)
Dr. Kyle Douglas-Mankin (krdmankin@gmail.com)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Parameterization and Validation of APEX to Support Nation-wide Deployment of Nutrient Tracking Tool

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: The USDA is using the Nutrient Tracking Tool (NTT) as one of interactive environmental market tools to account for environmental benefits of conservation practices. The Agricultural Policy Environmental eXtender (APEX) is the core model on which NTT is based. NTT is a web-based interface that compares agricultural management systems to calculate a change in nitrogen, phosphorous, sediment loss potential, and crop yield. There is a need to parameterize and validate the APEX model in multiple regions to increase confidence over the reliability and consistency of simulated results.

Objective: To parameterize and validate the APEX model for the nation-wide deployment of NTT

Methods: Sites where multiple years of measured streamflow and water quality data for model calibration and validation are available were selected from several regions. These regions include the Pacific Northwest, Great Lakes and Ohio River Basin, Mississippi River Basin, Gulf Coast, Plains, and California regions. Available data is obtained from collaborators, QA/QC performed, and formatted for use in APEX. Using DEM, soils, and landuse GIS layers and PRISM weather data obtained from reliable sources, projects are built using the ArcAPEX and NTT interfaces. To parameterize and validate APEX, the framework (page 37 for more information) developed for this purpose is utilized using APEXSENSUN software package (See page 39 for more information).

A global sensitivity analysis is carried out to determine the most sensitive parameters for each study site. Calibration is performed to ensure that the resulting hydrologic and water quality constituent budgets and crop yields are reasonable. Model runs that meet multiple model performance criteria are used to determine reasonable combination of values for the most sensitive parameters. The parameter values for these model are validated by running them for a different time period. If the model outputs meet the criteria, the parameter values are considered robust. Finally, confidence intervals and uncertainty ranges of outputs of interest are computed from successful model runs.

Current/Future Study Sites:

- Rock Creek, Ohio; Great Lakes region
- Upper Walnut (subwatershed B), Ohio; Ohio region
- Willamette, Oregon; Pacific North West region
- Klamath, Oregon; Pacific North West region
- Yakima, Washington; Pacific North West region
- Mason Creek, Idaho; Pacific North West region
- Bushlands, Texas; Plains regions

Additional Research Questions: Due to resource constraints, availability of long-term monitoring data for calibrating and validating H/WQ models are rare. As a result, most models are calibrated and validated using limited measured data. Uncertainty of the simulated outputs due to use of limited calibration and validation data is unknown. We are examining the effect the impact of the length of calibration period (amount of data available for calibration) on APEX calibration parameters and the associated simulation performance and output uncertainty.

Contact Persons:
Dr. Amanda Nelson (Amanda.Nelson@ars.usda.gov)
Dr. Daniel Moriasi (Daniel.Moriasi@ars.usda.gov)
Dr. Mansour Talebizadeh (Mansour.Talebizadeh@gmail.com)
Dr. Haile Tadesse (Haile.Tadesse@ars.usda.gov)
Dr. Jean Steiner (Jean.Steiner@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

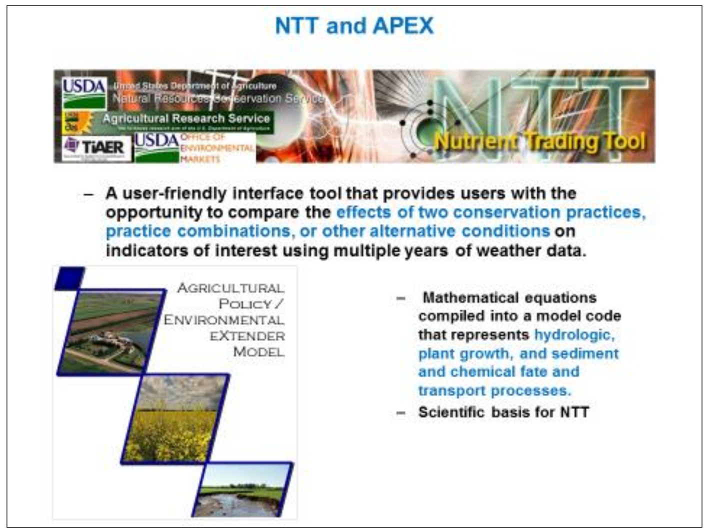
https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Framework to Parameterize and Validate APEX to Support Deployment of the Nutrient Tracking Tool

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: The Agricultural Policy Environmental eXtender (APEX) model is the scientific basis for the Nutrient Tracking Tool (NTT). NTT is an enhanced version of the Nitrogen Trading Tool, a user-friendly web-based computer program originally developed by the USDA. NTT was developed to estimate reductions in nutrient losses to the environment associated with alternative practices. The accessibility and ease with which the interface can be used has provided opportunities to demonstrate NTT in locations throughout the country; however, the absence of a clearly defined, consistent approach to parameterization and validation has raised questions over the reliability and consistency of simulated results.



Objectives: Develop a framework to parameterize and validate APEX to support NTT.

What we did: We performed a comprehensive literature review of recent APEX, NTT, and other modeling studies to determine current parameterization and validation methods used. The findings from this literature review along with our personal experience were used to develop guidelines, which together with the Ohio watershed case study, constitute the framework.

Summary of framework: The developed guidelines are in the form of recommendations covering essential phases of model simulation studies as well as a clear interpretation of model performance evaluation criteria thresholds and model simulation performance results, scenario validation and documentation. These include:

- Clear definition of purpose of study, detailed description of study area, and identification of major processes.
- Model building: proper study site representation to ensure that all important physical features of the study area are included.
- Parameterization and validation approaches: Including model input and calibration/validation data. Utilize the input data from credible sources (QA/QC) while documenting the quality of data used for calibration and validation.

		Category		
Step	Characteristic	Ideal	Typical	Minimum Required
Parameterization	Calibration	not needed	needed	needed
	Source of values for sensitive parameters	a) direct measurement	a) direct measurement b) literature and/or recommended estimates c) calibration - using available measured data	a) literature and/or recommended estimates b) calibration - using study area or region long-term annual average budgets, information from intermittent data in study area, and recommended estimates from people familiar with area of study
Validation	Validation process	a) select appropriate performance measures and corresponding criteria b) process-based c) appropriate strategy d) determine output uncertainty and confidence interval e) if necessary; recheck quality of measured data used or make recommendation for pertinent process code modification f) detailed documentation and reporting of the sources of input data used and their corresponding accuracy	a) same as ideal b) also, discuss cases in which measured data or information for a given major process or several major processes were lacking and how this was addressed c) finally, make the case, as part of recommendations, for the need to collect the missing data in order to minimize uncertainty and, thereby, improve modeling results.	a) same as typical
	Good quality measured data to validate major process for constituent of interest	available for all major processes	available for some of major processes	none available
	Uncertainty of available measured validation data (Harmel et al., 2006)	best and typical case scenario data quality	hybrid - best, typical, worst case scenarios data quality	worst case scenario data quality

- Interpretation of statistical performance evaluation criteria and model performance results: Understanding is vital to accurate interpretation of the APEX parameterization and validation results.
- Validation of scenario results: Ensure scenario results are realistic
- Detailed documentation and reporting: Enable others to audit, reconstruct, repeat, and reproduce the modeling process and results.

Contact Persons:

Dr. Daniel Moriasi (Daniel.Moriasi@ars.usda.gov)
Dr. Kevin King (Kevin.King@ars.usda.gov)
Dr. David Bosch (David.Bosch@ars.usda.gov)
Dr. Dave Bjorneberg (Dave.Bjorneberg@ars.usda.gov)
Stephen Teet (Stephen.Teet@ars.usda.gov)
Dr. Jorge Guzman (jorge.guzman@ou.edu)
Dr. Mark Williams (Mark.Williams@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Development of APEXSENSUN Software for Uncertainty and Sensitivity Analysis of the APEX Model

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Determining proper values for watershed model parameters is a crucial part of any modeling application. However, determining sensitive parameters, especially in large watersheds with high levels of temporal and spatial heterogeneity could be a difficult task. Development of a flexible software capable of performing uncertainty and sensitivity analysis would greatly assist watershed modelers and stakeholders to better allocate their resources to measure important model parameters and devise cost-effective measurement campaigns for different watersheds. In addition, sensitivity analysis can be used to quantify the contribution of change in model parameters to change in the magnitude of watershed outputs (e.g. flow, sediment load, yield, etc.). This feature would be very useful in identifying best management practices for achieving the desired objectives under certain constraints in a watershed. Moreover, the Monte Carlo-based uncertainty analysis modules of the developed software can be used separately from the sensitivity analysis modules to aid with calibration and in quantitative risk analysis studies for different watersheds under different agri-meteorological conditions.

Objectives:

1) Identification of important model parameters for model calibration using sensitivity analysis
2) Quantification of the contribution of change in model parameters to the change in the magnitude of model outputs
3) Automated or semi-automated model calibration and validation through a Monte Carlo simulation framework
4) Development of a flexible platform for watershed simulation using different sets of model parameters through a Monte Carlo simulation framework

What we are doing: A flexible software named APEXSENSUN is being developed using R language to streamline uncertainty and sensitivity analyses and calibration of the APEX model. The APEXSENSUN provides its users with a wide range of sensitivity analysis options that can be implemented for different watersheds depending on the availability of data, computational power, as well as the purpose of the sensitivity analysis.

Proposed Evaluations:

APEXSENSUN can be used in numerous watershed studies in order to provide reliable and rigorous answers to some of the questions that affect the modeling or management practices in watersheds.

The following summarizes two main domains of APEXSENSUN applications in watershed studies:

1) Sensitivity analysis on model performance with respect to observed data (e.g. Mean Square Error)

a. Reducing the number of uncertain parameters (i.e. identifying and fixing on-influential model parameters) for better resources allocation for measuring/eliciting model parameter values

b. Accelerating model calibration by reducing the dimension of unknown model parameters and autocalibration

c. Compiling a database containing influential model parameters and their typical values, considering climate and geospatial characteristics as well as management practices in different regions (very useful for the modeling of watershed with limited information on model parameters)

2) Sensitivity analysis on model outputs (e.g. sediment load, N or P loadings from a watershed)

a. Identifying the important parameters affecting an output for watershed management

b. Determining the contribution of different model parameters (as a result of adopting a set of management practices) on the magnitude of model outputs (very useful for determining optimum management measures)

Contact Persons:

Dr. Mansour Talebizadeh (mansour.talebizadeh@gmail.com)
Dr. Daniel Moriasi (Daniel.Moriasi@ars.usda.gov)
Dr. Amanda Nelson (Amanda.Nelson@ars.usda.gov)
Dr. Jean Steiner (Jean.Steiner@ars.usda.gov)
Dr. Gowda Prasanna (Prasanna.Gowda@ars.usda.gov)
Dr. Patrick Starks (Patrick.Starks@ars.usda.gov)
Dr. Haile Tadesse (Haile.Tadesse@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

SWATmf: An Integrated Surface-Groundwater Model

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Assessing the impacts of anthropogenic and naturally driven changes in watershed dynamics (e.g., hydrological response, transport of contaminants, and ecosystem services) requires integration of knowledge and modeling capacities spanning biophysical responses, environmental problems, policies, economic activity, and datasets that are either connected to the surface watershed or aquifer (subsurface) system. Model integration bridges cross-disciplinary knowledge to improve evaluation of hypotheses and system response under present and future changing conditions in a realistic manner.

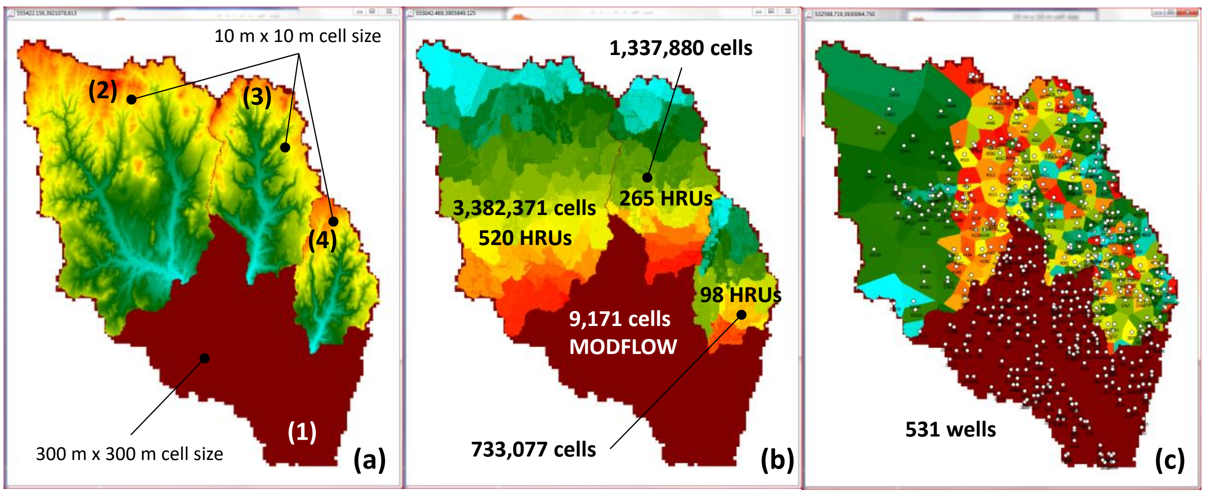


Figure 1. Surface and subsurface watersheds spatial discretization, a) surface and subsurface project domains: (a1) Rush Spring aquifer (maroon colored) at the Fort Cobb Reservoir Experimental watershed (FCREW), (a2) Cobb Creek surface watershed, (a3) Lake Creek surface watershed, and (a4) Willow Creek surface watershed, b) SWAT Hydrologic Response Units (HRU) raster discretization, c) well-to-irrigation contributing areas per well per surface watershed.

The Soil and Water Assessment Tool (SWAT) and the Modular Three-Dimensional Finite-Difference Groundwater Flow (MODFLOW) models are well accepted hydrologic models commonly used to assess hydrological phenomena at the surface watershed or aquifer system, respectively. However, neither can fully simulate the hydrological cycle. Full hydrologic simulation requires integration of the two models.

Objective: Developing dynamically linked the SWAT and MODFLOW models to improve hydrologic and water quality simulations in the surface and groundwater domains and a conceptual modeling framework that allows future incorporation of agro-ecosystem modeling elements.

What we did: We developed three stages for model integration: 1) a conceptual framework, 2) a new application tool to setup the integrated/coupled model, and 3) and insertion of hard-coded routines interfacing the models into a single code.

Outcomes: Coupled the SWAT and MODFLOW models by integrating FORTRAN codes and subroutines in a single native code; Developed the SWATmf application for rapid development and evaluation of the integrated SWAT-MODFLOW projects; Developed a conceptual modeling framework for GRID-base model integration in which multiple surface and disconnected watersheds contribute to a single aquifer system, and integrated the SWATmf application with SPELLmap for model output data extraction and visualization. Example results for FCREW are shown in Fig. 2.

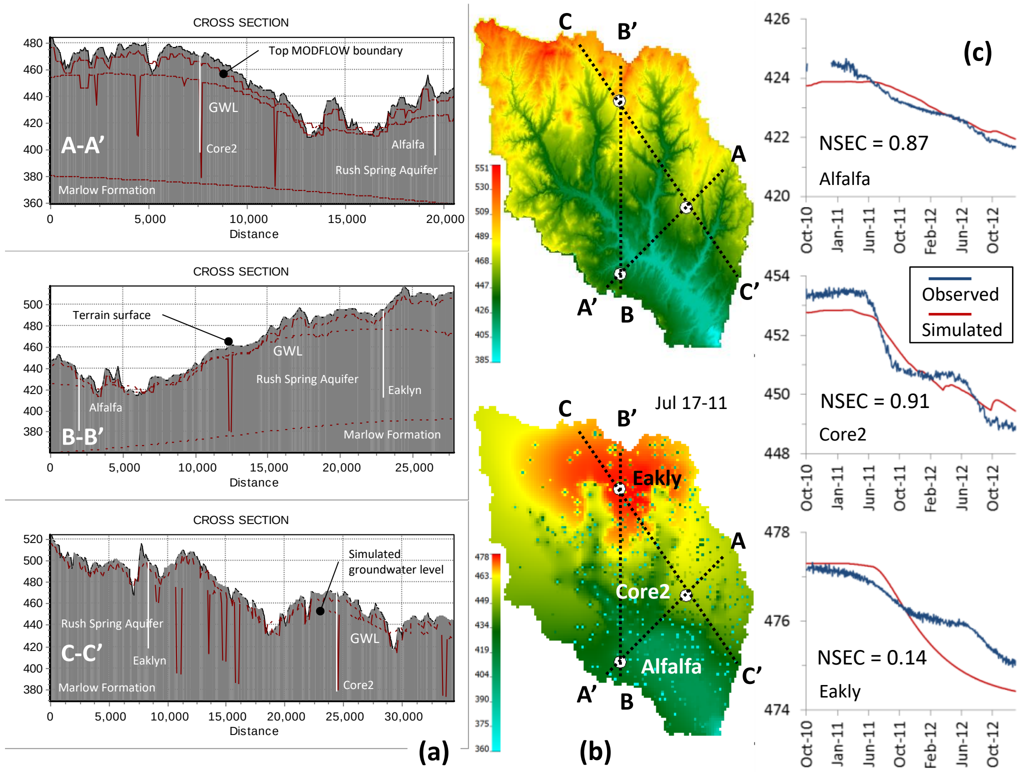


Figure 2. Observed and simulated groundwater levels, a) Simulated groundwater cross sectional levels on 17 July 2011, b) Topography (top) and groundwater (bottom) digital elevation models indicating the cross sectional profiles, and groundwater real-time sites locations, c) simulated and observed daily time series at Eakly, Core2 and Alfalfa groundwater monitoring wells.

Contact Persons:

Dr. Daniel Moriasi (Daniel.Moriasi@ars.usda.gov)
Dr. Jorge Guzman (jorge.guzman@ou.edu)
Dr. Prasanna Gowda (Prasanna.Gowda@ars.usda.gov)
Dr. Jean Steiner (Jean.Steiner@ars.usda.gov)
Dr. Patrick Starks (Patrick.Starks@ars.usda.gov)

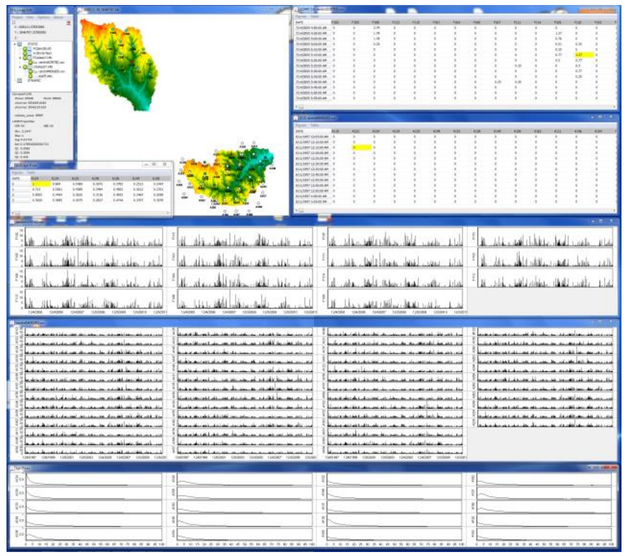
7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036
Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

The SPELL project

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017



Rationale: High spatial and temporal resolution observations help us to better understand the rapid changes in biophysical responses at the watershed or edge-of-the-field scale. In most cases, the lack of computational tools with the capacity to integrate large datasets in a comprehensive manner becomes a limitation to fully utilize this information for analysis of cause-and-effects scenarios. A common practice to overcome the burden of massive data is to aggregate observations to a given spatial or temporal scale, for example, farm size at daily and annual basis. This practice helps to speed up computations while facilitating communication with shareholders. However, it may also smooth important information of the phenomena under investigation and can bypass important watershed interactions.

Data collection is expensive and challenging, and not all data collected add knowledge about the phenomenon being investigated. However, in natural systems, the measurment of the expected mean and its varibility for a given variable (e.g., rainfall, nitrogen concentration) is important, especially in those rare occasions where unexpected events can lead to the identification of long-term changing conditions. These two properties of data provide valuable knowledge about the phenomenon of interest when properly measured, analyzed, and modeled. For example, during a rainfall event we are interested in knowing the amount of water that falls in a certain period of time (e.g., day, hour, or minutes). Also, we find important to know how different the rainfall events were at other locations and how rapidly it changes in time. To do this, we need to deploy the necessary density of sensors to observe the phenomenon, be prepared to measure unexpected responses, and have the capacity to efficiently process this data. Measuring and being able to visualize, quantify, and idealize these differences (variability) in space and time may help to undertand significant differences in sediment, nitrogen, and phosporous responses occurring in contiguous areas sharing similar land uses and soils that may ocurr in very short period of time.

Objective: To develop computational tools with the capacity to incorporate high spatio-temporal resolution datasets facilitating data processing, analysis, and classification of agro-ecosystems responses under present and future scenarios.

The ultimate goal of the SPELL project is to provide the computational environment to assist with the challenging task of processing, segregating, and assist the analysis of large watershed datasets.

What we are doing: We identify, idealize, and develop computational tools to better link data, data properties, and data segregation to speed-up analysis of water and bio-chemical fluxes that take advantage of big data.

We aim to improve the prediction of the responses of our agro-production systems, reduce uncertainties, and provide better decision making tools.

Contact Persons:

Jean L. Steiner (Jean.Steiner@ars.usda.gov)
Jorge A. Guzman, Center for Spatial Analysis, University of Oklahoma (Jorge.Guzman@ou.edu)
Daniel N. Moriasi (Daniel.Moriasi@ars.usda.gov)
Maria L. Chu, ABE, University of Illinois (mlchu@illinois.edu)
Patrick J. Starks (Patrick.Starks@ars.usda.gov)
Xiangming Xiao, Earth Observation and Modeling Facility, OU (Xiangming.Xiao@ou.edu)
Prasanna Gowda (Prasanna.Gowda@ars.usda.gov

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

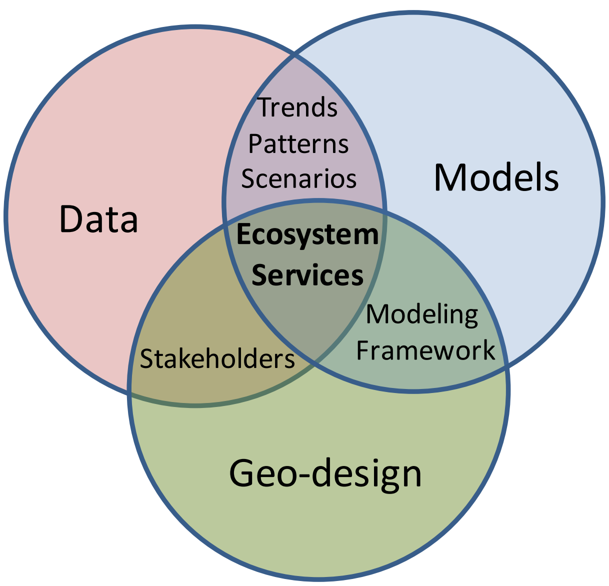
https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Modeling Complexity in Agro-Production Systems Proposed Research

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Agriculture is facing and will continue to face major challenges such as how to adapt our agro-production systems to limited water availability, improve yields to satisfy increasing demand for food production, and decrease environmental footprint. Addressing these challenges requires a thorough understanding of the fundamental biophysical and societal interactions at the local and regional scales in order to determine cost-effective adaptation plans. These systems are at the core of our societies, complex, and sustain our standard of living in which large scale experimentation is far an option. Today's actions have short and long term repercussions on the future that are difficult to predict. As a result, we rely on idealizations, computational models, expertise, and communities' feedbacks and perceptions to assess and quantify future outcomes of plausible scenarios in order to minimize the risk of undesired impacts while optimizing societal benefits.



Climate and water variability (runoff and groundwater) are dominant to the challenges faced by our agro-production system. Understanding the processes and interactions that drive significant changes in agro-production is central when implementing measures to ensure sustainability in agriculture. To achieve this, we rely on the capacity of models, expertise, and societal feedbacks to assess and quantify long-term historic and future responses in a realistic manner. Currently, most models use simplified equations to represent the complex environment without incorporating societal dimensions when exploring the impacts of probable future scenarios. Furthermore, advances in data collection techniques and analytics have resulted in a plethora of information that these models cannot incorporate as currently structured. As a result, these models simplify richer available spatio-temporal data that can provide significant details necessary to reduce the uncertainty associated to model prediction.

Objective: Our long-term goal is to better understand vulnerabilities and resilience of agro-production systems under changing scenarios (climate variability, population growth, economic stressors, urbanization expansion, groundwater depletion, and management), and their impacts on ecosystems services at local and regional scales.

We aim to promote capacity building, strengthen inter-institutional collaboration, encourage stakeholder engagement, and train and educate the next generation of scientists and practitioners to collectively address the challenges of an uncertain future.

What we are doing: We are idealizing and developing an integrated modeling framework to better represent fluxes of biophysical variables that take advantage of big data, with the capacity to incorporate feedback information from our stakeholders. We aim to improve the prediction of the responses of our agro-production systems, reduce uncertainties, and provide better decision making tools.

Contact Persons:

Jean L. Steiner (Jean.Steiner@ars.usda.gov)
Jorge A. Guzman (Jorge.Guzman@ou.edu) Center for Spatial Analysis, University of Oklahoma
Daniel N. Moriasi (Daniel.Moriasi@ars.usda.gov)
Maria L. Chu (mlchu@illinois.edu) ABE, University of Illinois
Patrick J. Starks (Patrick.Starks@ars.usda.gov)
Xiangming Xiao (Xiangming.Xiao@ou.edu) Earth Observation and Modeling Facility, OU
Prasanna Gowda (Prasanna.Gowda@ars.usda.gov

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

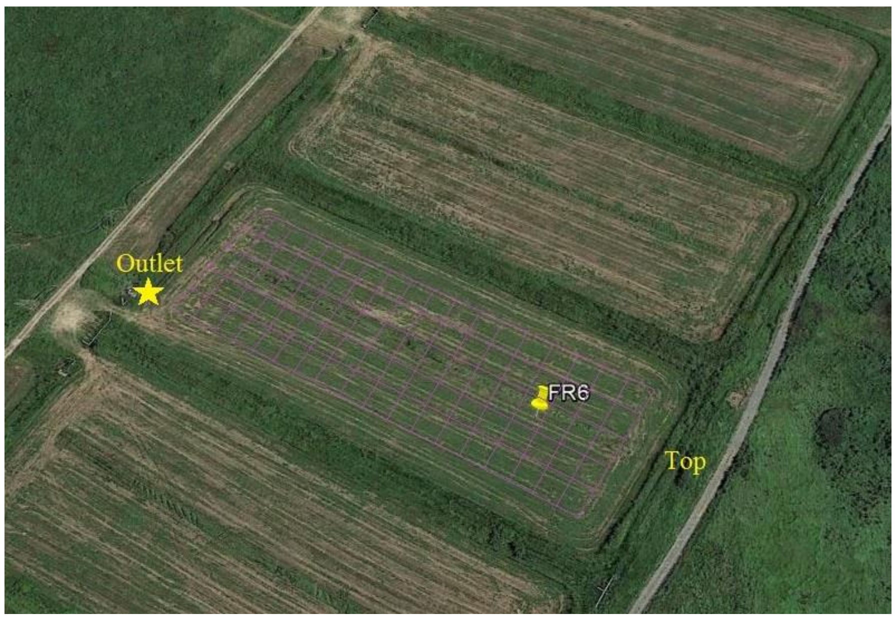
https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Evaluating WEPP Soil Erosion Model using Cesium-137 Derived Spatial Soil Erosion Data on a Hillslope

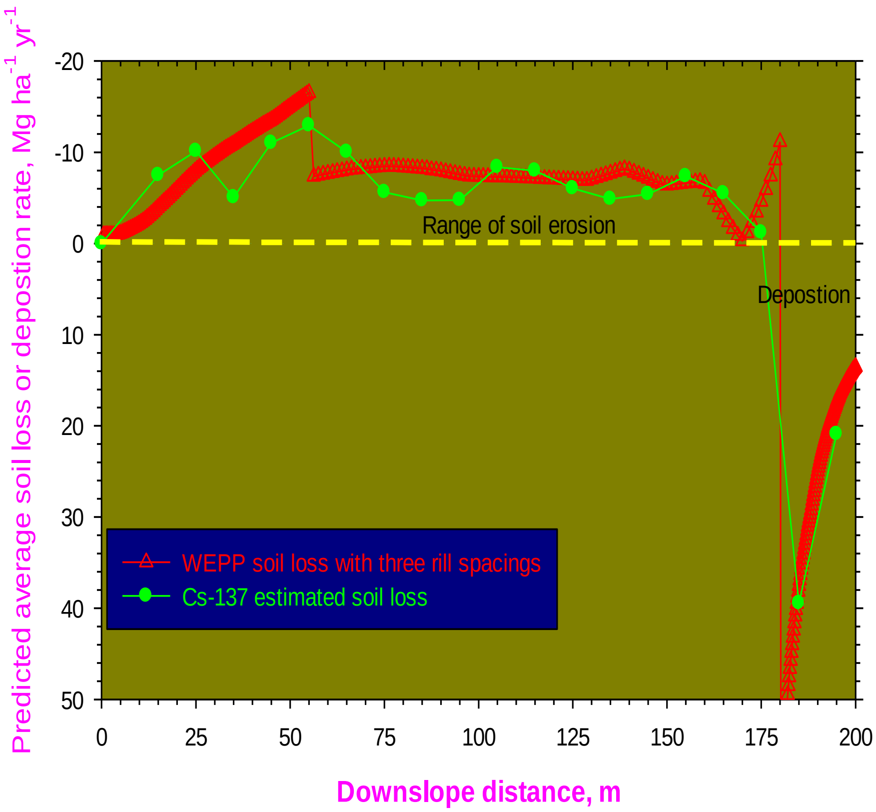
Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Although empirically based erosion prediction models or tools such as the Universal Soil Loss Equations (USLE) and its revision (RUSLE) have been widely used throughout the world, many process-based prediction models such as the Water Erosion Prediction Project (WEPP) model have been developed to overcome the spatio-temporally lumped nature that empirically based models normally possess. One major advantage that process-based erosion models have over empirical models is their capabilities for estimating spatial and temporal distributions of net soil losses or gains for any places on the hillslope on an event, monthly, annual, and average annual basis. Process-based models are the only tools that can predict offsite-sediment delivery and onsite-deposition of sediment for different particle-size classes, which are increasingly needed for downstream water quality assessment and infield precision conservation planning. However, such capabilities of process-based models to predict spatially distributed soil erosion patterns have not yet been fully validated with spatial data due to the lack of spatially distributed soil erosion data. Thus, the availability of spatially distributed erosion data is critical for rigorously validating spatially distributed models and for further improving and applying such models.



Objective: Derive spatially distributed soil erosion data using the cesium-137 erosion tracer in a 4-acre unit source watershed (FR6), located at the Grazinglands Research Lab (above), and compare the spatial patterns of soil erosion estimated with the cesium-137 method with those predicted by the process-based WEPP soil erosion model.

What we have found: The WEPP-simulated average annual soil loss rates along the hillslope was -2.92 Mg ha^{-1} yr^{-1}, compared favorably with the measured mean of -2.7 Mg ha^{-1} yr^{-1}. The spatial erosion patterns simulated using three rill spacings (10 m for top section, 0.5 m for middle section, and 0 for bottom section) matched the ^{137}Cs-predicted soil erosion patterns reasonably well. That is, soil loss increased from 0 to 55 m and remained somewhat constant between 55 and 180 m, while deposition occurred between 180 and 200 m. This study demonstrates that rill spacing is an important model input parameter for correctly simulating spatial soil erosion patterns with the WEPP model. Rill spacing that varies with slope gradient, slope length, and slope shape is expected to change along a hillslope. Knowledge of rill spacing distribution on a hillslope would definitely improve the prediction of spatial erosion patterns and therefore total sediment yields.



Contact Person:

Dr. John Zhang (John.Zhang@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Wind + a Spark = A Grassland Wildfire, Monitoring of a Native Grassland Burn

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Controlled burning in the Southern Plains is a common practice to manage non-native species, remove biomass, and help to keep rangeland clear for optimum forage growth. Prescribed burns are started, monitored, and stopped by man. An alternative to prescribed burns are wildfires that are started from lightening or some other spark that also remove vegetation from the landscape.

Burning also affects the soil nutrient cycling and has been noted to exacerbate the loss of carbon and nitrogen in the form of greenhouse gases. Monitoring of these soil nutrient elements has not been documented in perennial grassland wildfires of the Southern Plains.

On March 4, 2017, a grassland fire occurred when high winds caused an electrical fire that burned ~40 acres. Monitoring such a site in tandem with non-burned area allows researchers to better understand the effect of fire on the landscape. Assessing soil moisture, greenhouse gas flux, soil carbon and nitrogen, and soil microbial community over a designated time will describe specific changes to grassland soils which will help to better understand the impact of fire.

Knowledge of how fire, a common management practices of the Southern Plains' perennial cropping systems, alter soil nutrient cycling and greenhouse gas emissions will help to determine drivers in greenhouse gas emissions and establish sustainable management practices in the future to ensure agricultural resources.

Objective: The overall objective of this study was to monitor the effect of fire on soil C and N cycling in perennial grasslands of the Southern Plains. Additionally, we determined microbial community diversity of burned and unburned soils.

What we going to do: We evaluated burned and unburned field sites post burn in March 2017 for two weeks for changes in soil carbon and nitrogen cycling. This study was also recreated by taking burned and unburned soil samples to the laboratory. Both the field and laboratory studies were monitored under controlled temperature and moisture conditions at time zero, three, six, nine, 24, 48, 72, 96, to two weeks.

Treatments include:
1) Native Warm-Season Pasture Non-Burned
2) Native Warm-Season Pasture Burned

Soil Analysis at each time period:
Soil Water Content
Soil Inorganic Nitrogen- Ammonium and Nitrate Content
Total Nitrogen
Dissolved Organic Nitrogen
Microbial Biomass Nitrogen
Total Carbon
Dissolved Organic Carbon
Microbial Biomass Carbon
Microbial Fatty Acid Community Assessment

Greenhouse Gas Analysis at each time period:
Carbon Dioxide
Nitrous Oxide
Methane

Proposed Outcomes:
- Assess greenhouse gas flux given burning.
- Determine soil priming caused by burning.
- Determine how fire affects microbial community changes post application.

Contact Persons:
Dr. Brekke Munks (Brekke.Peterson@ars.usda.gov)
Dr. Jean Steiner (Jean.Steiner@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Greenhouse Gas Fluxes and Soil Carbon and Nitrogen Cycling following Chisel Plow Application in Winter Wheat Cropping System

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Disturbance in the form of tillage can increase soil carbon and nitrogen cycling. Tillage is commonly used to control weeds and prepare fields for planting. Repeating this practice can result in increased soil drying, sudden bursts of mineralized carbon and nitrogen from soil organic matter, and alterations in soil microbial communities.

When priming (a flush of carbon and nitrogen into the soil matrix) occurs, soil organic matter is mineralized and converted to plant- and microbe-usable forms of carbon and nitrogen. However, if the carbon or nitrogen is not immediately immobilized, it is further processed by microbes and released to the atmosphere as greenhouse gases (GHG) in the form of carbon dioxide or nitrous oxide in semi-arid regions.

The effects of tillage on winter wheat cropping systems of the Southern Plains is not well understood. The use of tillage tools can impact the nutrient cycling of soils and GHG flux. The impact of tillage equipment on disturbance of soil is well established, however, has not been studied in the Southern Plains' Winter Wheat production system.

Revision to classic field management strategies could lead to stored carbon and nitrogen, which in turn would enhance soil organic matter and ideally reduce greenhouse gas emissions. Knowledge of how different tillage practices alter soil priming and GHG emissions will help to establish sustainable management practices and improve ecosystem services, while reducing input cost.

Objective: Determine the impact of chisel plow tillage tool use on soil priming of carbon and nitrogen cycling and GHG flux in winter wheat production.

What we are doing: We established two half-acre wheat plots that represent chisel plowing (conventional tillage), and no-tillage (control) treatments. Within each treatment five replicates were established to monitor the effects of tillage treatments over 336 hours after tillage. Each plot was monitored for soil carbon, soil nitrogen, soil water content, soil microbial community, and GHG (carbon dioxide, nitrous oxide, and methane) assimilation at time zero, 3, 6, 9, 24, 48, 96, 168, and 336 hours after tillage. Study was conducted in July of 2015 and 2016.

Treatments include:
1) Winter Wheat Production-Post Harvest with Chisel Plow
2) Winter Wheat Production-Post Harvest No-Tillage (Control)

Soil Analyses at each time period:
Soil water content
Soil Inorganic Nitrogen- Ammonium and Nitrate Content
Total Nitrogen
Dissolved Organic Nitrogen
Microbial Biomass Nitrogen
Total Carbon
Dissolved Organic Carbon
Microbial Biomass Carbon
Microbial Fatty Acid Community Assessment

Greenhouse Gas Analyses at each time period:
Carbon Dioxide
Nitrous Oxide
Methane

Proposed Evaluations:

- Assess cumulative greenhouse gas flux given tillage type.
- Determine soil priming caused by tillage and respective types.
- Determine how tillage post application affects microbial community changes.

Contact Persons:

Dr. Brekke Munks (Brekke.Peterson@ars.usda.gov)
Dr. Jean Steiner (Jean.Steiner@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Monitoring of Seasonal Soil Nutrient Cycling and Greenhouse Gas Flux in the Southern Plains

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Climate variability in the Southern Plains region of the US is an abiotic factor that could greatly alter management plans for regional land stewards. As land managers, we often plan for ideal weather and in-turn experience 100-year rains or prolonged drought that affect not only our crops, but the nutrient cycling that occurs in the soil.

Severe drought in the region is not uncommon, but reduces biomass production, perennial forage quality, and livestock production. Much of the Southern Plains region relies on summer forage production in perennial grasslands to reduce the need for supplemental forage to livestock and the potential trucking of feed from outside the region. During the winter, annual production systems such as winter wheat supplement forage.

In the region, natural disturbances, like prolonged drought followed by intense rainfall, are speculated to occur, but anthropogenic disturbances like tillage, burning, and input addition also can affect soil nutrient cycling. Management practices can cause excessive soil organic matter mineralization. When the soil system does not have an established growing crop or microbial population, the usable carbon and nitrogen from the soil organic matter can be lost in the form of greenhouse gas emissions.

Knowledge of how common management practices of the Southern Plains' perennial and annual cropping systems alter soil nutrient cycling and greenhouse gas emissions will help to determine drivers in greenhouse gas emissions and establish sustainable management practices in the future to ensure agricultural resources.

Objective: The overall objective of this study was to monitor the seasonal effects of soil C and N cycling in perennial grasslands of the Southern Plains.

What we are doing: We have evaluated native, non-native, and annual crops since 2015 for changes in soil carbon and nitrogen cycling. We have monitored treatments throughout the whole year, paying close consideration to natural and anthropogenic disturbances.

Treatments include:

1) Native Cool-Season Pasture (Control) - GRL, Samuel R. Noble Foundation and Marena Prairie
2) Non-native Warm-Season Pasture (Control) - GRL
3) Winter Wheat Conventional and No-Tillage - GRL
4) Winter Canola Conventional and No-Tillage - GRL

Soil Analysis at each time period:

Soil water content
Soil Inorganic Nitrogen- Ammonium and Nitrate Content
Total Nitrogen
Dissolved Organic Nitrogen
Microbial Biomass Nitrogen
Total Carbon
Dissolved Organic Carbon
Microbial Biomass Carbon
Microbial Fatty Acid Community Assessment

Greenhouse Gas Analysis at each time period:

Carbon Dioxide
Nitrous Oxide
Methane

Proposed Outcomes:

- Assess cumulative greenhouse gas flux given wetting.
- Determine soil priming caused by wetting.
- Determine how soil wetting affects microbial community changes post application.

Contact Persons:
Dr. Brekke Munks (Brekke.Peterson@ars.usda.gov)
Dr. Jean Steiner (Jean.Steiner@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

GRL-FLUXNET: A Network of Integrated Flux Measurement Systems in the Southern Great Plains

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Accurate estimation of carbon and nutrient dynamics and evapotranspiration (ET) across space (point, plot, and landscape) over time is vital to quantify carbon, nutrient, and water balances. Eddy covariance (EC) technique is recognized as the standard method to measure exchange of energy, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and ET between terrestrial ecosystems and the atmosphere at landscape levels. Such data on major agroecosystems is essential to develop, test, and improve crop and hydrologic models, satellite-based production efficiency, and ET models from local to global scales. In addition, this will lead to better understanding of the potential of agroecosystems to mitigate rising atmospheric CO_2 and other greenhouse gases and their effects on climate change. Microbes play a key role in carbon and nitrogen cycles in agroecosystems. To understand how climate change and/or management alternatives could affect the ecosystem services, we also have to understand how soil microbes respond to the environmental variations. However, availability of such a comprehensive dataset for major agroecosystems in the U.S. Southern Great Plains is limited.

Objective: Monitor and develop a comprehensive database consisting of surface energy, water, carbon, nutrient budgets, and soil biology of a diverse range of terrestrial ecosystems in the U.S. Southern Great Plains to support ARS Grand Challenge Research Goals on soil and water quality, sustainable crop production, and mitigation of GHG emissions.

What we are doing: The GRL-FLUXNET is a network of integrated flux measurement stations coupled with static chambers for measuring GHG emissions established in 2016 to develop a comprehensive database for development, evaluation, and enhancement of various environmental and ecological models. This network is located within the 3,000 ha USDA-ARS Grazinglands Research Laboratory (GRL) in El Reno, Oklahoma. It is currently consists of 14 eddy covariance systems to measure exchanges of CO_2, H_2O, CH_4, and energy fluxes between the atmosphere and a diverse range of terrestrial ecosystems including native and introduced tallgrass prairie pastures, burned and unburned prairie pastures, alfalfa, and grazed/non-grazed winter wheat, canola, and other forage crops under till and no-till practices. Data on biometerological variables (LAI, % cover, canopy height, and biomass), soil chemistry (total soil C and N, extractable soil C, NO_3, NH_4, and basic organic acids) and soil microbial community are being collected periodically at the study sites. In addition, measurements of surface reflectance (400-2400 nm range), surface temperature, net radiation, photosynthetically active radiation, and soil heat fluxes are being made. Chamber-based measurements of three major greenhouse gases (CO_2, CH_4, and N_2O) and soil heterotrophic respiration are being carried at all sites. Efforts are also being made to acquire very high resolution hyperspectral and thermal images of the integrated flux measurement sites.

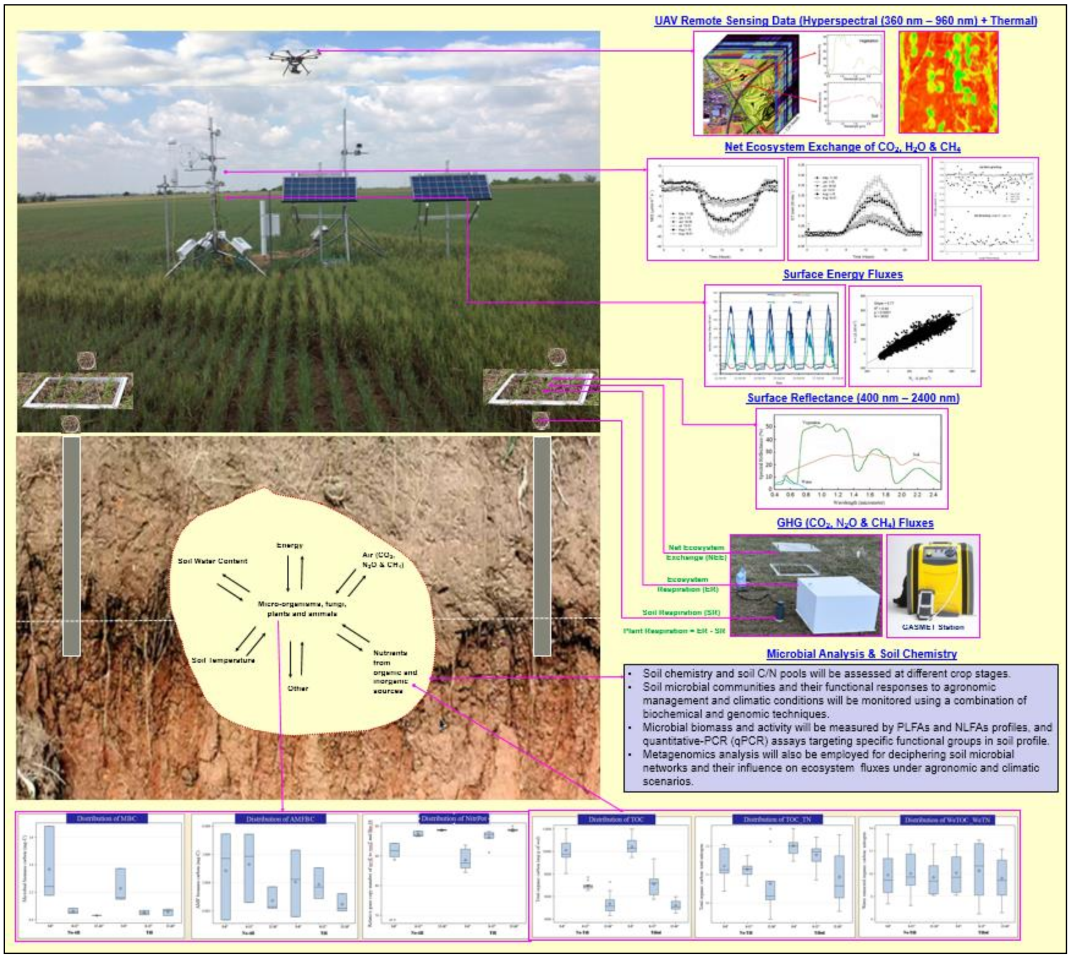


Fig. 1. An integrated flux measurement system.

Contact Persons:

Dr. Prasanna Gowda (Prasanna.Gowda@ars.usda.gov)
Dr. Jean Steiner (Jean.Steiner@ars.usda.gov)
Dr. Pradeep Wagle (Pradeep.Wagle@ars.usda.gov)
Dr. Brian Northup (Brian.Northup@ars.usda.gov)
Dr. Jesse DuPont (Jesse.DuPont@ars.usda.gov)
Dr. Anil Somenahally (Anil.Somenahally@ag.tamu.edu)
Dr. Tanka Kandel (tankakandel@gmail.com)
Priyanka Manjunatha (paggala@ostatemail.okstate.edu)

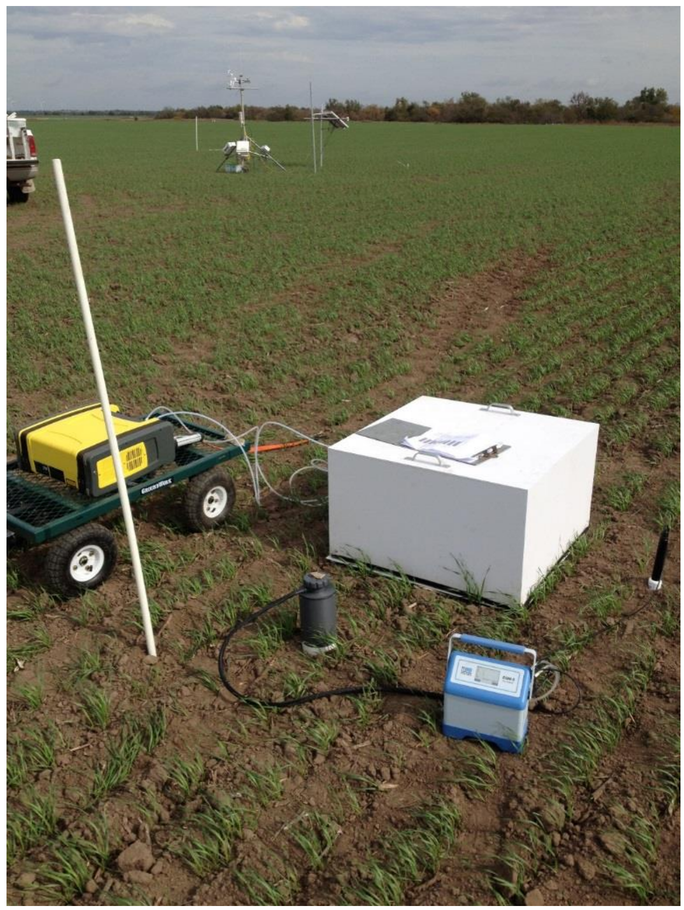
7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036
Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Measurement of GHG (CO_2, CH_4, N_2O) Emissions from Different Agroecosystems in the Southern Great Plains

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017



Rationale: Conventional agriculture, which includes regular tillage and fertilization, contributes substantially to total terrestrial greenhouse gas (GHG) emissions. Conservation agriculture such as no-till and cover crops, however, may provide options to mitigate GHG fluxes. Winter wheat is a major cash crop in Southern Great Plains (SGP). In recent decades, no-till is increasingly practiced for winter wheat cultivation in the region. Summer-grown cover crops such as pigeon pea, cowpea, and soybean in rotation with winter wheat cropping system are being evaluated as management options to increase net income to producers. The legumes cultivated as cover crops increase total green periods, fix atmospheric carbon and nitrogen to soil, and reduce leaching of nutrients and soil erosion. When cover crops are incorporated in the soil or left in the field, the decomposing biomass may release nitrogen which may be available for subsequently planted winter wheat. Although no-till and inclusion of cover crops have normally shown positive impacts on crop yield and soil health in the long run, overall GHG budgets in conventional and conservation agriculture are not well documented in the SGP. Monitoring of these systems for GHG emissions will help to understand impact of such conservation practices in overall annual GHG budgets and their GHG mitigation potential.

Objective: The main objective of this study is to understand effects of soil type, tillage management, crop type and rotation, and fertilizer type and rate of application on GHG emissions, and to quantify annual GHG balances.

Comparisons:

1. Crops and managements: Wheat (grain-only, graze and grain, and graze-out) and canola in rotation on large plots (n =8) representing individual watersheds.
2. Tillage: Conventional and no-till
3. Nitrogen rates and sources: Mineral (0, 45 and 90 kg N ha^{-1}) and organic (e.g., cowpea cultivated as a summer cover crop) in small replicated plot experiments.

Measurements:

The following measurements are being made biweekly to develop annual GHG budgets:

1. Fluxes of CO_2 with plants (gross primary production and ecosystem respiration).
2. Fluxes of CO_2 without plants (soil respiration)
3. Fluxes of CH_4 and N_2O
4. Supporting environmental variables: Soil moisture, soil temperature, air temperature, photosynthetically active radiation
5. Supporting crop development measurements: Canopy spectral reflectance, biomass yield, root/shoot ratio

---

Contact Persons:

Dr. Tanka P. Kandel (tankakandel@gmail.com)
Dr. Prasanna H. Gowda (Prasanna.Gowda@ars.usda.gov)
Dr. Brian Northup (Brian.Northup@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Measurements of Carbon Dioxide, Methane, Water Vapor, and Energy Fluxes from Different Ecosystems in Oklahoma using Eddy Covariance Systems

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: The atmospheric concentration of major greenhouse gases (GHGs) such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) is rising. The eddy covariance (EC) technique is the most widely used micrometeorological technique to directly measure net exchange of trace GHGs. In addition, information on exchange of energy and water vapor (H_2O) fluxes between major terrestrial ecosystems and the atmosphere is vital. Ecosystem level measurements of GHGs and H_2O fluxes are necessary to quantify GHGs and water balances from local to global scales. These measurements are also useful to develop and validate statistical, biophysical, and satellite-based production efficiency and evapotranspiration (ET) models. In addition, these measurements help us to evaluate the impact of different management practices on GHG emissions, water use, and crop yield/productivity, and to identify or develop the best management practices for climate change mitigation and adaptation.

A network (GRL-FLUXNET) of eddy flux towers has been established over a diverse range of terrestrial ecosystems, including native and planted tallgrass prairie, alfalfa (*Medicago sativa* L.), soybean (*Glycine max* L.), till and no-till canola (*Brassica napus* L.), and till and no-till winter wheat ((*Triticum aestivum* L.) with different grazing treatments at the USDA-ARS, Grazinglands Research Laboratory, El Reno, OK.

Fig. 1. An eddy covariance system measuring CO_2, H_2O, CH_4, and energy fluxes.

Objective: Examine seasonal dynamics and inter-annual variabilities of CO_2, H_2O, CH_4, and energy fluxes from different terrestrial ecosystems in response to major biophysical factors such as photosynthetic photon flux density (PPFD), air temperature (T_a), and vapor pressure deficit (VPD), soil water content (SWC), rainfall, leaf area index (LAI), and vegetation indices.

Preliminary Results (only soybean here):

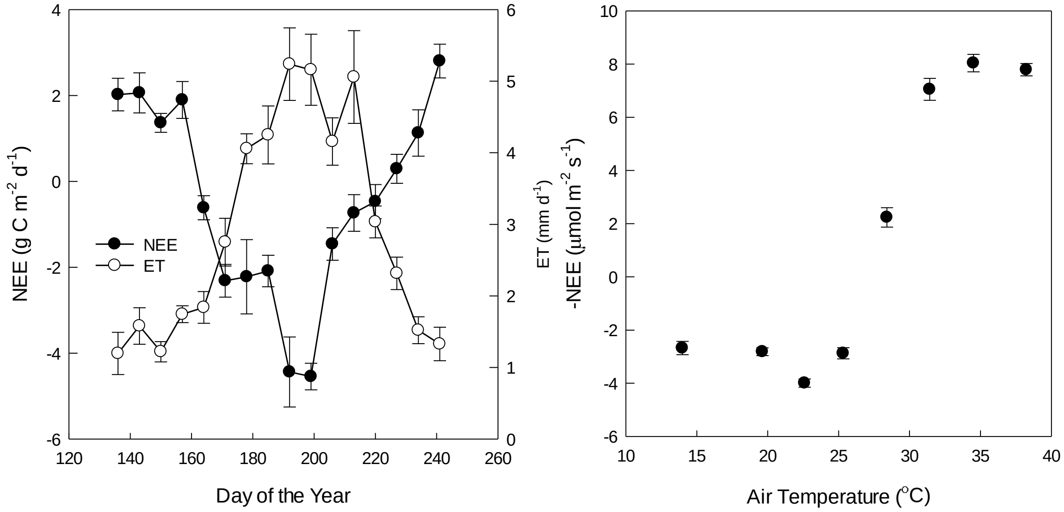


Fig. 2. Seasonal patterns of net ecosystem CO_2 exchange (NEE) and evapotranspiration (ET) in soybean during the 2016 growing season (left) and response of soybean NEE to air temperature (right).

- ➢ Daily NEE reached about -4.55 g C m^{-2} d^{-1} and ET reached > 5 mm d^{-1} in soybean.
- ➢ Optimum T_a and VPD for NEE were approximately 30 ºC and 2.5 kPa, respectively.
- ➢ The soybean ecosystem was a net carbon sink for about two months and gained about -54 g C m^{-2} during the growing season (DOY 132-243).

Proposed Evaluations:

- ❖ Biophysical controls on CO_2, H_2O, CH_4, and energy fluxes and the underlying mechanisms will be investigated for each ecosystem.
- ❖ Optimum threshold values of major climatic variables such as PPFD, T_a, and VPD for carbon fluxes and ET will be determined.
- ❖ Seasonal patterns and magnitudes of ecosystem light use efficiency (ELUE) and ecosystem water use efficiency (EWUE) in response to controlling factors will be investigated.

Publication:

Wagle, P., P. H. Gowda, S. S. Anapalli, K. R. Reddy, and B. K. Northup. 2017. Growing season variability in carbon dioxide exchange of irrigated and rainfed soybean in the southern United States. *Science of the Total Environment* 593-594: 263-273.

Contact Persons:

Dr. Pradeep Wagle (Pradeep.Wagle@ars.usda.gov)
Dr. Prasanna Gowda (Prasanna.Gowda@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036
Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Methane Production from Individual Grazing Cows and Cow Herds

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Methane production in ruminants is associated with feed quality and level of intake. Knowing methane production from individual cows and a herd of grazing beef cattle is important in understanding overall greenhouse gas (GHG) inventories.

In recent years, mitigating greenhouse gasses generated by a range of agricultural practices has become important. Dynamic weather conditions in the southern Great Plains necessitate research to better understand the impacts of agricultural production systems on environmental, water, and air quality factors. Knowledge will help refine managements of on-farm resources to increase production potential, while improving resilience and minimizing environmental impacts.

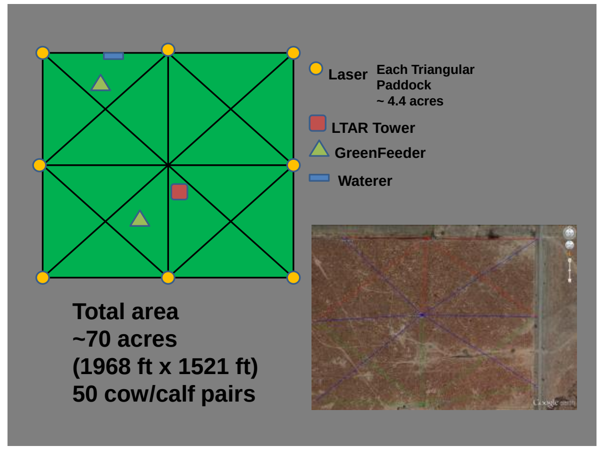
Objective: Establish real-time on-site monitoring of methane emissions from grazing beef cattle.

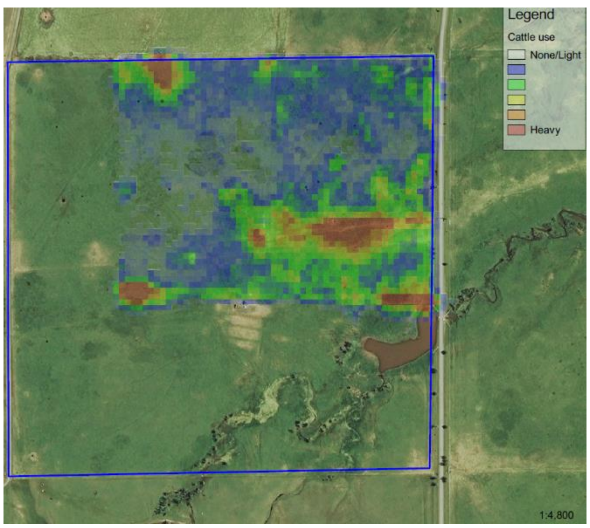
What we are doing: A portable automated gas quantification system (GreenFeed; C-Lock Inc., Rapid City, SD, USA) is used to collect GHG data from grazing cattle. A GreenFeed emission monitoring unit is basically a "breathalyzer" that allows for automated, quantitative measurement of methane (CH_4) and carbon dioxide (CO_2) in real time from individual cows allowing for minimal disturbance of cow's natural grazing behavior. →

We initiated year-round monitoring of CH_4 and CO_2 emissions using the GreenFeed system from cows grazing native prairie pastures. Angus cows are of two different frame sizes (small and medium). In addition, we determined forage nutritive value and intake of grazed forage by cattle to better interpret and understand the CH_4 and CO_2 output from these grazing cows based on the frame size and the digestibility of the forage. Along with ARS-Bushland, TX and ARS-Woodward, OK researchers, total methane released from a herd of grazing beef cows in a native pasture along with the location of the cow herd within the pasture is being monitored at specific times using a collar with an attached global positioning system (GPS) devise fitted on each cow.

2014-2017. Baseline data of CH_4 and CO_2 being released from beef cows were monitored when cows grazed native prairie pastures in late June/early July 2014 (high forage nutritive value), in October 2015 (declining, medium forage quality), and in February 2017 (dormant, low forage quality). These animals had access to the GreenFeed System.

In addition, dispersion analysis, coupled with measurements of atmospheric gas concentration and key meteorological variables, were used to quantify CH_4 emissions from the grazing cattle herd during the months listed above. Dispersion analysis also corrects for upwind and downwind CH_4 concentrations and characterization of turbulence. In 2014, researchers divided the pasture using open path laser sensors positioned above the cows in order to collect multiple concentration CH_4 measurements as the cows grazed. →





← It was also critical to know the locations of the grazing cows in the pasture for interpretation of CH_4 data, so each cow was fitted with a collar that held a battery-powered GPS device to track cattle movement over a ten-day period in the 70-acre research area. A summary map of cattle locations for the ten-day period in 2014 is shown.

Contact Persons:
Dr. Kenneth Turner (Ken.Turner@ars.usda.gov)
Dr. James Neel (Jim.Neel@ars.usda.gov)
Dr. Richard Todd (ARS-Bushland, TX; Richard.Todd@ars.usda.gov)
Dr. Corey Moffet (ARS-Woodward, OK; Corey.Moffet@ars.usda.gov)
Dr. Prasanna Gowda (Prasanna.Gowda@ars.usda.gov)
Dr. Jean Steiner (Jean.Steiner@ars.usda.gov)

Grazinglands Research Laboratory
7207 West Cheyenne Street
El Reno, OK 73036
Telephone: (405) 262-5291
FAX: (405) 262-0133

www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Production Efficiency in Replacement Heifers in Relation to their Efficiency as Mature Cows

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: The cow herd consumes 70% of the total feed consumed by beef cattle in the U.S. Yet, most feed efficiency research is conducted with young growing animals with the assumption that efficient, young growing cattle will also be efficient as lactating cows. We are conducting a long-term assessment of feed efficiency in cows, leading to a comparison of efficiency in growing heifers and cows.

Objective: Determine the relationship between Residual Feed Intake (RFI) evaluations conducted in growing heifers and those conducted again in the same animals as mature cows.

What We Are Doing: All replacement heifers are being evaluated for feed efficiency after being backgrounded at least 45 d following weaning and before the animals are 16 months of age. They are placed in the Calan headgate barn, allowed to acclimate, trained for the headgates, and fed an alfalfa hay diet to achieve 1 kg/d gain. Intake and efficiency will be determined on individual heifers over 70 d. After the heifers reach maturity they will again be evaluated. When cows reach 5 years of age, they will not be bred to calve the following year. After weaning calves from nonpregnant cows and the cows will be evaluated for weight loss and gain efficiency. First, cows will be fed a ration consisting of ground alfalfa hay at below maintenance level energy intake with subsequent weight loss. After the weight loss period, cows will be offered ad libitum access to the same ration. During this phase, cows will be in a positive weight gain period.

Heifer/Cow Types Being Evaluated

Small-Medium Frame Angus (SMA)

Medium-Large Frame Angus (MLA)

SMA X Brahman F1s

MLA X Brahman F1s

Contacts:
Dr. Jim Neel (Jim.Neel@ars.usda.gov)
Dr. Prasanna Gowda (Prasanna.Gowda@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Impact of Cattle Genetics, Frame Size, and Pre-slaughter Diet on Productivity and Beef Quality

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Local markets for farm-finished beef with a natural or organic label are growing. These systems often use higher proportions of forage and many seek to use only forage. Increased costs of feed grains have revived interest in increasing the use of forages and grazing in order to either market as forage-finished beef or to produce heavy calves that will finish on less grain. We will determine if frame score is a factor in carcass marbling, meat organoleptic characteristics, and economic outcomes in beef finished on all-forage systems.


Objective: Determine how cattle frame size and genetics impacts growth rate, carcass and beef quality, and economic returns under different finishing systems.

What We Are Doing: Following the winter stocker phase, steers and heifers produced by GRL-ARS-USDA are finished on either a conventional concentrate diet or grazed on alfalfa re-growth. Stocker-finish cattle types include small-medium (4.6 or less frame score) and medium-large frame Angus, and what would be considered a typical terminal cross animal produced from Angus X Brahman F1 cows bred to Charolais bulls (generally medium-large in frame size). Both finishing treatments began in mid-June, with concentrate cattle and the first slaughter group from alfalfa being killed after approximately 90 days of being on their respective finish diets. Another group of like cattle are carried approximately another 40 days (130 days total) on alfalfa prior to slaughter. Carcass data is collected at slaughter, and beef quality attributes were/are being evaluated in collaboration with Oklahoma State University.

Preliminary Results:

- Cattle on the concentrate diet achieved an ADG of 3.0 lb, while both alfalfa groups had ADGs of 2.25 lb.
- Across finish treatments, S-M frame size cattle averaged 2.3 lb per day gain while M-L averaged 2.5 lb.
- Hot carcass weights by finishing treatment were 674, 567, and 628 lb for concentrate, short, and long-fed alfalfa cattle, respectively.
- Hot carcass weights by frame size were 581 and 637 lb for S-M and M-L cattle, respectively.
- Frame size and finish diet did not impact Warner Bratzler tenderness scores, with all beef rated as tender.

Contacts:

Dr. Jim Neel (Jim.Neel@ars.usda.gov)
Dr. Ken Turner (Ken.Turner@ars.usda.gov)
Dr. Brian Northup (Brian.Northup@ars.usda.gov)
Dr. Prasanna Gowda (Prasanna.Gowda@ars.usda.gov)

Dr. Deb VanOverbeke, Department of Animal Science, Oklahoma State University

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture

Agricultural Research Service

Forage Potential of Novel Old- and New-World Warm-Season Grain Crops for Beef Production

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Oklahoma and the southern Great Plains (SGP) have periods of time during summer when there is a shortage of high quality forage to support stocker growth, which has resulted in a continued search for effective plant materials. There is a broad range of potential grass and legumes native to Africa, India, and South and Central America that are grown for grain crops that may also function as forages for the SGP. However, the capacity of such crops to function as effective forages to support stocker cattle in the SGP is unknown. Defining such potential requires a multi-experiment approach to define the potential of such crops to grow in Oklahoma, and whether cattle will actively graze these crops.

Objective: Search for functional annual forages among a diverse group of novel warm-season annual grain legumes and grasses, and identify those capable of providing high quality forage, and improve animal performance.

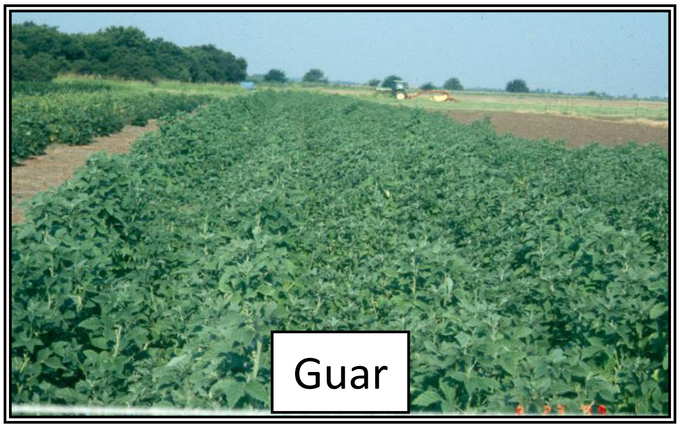
What We Did: We are addressing the issue of adaptability of novel forages, in collaboration with researchers at the Oklahoma State University, by applying a **series of experiments over 5 years (2017 to 2022)**. These experiments will: 1) screen a number of species, cultivars and lines of grasses and legumes to identify those that will grow in Oklahoma; 2) identify basic management techniques that provide optimum amounts of forage from crops identified by the first experiment as effective for Oklahoma; 3) describe animal preference for the forages identified as most-effective; and 4) evaluate performance of stocker cattle on species or cultivars identified as the most productive and preferred by cattle.

These experiments will allow a test of 24 cultivars and lines of grasses and legumes that could be useful for forage production systems that support summer grazing by stocker cattle in Oklahoma. Information related to the amount and nutritional value of biomass produced by the different plant materials will be described. The response of stocker cattle will be monitored to help define palatability of the most effective lines, as well as the gains by cattle.

Proposed Evaluations: Among the species to be tested will be:

- **Tepary Bean:** Tepary is a grain legume grown in the Desert Southwest, Mexico, and Central America. This legume dates back beyond the Aztec Empire, and has been an important food source for the Native American Hopi and Tohono O'odham Nations. This legume can produce biomass and grain on little rain (<16 inches/year) and low fertility soils, so it could be a useful legume for Oklahoma producers during droughts.
- **Moth Bean:** Moth bean is an annual legume grown for grain in the drier provinces of India. It is a short-season species capable of producing biomass with little water and infertile soils.

- **Guar:** Guar is an East Indian-origin legume that has seen some development for forage production, making it a potentially useful multi-product crop. Immature guar pods are used as a vegetable in East Indian cuisine and the grain is used in the cosmetic, pharmaceutical, food, and petroleum industries, so it is a true industrial crop. Guar produces high quality forage and is tolerant of dry growing conditions. Farmers in India noted that cattle do not readily graze guar in pasture settings but will eat guar hay, so guar might be a useful annual replacement for alfalfa on dryland farms in west Oklahoma and the Panhandle.



- **Finger Millet:** This annual grass is used for cereal production in India and Africa. The grain of finger millet contains amino acids and a broad range of macro- and micro-nutrients which can have positive benefits for human health, particularly infants and people with diabetes. Some studies have shown the quality of finger millet forage to be a good hay for dairy cattle, but no trials have been conducted on its capacity to function as grazed pasture.
- **Teff:** Teff is an annual grass that has been used as a grain crop in the 'horn of Africa,' which includes present-day Ethiopia and Somalia. This grass is capable of growth on small amounts of precipitation, and can rapidly produce biomass. There has been some cultivar development of teff for both grain and forage, and has been used in the U.S. mainly as a source of horse hay.

Contact Persons:
Dr. Brian K. Northup (Brian.Northup@ars.usda.gov)
Dr. Ken Turner (Ken.Turner@ars.usda.gov)
Dr. Prasanna Gowda (Prasanna.Gowda@ars.usda.gov)

Collaborators:
Dr. Alex Rocateli, OSU Plant and Soil Sciences (alex.rocatelli@okstate.edu)
Mr. Gurjinder Baath (PhD. student)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

Soil Nitrogen Availability for Continuous Winter Wheat in Response to Summer 'Green' N Crops

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

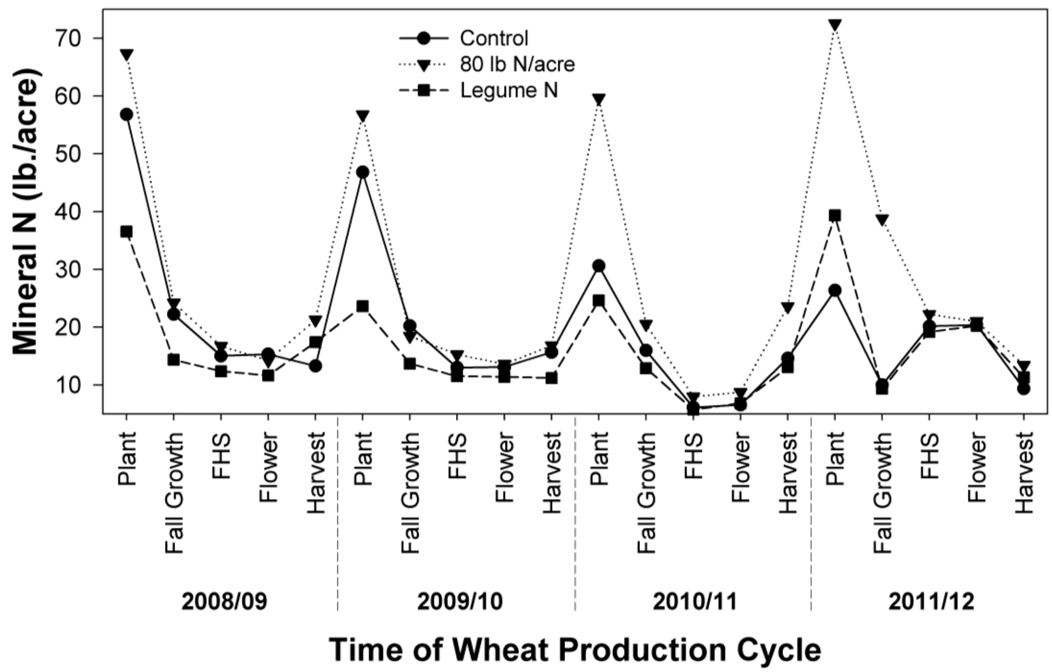
Rationale: The rising cost of inorganic nitrogen (N) fertilizer has renewed interest in supplying cash crops with N fixed, or captured, by cover crops. There is a wide level of variation in N capture by legume cover crops, and capture does not represent the amount of N supplied to following crops. For example, the amount of N fixed by legumes and transferred to following crops can be <30% of the total amount available. Under no-till, the lack of cultivation to incorporate plant residues could also reduce the amount of N available to the following crop. Such issues show the importance of understanding how 'green' N sources function within production systems, to define their value as fertilizers.

Objective: Describe influences of two forage legumes, used as 'green' N sources to support dual-purpose (fall through early-spring grazing + grain production) winter wheat, on mineral N in soil compared to summer fallow + applied inorganic N fertilizer over multiple years.

What We Did: We used two summer legumes ('Laredo' forage soybean, and 'Rio Verde' lablab) as green manures in small plot studies on highly productive clay loam soils in bottomland landscapes. Half of the plots were managed by no-till (herbicides only) and the second half by conventional tillage (disking and roto-tilling). The 'green' N crops were planted after wheat grain harvest (early-June) and grown through late-August to provide N. The plots then received their assigned tillage systems; shred and incorporate plant residues with tillage, or shred and spray with glyphosate (Round-up). Winter wheat was planted in early-September, as is normal for dual-purpose wheat. Additional plots at each location received one of two levels of inorganic N fertilizer (none and 80 lb N/acre) as dry urea. The 80 lb N/acre treatment was similar to recommended fertilizer rates for wheat grown on similar soils. Wheat was grown to maturity (early-June), and soils were sampled to 6 inches depth at different times of wheat production cycles and analyzed for mineral N.

Results: The following results are for a **4-year (2008 to 2012) experiment**.

- The first three growing seasons (September planting in one year through harvest in June the next year) were affected by low amounts of precipitation. Production of both 'green' N crops and wheat were reduced, as was the supply of mineral N for wheat production.
- Conventional tillage provided ~6 lb/acre more mineral N than no-till though this was not a significant difference; natural variation of soil mineral N ranged from 5 to 14 lb/acre.
- The inorganic N, control and legume N treatments provided, respectively, 64(±6), 40(±12), and 31(±7) lb/acre of mineral N in the upper 6 inches of soil at wheat planting (see figure). Mineral N in legume plots rarely exceeded N in plots managed as unfertilized control.



- Legume-treated plots had less N than control plots at planting of the first 3 growing seasons.
- Available mineral N at planting declined under control and legume treatments in the first 3 growing seasons; mineral N under the inorganic N treatment was higher and more consistent.
- The legumes provided 33 and 35 lb N/acre at planting of the first and last growing seasons; little improvement in N over 4 years.
- The low amounts of soil mineral N generated by legume treatments indicated more time will be required to improve soil fertility and support wheat production with 'green' N crops.
- This study provided information used to develop 2 longer-term agro-ecological experiments.

➢ Integrated (soil-plant) systems-level study of annual summer legumes as green N crops for continuous grain-only winter wheat – currently in 6^{th} Year.

➢ Integrated (soil-plant-animal) systems-level study of cool-season annual cover crops as green N sources for continuous grazed sorghum-sudangrass – currently in 5^{th} Year.

Contact Persons:

Dr. Brian K. Northup (Brian.Northup@ars.usda.gov)
Dr. Srinivas C. Rao, Retired

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0450

https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Soil Water Availability in Continuous Winter Wheat-Summer 'Green' N Crop Rotations

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

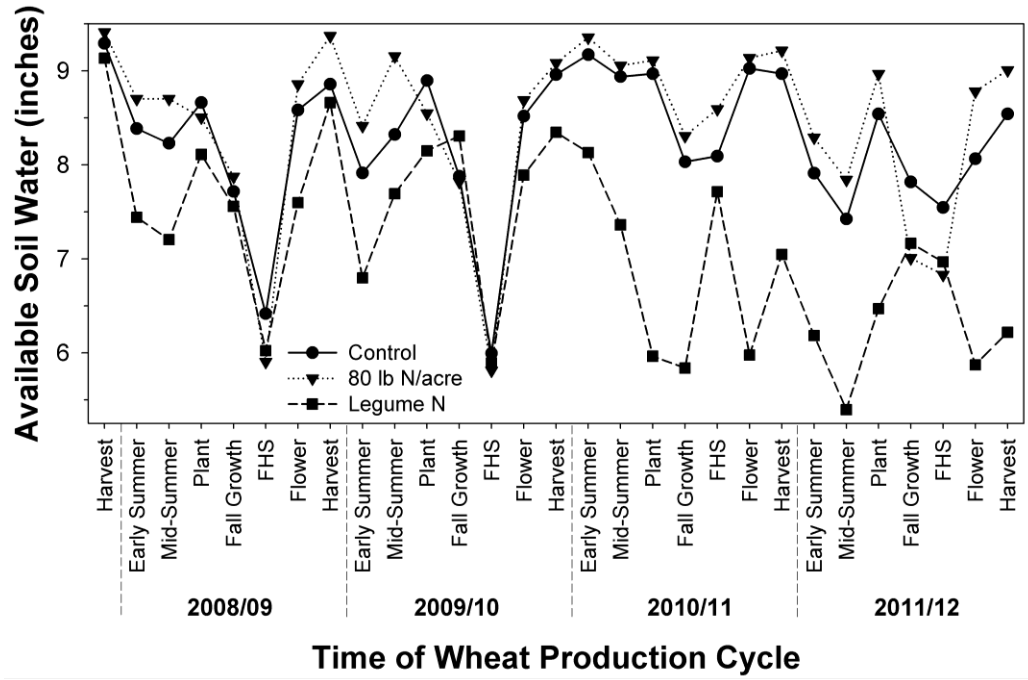
Rationale: Rising cost of inorganic nitrogen (N) fertilizer has renewed interest in supplying cash crops with N fixed, or captured, by cover crops. There is a wide level of variation in N capture by legumes, and capture does not always represent the amount of N supplied to following crops. Further, capture of green N with crops grown during summer fallow requires use of soil water normally conserved for the next wheat crop. Such repeated double-cropping could affect system productivity. Such issues show the importance of understanding how 'green' N will affect available soil water over the full period of wheat production cycles.

Objective: Describe the effects of 2 forage legumes used as 'green' N crops to support dual-purpose (fall through early-spring grazing + grain production) winter wheat, compared to summer fallow + applied inorganic N, on available soil water over multiple years.

What We Did: Half the plots were managed by chemical no-till and half by conventional tillage (disking and roto-tilling). 'Green' N crops were planted after wheat grain harvest (early-June) and grown until early-September to provide N. We used two annual legumes ('Laredo' forage soybean, and 'Rio Verde' lablab) as 'green' N crops. The plots then received assigned tillage systems; shred and incorporate plant residues by tillage or shred and spray with Glyphosate (Round-up). Winter wheat was planted 10 days after terminating legumes. Additional plots managed by summer fallow received 2 levels of inorganic N; none (the control) and 80 lb N/acre as dry urea to support wheat. Wheat was grown to maturity and amounts of soil water in the upper 30 inches of soil were measured during the summer fallow and wheat growth phases of the traditional production cycle of winter wheat for 4 years.

Results: The following results (reported amounts of soil water are similar to inches of rainfall) for a **4-year experiment (2008 to 2012).**

- Tillage system had minor effects. No-till provided 0.12 inches more water per 7.5 inch soil depth than conventional till. Natural variation in water per soil depth was ±0.15 inch.
- Greatest amounts of soil water during summers were recorded under the fallowed 80 lb N/acre treatment (see figure). Fallowed plots receiving the unfertilized control had slightly lower amounts of water present; legume-treated plots had the least.
- Legume-treated plots utilized 1.4 to 3.2 inches more soil water than summer fallowed treatments in June to early-September.
- Legumes resulted in 2.2±0.8 inches less soil water at wheat planting than fallowed plots; the lower amounts started at legume planting (10 days post-harvest, vertical dashed lines) in June.



- Water under legume treatments was more similar to fallowed treatments in early-March at first hollow stem (FHS).
- Much of the soil water removed from fallowed plots in Sept through March was related to high rates of wheat growth from planting through FHS.
- Water availability under legume treatments declined with length of study; fallowed treatments provided more uniform amounts of available soil water over life of study.
- Results show 'green' N treatments used as long-term planned tools have costs (use of scarce water resources) and potential carryover effects on wheat production over a series of years.
- This study provided information that helped develop 2 long-term agro-ecological experiments.

➢ Integrated (soil-plant) systems-level study of annual summer legumes as green N crops for continuous fall-planted winter wheat – currently in 6th Year.

➢ Integrated (soil-plant-animal) systems study of spring planted cover crops as green N sources for continuous grazed sorghum-sudangrass pasture – currently in 5th Year.

Contact Persons:

Dr. Brian K. Northup (Brian.Northup@ars.usda.gov)
Dr. Srinivas C. Rao, Retired

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036
Telephone: (405) 262-5291
FAX: (405) 262-0450

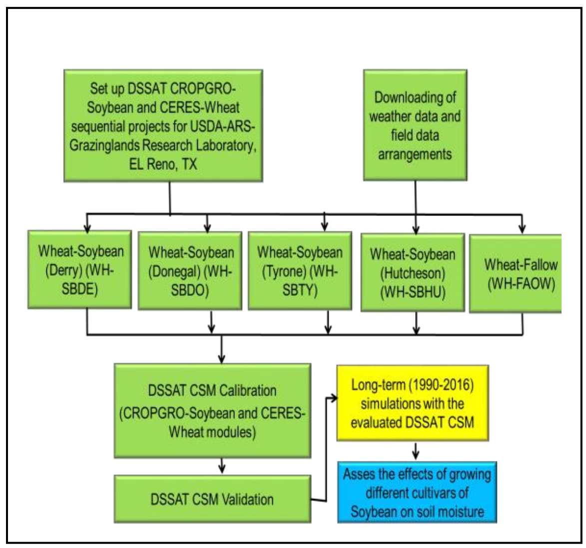
https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Assessing Soybean-Winter Wheat Sequences using the DSSAT-CSM in the Southern Great Plains

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Growing legume-cereal crops in succession has been practiced in the U.S. Southern Great Plains (SGP) to provide food for humans and feeds for livestock. The rise in costs of commercial fertilizer has increased interest to include legume crops in rotation with winter wheat as a source of nitrogen (N) and to build soil health. In addition, growing legumes-cereal sequences is expected to help reduce soil erosion, surface runoff, and pollution of surface water during summer rainfall events. In the SGP where animal production is a major economic activity, legume crops could serve as a source of late summer forage for stocker cattle. However, there is always a concern that growing legumes could potentially reduce available soil moisture for winter wheat and thereby affect its yield. Numerous studies conducted in the SGP demonstrated mixed results with some showing a reduction and others indicating no significant impact on yield of subsequent crops.



Decision Support System for Agrotechnology Transfer (DSSAT) Cropping System Model (CSM) is a widely used tool and capable of simulating the crop growth stage, development, and yield in response to variable weather conditions, crop management practices, and soil properties, including soil moisture. A well calibrated DSSAT-CSM model using field data is useful to evaluate crop responses under various sets of growing conditions, which ultimately assists decision making. Various researchers used calibrated DSSAT-CSM for evaluating soil, tillage, land use, and water management practices under spatially and temporally variable climate conditions.

Objective: (i) Calibrate and validate DSSAT-CERES-Wheat and DSSAT-CROPGRO-Soybean modules within the DSSAT-CSM for the Southern Great Plains using measured crop rotations data during 2001-2008 at the USDA-ARS Grazinglands Research Laboratory, El Reno, Oklahoma (ii) Assess the effects of growing legumes crops on soil moisture availability and winter wheat yield during wet, normal, and dry years.

What we are doing: Different sequential DSSAT projects were created using CROPGRO-Soybean and CERES-Wheat modules. Measured crop management data including tillage, planting and harvesting dates, rate and timing of fertilizer application, grain yield, above ground biomass of both winter wheat and soybean (four cultivars - Derry, Donegal, Tyrone, Hutcheson), and soil moisture during crop growing seasons 2001-2002, 2002-2003, and 2003-2004 were used for model calibration. Similar data collected during 2004-2005, 2005-2006, 2006-2007, and 2007-2008 cropping seasons were used for model validation. These calibrated and validated modules will help to simulate future crops yield and assists in crop management decision making process.

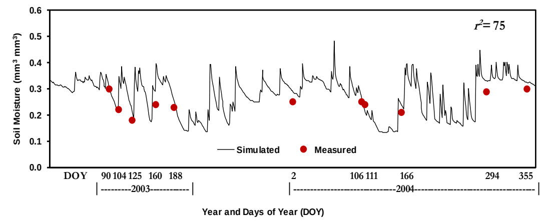


Figure 2: Comparison of simulated (lines) and measured (symbols) soil moisture content at 0-20 cm soil profile in wheat-soybean (WH-SBDE; derry soybean cultivar) crop sequence during calibration period at EL Reno, OK. Statistics shown is coefficient of determination (r^2)

Contact Persons:

Dr. Pradip Adhikari (Pradip.Adhikari@oksstate.edu)
Dr. Brian Northup (Brian.Northup@ars.usda.gov)
Dr. Prasanna Gowda (Prasanna.Gowda@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

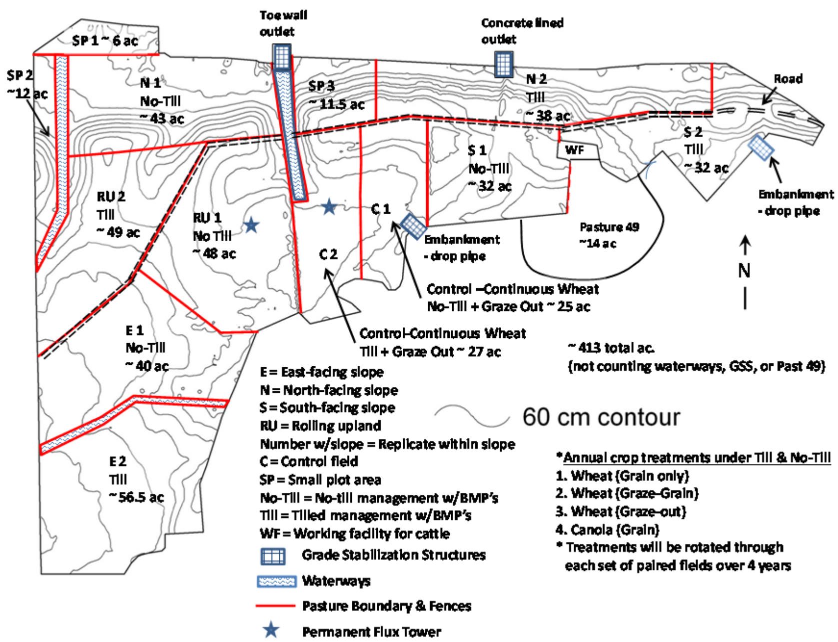
https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Integrated Wheat-Canola-Cattle Production System: Research Field Site Overview

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Production of winter wheat is an important part of cropping systems in the southern Great Plains, and is typically used for both pasture and as grain. In recent years, interest has increased in using winter canola in rotation with winter wheat. Wheat-canola crop rotations increase soil fertility, reduce incidence of wheat disease and insect pests, improve weed control, increase wheat grain yields following canola, and improve farm income from selling a more diverse range of products (wheat, canola, grazing cattle). Interest has also increased in no-till or minimum- tillage farming to improve production and reduce negative impacts on the environment. Proposed benefits from no-till/minimum-tillage systems include more effective control of wind and water erosion, improved water infiltration retention into soil, less runoff, long-term improvement in soil properties, decreased compaction, and fuel savings.



In recent years, mitigating greenhouse gasses (methane and carbon dioxide) generated by agricultural practices has become important. Dynamic weather conditions in the southern Great Plains necessitate research to better understand the impacts of agricultural production systems on environmental, water, and air quality factors. Knowledge will help refine management of on-farm resources to increase production potential, while improving resilience and minimizing environmental impacts.

Objective: Establish field-scale watersheds to evaluate environmental and atmospheric effects from integrated production of wheat, canola, and beef cattle under till and no-till farming practices.

What we did: We established a ~450-acre wheat farm to compare tillage and no-tillage/minimum tillage farming practices. Using soil type and slope, paired fields (till and no-till) were mapped. Each field (~ 40 to 50 acres) is an individual watershed. Managed waterways, grass buffer strips, and erosion-control structures for water control were developed and installed with USDA-NRCS specialists. Specific equipment for collection of water samples and research data from individual field-scale pastures allow for computation of water budgets and water-use efficiency in each field.

There are also control fields (till and no-till) of continuous wheat for graze-out by stocker cattle (Nov through May) year after year. Canola and beef cattle will be included in the crop rotation on the other pastures. Rotational treatments each year on the paired fields are: 1) Wheat (Grain; No Graze); 2) Wheat (Graze:Grain; grazed Nov through ~ Feb); 3) Wheat (Graze-out; No Grain); and 4) Canola (Grain; No Graze). In the field crop rotation schedule each year (below), graze-out wheat is followed by canola, and canola is followed by wheat for grain. Canola does not germinate well in heavy plant residues, and canola may benefit wheat for grain by providing pest/weed control.

		No-Till				Till			
Year	Time	RU-1	E-1	S-1	N-1	RU-2	E2	S-2	N-2
2016	Fall	Canola	Wheat	Wheat	Wheat	Canola	Wheat	Wheat	Wheat
2016	Fall	No Graze	No Graze	Graze	Graze	No Graze	No Graze	Graze	Graze
2017	Spring	No Graze	No Graze	Off	Grazeout	No Graze	No Graze	Off	Grazeout
2017	Summer	Grain	Grain	Grain		Grain	Grain	Grain	
2017	Fall	Wheat	Wheat	Wheat	Canola	Wheat	Wheat	Wheat	Canola
2017	Fall	No Graze	Graze	Graze	No Graze	No Graze	Graze	Graze	No Graze
2018	Spring	No Graze	Off	Grazeout	No Graze	No Graze	Off	Grazeout	No Graze
2018	Summer	Grain	Grain		Grain	Grain	Grain		Grain
2018	Fall	Wheat	Wheat	Canola	Wheat	Wheat	Wheat	Canola	Wheat
2018	Fall	Graze	Graze	No Graze	No Graze	Graze	Graze	No Graze	No Graze
2019	Spring	Off	Grazeout	No Graze	No Graze	Off	Grazeout	No Graze	No Graze
2019	Summer	Grain		Grain	Grain	Grain		Grain	Grain
2019	Fall	Wheat	Canola	Wheat	Wheat	Wheat	Canola	Wheat	Wheat
2019	Fall	Graze	No Graze	No Graze	Graze	Graze	No Graze	No Graze	Graze
2020	Spring	Grazeout	No Graze	No Graze	Off	Grazeout	No Graze	No Graze	Off
2020	Summer		Grain	Grain	Grain		Grain	Grain	Grain

No-Till and Till Fields:
RU= Rolling Upland
E = East-facing slope
S = South-facing slope
N = North-facing slope

Contact Persons:

Dr. Kenneth Turner (Ken.Turner@ars.usda.gov)
Dr. Patrick Starks (Patrick.Starks@ars.usda.gov)
Dr. James Neel (Jim.Neel@ars.usda.gov)
Dr. Prasanna Gowda (Prasanna.Gowda@ars.usda.gov)
Dr. Brian Northup (Brian.Northup@ars.usda.gov)
Dr. Jean Steiner (Jean.Steiner@ars.usda.gov)

Grazinglands Research Laboratory
7207 West Cheyenne Street
El Reno, OK 73036
Telephone: (405) 262-5291
FAX: (405) 262-0450

www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

Recent Forage Grass Cultivar Releases by the Grazinglands Research Laboratory: "*Artillery*" Smooth Bromegrass & "*Armory*" Endophyte Free Tall Fescue

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Agriculture in the Southern Great Plains (SGP) is mixed with cropland, pastureland, and native prairie rangelands interspersed within individual farms across the landscape. These transitional lands range between both humid and arid zones. However, crop and animal production and farm income in the SGP fluctuate wildly because of large climate variability. Forage resources in this transition zone include both tall-grass prairie and introduced perennial grasses that provide resilience to the summer forage supply during variable climate conditions. Winter wheat is the principal annual crop, with much of it serving dual use as a cool-season forage as well as for grain production. Production from existing forage crops is, however, seasonal in nature and grazing livestock are confronted with significant periods of forage deficit throughout the year. As such, the identification or development of plant materials and improved technology to provide improved quantity and quality of forage is essential. Current livestock production systems face serious challenges due to increasing production costs, climatic uncertainties and environmental concerns. As a consequence, adapted, perennial cool-season grass forages have been developed, released, and commercially marketed to fill forage gaps between the winter wheat and perennial summer grazing periods in the Southern Plains Region.

'Artillery" smooth bromegrass in Albany, OR

Objective: Develop persistent, perennial, cool-season grass forages that will improve productivity and sustainability of grazing and crop lands in the Southern Great Plains.

What we are doing: The perennial, cool-season grass forage program was initiated at the Grazinglands Research Laboratory in 2000. Since that time, we have searched the world for species and accessions that exhibit tolerance to the environmental extremes of the Southern Plains Region. For nearly a decade, we have performed hybridizations and selections within the gene pool of these materials to identify particular genotypes that are persistent and adapted to the environmental extremes of the Southern Plains. Specifically, these extremes include long periods of elevated temperature and drought, two traits not commonly found in cool season grass forages.

From this program, two cultivars have been recently released for use in the Southern Plains. "*Artillery*," a smooth bromegrass, and "*Armory*," a semi-rhizomatous, endophyte free tall fescue. Each were evaluated against popular commercial checks and across multiple locations across the USA. Both releases exhibit competitive forage production to commercial cultivars and each are superior performers under drought conditions. Plant Variety Protection was granted on both cultivars in 2016 and both are to be marketed by Barenbrug Seeds USA beginning in fall of 2017.

Contact Person:
Dr. Bryan Kindiger (Bryan.Kindiger@ars.usda.gov)

7207 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 262-5291
FAX: (405) 262-0133

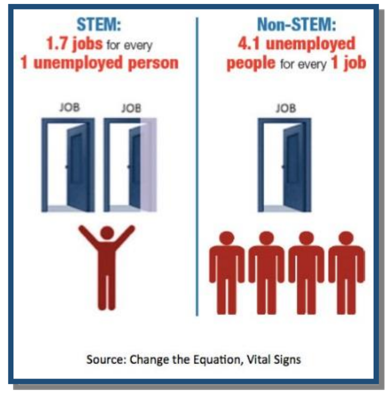
https://www.ars.usda.gov/plains-area/el-reno-ok/grazinglands-research-laboratory/

United States Department of Agriculture
Agricultural Research Service

BlueSTEM AgriLearning Center

Grazinglands Research Laboratory, El Reno, Oklahoma May 2017

Rationale: Science, technology, engineering, and mathematics (STEM) are necessary components in the American workforce to sustain American competitiveness in the global economy. The interest in STEM careers are on the decline, while STEM positions in the workforce are on the rise. There are currently 1.7 STEM jobs for every unemployed individual. The US Department of Education (USDE) reports that the percentage of bachelor's degrees in STEM fields have declined in the past decade. A STEM education not only creates more opportunities for involvement in STEM careers, it also nurtures critical thinking and problem solving skills that equip learners to be adept citizens. The BlueSTEM Agrilearning Center is a collaborative effort between the US Department of Agriculture (USDA)-Agricultural Research Service-Grazinglands Research Laboratory (GRL) and Historic Fort Reno, Inc (HFRI) which strives to connect research and historic preservation to the greater community.



Objective: The BlueSTEM AgriLearning Center (BALC) serves to strengthen the STEM pipeline by enhancing STEM educational opportunities for students K-12 through graduate school, engaging students in future STEM careers, and strengthening and diversifying the work force of the next generation.

What we are doing:

ERPS Experiential Research Class: El Reno Public School High School students attend an Experiential Research Class at Grazinglands Research Laboratory in which they take part in primary research under the mentorship of USDA-GRL scientists. Students earn a high school science credit for taking this class. Students that take part in this class for the second year will be concurrently enrolled at Redlands Community College and will earn 3 credits in Applied Science each semester.

Teacher Professional Development: BALC provides various teacher professional development opportunities throughout the year including topics in water education, environmental education, soil science, native plant identification, and natural history.

STEM Day Camps: These educational opportunities are offered during the summer months to students from K-6th grade.

Family Science Nights: Various Family Science Nights are offered throughout the summer including Firefly Night, Go Batty! (Bat Night), and Pollination Ecology.

Future Proposed Projects:

- Citizen Science Programs
- Education Garden
- School Pilot Programs
- Online Curriculum
- Traveling STEM Labs

Contact Persons:

Ann Marshall (bluestem@fortreno.org)
Dr. Daniel Moriasi (Daniel.Moriasi@ars.usda.gov)
Dr. Jean Steiner (Jean.Steiner@ars.usda.gov)

7101 West Cheyenne Street
Grazinglands Research Laboratory
El Reno, OK 73036

Telephone: (405) 422-5072
FAX: (405) 262-0133

bluestemagrilearning.org