# Application to the USDA-ARS

# LONG-TERM AGRO-ECOSYSTEM RESEARCH (LTAR) NETWORK

# TO ESTABLISH THE

# PLATTE RIVER – HIGH PLAINS AQUIFER LTAR

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**LIST OF ACRONYMS**

| | |
|---|---|
| ADWN | Automated Weather Data Network |
| ARDC | Agricultural Research and Development Center |
| AVHRR | Advanced Very High Resolution Radiometer |
| BBR | Barta Brothers Ranch |
| CALMIT | Center for Advanced Land Management Information Technologies |
| DIR | Drought Impact Reporter |
| GRACE | Gravity Recovery and Climate Experiment |
| GRACEnet | Agricultural Carbon Enhancement Network |
| DNR | Department of Natural Resources |
| DSSAT | Decision Support System for Agrotechnology Transfer |
| EROS | Earth Resources Observation Science |
| GSL | Gudmundsen Sandhills Laboratory |
| HAL | Haskell Agricultural Laboratory |
| HPRCC | High Plains Regional Climate Center |
| IANR | Institute of Agriculture and Natural Resources |
| LTAR Network | Long-term Agro-ecosystem Research Network |
| MARC | Meat Animal Research Center |
| NADP | National Atmospheric Program |
| NASA | National Aeronautics and Space Administration |
| NDMC | National Drought Mitigation Center |
| NOAA | National Oceanic and Atmospheric Administration |
| NPAES | North Platte Agricultural Experiment Station |
| NRDs | Natural Resources Districts |
| NSM | Nebraska Soil Moisture network |
| NTN | National Trends Network |
| PREC | Panhandle Research and Extension Center |
| REAP | Renewable Energy Assessment Project |
| RGLMN | Real-Time Groundwater Level Monitoring Network |
| RMF | Rogers Memorial Farm |
| SCAL | South Central Agricultural Laboratory |
| SNR | School of Natural Resources |
| UNL | University of Nebraska-Lincoln |
| USBR | U.S. Bureau of Reclamation |
| USCRN | U.S. Climate Reference Network |
| USDA-ARS AMRU | USDA-ARS Agro-ecosystem Management Research Unit |
| USDA-ARS EMRU | USDA-ARS Environmental Management Research Unit |
| USDM | U.S. Drought Monitor |
| USGS | U.S. Geological Survey |
| UV-B | Ultraviolent-B |
| VegDRI | Vegetation Drought Response Index |
| WCRE | West Central Research and Extension Center |
| WRF | National Weather Research and Forecasting |

## INTRODUCTION

### Goal and Objectives

The University of Nebraska-Lincoln (UNL), the USDA-ARS Agro-ecosystem Management Research Unit (AMRU) in Lincoln, and Environmental Management Research Unit (EMRU) in Clay Center propose to establish a Long-term Agro-ecosystem Research (LTAR) Network site with a focus on the northern portion of the High Plains Aquifer. Over 95 percent of the water withdrawn from the aquifer is for agricultural use, and – unlike the portion of the aquifer underlying southern Kansas, Oklahoma, and Texas where significant drawdown has occurred – ground water levels have remained relatively stable since 1960. However, this stability might be in jeopardy with projected climate variability and change for the region. Establishing an LTAR to examine and make available data regarding the northern portion of the aquifer will fill a geographical and hydrologic gap not currently addressed through the LTAR Network while complementing the Ogallala Aquifer Initiative, established by USDA in 2003 to address unsustainable groundwater use in the southern portion of the aquifer.

The ***overall goal*** of the Platte River – High Plains Aquifer LTAR will be to make available historical long-term data, cross-site research data, and common geographically-scalable databases necessary to deliver knowledge and develop applications to address increasingly critical agricultural challenges associated with producing the food, feed, fiber, and feed stocks needed by society. These data will play a critical role in developing production systems that are economically profitable while securing a high quality of life among populations living in rural communities and maintaining or improving air, water, and soil quality. To accomplish this goal, the proposed LTAR will pursue ***four primary objectives***:

1. Provide scientific and programmatic leadership and infrastructure to ensure the Platte River – High Plains Aquifer LTAR functions efficiently and effectively in accomplishing its mission and is responsive to emerging data needs and challenges.
2. Collect and make available a core set of common measurements that will be compatible across LTAR sites, meet established quality standards, and be maintained in a Network agreed-upon, publicly-accessible format.
3. Develop research partnerships with a wide variety of stakeholders, including other local, state, and federal governmental agencies, universities, and the private sector, to develop the depth and breadth of expertise necessary to compete for and secure funds to support collaborative long-term research.
4. Participate in LTAR Network meetings and workshops to share research progress, discuss methodological and operational issues, and plan future Network activities and initiatives.

Experienced personnel affiliated with multiple core geographical sites located across Nebraska will collaborate to accomplish these objectives. Data sets and research experience provided through this LTAR fall within four primary research clusters, all of which are of significance to the LTAR Network: cropping systems, beef cattle and grassland systems, water resources, and regional modeling and integration.

### Overview of the High Plains Aquifer and Need for the Proposed LTAR Site

The High Plains Aquifer underlies an area extending from South Dakota to Texas, including 165,000 $km^2$ in Nebraska and 79,000 $km^2$ in Kansas. The portion of the aquifer underlying Nebraska and Kansas contains 75 percent of the drainable water in storage. Recharge of the aquifer is primarily by infiltration of precipitation and infiltration from streams and canals. Natural discharge from the aquifer is to springs, seeps, and streams. There is significant interaction between the Platte River and the High Plains Aquifer in Nebraska, with the aquifer acting as a contributor to river flow in the lands overlying the western-portion of the aquifer and the river acting as a recharge source for the aquifer further downstream.

Utilization of the High Plains Aquifer began in the 1800s with the use of windmills as pumps. Use of the aquifer for public and private use increased over time with significant increases in response to droughts in the 1930s, 1950s, and 1980s. Over 4.5 million ha of 11.9 million ha (38 percent) of cropland overlying the northern portion of the High Plains Aquifer is currently under irrigation. Ground water provided via over 115,606 registered wells supplies nearly all of the irrigation (Fig. 1). Therefore, irrigation wells represent a major discharge from the aquifer (0.8 million ha m in 2008). Over 95 percent of the water withdrawn from the High Plains Aquifer is for agricultural use. In spite of this level of use, water levels in this portion of the High Plains Aquifer remain relatively stable, which is in contrast to the portion of the aquifer underlying southern Kansas, Oklahoma, and Texas where significant drawdown of the aquifer has occurred. In 2003, the Ogallala Aquifer Initiative, involving ARS-USDA (Lubbock, TX and Bushland, TX), Kansas State University, Texas AgriLife Research and Extension Service, Texas Tech University, and West Texas A&M University, was initiated to address unsustainable use of the southern portion of the aquifer. The proposed Platte River – High Plains Aquifer LTAR in the northern portion of the aquifer would complement the Ogallala Aquifer Initiative by developing sustainable management practices for this critical water resource.

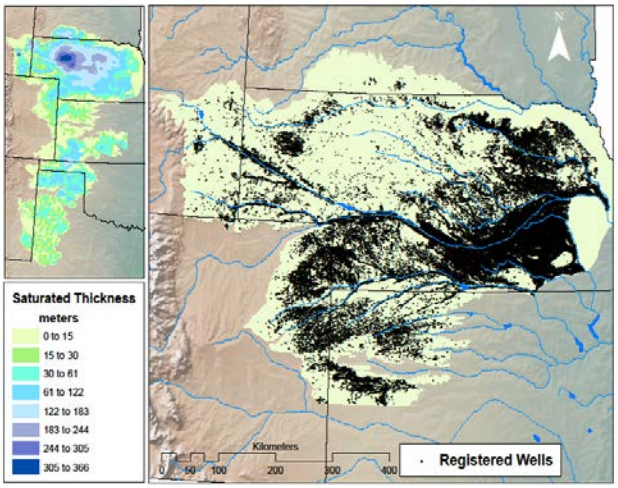


***Figure 1.*** *Distribution and saturated thickness of the High Plains Aquifer and location of registered wells within the proposed LTAR.*

The surface area of the High Plains Aquifer is dominated by a variety of land uses, including cropping systems, beef cattle and grassland systems, and water resources (Fig. 2). Livestock grazing on 9.7 million ha of rangeland and pasture and grain production (~38.1 million Mg of corn and ~3.5 million Mg of soybean in 2011 with lesser amounts of wheat and sorghum) are the main agricultural practices. Grazing of pasture and rangeland and feeding of about 40 percent of the corn results in five to six million beef cattle being fed and marketed each year. With passage of the Renewable Fuel Standard in 2005 there also has been a rapid expansion of ethanol production. There are currently 24 ethanol plants in the region utilizing ~30 percent of the corn grain to produce 7.6 billion liters of ethanol. While use of corn as a biofuel feedstock competes with livestock for available corn, grain-based ethanol production also produces ~5 million Mg of distiller's grain that is fed to livestock (Fig. 2). Feeding distiller's grain requires a roughage source and baling of crop residue for use as a feed source is a common practice. Expansion of the ethanol industry has resulted in rapid changes in land management. A better understanding of how these management changes affect sustainability is needed to ensure that the food, feed, fiber, and fuel demands of society are met, that all sectors are profitable, that the rural quality of life is acceptable, and that environmental quality remains high.

Despite relatively stable water levels, portions of the High Plains Aquifer are over appropriated and as competing demands for water increase across the region, agriculture will need to continue becoming more water efficient. Progress has been made in water use efficiency as furrow irrigation has been replaced by sprinkler systems; high pressure sprinkler systems replaced by low pressure systems; and development of improved irrigation scheduling. Further improvements will result from a better understanding of crop water use in spatially variable landscapes, development of deficit irrigation practices, adoption of crop varieties with improved water use efficacy, increased use of drip irrigation, and other yet to be identified approaches. Future efforts to make better use of the High Plains Aquifer will require that the crop,

livestock, wildlife, biofuel production, and socio-economics of communities be studied as an integrated system.

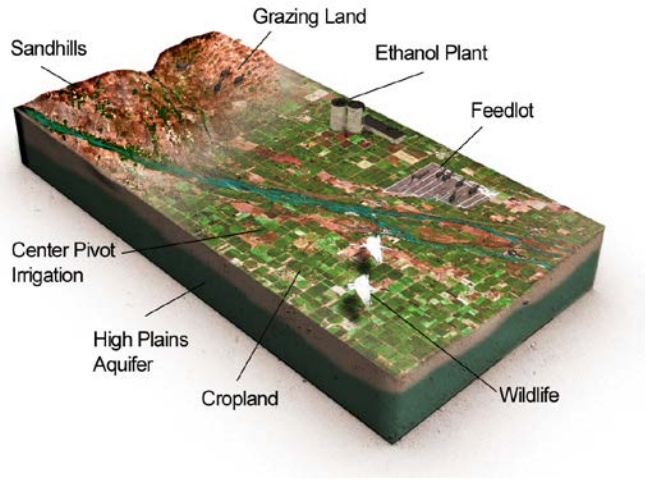


***Figure 2.*** *Common land uses in the Sandhills and cropland impacting the Platte River and Aquifer.*

Long-term UNL data sets on precipitation, soil moisture and groundwater levels across Nebraska facilitate research at multiple spatial scales, ranging from local water balance estimates for irrigators to landscape level estimates of evapotranspiration and groundwater recharge to regional water balances. For example, UNL's data on water from the soil surface to the underlying High Plains Aquifer was instrumental in the calibration of National Aeronautics and Space Administration (NASA)'s Gravity Recovery and Climate Experiment (GRACE) satellite hydrologic assessment system (Strassberg et al., 2009). Much as a state-of-the-art watershed study integrates diverse point-based data to achieve a landscape-level picture of water fluxes and storage, we will take an integrated approach to understanding the groundwater-dominated landscape of the High Plains and the varied ecosystems supported (including range and crop agro-ecosystems).

## PRODUCTIVITY

### Partners and Participation Research Units

UNL and USDA-ARS will partner to establish the Platte River – High Plains Aquifer LTAR. ***USDA-ARS AMRU*** is a diverse research unit whose joint missions are to: 1) develop sustainable food, feed, fiber, and feedstock production systems and livestock management technologies and 2) disseminate useful information and technologies to stakeholders. USDA-ARS AMRU scientists accomplish these missions by identifying and pursuing priority research to address livestock-associated issues. End goals include improving the management of natural and renewable resources and making agriculture more sustainable. ***USDA-ARS EMRU*** is one of six research units comprising the Meat Animal Research Center (MARC) located near Clay Center, Nebraska. Scientists at USDA-ARS EMRU develop tools to assist livestock producers in making sound management decisions with respect to production and environment management. Short- and long-term management is conducted to better understand the interactions between animal production and air, land, and water resources.

***UNL*** is a land-grant university recognized by the Carnegie Foundation as a Doctoral/Research Extensive university and accredited by the Higher Learning Commission of the North Central Association of Colleges and Schools. Through its missions of teaching, research, and outreach, UNL is Nebraska's primary intellectual center and it provides leadership across the state and nation and around the world, offering quality education and serving as a source of new knowledge. An array of academic programs are available, including those in agricultural and food sciences, physical and life sciences, and natural resources, and UNL has long been the site of educational and research innovation, as evidenced by: 1) leadership in formal and informal education, research, and outreach; 2) a robust portfolio of externally funded projects; 3) an impressive network of outreach partners; and 4) a commitment to developing long-term, sustainable relationships with innovative programs and partnerships proven to have broad, positive impact.

A majority of the UNL units whose faculty will participate in the Platte River – High Plains Aquifer LTAR are located within the university's **Institute of Agriculture and Natural Resources (IANR)**. IANR is a global leader in agricultural education, research, extension, and outreach and has established long-term collaborations in crop and soil science, plant breeding, food science and technology, horticulture, agricultural engineering, animal science, and veterinary medicine. Comprehensive extension services and advanced distance education systems deliver education and training. IANR units that will play a critical role in the proposed LTAR include the School of Natural Resources (SNR) and the Departments of Agricultural Economics, Agronomy and Horticulture, Animal Science, and Biological Systems Engineering.

SNR is broadly charged with providing water and mineral resources programs; augmenting the understanding, management, and stewardship of Nebraska's soil and rangeland resources; supporting programs on remote sensing, geographic information systems (GIS), climate, and natural resource database activities; supporting programs on global climate and environmental change; and enhancing Nebraska's grasslands, woodlands, agro-ecosystems, wildlife, fisheries, and other aquatic resources through research, education, and service programs. Several key centers within SNR will contribute directly to the accomplishment and implementation of LTAR objectives:

- *National Drought Mitigation Center (NDMC)* helps develop and implement measures to reduce societal vulnerability to drought, stressing preparedness and risk management rather than crisis management. The NDMC also works with USDA's eXtension program, which is the national and local online connection to the Cooperative Extension Service.
- *Center for Advanced Land Management Information Technologies (CALMIT)* is nationally recognized as a center-of-excellence for the use of remote sensing, GIS, and other geospatial technologies for agricultural and natural resource applications. CALMIT maintains considerable infrastructure to collect key remotely sensed data and geographic information for agriculturally intensive regions at laboratory, field, state, and regional scales. The Center has a state-of-art spectral laboratory coupled with advanced close-range remote sensing systems that are deployable in the field and aircraft-based, high spatial resolution (~1-2 meter) hyperspectral imaging systems utilized for agriculture monitoring and research.
- *High Plains Regional Climate Center (HPRCC)* coordinates data acquisition from over 170 automated weather stations, providing comprehensive data for use in agricultural decision making for the region. Sensors at weather stations measure temperature, humidity, solar radiation, wind speed and direction, precipitation, soil temperature, and soil moisture.

The Department of Agricultural Economics houses expertise in sustainability and profitability of agricultural firms; food, energy, and resource policy; industrial organization of the agri-food system; and rural innovation and development. Related to the agro-ecosystem datasets provided within the proposed LTAR, expertise is available to evaluate the "human dimensions" of decision making by producers, consumers, and policy makers and the impacts of decisions on food, fuel, water, and land-use decisions.

The Department of Agronomy and Horticulture is home to plant geneticists, physiologists, ecologists, soil and water scientists, and landscape architects. This diversity supports the department's objectives of developing students who are prepared for service to society, cropping systems that are increasingly productive and efficient, landscape and horticultural designs, and food and fiber products, all to enhance quality of life and protect and nurture natural resources.

Faculty in the Department of Animal Science provide leadership worldwide in animal biology research and education in support of sustainable use of domestic animals for food, fiber, work, and recreation. Programs within the department educate students for careers in animal biology and management.

Biological Systems Engineering faculty conduct research in five focus areas: bioengineering for health and productivity, environmental engineering, bioprocess engineering for adding value, site-specific crop management, and water resources and ecosystems engineering. As is the case with most of the

participating university units, research is conducted in university laboratories and in the field utilizing four research and extension centers located throughout Nebraska.

**Leadership Team**

The proposed LTAR will be part of IANR and will report administratively to the Deans of the Agricultural Research Division and IANR Vice Chancellor. Two LTAR Directors – Drs. Brian Wienhold and Tala Awada – will lead the site with input from an internal advisory committee comprised of key scientists. See Appendix 1 for biographical sketches for the co-Directors and members of the internal advisory committee. A data curator will be hired to assist the co-Directors and act as the primary point-of-contact for LTAR members and stakeholders. The data curator will report to the Director and handle critical activities related to data and grant management and interactions and communications, as well as provide support for any educational activities to be performed. The data curator will also be a key part of the internal interactions with university faculty and USDA-ARS scientists. The leadership team will meet monthly to review progress and make refinements to LTAR activities.

**Research Clusters**

Together, faculty and staff from the participating units have collected significant data and resources relevant to the LTAR Network in four primary research areas: cropping systems, beef cattle and grassland systems, water resources, and regional modeling and integration. The LTAR offers, for the first time, an opportunity to bring the data together under one centralized umbrella. LTAR-affiliated faculty (see Appendix 2) also have the expertise and resources to continue collecting data into the future, with existing strengths as data creators and users, specifically in regard to scientific validity of data, good database design, modeling capability, and model validation; the scientific depth to provide consulting in data use and interpretation, especially with respect to interdisciplinary applications; and the technical depth to manage relevant data systems and assure their sustainability. Faculty involved with the research clusters will utilize data from multiple core sites across the state (see Fig. 3 and Infrastructure Capacity). A summary of each research cluster and level of existing process-based understanding is provided below.

***Cropping Systems*** Faculty and staff who are part of the cropping systems research cluster use an interdisciplinary approach to design and conduct research relevant to the region. Research facilities located throughout the proposed LTAR provide the opportunity to evaluate crop productivity, fertilizer response, and emissions across the climatic gradient (Fig. 3). Research under rainfed and irrigated settings provides information on crop productivity (Grant et al., 2007), soil processes (Kochisek et al, 2009), nutrient use efficiency (Dobermann, et al., 2011; Wortmann et al., 2011), water use efficiency (Verma et al., 2005; Suyker and Verma, 2010), and impacts to the underlying aquifer. Ongoing studies are assessing crop rotation and cropping intensity effects on crop production and soil properties (Varvel, 2006; Varvel and Wilhelm, 2011), crop response to fertilizer rate and nitrification inhibitors (Lyon and Hergert, 2012, Dobermann et al., 2011, Wortmann et al., 2009, 2011), nitrogen management effects on nitrate leaching (Katupitiya, et al., 1997; Ferguson, et al., 1991), crop and soil response to crop residue removal for livestock feed or use as a biofuel feedstock (Varvel,et al., 2008; Wilhelm et al., 2010; Johnson et al., 2010; Varvel and Wilhelm, 2008; Wienhold et al., 2011; Wienhold and Gilley, 2010), and tillage intensity effects on crop production and soil properties (Cahoon et al., 1999; Varvel and Wilhelm, 2010, 2011).

The duration of many of these ongoing studies provides data on crop and soil response to highly variable precipitation and temperature common to the region (Wilhelm and Wortmann, 2004). Plant responses to management and the environment are conducted across scales ranging from processes in individual leaves and plants to chamber scale fluxes from plot level treatments (Ginting and Eghball, 2005) to field-scale fluxes measured with tower based methods (Arkebauer et al., 2009) to satellite-based energy balances of water consumption and landscape scale tillage effects (Singh and Irmak, 2009; Irmak et al., 2012). Results have been used in regional assessments (Wienhold et al., 2006) and continental scale simulations (Owen et al., 2007; Xiao et al., 2008, 2010). Modeling expertise within the research cluster has developed crop growth models (e.g., Hybrid Maize, Yang et al., 2004) and conducted simulations for decadal

agroecosystem responses to climate change (Dietze et al., 2011) and life-cycle analyses for biofuel production systems (Liska et al., 2009; Schmer et al., 2008).

***Beef Cattle and Grassland Systems.*** UNL and USDA-ARS scientists have studied the Great Plains grasslands for almost a century, starting with the classic research of Charles Bessey, Frederic Clements, and John Weaver. UNL maintains this tradition of grassland research with research scientists across the state and over 8,100 grassland ha managed for research. Over 90 percent of the region's grasslands are privately owned and their primary use is grazing beef cattle. Interdisciplinary research has been successful in guiding grassland management in the region. Principal factors affecting plant (Reece et al., 2007) and community (Mousel et al., 2011) productivity and resilience to defoliation and to grazing strategies (Schacht and Reece, 2008; Stephenson et al., *in press*) have been identified along with the development of long-yearling production systems (Griffin et al., 2007) and summer calving cow systems (Lardy et al., 2004) that have improved beef production profitability. Ongoing research is assessing management strategy effects on litter deposition and mineral cycling (Mousel et al., 2011), root production (Craine et al. 2002, Mousel et al. 2005, Volesky et al., 2011), and soil microbial activity (Bradley et al., 2006) on grasslands; co-product utilization from wet and dry corn milling on pastures (Greenquist et al., 2009; Watson et al., 2012) and feedlots (Klopfenstein et al., 2008; Erickson et al., 2012); N cycling and use efficiency in grazed systems (Greenquist et al., 2011) and open-dirt feedlots (Erickson and Klopfenstein, 2001); management of irrigated pasture and subirrigated meadow for beef production (Volesky et al., 2002; Volesky and Anderson, 2007.); and grassland use effects on wildlife populations (Matthews et al., 2011). Recent research also emphasizes the role grasslands play in regional ecosystem functioning, including the encroachment of woody species in the Great Plains (Eggemeyer et al. 2006; Eggemeyer et al., 2009; Awada et al., 2013), groundwater recharge (Szilagyi et al. 2011), evapotranspiration (Billesbach and Arkebauer 2012, Istanbulluoglu et al. 2012; Awada et al., 2013), life cycle analysis of grazing and beef production systems (Bremer et al. 2010), and long-term grassland responses to climate variability and change (Miao et al. 2007, Sridhar et al. 2006).

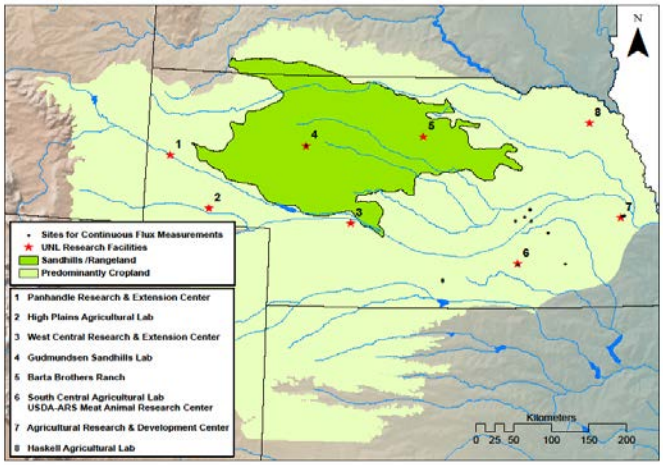


***Figure 3.*** *Location of research and extension facilities and flux tower network locations within the proposed LTAR .*

***Water Resources.*** Water resources research in Nebraska spans a number or organizations, including the U.S. Geological Survey (USGS), Nebraska Department of Natural Resources (DNR), 23 Nebraska Natural Resources Districts (NRDs), U.S. Bureau of Reclamation (USBR), USDA-ARS and USDA-NRCS and various departments at UNL, as well as the Nebraska Water Center (http://watercenter.unl.edu/) and the Water for Food Institute (http://waterforfood.nebraska.edu/). These entities have strong collaborative ties; effective data sharing and systems modeling, including multi-agency staff support and data collection; and are at the international forefront in developing state-of-the-art tools for data collection and presentation. DNR's Natural Resources Data Bank stores, processes, and manages natural resources data relating to land and water resources (http://www.dnr.ne.gov/databank/dbindex.html). UNL is part of the eight-member North Central Climate Science Center. Regional climate simulations have been made by Dr. Bob Oglesby of UNL for the High Plains Aquifer in the form of NCAR CCSM4 CMIP5/AR5 simulations and are publicly available, with downscaling to 24 km. A 4 km set of runs is underway.

***Regional Modeling and Integration.*** Scientists at UNL have been involved in developing, improving, and using models at different scales through an interdisciplinary approach as a means of dynamically integrating, guiding, and using knowledge regarding aquifer recharge-discharge; land use impacts on hydrology; agro-ecosystem responses to climate change (Dietze et al., 2011); and life-cycle analyses for biofuel production systems (Liska et al., 2009; Schmer et al., 2008). In the last decade, an increased number of modeling papers on grassland productivity, groundwater recharge, and evapotranspiration for the region have been published to support the rich databases developed in the region.

In addition, UNL has expertise in crop modeling as is evidenced by the Hybrid Maize model (Yang et al., 2004) and the Decision Support System for Agrotechnology Transfer (DSSAT) with models for 29 crops (Jones et al., 2003). These models have been used to study the impacts of climate variability and climate change to support farmers and other stakeholders in making decisions. SNR faculty have studied precipitation variations in the Great Plains (Hu et al., 2011; Veres and Hu, 2012) and impacts of climate on crops (Hu et al., 2006), and developed statistical and stochastic methods to downscale climate forecasts and projections to link crop models with global and regional climate models to facilitate the use of climate information in agricultural outcomes and to support farmers on decision making (Baigorria et al., 2007, 2008a, b, and 2010). Researchers are working on developing the next generation of coupled climate/land surface/crop models to dynamically integrate the regional feedback of human activities in the agricultural sector to the regional climate. Nebraska is one of the best natural laboratories to develop, calibrate, and validate this new generation of models. Finally, the Nebraska Water Optimizer is as a day-to-day decision management tool to assist irrigators in making decisions on crop(s) to plant and how much irrigation to apply, given a fixed water supply (http://agecon.unl.edu/wateroptimizer). The CROPSIM model developed at UNL (Martin et al., 2010) has computed daily water balances for irrigated corn and net irrigation water requirements for an array of weather stations across the state. CROPSIM-generated parameters across Nebraska, Kansas, and Colorado are used to calculate yield changes when irrigation water supplies change (http://www.ca1.uscourts.gov).

## INFRASTRUCTURE CAPACITY

Eleven long-term research facilities across Nebraska (also see Fig. 3) will serve as core sites for the proposed LTAR. These sites include the following sites. For additional information on the research sites, see Appendix 3.

- ***Agricultural Research and Development Center.*** The Agricultural Research and Development Center, located near Ithaca, Nebraska, has 3,360 ha of land devoted to crop and range research.
- ***Barta Brothers Ranch.*** The Barta Brothers Ranch, located near Long Pine, Nebraska, has 2,430 ha of land devoted to range research.
- ***Gudmensen Sandhills Laboratory.*** The Gudmensen Sandhills Laboratory, located near Whitman, Nebraska, has 5,185 ha of land devoted to range research.
- ***Haskell Agricultural Laboratory.*** The Haskell Agricultural Laboratory, located near Concord, NE, has 195 ha of land develoted to crop research.
- ***Havelock Farm.*** The Havelock Farm near Lincoln, Nebraska has 285 ha of land devoted to crop research.
- ***High Plains Agricultural Laboratory.*** The High Plains Agricultural Laboratory is located near Sidney, Nebraska and has 970 ha of land devoted to crop and range research.
- ***Panhandle Research and Extension Center.*** The Panhandle Research and Extension Center is located near Scottsbluff, Nebraska. This research site has 235 ha of land devoted to crop and range research.
- ***Rogers Memorial Farm.*** The Rogers Memorial Farm, which is located near Lincoln, Nebraska, has 130 ha of land devoted to crop research
- ***South Central Agricultural Laboratory.*** The South Central Agricultural Laboratory, located near Clay Center, Nebraska, has 260 ha of land devoted to crop research. The lab has several state-of-the-

art irrigation systems, including one center pivot and five linear move sprinkler systems (one of which is equipped for variable rate irrigation studies) and two sub-surface drip irrigation systems.

- ***U.S. Meat Animal Research Center.*** The U.S. Meat Animal Research Center was authorized by Congress on June 16, 1964 to develop new technology in order to increase the efficiency of livestock production and benefit consumers. The USMARC is situated in south central Nebraska on 14,175 ha of crop and range land near Clay Center, Nebraska. Presently, research programs are using a female breeding population of 7,000 breeding age cattle of 18 breeds, 4,000 breeding age sheep of 10 breeds, and 720 swine litters per year.
- ***West Central Research and Extension Center.*** The West Central Research and Extension Center, located near North Platte, Nebraska, has 610 ha of land and the affiliated Brule Water Resource Laboratory has 520 ha of land devoted to crop and range research.

## DATA RICHNESS

The rich supply of data available through the participating units and core sites is divided into the four research clusters and summarized below. Numerous studies of varying duration are being conducted. These studies range in size from plot to field to large units of grassland. Data collected provides the information needed to understand the impact of land management activities on the underlying aquifer. In addition, data collected at several sites are contributing to the Renewable Energy Assessment Project (REAP), Agricultural Carbon Enhancement Network (GRACEnet), and Ameriflux datasets. Additional information regarding active data monitoring programs is included as Appendix 4.

### Cropping Systems

- ***Long-term Manuring and Continuous Corn (PREC, established 1912).*** The Knorr-Holden irrigated continuous corn plot contains two manure treatments (0 and 27 Mg/ha/yr) that have N rate splits (0 to N rate for optimum yield with no manure) on a sandy loam soil. Yield data have been collected for 100 years (Anderson and Peterson, 1973). Soil analysis has been conducted at irregular intervals (Eghball et al., 1996; Kubota et al., 1947).
- ***Long-Term Dryland Tillage Plots (PREC-Sidney, established 1970).*** The Sidney dryland wheat plots have over 40 years of data comparing conventional fallow, chemical fallow, and subtillage. Yields and soil quality parameters have been determined (Fenster and Peterson, 1979; Lyon et al., 1996; Peterson et al., 1998).
- ***Deficit Irrigation in a Semi-arid Climate (PREC-Scottsbluff, established 2005).*** Deficit irrigation (low, medium, full evapotranspiration) of corn, dry beans, canola, and winter wheat with accompanying soil water balance data have been collected for nine years on a fine sandy loam soil. Additional experiments on deficit irrigation, evapotranspiration, and water balance data from warm- and cool-season grasses has been conducted at Scottsbluff and Sidney since 2009. Yields are available for all years. Soil quality parameters are currently being determined.
- ***Tillage by Crop Rotation (SCAL, established 1976).*** This study contains treatments that have been in place for 37 years to evaluate interactions of tillage methods (chisel/disk, ridge-till and slot plant) and crop rotation with furrow-irrigation (corn/corn, corn/soybean) on crop response and fate of nutrients and pesticides (Zara, et al., 1994; Katupitiya, et al., 1997; Cahoon, et al., 1999).
- ***Nitrogen Rate by Tillage by Nitrogen Timing by Nitrification Inhibitor (SCAL, established 1986).*** This study has been in continuous sprinkler-irrigated corn production since 1986, evaluating interactions of nitrogen fertilizer rate (including check treatments to which no N has been applied for continuous corn for 27 years), tillage method (no-till, chisel/disk), fertilizer timing (preplant, sidedress), and use of the nitrification inhibitor nitrapyrin (Schepers et al., 1990; Ferguson et al., 1991; Katupitiya et al., 1997).
- ***Cropping Rotation Study (ARDC, Established 1983).*** Treatments in this study include cropping intensity (three monocultures, two two-year rotations, and two four-year rotations) under three N-fertilizer rates. Annual measurements include crop yield and N content. Changes in soil C have been

quantified every four years (Varvel, 2006; Varvel and Wilhelm, 2011). This study has been used to assess the role of cropping rotation in reducing agronomic risk (Helmers et al., 2001), and served as a site in a regional soil quality study (Wienhold et al., 2006).

- ***Tillage Study (Rogers Memorial Research Farm, Established 1979).*** This study contributes to ARS greenhouse gas reduction through GRACEnet. Treatments include tillage intensity (six treatments ranging from plow tillage to no-tillage) and crop (continuous corn, continuous soybean, and corn-soybean rotation). Annual measurements include crop yield and N content (Wilhelm and Wortmann 2004). This study has been used to assess tillage intensity effects on soil C (Varvel and Wilhelm, 2010 and 2011) and cropping system energy balances (Rathke et al., 2007).
- ***Biofuel Feedstock Studies (ARDC, Annual – perennial feedstock system comparison established 1998, Irrigated residue removal study established 2001).*** These two studies contribute to REAP. Annual measurements include crop yield and N content (Varvel et al., 2008) and greenhouse gas emissions. Additional biofuel feedstock studies have quantified the distribution of dry matter (Wilhelm et al., 2010) and nutrients (Johnson et al., 2010) in corn stover, cob component of stover production (Varvel and Wilhelm, 2008), decomposition (Wienhold et al., 2011), and role in preventing soil erosion (Wienhold and Gilley, 2010). Additional research on switchgrass management (Perrin et al., 2008; Kiniry et al., 2008; Schmer et al., 2006, 2010a, 2010b, 2011, and 2012) and effect on soil properties (Liebig et al., 2008) has also been conducted.
- ***Amelioration Practices for Residue Removal (SCAL, established 2010).*** This study complements REAP studies by assessing the potential for cover crops or beef feedlot manure application to offset negative impacts of removing crop residue for feed or future biofuel feedstock use. Annual measurements include crop yield and N content, greenhouse gas emissions, and soil water dynamics. Soil C content will be determined every four years.
- ***Pennycress as an Oilseed Feedstock (ARDC and SCAL, established 2012).*** This study supports an agreement between ARS, the Department of the Navy, and the airline industry to assess winter annual oilseeds as a feedstock for drop-in aviation biofuel. The objectives are to develop agronomic practices for producing pennycress in a corn-soybean rotation and to assess the risk to the subsequent soybean crop when pennycress is added to the rotation.

**Beef Cattle and Grassland Systems**

- ***Smooth Bromegrass Grazing Trial (ARDC, established 2005).*** This study compares beef and vegetation production under different N fertilizer forms and rates. N budgets facilitate calculation of N budgets and N-use efficiency (Greenquist et al., 2009, 2011; Watson et al., 2012).
- ***Grassland Response to Fire and Mowing (ARDC, established 1981).*** This study compares vegetation productivity and composition and soil chemical and biological properties under several fire and mowing regimes (Schacht et al., 1996).
- ***Sandhills Grassland Ecology (GSRL and BBR, established 1997).*** This study quantifies annual productivity and botanical composition (Schacht et al., 2000).
- ***Grassland Response to Grazing (BBR established 2010).*** This study compares the effect of grazing period and stocking density on vegetation productivity botanical composition, and soil N and C content (Volesky, Schacht, and Wedin).
- ***Sandhills Vegetation Dynamics (U.S. Forest Service Upland Sites, Sandhills survey sites established 1926).*** Annual survey of botanical cover and composition and periodic monitoring of soil quality (Stubbendick and Tunnell, 2008).
- ***Invasive Species Impacts (Sandhills Survey Sites established 2001).*** This study quantifies the impact invasive species have on botanical composition, productivity, and soil moisture (Eggemeyer et al., 2006, 2009).

**Water Resources**

- ***Water and Energy Fluxes (NEBFLUX, Sandhills).*** UNL operates four Bowen ratio towers and two eddy covariance flux towers at the Gudmundsen SandHills Research laboratory. These systems have

compiled a seven-year record of evapotranspiration from three key SandHills ecosystems and, combined with precipitation data, yield the first estimates of annual aquifer recharge in the central SandHills by direct surface water balance. One of the eddy covariance towers is an AmeriFlux site and has contributed five years of carbon, water, and energy flux data to that archive. The other eddy covariance site is under development and is intended to also be part of the AmeriFlux network.

- ***Carbon and Water Fluxes at Mead, Nebraska (Ameriflux).*** UNL has participated in Ameriflux since 2001 when a team of interdisciplinary scientists established a state-of-the-art field research facility that allows a comprehensive study of C sequestration in major agro-ecosystems of the north-central United States. This effort is unique in three ways. First, we are quantifying net $CO_2$ exchange at the landscape level by two independent methods: eddy covariance and direct measurements of changes in soil C that account for within-field spatial variability in soil properties. The landscape-level flux measurements are accompanied by concurrent studies of soil-plant C dynamics to elucidate critical process controls. Second, this research is being conducted in three production-scale fields (each 50-65 ha): a no-till irrigated continuous maize system, a no-till irrigated maize-soybean rotation, and a no-till rainfed maize-soybean rotation. Fluxes of $N_2O$ and $CH_4$ are also being measured to allow a complete assessment of the global warming potentials of these cropping systems. Third, progressive management practices are being used in each cropping system to achieve high yields and input use efficiencies that are well above those achieved by most farmers in comparable systems.
- ***Spatial Tools for Hydrologic Information.*** Water resources research in Nebraska includes development of spatial tools to organize hydrologic information layers that drive water and crop growth models. NEBHYDRO (http://nebhydro.com/) is a UNL-based toolset for publishing and analyzing hydrologic datasets on the Internet. NEBHYDRO goals are to unite hydrological information, make it universally accessible and useful, and provide access to the data sources and models that enable the synthesis, visualization, and evaluation of the behavior of spatial hydrologic systems in Nebraska.

**Regional Modeling and Integration**

High resolution (30 m) scale evapotranspiration maps are available for western and central Nebraska based on the METRIC-Landsat model (Hergert et al., 2009; Irmak and Ratcliffe, 2010) that have been used to identify ranges in water consumption associated with rainfed and irrigated systems and with cropland, grassland, and riparian systems (Irmak et al., 2009). The water consumption maps also support current regional programs studying ground-water curtailment in over-appropriated areas. Efforts are underway to use these high resolution maps to improve surface flux parameterizations in land simulation models of the National Weather Research and Forecasting (WRF) system (NASA News project-Kilic, SNR/CIVE).

Ground-water modeling of the High Plains Aquifer began in the early 1960s and 1970s with Lappala (1975) predicting water-level declines and streamflow depletion for the Platte River Valley. Later modeling has utilized the USGS MODFLOW system (McDonald and Harbaugh, 1988) to develop regional groundwater flow models to evaluate stream-aquifer interactions perturbed by groundwater irrigation and changes in precipitation and land use (Chen and Yin, 1999; Chen and Chen, 2004; Chen and Shu, 2006). At present, five groundwater models are under development spanning the Platte River Valley (Peterson 2007; Chen and Ou, 2012), including analysis of stream-aquifer interactions impacted by groundwater irrigation in Nebraska (Ou et al., 2012; Ou and Chen, 2013).

A statewide effort to monitor groundwater levels began in 1930. Twenty-three Nebraska NRDs, USGS, and USBR collect water levels from designated monitoring wells at least twice a year and report these data to UNL's Conservation and Survey Division, which develops and maintains state-wide groundwater level database and produces annual groundwater level map. Since the 1930s, aquifer tests have been conducted to study the aquifer's hydraulic properties (Wenzel, 1942; Chen and Ayers, 1997; Zlotnik and Zurbuchen, 2003; Chen et al., 2005; Chen 2010) and to determine hydrologic relationships between the streams and the aquifer (Kollet and Zlotnik, 2003; Chen and Chen, 2003; Cheng and Chen, 2007). Over

the last 12 years, UNL has developed methods for investigating streambed hydraulic properties and hydraulic connectedness between the Platte River and its numerous tributaries and the acquifer (Chen, 2000; Landon et al., 2001; Rus et al., 2001; Cardenas and Zlotnik, 2003; Chen, 2004; Chen, 2007; Song et al., 2007; Chen et al., 2008; Cheng et al., 2010; Lu et al., 2012; Dong et la., 2012).

Structural databases of climate and soils in the region have feed empirical and process-based models in the region to provide stakeholders with valuable information to support decision making. For example, crop growth and yield simulations from the crop models have been used to guide farmers to improve climate-based decisions such as changing planting dates, varieties, optimal irrigation scheduling (in process), and in the future spray applications and market decisions based on seasonal climate forecasts. Modeling outputs from our climate team are ready to link our crop and hydrologic models to assess the impacts of projected climate change in the region.

A program of systematic drilling across Nebraska, carried out as a cooperative project between the Conservation and Survey Division and USGS, has resulted in the major source of detailed information for characterization of the High Plains Aquifer. Conservation and Survey Division continues to generate the geological information on the High Plains Aquifer from various projects supported by the NRDs. The test-hole logs are housed in UNL's, and are accessible to researchers for examination.

**Cross-cutting Data Sets**

In addition to the data sets described above, the Platte River – High Plains Aquifer LTAR will have access to data sets that cut across the four research clusters. These data sets are summarized below.

- ***U.S. Drought Monitor (USDM):*** USDM is a weekly assessment of national drought conditions. The NDMC is the home for the shape files and additional decision support tools provided by the USDM product each week. This information is available on the NDMC's website for the period 1999 to present, and for a variety of spatial scales from national, regional, state, and county level. (http://droughtmonitor.unl.edu).
- ***Drought Impact Reporter (DIR).*** The DIR is a national archive of drought impacts. Developed in 2005, the DIR has a user interface hosted by the NDMC, and an archive of drought impacts collected from a variety of sources and archived by sector. (http://droughtreporter.unl.edu).
- ***Vegetation Drought Response Index (VegDRI).*** The VegDRI is a bi-weekly depiction of vegetation stress across the contiguous United States based on remote sensing data, climate data, and biophysical data to determine the cause of the vegetation stress. The VegDRI has a network of "evaluators" that provide feedback on the product. (http://vegdri.unl.edu).
- ***Drought Risk Atlas.*** The Drought Risk Atlas is a decision-support tool that is in development and will be released soon. This tool will provide users with a comprehensive, site-specific assessment of the history, frequency, intensity, duration and patterns of drought in the past century.

CALMIT has acquired and maintains a considerable historical archive (over 40 years) of remote sensing imagery across the state of Nebraska and surrounding states that documents the transformation of the proposed LTAR's agricultural landscape transformation. These historical image assets include Landsat imagery dating back to the 1970s, a temporally-complete time series of Advanced Very High Resolution Radiometer (AVHRR) vegetation index images from 1989 to present, and hyperspectral imagery for target locations and times across the LTAR. CALMIT has also generated several historical land cover data sets across the LTAR documenting land use/land cover patterns and changes related to both crops and natural vegetation types, and maintains strong collaborative ties with the USGS's Earth Resources Observation Science (EROS) in Sioux Falls, South Dakota, which is a designated facility to archive all land-related imagery resources for the United States. CALMIT has had and is currently involved in several remote sensing projects with EROS to investigate land cover-related issues across the U.S. Central Great Plains. CALMIT faculty are also utilizing satellite-based thermal imagery to estimate and map evapotranspiration and estimate water consumption rates at field to regional scales within the LTAR. Additionally, CALMIT is helping to develop groundwater and soil moisture maps from the satellite-based

GRACE instrument in support of drought monitoring, which can be incorporated into the LTAR activities. Finally, CALMIT maintains an extensive spectral library for irrigated and rain-fed maize gathered at the Agricultural Research and Development Center over the last 12 growing seasons.

The HPRCC maintains over 170 automated weather stations within the proposed LTAR and surrounding states, providing comprehensive data for use in agricultural decision making for the region. This is a unique non-federal network formed by cooperation between climatologists in the various High Plains states. The sensors measure temperature, humidity, solar radiation, wind speed and direction, precipitation, soil temperature and soil moisture. These variables are required as input to crop growth models and as input to equations that estimate crop water use. The network data is used to update a series of maps on a daily basis so that weather patterns can be observed easily across the region. (http://www.hprcc.unl.edu/products/awdn.html).

Another example of data provided by HPRCC is the automated soil moisture monitoring network. Since 1998, the HPRCC (in cooperation with USDA/NRCS) has continuously measured soil moisture at 14 of its Automated Weather Data Network (ADWN) locations across Nebraska. Data for soil moisture at 10cm, 25cm, 50cm, and 100cm depths are available on line together with integrated state-wide soil moisture maps by depth. This data set includes several of the long-term research sites that will be part of this LTAR (Gudmensen Sandhills Laboratory and Barta Brothers Ranch). In addition, a high spatial-temporal resolution soil moisture data set was established at the Barta Brothers Ranch by the Sandhills Biocomplexity Project and UNL range ecologists in 2002. These measurements are made monthly to 300cm depth at 60 locations ranging from dune ridges to interdunal wetlands.

## DATA AVAILABILITY (ACCESSIBILITY)

UNL and USDA-ARS AMRU and EMRU have experience is the collection and dissemination of key agricultural data sets as is evidenced in the roles they have played in the development of the GRACEnet and REAP databases. USDA-ARS AMRU is (along with six current LTAR sites) one of the 36 GRACEnet sites and one of the 24 REAP sites uploading data to these databases.

UNL, through the HPRCC, is one of several regional climate centers funded by the National Oceanic and Atmospheric Administration (NOAA). In addition to management and analysis of long-term (>100 yr) weather data sets for the northern Great Plains, HPRCC maintains ADWN. These stations have web accessible long-term data on precipitation, temperature, vapor pressure, radiation and wind speed/direction, and calculated estimates for potential evapotranspiration. ADWN weather stations are located at the long-term research sites in this proposal. Gudmensen Sandhills Laboratory also has a NOAA Climate Reference Network Station, the "gold standard" for weather stations. In addition, CALMIT is actively engaged in assembling statewide digital databases on geology and soils, water, and land use/land cover. All GIS databases are made available in both State Plane and UTM map projections. Additional data resources include the Nebraska Department of Natural Resources. CALMIT's spectral library is stored in comma delimited format along with text metadata covering the observation conditions under which the data were obtained.

We anticipate that shortly after notification of LTAR designation, the leadership team will receive guidance from the LTAR Network regarding protocol and services for collection, verification, organization, archives, access, bases for analysis, and distribution of data, with an overarching aim of building and maintaining an archive of LTAR data files that are fully documented, error free, and organized in useful and accessible for potential data users. We will work with the LTAR Network to complete site-based research metadata surveys and complete any required metadata documentation. Common metadata and documentation will link our data products to international standards so they may, over time, be integrated with other national networks as appropriate. It is envisioned that data will be made publically available through an ARS LTAR portal within two years of study completion, unless a principal investigator can justify and requests a later date.

The primary contact for users will be a data curator who will be responsible for ensuring spatial, temporal, and metric quality of ingested data and the availability and accuracy of appropriate metadata. The curator will develop and maintain an online data catalogue enabling efficient data identification, selection, and access by users. To accomplish this, the curator will define data and metadata standards, the process for data ingest, the methods for assuring data quality control, and the mechanisms to convert data and metadata, if necessary, to formats compatible with LTAR standards. The curator will also collect and make available analysis and display algorithms and/or software appropriate to each data type. Although not expected to be a domain expert in any particular discipline related to the generation or use of LTAR data, the curator will have the skills to understand user needs, help them identify relevant data (while being cognizant of data limitations), and recommend appropriate analytical tools.

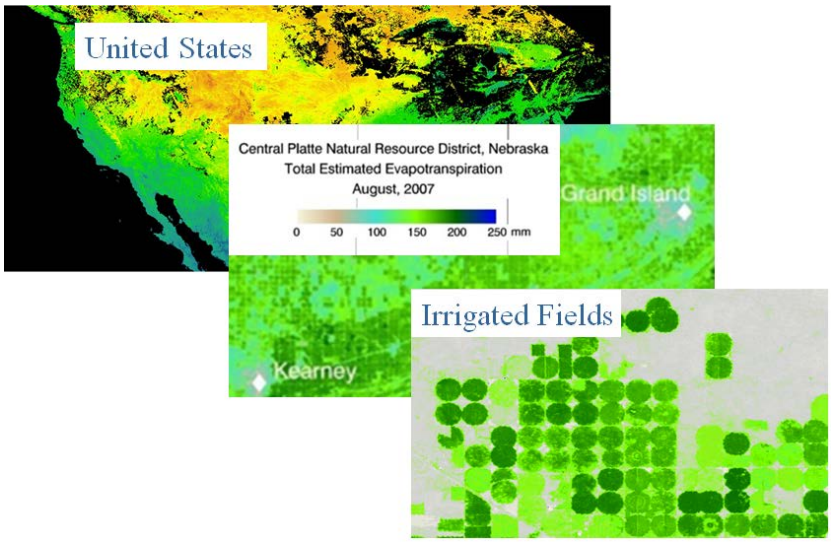


***Figure 4.*** *Evapotranspiration has been mapped for substantial areas of irrigated agriculture along the Platte River at multiple spatial scales using MODIS (top) and Landsat-based surface energy balance (middle and bottom). (From Kamble 2012, Irmak (Kilic), 2012).*

As a member of the leadership team, the data curator will make recommendations as necessary to assure data quality and availability. The curator will be consulted in all technical matters regarding the data holdings of the proposed LTAR system. Appropriate to this role, the curator will be a user's first point of contact for issues regarding data identification, access, and retrieval. The curator will also establish and maintain contact with data administrators, managers, and curators for the other LTAR sites to facilitate solutions to common problems and identifying opportunities to improve LTAR overall.

## GEOGRAPHIC COVERAGE AT VARIOUS SCALES

The Platte River – High Plains Aquifer LTAR's focus on a dynamic agro-ecosystem overlying a major national groundwater resource will make it a unique and essential addition to the LTAR Network. The surface water component of the proposed LTAR, the Platte River, lies in the southern portion of the Missouri River Basin, Hydrologic Unit Code (*HUC2*) 10, and expands and strengthens the contributions of the Northern Great Plains LTAR to this HUC region. In addition, the proposed LTAR is located in the transition of the Northern Great Plains, Heartland, and Prairie Gateway U.S. *agro-ecosystems* and the Prairie Peninsula, Northern Plains, and Central Plains *NEON* domains. Extensive collaboration exists between researchers in the proposed LTAR and those at the existing Central Plains Experimental Range, Northern Great Plains, and Mississippi River Basin LTARs. These collaborations cover the grassland dominated systems in the west and transition to the row-crop dominated systems to the east. Collection of data occurs over a wide range of scales and across the substantial climatic gradient that exists in this region. Data are collected from plot to field scale experiments at the existing research and extension facilities within the proposed LTAR, and instrumentation appropriate for plot or field scale measurements and access to hand-held, airplane-, or satellite- based remote sensing data collection, including the assembly of MODIS satellite imagery for creating national and regional maps of water consumption at a 1

km scale and use of Landsat satellite imagery to create close-up mapping of water consumption at the subfield (30 m) scale, are available (Fig. 4).

## PARTNERSHIPS

### Stakeholders and Formal Associations with Long-term Research Networks

The partners and participating units have strong existing partnerships with producers, other stakeholders, and federal agencies as is evidenced by their strong research, education, and outreach networks. Examples of associations with long-term research networks include VegDRI, a partnership between the NDMC, CALMIT, HPRCC, USGS and EROS, and USDA's Risk Management Agency.

The 23 NRDs in Nebraska are watershed-based local government entities charged with protecting and managing natural resources in their district, such as soil and water. They are managed through an elected board of directors, with much of their funding coming from local property taxes. NRDs partner with UNL and USDA-ARS in conducting research and educational programming, especially related to water quantity and quality issues. In areas where water quality or quantity are threatened or impaired, NRDs have regulatory authority, such as restricting the timing of nitrogen fertilizer application, or the amount of irrigation water that can be used in a growing season. UNL has partnered with several of the NRDs in Nebraska to produce and implement Landsat-scale (30 m) maps of water consumption (A. Kilic) into daily business operations that include monitoring surface and ground-water abstractions, monitoring soil and water conservation practices, and regulating water use under scarcity.

As mentioned previously, USDA-ARS AMRU was one of the organizing locations for REAP and the subsequent Department of Energy-funded Sungrant consortium. Through REAP/Sungrant activities USDA-ARS AMRU actively collaborates with staff at the 24 REAP locations, including the Northern Great Plains Research Laboratory and Upper Mississippi River Basin Experimental Watersheds LTAR sites. In addition, USDA-ARS AMRU has been a participant in GRACEnet since its inception. Through GRACEnet activities USDA-ARS AMRU actively collaborates with staff at the 36 GRACEnet sites, including the Northern Great Plains Research Laboratory, Central Plains Experimental Range, and Upper Mississippi River Basin Experimental Watersheds LTAR sites. USDA-ARS AMRU also collaborates with the Goodwater Creek Experimental Watershed LTAR.

UNL faculty are members of the AmeriFlux management team, co-direct the AmeriFlux QA/QC laboratory, and work to facilitate bringing new members into the AmeriFlux system (http://ameriflux.lbl.gov). Furthermore, UNL hosts one of 34 climatological Ultraviolet-B (UV-B) stations of the USDA's UV-B Monitoring and Research Program, which is located at the Agrometeorology Laboratory. UV-B radiation is known to have damaging effects on plants. The severity of damage is related to how much radiation beyond the UV-B is present. Data from the monitoring program provides information important for assessing the local impact of UV-B radiation on human health, plants, the environment and materials. Stations are located primarily in rural areas, particularly in agricultural and forested regions. The UV-B Monitoring Program was initiated in 1992 to provide information regarding the distribution of and trends in UV-B radiation in the United States. The Agricultural Research and Development Center UV-B station was set up in a grassy area east of the Agrometeorology Laboratory building. This area is also the location for the Automated Weather Data Network and National Atmospheric Deposition Program stations. UV-B data have been collected from the station since May 1996. The data from the monitoring program has been valuable for UV-related research projects conducted in nearby Agricultural Research and Development Center fields and for classroom discussions and instruction regarding energy from sunlight at the earth's surface. UNL hosts one of the National Atmospheric Program laboratories, which consists of a field facility where precipitation chemistry is monitored year-round as part of the National Atmospheric Program/National Trends Network (NADP/NTN). The purpose of this network is to provide information on the chemistry (e.g., sulphate, nitrate, ammonium) to help monitor temporal and geographical trends. This site is one of the inaugural sites started in 1978. Now, the network consists of over 250 sites nationally.

**Potential for Education and Outreach**

The UNL Extension System is the primary means of interacting with clientele within Nebraska at multiple levels. Many research faculty engaged in the LTAR effort also have joint Extension appointments. This enables scientists to learn directly from clientele of important issues to consider as research topics, as well as provides the opportunity for direct transfer of research information to end-users. Scientists with USDA-ARS research units contribute significantly to education and outreach efforts as well, frequently participating in preparation of Extension publications and teaching at workshops and field days. Extension Educators present in most counties in the state, and actively participate in research efforts within their region while leading educational efforts to clientele. A growing tool to facilitate these educational efforts in agriculture is on-farm research, in which growers participate in programs to conduct scientifically-sound comparisons of new and emerging technologies on their own farms – for their own education as well as to share with other participants in the programs. LTAR will leverage its research sites to contribute to education and outreach students and stakeholders.

## INSTITUTIONAL COMMITMENT

UNL and USDA-ARS are fully committed to the proposed LTAR and its long-term sustainability and continued operation (see Appendix 5). As evident of this commitment, the following infrastructure and resources will be made available to aid in the accomplishment of the Platte River – High Plains Aquifer LTAR's objectives: 1) long-term support of the faculty expertise and core sites necessary to make the LTAR a success; 2) access to state-of-the-science data management resources, including a variety of core computing facilities that will be necessary to support the infrastructural backbone of the UNL-ARS LTAR and its data collection and data sharing efforts; 3) LTAR-specific human resources – including funds to support a dedicated data curator – that will be necessary to fulfill the daily administrative needs of the UNL-ARS LTAR and implementation of its activities; 4) dedicated office space on UNL's East Campus to house the data curator along with office space and office equipment necessary to complete LTAR activities; and 5) access to existing resources available through the Office of Research and Economic Development to support the development of competitive grant applications, including provision of expert scientific review of proposals prior to submission and assistance from a staff of proposal development professionals. Significantly, the majority of the UNL faculty members participating in this effort are members of IANR. IANR is a global leader in the LTAR's primary disciplines, including agricultural and natural resource education, research, extension, and outreach. IANR and its programs are robust, as is evidenced by the fact it is hiring 36 new tenure-track faculty members in the focus areas of science literacy, stress biology of plants and animals, healthy humans, healthy agriculture and natural resources systems, and computational sciences. Additional faculty positions will strengthen core areas of several departments. Over 20 of these new faculty members could be collaborating scientists with the UNL-ARS LTAR. For a list of scientists and staff associated with the proposed LTAR see Appendix 2.

## REFERENCES CITED


Albertson, F.W. and J.E. Weaver. 1944. Nature and degree of recovery of grassland from the Great Drought of 1933 to 1940. Ecological Monographs 14:393-479.

Anderson, F.N. and G.A. Peterson. 1973. Effects of continuous corn (Zea mays L.), manuring, and nitrogen fertilization on yield and protein content of the grain and on the soil nitrogen content. Agronomy Journal, 65:697-700.

Arkebauer, T.J., E.A. Walter-Shea, M.A. Mesarch, A.E. Suyker, and S.B. Verma. 2009. Scaling up $CO_2$ fluxes from leaf to canopy in maize-based agroecosystems. Agric. For. Meteorol. 149:2110-2119.

Awada, T., El-Hage, R., Geha, M., Wedin, D.A., Huddle, J.A., Zhou, X., Msanne, J., Sudmeyer, R.A., Martin, D.L., and Brandle, J.R. (2013). Intra-annual variability and environmental controls over transpiration in a 58-year-old even-aged stand of invasive woody Juniperus virginiana L. in the Nebraska Sandhills, USA. Ecohydrology. In press (early online view DOI: 10.1002/eco.1294).

Baigorria, G.A., M. Chelliah, K.C. Mo, C.C. Romero, J.W. Jones, J.J. O'Brien and R.W. Higgins. 2010. Forecasting cotton yield in the southeastern USA using coupled global circulation models. Agronomy Journal, 102(1): 187-196. doi:10.2134/agronj2009.0201.

Baigorria, G.A., J.W. Hansen, N. Ward, J.W. Jones and J.J. O'Brien. 2008a. Assessing predictability of cotton yields in the Southeastern USA based on regional atmospheric circulations and surface temperatures. Journal of Applied Meteorology and Climatology, 47(1): 76-91. doi:10.1175/JAM2592.1.

Baigorria, G.A., J.W. Jones and J.J. O'Brien. 2008b. Potential predictability of crop yields using an ensemble climate forecast by a regional circulation model. Agricultural and Forest Meteorology, 148(8-9): 1353-1361. doi:10.1016/j.agrformet.2008.04.002.

Baigorria, G.A., J.W. Jones, D.W. Shin, A. Mishra and J.J. O'Brien. 2007. Assessing uncertainties in crop model simulations using daily bias-corrected regional circulation model outputs. Climate Research, 34(3): 211-222. doi:10.3354/cr00703.

Billesbach, D.P, and T.J. Arkebauer. 2012. First Long-Term, Direct Measurements of Evapotranspiration and Surface Water Balance in the Nebraska SandHills. Ag. & Forest Met. 156, 104 – 110.

Bradley, K., R.A. Drijber, and J. Knops. 2006. Increased N availability in grassland soils modifies their microbial communities and decreases the abundance of arbuscular mycorrhizai fungi. Soil Biology and Biochemistry 38:1583-1595.

Bradley, K., Drijber, R.A., Knops, J. 2006. Increased N availability in grassland soils modifies their microbial communities and decreases the abundance of arbuscular mycorrhizal fungi. Soil Biology & Biochemistry 38:1583-1595.

Cahoon, J.E., D.E. Eisenhauer, R.W. Elmore, F.W. Roeth, B. Doupnik, Jr., R.A. Selley, K. Frank, R.B. Ferguson, M. Lorenz, and L.J. Young. 1999. Corn Yield Response to Tillage With Furrow Irrigation. J. Prod. Ag. 12:269-275.

Cardenas, M. B., and V. Zlotnik, 2003. Three-dimensional model of modern channel bend deposits. Water Resources Research 39(6), DOI: 10.1029/2002WR001383

Chen, X.H., and J.F. Ayers, 1997. Utilization of the Hantush solution for the simultaneous determination of aquifer parameters. Ground Water 35(5), 751-756.

Chen, X.H., and Y. Yin. 1999. Modeling of groundwater flow and analysis of stream-aquifer interactions, Franklin County, South-central Nebraska (Report to the Nebraska Department of Water Resources), Conservation and Survey Division Open-file Report 69, University of Nebraska-Lincoln, 140 p.

Chen, X. H., 2000. Measurement of streambed hydraulic conductivity and its anisotropy, Environmental Geology 39 (12), 1317-1324.

Chen, X.H., and X. Chen, 2003. Sensitivity analysis and determination of streambed leakance and aquifer hydraulic properties. Journal of Hydrology 284(1-4), 270-284, DOI:10.1016/j.jhydrol.2003.08.004.

Chen, X. H., J. Goeke, J. F. Ayers, and S. Summerside, 2003. Observation well network design for pumping tests in unconfined aquifers. Journal of the American Water Resources Association 39(1), 17-32.

Chen, X.H., and X. Chen. 2004. Simulating the effects of reduced precipitation on groundwater and streamflow in the Nebraska Sand Hills. Journal of the American Water Resource Association 40(2), 419-430.

Chen, X. H., 2004. Streambed hydraulic conductivity for rivers in south-central Nebraska. Journal of the American Water Resource Association 40(3), 561-574.

Chen, X.H., Y. Yin, J.W. Goeke, and R.F. Diffendal, Jr. 2005. Vertical movement of water in a high plains aquifer induced by a pumping well. Environmental Geology 47(7), 931-941, DOI: 10.1007/s00254-005-1223-4.

Chen, X.H., and L. Shu, 2006. Groundwater evapotranspiration captured by seasonally pumping wells in river valleys. Journal of Hydrology 318(1-4), 334-347, DOI:10.1016/j.jhydrol.2005.06.025.

Chen, X. H., 2007. Hydrologic connections of a stream-aquifer-vegetation zone in south-central Platte River Valley, Nebraska. Journal of Hydrology 333(2-4), 554-568, DOI:10.1016/j.jhydrol.2006.09.020.

Chen, X. H., M. Burbach, and C. Cheng, 2008. Electrical and hydraulic vertical variability in channel sediments and its effects on streamflow depletion due to groundwater extraction. Journal of Hydrology 352(3-4): 250-266, DOI:10.1016/j.jhydrol.2008.01.004.

Chen, X.H., 2010. Vertical hydraulic conductivity of highly permeable alluvial aquifers. In Hydraulic Engineering: Structural Applications, Numerical Modeling and Environmental Impacts Book Editor(s): Hirsch, G; Kappel, B, p. 323-337, Nova Science Publishers Inc., 375 p.

Chen, X.H. and G.X. Ou, 2012. Development of Groundwater Flow Model for the Lower Platte North Natural Resources District Area, Nebraska, 83 p.

Cheng, C. and X. H. Chen, 2007. Evaluation of methods for determination of hydraulic properties in an aquifer-aquitard system hydrologically connected to a river. Hydrogeology Journal 15(4), 669-678, DOI: 10.1007/s10040-006-0135-z.

Cheng, C., J.X. Song, X.H. Chen, and D. Wang, 2011. Statistical distribution of streambed vertical hydraulic conductivity along the Platte River, Nebraska. Water Resources Management 25(1), 265-285, DOI: 10.1007/s11269-010-9698-5.

Craine, J.M., D.A. Wedin, F.S. Chapin III, and P.B. Reich. 2002. Relationship between the structure of root systems and resource use for 11 North American grassland plants. Plant Ecology 165:85-100.

Dietze, M.C., R. Vargas, A.D. Richardson, P.C. Stoy, A.G. Barr, R.S. Anderson, M. Altaf Arain, I.T. Baker, T. A. Back, J.M. Chen, P. Ciais, L.B. Flanagan, C.M. Gough, R.F. Grant, D. Hollinger, C. Izaurralde, C.J. Kucharik, P. Lafleur, S. Liu, E. Lokupitiya, Y. Luo, J.W. Munger, C. Peng, B. Poulter, D.T. Price, D.M. Ricciuto, W.J. Riley, A. Kumar Sahoo, K. Schaefer, A.E. Suyker, H. Tian, C. Tonitto, H. Verbeeck, S.B. Verma, and W. Wang. 2011. Characterizing the performance of ecosystem models across time scales: A spectral analysis of the North American Carbon Program site-level synthesis. Journal of Geophysical Research-Biogeosciences. 116:G04029, doi:10.1029/2011JG001661.

Dobermann, A., C. S. Wortmann, R. B. Ferguson, G. W. Hergert, C. A. Shapiro, D. D. Tarkalson and D. T. Walters. 2011. Nitrogen response and economics for irrigated corn in Nebraska. Agron. J. 103: 67-75.

Dong, W.H., X.H. Chen, Z.W. Wang, G.X. Ou, and C. Liu, 2012. Comparison of vertical hydraulic conductivity in a streambed-point bar system of a gaining stream. Journal of Hydrology 450-451, 9-16, DOI: 10.1016/j.jhydrol.2012.05.037.

Eggemeyer, K.D., Awada, T., Harvey, F.E., Wedin, D., Zhou, X. and Zanner, R. 2009. Seasonal Changes in depth of water uptake for encroaching trees Juniperus virginiana and Pinus ponderosa and two dominant $C_4$ grasses in a semi-arid grassland. Tree Physiology. 29:157-169.

Eghball, B., G.D. Binford and D.D. Baltensperger. 1996. Phosphorus movement and adsorption in a soil receiving long-term manure and fertilizer application. Journal of Environmental Quality, 25:339–1343.

Emery, P.A., 1966. Use of Analog Model to Predict Streamflow Depletion, Big and Little Blue River Basin, Nebraska. Ground Water 4(4), 13-19.

Erickson, G. E., T. J. Klopfenstein, and A. K. Watson. 2012. Utilization of feed coproducts from wet or dry milling for beef cattle. In H. P. S. Makkar, editor, Biofuel co-products as livestock feed - Opportunities and challenges. FAO. Rome, Italy. p. 77-99.

Erickson, G. E., and T. J. Klopfenstein. 2001. Nutritional methods to decrease N volatilization from open-dirt feedlots in Nebraska. Nitrogen and the Environment, The Scientific World. 1(52):836-843.

Fenster, C.R. and G.A. Peterson. 1979. Effects of no-tillage fallow as compared to a conventional tillage in a wheat-fallow system. UNL Res. Bull 289. 40pp.

Ferguson, R. B., J.S. Schepers, G.W. Hergert, and R.D. Lohry. 1991. Nitrogen uptake in corn (Zea mays L.,) and accumulation in soil: Effects of nitrogen rate, nitrapyrin and corn hybrid. Soil Sci. Soc. Am. J. 55:875-880.

Ferguson, R.B., C.A. Shapiro, G.W. Hergert, W.L. Kranz, N.L. Klocke and D.H. Krull. 1991. Nitrogen and Irrigation Management Practices to Minimize Nitrate Leaching from Irrigated Corn (Zea mays L.). Journal of Production Agriculture 4:186-192.

Ginting, D., and B. Eghball. 2005. Nitrous oxide emission from no-tillage irrigated corn: temporal fluctuation and wheel traffic effects. Soil Sci. Soc. Am. J., 69, 915-924.

Grant, R.F., T.J. Arkebauer, A. Dobermann, K.G. Hubbard, T.T. Schimelfenig, A.E. Suyker, S.B. Verma, and D.T. Walters. 2007. Net biome productivity of irrigated and rainfed maize-soybean rotations: modeling vs. measurements. Agronomy Journal 99:1404-1423.

Greenquist, M.A., T.J. Klopfenstein, W.H. Schacht, G.E. Erickson, K.J. Vander Pol, M.K. Luebbe, K.R. Brink, A.K. Swartz, and L.B. Baleseng. 2009. Effects of nitrogen fertilization and dried distillers grains supplementation: forage use and performance of yearling steers. J. Anim. Sci. 87:3639-3646.

Greenquist, M.A., A. K. Schwarz, T. J. Klopfenstein, W. H. Schacht, G. E. Erickson, K. J. Vander Pol, M. K. Luebbe, K. R. Brink and L. B. Boleseng. 2011. Effects of fertilization and dried distillers grains supplementation: Nitrogen Use efficiency. J. Anim. Sci. 89:1146-1152.

Griffin, W. A., T. J. Klopfenstein, G. E. Erickson, D. M. Feuz, J. C. MacDonald, and D. J. Jordon. 2007. Comparison of performance and economics of a long-yearling and calf-fed system. The Professional Animal Scientist. 23:490-499.

Healey, N.C., A. Irmak, R. Allen, J. Kjaersgaard, T.J. Arkebauer, D.P. Billesbach, J.D. Lenters, and K.G. Hubbard. 2011. Remote Sensing and In Situ-Based Estimates of Evapotranspiration for Subirrigated Meadow, Dry Valley, and Upland Dune Ecosystems in the Semi-Arid Sand Hills of Nebraska, USA. Irrig. and Drain. Syst. 25, 151 – 178.

Helmers, G.A., Yamoah, C.F., and Varvel, G.E. 2001. Separating the impacts of crop diversification and rotations on risk. Agronomy Journal 93:1337-1340.

Helmers, M.J., and D.E. Eisenhauer. 2006. Overland flow modeling in a vegetative filter considering non-planar topography and spatial variability of soil hydraulic properties and vegetation density. Journal of Hydrology. 328:267-282.

Hu, Q., S. Feng, and R.J. Oglesby, 2011. Variations in North America summer precipitation driven by the Atlantic Multidecadal Oscillation. J. Climate, 24, 5555-5570.

Hu, Q., A. Weiss, S. Feng, and P.S. Baezinger, 2006. Earlier winter wheat heading dates and warmer spring in the Great Plains of the United States. Agric. Forest Meteorol., 135, 284-290.

Huntoon, P.W., 1974. Predicted water-level decline for alternative groundwater development in the Upper Big Blue River basin, Nebraska. Conservation and Survey Division, University of Nebraska-Lincoln, Nebraska Geological Survey Resources Report No. 6, 106 p.

Irmak, A., R.G. Allen, J. Kjaersgaard, J. Huntington, B. Kamble, R. Trezza, and I. Ratcliffe. 2012. Operational Remote Sensing of ET and Challenges. Chapter in Evapotranspiration (A. Irmak (Kilic), editor), Publisher: InTech.

Irmak, S., M.J. Burgert, H.S. Yang, K.G. Cassman, D.T. Walters, W.R. Rathje, J.O. Payero, P. Grassini, M.S. Kuzila, K.J. Brunkhorst, B. Van DeWalle, J.M. Rees, W.L. Kranz, D.E. Eisenhauer, C.A. Shapiro, G.L. Zoubek and G.J. Teichmeier. 2012. Large scale on-farm implementation of soil moisture-based irrigation management strategies for increasing maize water productivity. Transactions of the ASABE 55(3): 881-894.

Istanbulluoglu E., T. Wang, and D.A. Wedin. 2012. Evaluation of Ecohydrologic Model Parsimony at Local and Regional Scales in a Semiarid Grassland Ecosystem. Ecohydrology 5:121-142.

Jenkins, K.H., J.C. MacDonald, F.T. McCollum III, and S.A. Amosson. 2009. Effects of level of supplementary dried distiller's grains on calves grazing native pastures and subsequent wheat pasture performance. Professional Animal Scientist. 25(2009)596-604.

Johnson, J.M.F., W.W. Wilhelm, D.L. Karlen, D.W. Archer, B.J. Wienhold**,** D.T. Lightle, D.A. Laird, J.M. Baker, T.E. Ochsner, J.M. Novak, A.D. Halvorson, F.J. Arriaga, and N.W. Barbour. 2010. Nutrient Removal as a Function of Corn Stover Cutting Height and Cob Harvest. BioEnergy Research 3:342-352.

Jones, J., Hoogenboom, G., Porter, C.H., Boote, K.J., Batchelor, W.D., Hunt, L.A., Wilkens, P.W., Singh, U., Gijsman, A.J., Ritchie, J.T., 2003. The DSSAT cropping system model, European Journal of Agronomy. 18, 235–265.

Kamble, B. 2012. Hydrological information system: Integrated system for modeling, simulation, analysis, and distribution of climate and hydrology data. Ph.D. Dissertation, Univ. Nebraska, Dept. Civil Engrg. 221 p.

Katupitiya, A., D.E. Eisenhauer, R.B. Ferguson, F.W. Roeth, R.F. Spalding and M.W. Bobier. 1997. Long-term Tillage and Crop Rotation Effects on Residual Nitrate in the Crop Root Zone and Nitrate Accumulation in the Intermediate Vadose Zone. Trans. ASAE 40(5):1321-1327.

Kiniry, J.R., M.R. Schmer, K.P. Vogel, R.B. Mitchell. 2008. Switchgrass biomass simulation at diverse sites in the Northern Great Plains. Bioenerg. Res. 1:259-264.

Klopfenstein, T. J., G. E. Erickson, and V. R. Bremer. 2008. BOARD-INVITED REVIEW: Use of distillers by-products in the beef cattle feeding industry. J. Anim. Sci. 86:1223-1231.

Knezevic S. Z. 2007. Herbicide tolerant crops: 10 years later. Maydica 52: 245-250.

Kochisek, A.E., J. Knops, D.T.Walters, and T.J. Arkebauer 2009, Impacts of management on decomposition and litter carbon balance in irrigated and rainfed no-till agricultural systems. Agric. For. Meteorol. 149: 1983-1993.

Kollet, S.J., and V.A. Zlotnik, 2003. Stream depletion predictions using pumping test data from a heterogeneous stream-aquifer system (a case study from the Great Plains, USA). Journal of Hydrology 281, 96–114.

Kubota, J., H.F. Rhoades and L. Harris. 1947. Effects of different cropping and manurial practices on some chemical properties of an irrigated Chestnut soil. Soil Science Society of America Proceedings, 12:304-309.

Landon, M.K., D.L. Rus, and E.F. Harvey, 2001. Comparison of instream methods for measuring hydraulic conductivity in sandy streambeds. Ground Water 39 (6), 870–885.

Lappala, E. G., 1975. Platte River Basin, Nebraska, Level B Study, Missouri River Basin Commission.

Lardy, G. P., D. C. Adams, T. J. Klopfenstein, and H. H. Patterson. 2004. Building beef cow nutritional programs with the 1996 NRC beef cattle requirements model. J. Anim. Sci. 82(E. Suppl.):E83-E92.

Liebig, M.A., M.R. Schmer, K.P. Vogel, R.B. Mitchell. 2008. Soil carbon storage by switchgrass grown for bioenergy. Bioenerg. Res. 1:215-222.

Liska, A., H.S. Yang, V.R. Bremner, T.J. Klopfenstein, D.T. Walters, G.E. Erickson, and K.G. Cassman. 2009. Improvements in life-cycle energy efficiency and greenhouse gas emissions of corn-ethanol. J. Industrial Ecology, 13, 58-74.

Lu, C. X.H. Chen, G. Ou, C. Cheng, L. Shu, D. Cheng and E. Appiah-Adjei, 2012. Determination of the anisotropy of an upper streambed layer in east-central Nebraska, USA. Hydrogeology Journal 20(1), p. 93-101, DOI 10.1007/s10040-011-0792-4.

Luebbe, M.K., G.E. Erickson, T.J. Klopfenstein, M.A. Greenquist, and J.R. Benton. 2011. Composting or Stockpiling of Feedlot Manure in Nebraska: Nutrient Concentration and Mass Balance. The Prof. Anim. Scient. 27:83-91.

Lyon, D.J. and G.W. Hergert. 2012. Nitrogen fertility in semiarid dryland wheat production is challenging for beginning organic farmers. Renewable Agriculture and Food Systems, Available on CJO2012. doi:10.1017/S1742170512000324. Published online Oct 23, 2012.

Lyon, D.J., C.A. Monz, R.E. Brown, and A.K Metherell. 1996. Soil organic matter
changes over two decades of winter-wheat fallow cropping in western Nebraska. p. 343-351. In Paul, E.A., K.A. Paustian, E.T. Elliott, and C.V. Cole (Eds.). Soil Organic Matter in Temperate Agroecosystems. Lewis Publishers, Boca Raton, FL.

Mader, T. L., M.S. Davis, and T. Brown-Brandl . 2006. Environmental factors influencing heat stress in feedlot cattle. J. Anim. Sci. 84:712-719.

Martin, D.L., R.J. Supalla, C.L. Thompson, B.P. McMullen, G.w. Hergert, and P.A. Burgener.
2010. Advances in deficit irrigation management. 5th National Decennial Irrigation Conference.
American Society of Agricultural and Biological Engineers.Publication No. 711 P081 Ocd.
Phoenix, AZ. Dec. 5-8, 2010.

McDonald, M. G., and A. W. Harbaugh, 1988. Modular three-dimensional finite-difference groundwater flow model. Techniques of Water-resources Investigations of U. S. Geological Survey. Book 6, CH. A1, 576p.

Miao, X., Mason, J. A., Swinehart, J. B., Loope, D. B., Hanson, P. R., Goble, R. J., and Liu, X., 2007, A 10,000 year record of dune activity, dust storms, and severe drought in the central Great Plains: Geology, v. 35, p. 119-122.

Mousel, E.M., W.H. Schacht, C.W. Zanner, and L.E. Moser. 2005. Effects of summer grazing strategies on organic reserves and root characteristics of big bluestem. Crop Sci. 45:2008-2014.

Mousel, E.M., W.H. Schacht, P.E. Reece, A.E. Herron, and A. Koehler. 2011. Vegetation production responses to October grazing in the Nebraska Sandhills. Rangeland Ecol. & Manage. 64:208-214.

Ou, G., X.H. Chen, A. Kilic, and S. Bartelt-Hunt, 2012. Development of a cross-section based streamflow routing package for MODFLOW. Environmental Modeling & Software, in review

Ou, G., and X.H. Chen, 2013. Manual for the Spreadsheet-based MODFLOW Pre-processor. A Software written for the Upper Big Blue Natural Resources District of Nebraska to assist the development of a

regional groundwater flow model cover the Blue and Little River Base and part of the Platte River Basin. School of Natural Resources, University of Nebraska-Lincoln, 11 p.

Owen, K.E., J. Tenhunen, M. Reichstein, Q. Wang, E. Falge, R. Geyer, X. Xiao, P. Stoy, C. Ammann, A. Arain, M. Aubinet, M. Aurela, C. Bernhofer, B.H. Chojnicki, A. Granier, T. Gruenwald, J. Hadley, B. Heinesch, D. Hollinger, A. Knohl, W. Kutsch, A. Lohila, T. Meyers, E. Moors, C. Moureaux, K. Pilegaard, N. Saigusa, S.B. Verma, T. Vesala, and C. Vogel. 2007. Linking flux network measurements to continental scale simulations: ecosystem $CO_2$ exchange capacity under non-water-stressed conditions. Global Change Biol., 13, 734-760.

Parker, D., J. Ham, B. Woodbury, L. Cai, M. Spiehs, M. Rhoades, S. Trabue, K. Casey, R. Todd, N. Cole. 2012a. Standardization of flux chamber and wind tunnel flux measurements for quantifying volatile organic compound and ammonia emissions from area sources at animal feeding operations. Atmospheric Environment, In Press doi:10.1016/j.atmosenv.2012.03.068.

Parker, D.B., J. Gilley, B. Woodbury, K-H Kim, S. Bartelt-Hunt, X. Li, D. Snow, G. Galvin. 2012b. Odorous VOC emission following land application of swine manure slurry. Atmospheric Environment (In Press). doi:10.1016/j.atmosenv.2012.01.001.

Pavlista, A.D., D.J. Lyon, D.D. Baltensperger, and G.W. Hergert. 2010. Grain Yield Components as Affected by Planting Dryland Maize in a Double-Skip Row Pattern. Journal of Crop Improvement 24:1-11.

Perrin, R.K., K.P. Vogel, M.R. Schmer, R.B. Mitchell. 2008. Farm-scale production cost of switchgrass for biomass. Bioenerg. Res. 1:91-97.

Peterson, G.A., A.D. Halvorson, J.L. Havlin, O.R. Jones, D.J. Lyon, and D.L. Tanaka. 1998. Reduced tillage and increasing cropping intensity in the Great Plains conserves soil C. Soil and Tillage Research. 47:207-218.

Peterson, S.M., 2007. Groundwater Flow Model of the Eastern Model Unit of the Nebraska Cooperative Hydrology Study (COHYST) Area, 80 p.

Rathke, G.-W., B.J. Wienhold, W.W. Wilhelm, and W. Diepenbrock. 2007. Tillage and rotation effect on corn-soybean energy balances in eastern Nebraska. Soil and Tillage Research 97:60-70.

Reece, P.E., J.W. Morris, W.H. Schact, A.E. Koehler, J.D. Volesky, and L.E. Moser. 2007 Prairie sandreed response to preceding-year defoliation and precipitation regime. Great Plains Res. 17:215-224.

Rosenzweig, C., J.W. Jones, J.L. Hatfield, A.C. Ruane, K.J. Boote, P. Thorburn, J.M. Antle, G.C. Nelson, C. Porter, S. Janssen, S. Asseng, B. Basso, F. Ewert, D. Wallach, G.A. Baigorria, and J.M. Winter. 2013. The Agricultural Model Intercomparison and Improvement Project (AgMIP): Protocols and pilot studies. Agricultural and Forest Meteorology, 2013, 170: 166-182. doi: 10.1016/j.agrformet.2012.09.011.

Rus, D.L., V.L. McGuire, B.R. Zurbuchen, and V.A. Zlotnik, 2001.Vertical profiles of streambed hydraulic conductivity determined using slug tests in central and western Nebraska. US Geological Survey Water-Resources Investigation Report 01-4212, 32 pp.

Schacht, W.H. and P.E. Reece. 2008. Impact of livestock grazing on extensively-managed grazing lands. In: Richard McDowell, ed. Impacts of pastoral grazing on the environment. CABI, Oxfordshire, UK.

Schepers, J.S., Francis, D.D., Ferguson, R.B., and Lohry, R.D. 1990. Comparison of early season stem nitrate and leaf total N concentrations across corn hybrids. Comm. Soil Sci. and Plant Anal. 21:1381-1390.

Schmer, M.R. K.P. Vogel, R.B. Mitchell, B.S. Dien, H.G. Jung, and M.D. Casler. 2012. Temporal and spatial variation in switchgrass biomass composition and theoretical ethanol yield. Agronomy Journal. 104:54-64.

Schmer, M.R., M.A. Liebig, K.P. Vogel, R.B. Mitchell. 2011. Field-scale soil property changes under switchgrass managed for bioenergy. GCB Bioenergy 3:439-448

Schmer, M.R., R.B. Mitchell, K.P. Vogel, W.H. Schacht, D.B. Marx. 2010a. Efficient methods of estimating switchgrass biomass supplies. Bioenergy Res. 3: 243-250.

Schmer, M.R., R.B. Mitchell, K.P. Vogel, W.H. Schacht, D.B. Marx. 2010b. Spatial and temporal effects on switchgrass stands and yield in the Great Plains. Bioenergy Res. 3:159-171.

Schmer, M.R., K.P. Vogel, R.B. Mitchell, R.K. Perrin. 2008. Net energy of cellulosic ethanol from switchgrass. Proc. Nat. Acad. of Sci. USA 105:464-469.

Schmer, M.R., K.P. Vogel, R.B. Mitchell, L.E. Moser, K.M. Eskridge, R.K. Perrin. 2006. Establishment stand thresholds for switchgrass grown as a bioenergy crop. Crop Sci. 46:157-161.

Shapiro, C.A., D.L. Holshouser, W.L. Kranz, D.P. Shelton, J.F. Witkowski, K.J. Jarvi, G.W. Echtenkamp, L.A. Lunz, R.D. Frerichs, R.L. Brentlinger, M.A. Lubberstedt, M. McVey McCluskey and W.W Stroup. (2001). Tillage and management alternatives for returning conservation reserve program land to crops. Agronomy Journal 4:850-862.

Song, J., X. H. Chen, C. Cheng, S. Summerside, and F. Wen, 2007. Effects of hyporheic processes on streambed vertical hydraulic conductivity in three rivers of Nebraska, Geophysical Research Letters, 34(7), L07409, DOI:10.1029/2007GL029254.

Spiehs, M.J., D.N. Miller, B.L. Woodbury, R.A. Eigenberg, V.H. Varel and D.B. Parker. 2012. Effect of feeding wet distillers grains with soluble to beef cattle on air and manure quality. Applied Engineering in Agriculture. 28(3): 423-430.

Sridhar, V., Loope, D., Swinehart, J., Mason, J., Oglesby, R., and Rowe, C., 2006, Large WindShift on the Great Plains During the Medieval Warm Period: Science, v. 313, p. 345-349.

Stephenson, M.B., W.H. Schacht, J.D. Volesky, K.M. Eskridge, and D. E. Bauer. 2013. Effect of grazing system and topography on livestock performance and vegetation characteristics in the Nebraska Sandhills. Rangeland Ecol. & Manage. In press.

Strassberg, G., Scanlon, B. R. and Chambers, D. 2009. Evaluation of groundwater storage monitoring 552 with the GRACE satellite: case study of the high plains aquifer, Central United States, Water Resources 45, W05410. DOI:10.1029/2008WR006892.

Suyker, A.E., and S.B. Verma. 2010. Coupling of carbon dioxide and water vapor exchanges of irrigated and rainfed maize-soybean cropping systems and water productivity. Agri. For. Meteorol., 150:553-563.

Szilagyi, J., V. Zlotnik, J. Gates and J. Jozsa. 2011. "Mapping mean annual groundwater recharge in the Nebraska Sand Hills, USA." Hydrogeology Journal 19(8): 1503-1513.

Tarkalson, D. D., van Donk, S. J. and Petersen, J. L. (2009). Effect of nitrogen application timing on corn production using subsurface drip irrigation. Soil Science174: 174-179.

Varvel, G.E. 2006. Soil organic carbon changes in diversified rotations of the western corn belt. Soil Science Society of America Journal. 70:426-433.

Varvel, G.E. and W.W. Wilhelm. 2008. Cob biomass production in the western corn belt. BioEnergy Research 1: 223-228.

Varvel, G.E., K.P. Vogel, R.B. Mitchell, R.F. Follett, and J.M. Kimball. 2008. Comparison of corn and switchgrass on marginal soils for bioenergy. Biomass and Bioenergy 32:18-21.

Varvel, G.E., and Wilhelm, W.W. 2010. Long-term Soil Organic Carbon as Affected by Tillage and Cropping Systems. Soil Sci. Soc. Am. J. 74:915-921.

Varvel, G.E., and Wilhelm, W.W. 2011. No-tillage increases soil profile carbon and nitrogen under long-term rainfed cropping systems. Soil & Tillage Research 114:28-36.

Veres , M.C., and Q. Hu, 2012. AMO-forced regional processes affecting summertime precipitation variations in the central United States. J. Climate, 26, 276-290.

Verma, S.B., A. Dobermann, K.G. Cassman, D.T. Walters, J.M. Knops, T.J. Arkebauer, A.E. Suyker, G.G. Burba, B. Amos, H. Yang, D. Ginting, K.G. Hubbard, A.A. Gitelson, and E.A. Walter-Shea. 2005. Annual carbon dioxide exchange in irrigated and rainfed maize-based agroecosystems. Agri. For. Meteorol., 131, 77-96.

Volesky, J.D., D.C. Adams, and R.T. Clark. 2002. Windrow grazing and baled-hay feeding strategies for wintering calves. J. Range Manage. 55:23-32.

Volesky, J.D. and B.E. Anderson. 2007. Defoliation effects on production and nutritive value of four irrigated cool-season perennial grasses. Agro. J. 99:494-500.

Volesky, J.D., W.H. Schacht, A.E. Koehler, E. Blankenship, and P.E. Reece. 2011. Defoliation effects on herbage production and root growth of wet meadow forage species. Rangeland Ecol. & Manage. 64:506-513.

Wang, T., D. A. Wedin**,** and V.A. Zlotnik. 2009. Field evidence for a negative correlation between saturated hydraulic conductivity and soil carbon in a sandy soil. Water Resources Research 45(7).

Watson, A. K., Klopfenstein, T., Schacht, W., Erickson, G., Mark, D. R., Luebbe, M., Brink, K. R., Greenquist, M. A. 2012. Smooth bromegrass pasture beef growing systems: fertilization strategies and economic analysis. Prof. Anim. Sci. 28:433-451.

Weaver, J.E. 1919. The ecological relations of roots. Carnegie Inst. of Washington, Pub.No.286.

Weaver, J.E., V.H. Hougen and M.D. Weldon. 1935. Relation of root distribution to organic matter in prairie soil. Botanical Gazette. 96:389-420.

Weaver, J.E. and E. Zink. 1946. Length of life of roots of ten species of perennial range and pasture grasses. Plant Physiology 21:201-217.

Weaver, J.E. and T.J. Fitzpatrick. 1934. The Prairie. Ecological Monographs 4:109-295.

Weaver, J.E. and V.H. Hougen. 1939. Effect of frequent clipping on plant production in prairie and pasture. American Midland Naturalist 21:396-414.

Wenzel, L.K., 1942. Methods for Determining Permeability of Water-bearing Materials. U. S. Geological Survey Water-Supply paper 887, 192 p.

Wienhold, B.J., J.L. Pikul, Jr., M.A. Liebig, M.M. Mikha, G.E. Varvel, J.W. Doran, and S.S. Andrews. 2006. Cropping system effects on soil quality in the Great Plains: Synthesis from a regional project. Renewable Agriculture and Food Systems 21:49-59.

Wienhold, B.J. and J.E. Gilley. 2010. Cob Removal Effect on Sediment and Runoff Nutrient Loss From a Silt Loam Soil. Agronomy Journal 102:1448-1452**.**

Wienhold, B.J., G.E. Varvel, and V.L. Jin. 2011. Corn cob residue carbon and nutrient dynamics during decomposition. Agronomy Journal 103:1192-1197.

Wilhelm, W.W., and C.S. Wortmann. 2004. Tillage and rotation interactions for corn and soybean production as affected by weather conditions. Agronomy Journal. 96:425-432.

Wilhelm, W.W., J.M.F. Johnson, D. Lightle, N.W. Borbour, D.L. Karlen, and D.A. Laird. 2010. Vertical distribution of corn stover dry mass grown at several U.S. locations. BioEnergy Research 4:11-21.

Woodbury, B.L.; R.A. Eigenberg, D.B. Parker and M.J. Spiehs. Effect of Pond Ash on Pen Surfaces Properties. Trans. of the ASABE. (In Press).

Wortmann, C.S., D. D. Tarkalson, C. A. Shapiro, A. R. Dobermann, R. B. Ferguson, G. W. Hergert and D. Walters. 2011. Nitrogen use efficiency of irrigated corn for three cropping systems in Nebraska. Agron. J. 103: 76-84.

Wortmann, C.S., A.R. Dobermann, R.B. Ferguson, G.W. Hergert, C.A. Shapiro, D.D. Tarkalson, D. Walters. 2009. High-yielding corn response to applied phosphorus, potassium, and sulfur in Nebraska. Agron J. 101: 546-555.

Yang, H.S., A. Dobermann, J.L. Lindquist, D.T. Walters, T.J. Arkebauer, and K.G. Cassman. 2004. Hybrid-Maize--A maize simulation model that combines two crop modeling approaches. Field Crops Res., 87, 131-154.

Xiao, J., Q. Zhuang, D.D. Baldocchi, B.E. Law, A.D. Richardson, J. Chen, R. Oren, G. Starr, A. Noormets, S. Ma, S.B. Verma, S. Wharton, S.C. Wofsy, P.V. Bolstad, S.P. Burns, D.R. Cook, P.S. Curtis, B.G. Drake, M. Falk, M.L. Fischer, D.R. Foster, L. Gu, J.L. Hadley, D.Y. Hollinger, G.G. Katul, M. Litvak, T.A. Martin, R. Matamala, S. McNulty, T.P. Meyers, R.K. Monson, J.W. Munger, W.C. Oechel, K.T. Paw U, H.P. Schmid, R.L. Scott, G. Sun, A.E. Suyker, M.S. Torn. 2008. Estimation of net ecosystem carbon exchange for the conterminous United States by combining MODIS and AmeriFlux data. Agric. Forest Meteorol., 148, 1827-1847.

Xiao, J., Q. Zhuang, B.E. Law, J. Chen, D.D. Baldocchi, D.R. Cook, R. Oren, A.D. Richardson, S. Wharton, S. Ma, T.A. Martin, S.B. Verma, A.E. Suyker, R.L. Scott, R.K. Monson, M. Litvak, D.Y. Hollinger, G. Sun, K.J. Davis, P.V. Bolstad, S.P. Burns, P.S. Curtis, B.G. Drake, M. Falk, M.L. Fischer, D.R. Foster, L. Gu, J.L. Hadley, G.G. Katul, R. Matamala, S. McNulty, T.P. Meyers, J.W. Munger, A. Noormets, W.C. Oechel, K.T. Paw U, H.P. Schmid, G. Starr, M.S. Torn, S.C. Wofsy. 2010. A Continuous Measure of Gross Primary Production for the Conterminous U.S. Derived from MODIS and AmeriFlux Data. Remote Sensing of Environment 114:576-591.

Zara, P.M, R. Selley, J.E. Cahoon, and R. Ferguson. 1994. Simulating N leaching in furrow-irrigated corn. Irrig. Sci. 15:167-172.

Zlotnik, V.A., and B. R. Zurbuchen, 2003. Field study of hydraulic conductivity in a heterogeneous aquifer: Comparison of single-borehole measurements using different instruments. Water Resources Research 39(4), DOI: 10.1029/2002WR001415.

## APPENDIX 1 – LEADERSHIP TEAM BIOGRAPHICAL SKETCHES

Biographical sketches for the leadership team follow.

**Tala Awada**
School of Natural Resources
University of Nebraska-Lincoln
904 Hardin Hall
Lincoln, NE 68583-0989
402-472-0232
tawada@unl.edu

**Education and Training**

| *Institution* | *Major/Area* | *Degree* | *Year* |
|---|---|---|---|
| Lebanese University | Agricultural Engineering | B.S. | 1992 |
| Mediterranean Agronomic Institute of Chania, Greece | Environmental and Renewable Resources | M.S. | 1995 |
| University of Saskatchewan | Plant Ecophysiology | Ph.D. | 2000 |

**Research and Professional Experience**

| *Year* | *Position* |
|---|---|
| 2012-present | Interim Director, School of Natural Resources, University of Nebraska-Lincoln<br>Professor, School of Natural Resources, University of Nebraska-Lincoln |
| 2012-present | Associate Director, School of Natural Resources, University of Nebraska-Lincoln |
| 2007-2012 | Associate Professor. School of Natural Resources, University of Nebraska-Lincoln |
| 2008 | Visiting Professor, Aristotle University of Thessaloniki and Forest Research Institute Thermis, Greece |
| 2001-2007 | Assistant Professor, School of Natural Resources, University of Nebraska-Lincoln |
| 1999-2001 | Research Assistant Professor, Department of Agronomy and Horticulture, University of Nebraska-Lincoln |

**Synergistic Activities**

***Professional Service***

- Participated in the External Evaluation of the Department of Forestry & Natural Environment, Aristotle University of Thessaloniki, Greece, May 28-June 2, 2012.
- Participated in the External Evaluation of the Graduate Program in Natural Resource Management, Texas Tech University, USA. Jan-Feb. 2012.
- Participated in the External Evaluation of the Department of Forestry, and Management of the Environment and Natural Resources, Democritus University of Thrace, Greece, May 5-9, 2011.
- Chair, University of Nebraska-Lincoln Research Council (2009-2011). Member (2012-2015).
- Graduate Chair, School of Natural Resources, UNL (2006-2010).
- University of Nebraska-Lincoln Conflict of Interest in Research Committee (2009-present).
- Ad Hoc Reviewer for 16 International Refereed Journals.
- Teach on an Annual Basis a Short Course on Plant Stress Physiology Mediterranean Agronomic Institute of Chania Greece (2004-2009).

***Grants (Total $2.7 M)***

- Forty-first Parallel Agro-Ecosystem Sustainability and Productivity, Funding Agency, IANR Strategic Investments, Enhancing Interdisciplinary Teams, UNL (Co-PI). $373,720. 2010-2013.
- Estimation of evapotranspiration from riparian invasive species using remote sensing, modeling and in situ measurements in the Republican River basin, Nebraska Department of Natural Resources, (Co-PI). $1,045,478, 2007-2011.
- Trees in the Great Plains: water and carbon uses, grasslands health and economic ramifications. McIntire Stennis Funds, USDA. (PI) $330,000 2007-2013.

**Publications (Last 4 years, Total 36)**

1. **Awada, T.,** El-Hage, R., Geha, M., Wedin, D.A., Huddle, J.A., Zhou, X., Msanne, J., Sudmeyer, R.A., Martin, D.L., and Brandle, J.R. (2013). Intra-annual variability and environmental controls over transpiration in a 58-year-old even-aged stand of invasive woody Juniperus virginiana L. in the Nebraska Sandhills, USA. *Ecohydrology,* In press (early online view DOI: 10.1002/eco.1294).
2. Chen, Y., Li, Y., **Awada, T.,** Han J., and Luo Y. (2012). Carbon sequestration in the total and light fraction soil organic matter along chronosequence in grazing exclosures in a semiarid degraded sandy site in China. *Journal of Arid Land*, 4:411-419.
3. Bazakos, B., Manioudaki, M.E., Therios, I., Voyiatzis, D., Kafetzopoulos, D., **Awada, T.,** and Kalaitzis, P. (2012). Comparative Transcriptome Analysis of Two Olive Cultivars in Response to NaCl-Stress. *PLoS ONE*, 7(8): e42931 doi:10.1371/journal.pone.0042931.
4. Bihmidine, S., Lin, J., Stone, J.M., **Awada, T.**, Specht, J.E., Clemente, T.E. (2012). Activity of the Arabidopsis RD29A and RD29B promoter elements in soybean. *Planta*, Pp.1-10. In press.
5. Chen, Y., Li, Y., Zhao, X., **Awada, T.,** Shang, W., and Han, J. (2012) Effects of Grazing Exclusion on Soil Properties and on Ecosystem Carbon and Nitrogen Storage in a Sandy Rangeland of Inner Mongolia, Northern China. *Environmental Management*, 50(4):622-632.
6. Msanne, J., Xu, D., Konda, A.R., Casas-Mollano, J.A., **Awada, T.,** Cahoon, E.B., and Cerutti, H. (2012). Metabolic and gene expression changes triggered by nitrogen deprivation in photoautotrophically grown microalgae *Chlamydomonas reinhardtii and Coccomyxa sp. C-169. Phytochemistry, 75:50-59.*
7. Li, Y.Q., **Awada, T.,** Shang, W., Chen, Y.P., Zhou, X.H., Zuo, X.A., Wang ,S.K., Liu, X.P., and Feng, J. (2012). Mongolian pine plantations enhance soil physico-chemical properties and carbon and nitrogen capacities in semi-arid degraded sandy land in China. *Applied Soil Ecology*, 45: 1-9.
8. Msanne, J., Jiusheng, L., Stone, J., and Awada, T. (2011). Characterization of abiotic stress-responsive *Arabidopsis thaliana* RD29A and RD29B genes and evaluation of transgenes. *Planta*, 234:97-107.
9. Zhou, X., Brandle, J., **Awada, T**., Schoeneberger, M.M., Martin, D.L., and Tang, Z. (2011). The use of forest-derived specific gravity for the conversion of volume to biomass for open-grown trees on agricultural land. *Biomass and Bioenergy*, 35: 17 2 1-17 3 1.
10. Huddle, J.A., **Awada, T.,** Martin, D., Zhou, X., Pegg, S.E., and Josiah, S. (2011). Do invasive riparian woody plants affect hydrology and ecosystem processes? *Great Plains Research*, 21:49-71.
11. Bazakos, C., Manioudaki, M., Therios, I., Voyiatzis, D., Kafetzopoulos, D., Sarropoulou, E., **Awada, T**., and Kalaitzis, P. (2011). Gene expression analysis of olive tree (*Olea europaea* L.) in response to salt stress. *Acta Horticulturae*, 924:47-54.
12. Bihmidine, S., Bryan, N.M., Payne, K.R., Parde, M.R., Okalebo, J.A., Cooperstein, S.E., and **Awada, T.** (2010). Photosynthetic performance of invasive *Pinus ponderosa* and *Juniperus virginiana* seedlings under gradual soil water depletion. *Plant Biology*, 12: 668 - 675.
13. Eggemeyer, K.D., **Awada, T.,** Harvey, F.E., Wedin, D., Zhou, X. and Zanner, R. (2009). Seasonal Changes in depth of water uptake for encroaching trees *Juniperus virginiana* and *Pinus ponderosa* and two dominant $C_4$ grasses in a semi-arid grassland. *Tree Physiology*, 29:157-169

**Brian J. Wienhold**
Supervisory Soil Scientist
USDA-ARS Agroecosystem Management Research Unit
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University of Nebraska-Lincoln
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As Research Leader of the Agroecosystem Management Research Unit, I supervise nine research scientists, three support scientists, and numerous support personnel. I provide leadership in: 1) developing management practices to reduce the incidence of manure borne pathogens, minimizing odor and greenhouse gas emissions from manured environments, and efficiently utilizing manure as a fertilizer resource; 2) understanding environmental conditions of filth fly developmental sites, quantifying the impact of filth flies on livestock production, and developing control practices for filth flies in pastures and feedlots; 3) and quantifying long-term impact of cropping rotation and tillage intensity on soils, quantifying greenhouse gas emissions from crop production systems, developing crop residue removal guidelines for feed and biofuel feedstock, and developing nutrient and water management practices for spatially variable fields.

My personal research program involves identifying the response of soil physical, chemical, and biological properties to soil management practices such as tillage, crop rotation, and fertilization within spatially variable fields; developing assessment tools and decision aids for improved soil management; and quantifying the role of crop residue as a nutrient and energy source for soil biota. The objective of this work is to develop tools producers can use to evaluate the effect management practices have on the soil resource and to develop management practices that improve the sustainability of agricultural systems.

I am a member of American Association for the Advancement of Science, Soil and Water Conservation Society, American Society of Agronomy, and Soil Science Society of America where I have served in numerous committee, leadership, and editorial positions. I am a panelist for the ARS Research Position Evaluation System (RPES) and serve on the ARS RPES Advisory Committee. I held an adjunct appointment at North Dakota State University and am currently an adjunct professor at the University of Nebraska-Lincoln. I have served as the research advisor for three M.S. students and two Ph.D. students and have served as a committee member for three M.S. students.

**Education and Training**

| ***Institution*** | ***Area*** | ***Degree*** | ***Year Awarded*** |
|---|---|---|---|
| Moorhead (MN) State University | Biology | B.A. | 1982 |
| North Dakota State University | Botany | M.S. | 1985 |
| University of Arizona | Range Management | Ph.D. | 1989 |

**Research and Professional Experience**

| ***Years*** | ***Position*** |
|---|---|
| 2008-present | Supervisory Soil Scientist, USDA – ARS, Lincoln, NE |
| 1997-2008 | Research Soil Scientist, USDA, ARS, Lincoln, NE |
| 1993-1997 | Soil Scientist, USDA, ARS, Mandan, ND |
| 1989-1993 | Soil Scientist, USDA, ARS, Beltsville, MD |

**Collaborators and Affiliations**

Mark Liebig, USDA-ARS, Mandan, ND
Doug Karlen, USDA-ARS, Ames, IA
Susan Andrews, USDA-NRCS, Lincoln, NE
Jane Johnson, USDA-ARS, Morris, MN
Diane Stott, USDA-ARS, West Lafayette, IN
Ted Zobeck, USDA-ARS, Lubbock, TX
Richard Ferguson, UNL, Lincoln, NE
Rhae Drijber, UNL, Lincoln, NE
Larry Hendrickson, John Deere, Peoria, IL

**Synergistic Activities**

***Professional Activities:***

ND SWCS Legislative Committee, 1994 -1997
ND SWCS President Elect, 1997
NE SWCS Annual Meeting Planning Committee, 1999
NE SWCS Chapter Secretary, 2001
Member of the Soil and Water Panel for the Binational Agricultural Research and Development Fund (BARD), 1998 to 2002. Chair 2000 to 2002.
Member of the editorial board for Arid Lands Research and Management, 1999 - 2012.
SSSA Applied Research Award Committee, 2001 – 2003
Associate Editor, Division (S-6) of Soil Science Society of America Journal, 2000 - 2006.
ASA Agronomic Service Award Committee 2005-2007.
SSSA Representative to AAAS Section O Agriculture, Food, and Renewable Resources Committee, 2004-2010.
Division Chair-elect, Chair, Past Chair, Soil and Water Management and Conservation Division (S-6) of Soil Science Society of America, 2006-2009.
SSSA Howard M. Taylor Memorial Lectureship Co-Chair, 2007-2008.
SSSA Program Planning Committee, 2008.
SSSA Nominations Committee, 2008-2010.
Technical Editor, Division (S-6) of Soil Science Society of America Journal, 2011 – present.

***Honors and Awards:***

Northern Plains Area, Early Career Scientist, 1996.
Organization for Economic Cooperation and Development (OECD) Fellowship, 2003.
*Fellow, Soil Science Society of America, 2011.*

***Grants:***

National Pork Board, $40000
John Deere, $20000

**Recent Publications (last four years)**

**Wienhold, B.J.**, G.E. Varvel, and W.W. Wilhelm. 2009. Container and installation time effects on soil moisture, temperature, and inorganic nitrogen retention for an *in situ* nitrogen mineralization method. Comm. Soil Sci. Plant Anal. 40:2044-2057.

**Wienhold, B.J.**, Douglas L. Karlen, Susan S. Andrews, and Diane E. Stott. 2009. Protocol for indicator scoring in the soil management assessment framework (SMAF). Renew. Agric. Food Syst. 24:260-266.

Spiehs, M.J., B.L. Woodbury, D.D. Tarkalson, **B.J. Wienhold**, R.A. Eigenberg. Long term effects of annual additions of animal manure on soil chemical, physical, and biological properties in the Great

Plains. Proceedings of International Symposium on Air Quality and Waste Management for Agriculture. Dallas, TX. 2010.

Stott, D.E., S.S. Andrews, M.A. Liebig, **B.J. Wienhold**, and D.L. Karlen. 2010. Evaluation of β-glucosidase activity as a soil quality indicator for the soil management assessment framework (SMAF). Soil Sci. Soc. Am. J. 74:107-119.

Johnson, J.M.F., W.W. Wilhelm, D.L. Karlen, D.W. Archer, **B.J. Wienhold**, D.T. Lightle, D.A. Laird, J.M. Baker, T.E. Ochsner, J.M. Novak, A.D. Halvorson, F.J. Arriaga, and N.W. Barbour. 2010. Nutrient removal as a function of corn stover cutting height and cob harvest. BioEnergy Res. 3:342-352.

Mitchell, R.B., L.L. Wallace, W. Wilhelm, G. Varvel, and **B. Wienhold**. Grasslands, rangelands, and agricultural systems, Biofuels and Sustainability Reports. Ecological Society of America. 2010.

**Wienhold, B.J.** and J.E. Gilley. 2010. Runoff losses of N and P after low phosphorus slurry application to no-tillage sorghum. Soil Sci. 175:201-206.

**Wienhold, B.J.** and J.E. Gilley. 2010. Cob removal effect on sediment and runoff nutrient loss from a silt loam soil. Agron. J. 102:1448-1452.

Zhu, J.J., C.A. Dunlap, R.W. Behle, D.R. Berkebile, and **B.J. Wienhold**. 2010. Repellency of a wax-based catnip-oil formulation against stable flies. Agric. Food Chem. 53:12320-12326.

Johnson, J.M.F., F.J. Arriaga, G.M. Banowetz, D.R. Higgins, D. Laird, M.J. Ottman, and **B.J. Wienhold**. 2011. Crop residues of the contiguous United States: Balancing feedstock and soil needs with conservation tillage, cover crops, and biochar. Pp 61-83 In: R. Braun, D. Karlen, and D. Johnson (Eds.). Sustainable Alternative Fuel Feedstock Opportunities, Challenges, and Roadmaps for Six U.S. Regions: Proceedings of the Sustainable Feedstocks for Advanced Biofuels Workshop. Soil and Water Conservation Society, Ankeny, IA.

Karlen, D.L., **B.J. Wienhold**, S. Kang, T.M. Zobeck and S.S. Andrews. Indices for soil management decisions. Pgs. 39-50. In: J.L. Hatfield and T.J. Sauer (Eds.) Soil Management: Building a Stable Base for Agriculture. American Society of Agronomy, Madison, WI. 2011.

**Wienhold, B.J.**, G.E. Varvel, and V.L. Jin. 2011. Corn cob residue carbon and nutrient dynamics during decomposition. Agron. J. 103:1192-1197.

Fortuna, A-M., C.W. Honeycutt, G. Vandemark, T.S. Griffin, R.P. Larkin, Z. He, **B.J. Wienhold**, K.R. Sistani, S.L. Albrecht, B.L. Woodbury, H.A. Torbert, J.M. Powell, R.K. Hubbard, R.A. Eigenberg, R.J. Wright, J.R. Alldredge, and J.B. Harsh. 2012. Links among nitrification, nitrifier communities and edaphic properties in contrasting soils receiving dairy slurry. J. Environ. Qual. 41:262-272.

**Wienhold, B.J.** and D.B. Taylor. 2012. Substrate Properties of Stable Fly (Dipera: Muscidae) Developmental Sites Associated with Round Bale Hay Feeding Sites in Eastern Nebraska. Environmental Entomology 41: 213-221.

Durso, L.M., D.N. Miller, and **B.J. Wienhold**. 2012. Distribution and quantification of antibiotic resistant genes and bacteria across agricultural and non-agricultural metagenomes. PLOS ONE 7(11): 1 - 12 (e48325).

Ferguson, R., M.R. Schmer, T. Shaver, **B.J. Wienhold**, S. Van Donk, S. Irmak, D. Rudnick, N. Ward, V.L. Jin, D.D. Francis, A.M. Bereuter, and L. Hendrickson. 2013. Landscape position influences on variable rate irrigation and nitrogen fertilization. European Conference on Precision Agriculture Proceedings. Lleida, Calatonia, Spain. 2013.

**Wienhold, B.J.**, G.E. Varvel, J.M.F. Johnson, and W.W. Wilhelm. 2013. Carbon Source Quality and Placement Effects on Soil Organic Carbon Status. BioEnergy Research. DOI 10.1007/s12155-013-9301-z.

Tian, H., R.A. Drijber, X. Li, D.N. Miller, and **B.J. Wienhold**. 2013. Arbuscular mycorrhizal fungi differ in their ability to regulate the expression of phosphate transporters in maize (*Zea mays* L.). Mycorrhiza. DOI 10.1007/s00572-013-0491-1.

**Wienhold, B.J.**, G.E. Varvel, V.L. Jin, R.B. Mitchell, and K.P. Vogel. 2013. Corn residue removal effects on subsequent yield. 2013 Nebraska Beef Report. Pgs 40-41.

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**Education and Training**

| *Institution* | *Area* | *Degree* | *Year Awarded* |
|---|---|---|---|
| Michigan State University | Botany | B.S. | 1979 |
| University of Florida | Horticulture | M.S. | 1981 |
| University of Nebraska-Lincoln | Agronomy | Ph.D. | 1986 |
| San Diego State University | Systems Ecology | Post-doc | 1987-89 |

**Research and Professional Experience**

| *Years* | *Position* |
|---|---|
| 2004-present | Professor, Department of Agronomy and Horticulture, University of Nebraska-Lincoln |
| 1995-2004 | Associate Professor, Department of Agronomy and Horticulture, University of Nebraska-Lincoln |
| 1989-1995 | Assistant Professor, Department of Agronomy and Horticulture, University of Nebraska-Lincoln |

**Collaborators and Affiliations**

R.G. Allen, University of Idaho; B. Amos, UNL; K. Bartlett, University of New Hampshire; D.P. Billesbach, UNL; C. Bruening, UNL; S. Bridgham, University of Oregon; R. Clement, The University of Edinburgh; P. Crill, Stockholm University; A. Datta, University of Nebraska-Lincoln (UNL); N. Dise, Manchester Metropolitan University, UK; R. Drijber, UNL; A. Elling, USDA Forest Service, Grand Rapids, MN; P. Flebbe, USDA Forest Service, Vallejo, CA; C. Francis, UNL; A.A. Gitelson, UNL; G. Gogos, UNL; E. Gorham, University of Minnesota; N. Guindin-Garcia, University of Maryland; R. Harriss, Houston Advanced Research Center; N.C. Healey, Florida International University; K.G. Hubbard, UNL; S. Irmak, UNL; C. Kelley, University of Missouri; J. Kim, Seoul National University; J. King, University of California-Santa Barbara; J. Kjaersgaard, South Dakota State University; S.Z. Knezevic, UNL; J. Knops, UNL; A.E. Kochisek, UNL; R. Kolka, USDA Forest Service, Grand Rapids, MN; J.D. Lenters, UNL; C. Martens, University of North Carolina-Chapel Hill; S. Narumalani, UNL; A.L. Nguy-Robertson, UNL; D. Olk, Iowa State University; Y. Peng, University of Maryland; R. Rapp, UNL; D.C. Rundquist, UNL; T. Sakamoto, National Institute for Agro-Environmental Sciences, Japan; D.L. Scoby, UNL; D. Sebacher, NASA Langley Research Center; J. Shanahan, Pioneer; M. Shibayama, National Institute for Agro-Environmental Sciences, Japan; N.J. Shurpali, University of Eastern Finland; K. Smemo, The Holden Arboretum; K. Smith, Carleton County Soil and Water Conservation District, MN; A.E. Suyker, UNL; S. Swain, UNL; R. Todd, USDA-ARS, Bushland, TX; S.M. Ulloa, UNL; S.B. Verma, UNL; S. Verry, USDA Forest Service, Grand Rapids, MN; A. Viña, UNL; D.T. Walters, UNL; E.A. Walter-Shea, UNL; B. Wardlow, UNL; D.A. Wedin, UNL; K, Wieder, Villanova University; P. Weishampel, Northland College; A.Weiss, UNL; C. Williams, Franklin and Marshall College; A. Wingeyer, UNL; J. Yavitt, Cornell University; A.I. Zygielbaum, UNL.

**Synergistic Activities**

***Teaching***

- Graduate course, Plant Water Relations (1990-present)
- Undergraduate course, Plant Physiology (2003)
- Undergraduate course, Introduction to Plant Science (2005-2009)

***Recent Grants Received***

- U.S. Department of Energy-EPSCoR, Award No. DE-FG02-00ER45827. 07/01/2003-06/30/2007. $1,025,066. Research Implementation Program: Carbon Sequestration and Global Climate Change. Co-PI.
- U.S. Department of Energy-National Institute for Global Environmental Change-National Institute for Climate Change Research, Award No. DE-FC02-06ER64158. 09/13/2005-09/14/2007. $188,545. Controls on Soil Surface $CO_2$, $N_2O$ and $CH_4$ Fluxes, Ecosystem Respiration and Global Warming Potentials in Great Plains Agricultural Ecosystems. PI.
- U.S. Department of Energy-Office of Biological and Environmental Research, Award No. DE-FG02-00ER45827. 09/15/2006-09/14/2010. $1,365,000. Carbon Sequestration in Dryland and Irrigated Ecosystems: Quantification at Different Scales for Improved Prediction. Co-PI.
- U.S. Department of Energy-Biomass Program, 9/10/2010-9/30/2013. $500,000. Award No. DE-EE-0003149. Second Generation Biofuels: Carbon Sequestration and Life Cycle Analysis. Co-PI.

**Recent Publications**


Kochisek, A.E., J. Knops, D.T.Walters, and **T.J. Arkebauer** (2009) Impacts of management on decomposition and litter carbon balance in irrigated and rainfed no-till agricultural systems. Agricultural and Forest Metorology 149: 1983-1993.

Zygielbaum, A. I., A. A. Gitelson, **T. J. Arkebauer**, and D. C. Rundquist (2009) Non-destructive detection of water stress and estimation of relative water content in maize, Geophysical Research Letters, 36, L12403, doi:10.1029/2009GL038906.

**Arkebauer, T.J.**, E.A. Walter-Shea, M.A. Mesarch, A.E. Suyker, and S.B. Verma (2009) Scaling up $CO_2$ fluxes from leaf to canopy in maize-based agroecosystems. Agricultural and Forest Meteorology, 149: 2110-2119.

Sakamoto, T., B.D. Wardlow, A.A. Gitelson, S.B. Verma, A.E. Suyker, and **T.J. Arkebauer** (2010) The two-step filtering approach for detecting maize and soybean phenology with time-series MODIS data. Remote Sensing of Environment 114: 2146-2159.

Hollinger, D.Y., S.V. Ollinger, A.D. Richardson, T.P. Meyers, D.B. Dail, M.E. Martin, N.A. Scott, **T.J. Arkebauer**, D.D. Baldocchi, K.L. Clark, P.S. Curtis, K.J. Davis, A.R. Desai, D. Dragoni, M.L. Goulden, L. Gu, G.G. Katul, S.G. Pallardy, K.T. Paw U, H.P. Schmid, P.C. Stoy, A.E. Suyker and S.B. Verma (2010) Albedo estimates for land surface models and support for a new paradigm based on foliage nitrogen concentration, Global Change Biology 16(2): 696-710.

Sakamoto, T., A.A. Gitelson, B.D. Wardlow, **T.J. Arkebauer**, S.B. Verma, A.E. Suyker, and M. Shibayama (2011) Application of day and night digital photographs for estimating maize biophysical characteristics. Precision Agriculture 13: 285-301.

Dise, N., N.J. Shurpali, P. Weishampel, S.B. Verma, S. Verry, E. Gorham, P. Crill, R. Harriss, C. Kelley, J. Yavitt, K. Smemo, R. Kolka, K. Smith, J. Kim, R. Clement, **T. Arkebauer**, K. Bartlett, D. Billesbach, S. Bridgham, A. Elling, P. Flebbe, J. King, C. Martens, D. Sebacher, C. Williams, and K, Wieder (2011) Carbon Emission from Peatlands. Chapter 10 in *Peatland Biogeochemistry and Watershed Hydrology at the Marcell Experimental Forest*, R. Kolka, S. Sebastyen, E.S. Verry, K. Brooks (eds.), CRC Press, Boca Raton, FL.

Ulloa, S.M., A. Datta, C. Bruening, G. Gogos, **T.J. Arkebauer**, and S.Z. Knezevic (2011) Weed control and crop tolerance to propane flaming as influenced by time of day. Crop Protection 31: 1-7.

Rapp, R., A. Datta, S. Irmak, **T.J. Arkebauer**, and S.Z. Knezevic (2012) Integrated management of common reed (*Phragmites australis*) along the Platte River in Nebraska. Weed Technology 26: 326-333.

Nguy-Robertson, A.L., A.A. Gitelson, Y. Peng, A. Viña, **T.J. Arkebauer**, D.C. Rundquist, (2012). Green leaf area index estimation in maize and soybean: Combining vegetation indices to achieve maximal sensitivity, Agronomy Journal, 104: 1336- 1347.

Wingeyer, A., D.T. Walters, R. Drijber, D. Olk, **T. Arkebauer**, D.A. Wedin, C. Francis, S. Verma (2012) Fall conservation deep tillage stabilizes maize residues into soil organic matter. Soil Science Society of America Journal 76: 2154-2163.

Guindin-Garcia, N., A.A. Gitelson, **T.J. Arkebauer**, J. Shanahan, and A.Weiss (2012) An evaluation of MODIS 8 and 16 day composite products for monitoring maize green leaf area index. Agricultural and Forest Meteorology, 161:15-25.

Billesbach, D.P. and **T.J. Arkebauer** (2012) First long-term, direct measurements of evapotranspiration and surface water balance in the Nebraska SandHills, Agricultural and Forest Meteorology 156: 104-110.

Zygielbaum, A.I, **T.J. Arkebauer**, E.A. Walter-Shea, and D.L. Scoby (2012) Detection and measurement of vegetation photoprotection stress response using PAR reflectance. Israel Journal of Plant Science 60: 37-47.

Swain, S., D. Rundquist, **T.J. Arkebauer**, S. Narumalani, and B. Wardlow (2012) Non-invasive estimation of relative water content in soybean leaves using infrared thermography: preliminary results. Israel Journal of Plant Science 60: 25-36.

Sakamoto, T., A.A. Gitelson, A.L. Nguy-Robertson, **T.J. Arkebauer**, B.D. Wardlow, A.E. Suyker, S.B. Verma, and M. Shibayama (2012) An alternative method using digital cameras for continuous monitoring of crop status. Agricultural and Forest Meteorology 154-155: 113-126.

Healey, N.C., A. Irmak, **T.J. Arkebauer**, D.P. Billesbach, J.D. Lenters, K.G. Hubbard, R.G. Allen, J. Kjaersgaard, (2012) Remote sensing and in situ-based estimates of evapotranspiration for subirrigated meadow, dry valley, and upland dune ecosystems in the semi-arid Sand Hills of Nebraska, USA. Irrigation and Drainage Systems 25: 151-178.

Sakamoto, T., A.A. Gitelson, and **T.J. Arkebauer** (2013) MODIS-based corn grain yield estimation model incorporating phenology information. Remote Sensing of Environment 131: 215-231.

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**Education and Training**

| *Institution* | *Area* | *Degree* | *Year Awarded* |
|---|---|---|---|
| Friends University, Wichita, KS | Biology/Chemistry | B.S. | 1976 |
| Kansas State University, Manhattan, KS | Agronomy | M.S. | 1981 |
| Kansas State University, Manhattan, KS | Agronomy | Ph.D. | 1985 |

**Research and Professional Experience**

| *Years* | *Position* |
|---|---|
| 2012-present | Associate Head, Department of Agronomy and Horticulture, University of Nebraska-Lincoln |
| 2011-2012 | Project Coordinator, Department of Agronomy and Horticulture, University of Nebraska-Lincoln |
| 2004-present | Professor-In-Charge, South Central Agricultural Laboratory, University of Nebraska-Lincoln |
| 2004-2006 | Administrative Intern, Agricultural Research Division, University of Nebraska-Lincoln, Lincoln, NE |
| 2000-2001 | Visiting Scientist, Silsoe Research Institute, Silsoe, United Kingdom |
| 1999-present | Professor, Department of Agronomy and Horticulture, University of Nebraska-Lincoln, Lincoln, NE |
| 1991-1999 | Associate Professor, Department of Agronomy and Horticulture, University of Nebraska-Lincoln, Lincoln, NE |
| 1985-1991 | Assistant Professor, Department of Agronomy, University of Nebraska-Lincoln, Lincoln, NE |
| 1979-1985 | Research Assistant, Department of Agronomy, Kansas State University, Manhattan, KS |

**Synergistic Activities**

***Research, Extension and Teaching efforts in:***

- Management practices to minimize nitrogen loss to the environment;
- Site-specific nutrient management;
- Environmental impacts of N fertilizer use;
- Use of crop canopy sensors for in-season assessment of crop stress;
- Water quality education projects for agricultural advisors and producers.

**Recent Publications**

Djamman, K., S. Irmak, D. Martin, **R. Ferguson**, M. Bernards. 2013. Plant nutrient uptake and soil nutrient dynamics under full and limited irrigation and rainfed maize production. Agron. J. (in press).

Torrion, J., J. Specht, T. Setiyano, K. Cassman, **R. Ferguson** and S. Irmak. 2012. Soybean root development relative to vegetative and reproductive phenology. Agron. J. 104:1702-1709.

Wortmann, C.S., C.A. Shapiro, **R. Ferguson** and M. Mainz. 2012. Irrigated soybean has a small response to nitrogen applied during early reproductive growth. J. Crop Management (in press).

Roberts, D.F., **R.B. Ferguson**, N.R. Kitchen, V.I. Adamchuk, and J.F. Shanahan. 2012. Relationships between soil-based management zones and canopy sensing for corn nitrogen management. Agron. J. 104:119-129.

Adamchuk, V.I., A.S. Mat Su, R.A. Eigenberg, and **R.B. Ferguson**. 2011. Development of an angular scanning system for sensing vertical profiles of soil electrical conductivity. Trans. of the ASABE 54(3):1-11.

Shiratsuchi, L., **R. Ferguson**, J. Shanahan, V. Adamchuk, D. Rundquist, D. Marx and G. Slater. 2011. Water and nitrogen effects on active canopy sensor vegetation indices. Agron. J. 103:1815-1826.

Abunyewa, Akwasi. A., **Richard B. Ferguson**, Charles S. Wortmann, Drew J. Lyon, Stephen C. Mason, Suat Irmak and Robert N. Klein. 2011. Grain sorghum water use with skip-row configuration in the Central Great Plains of the USA. African J. Agric. Research 6(23):5328-5338.

Setiyono, T.D., H. Yang, D.T. Walters, A. Dobermann, **R.B. Ferguson**, D.R. Roberts, D.J. Lyon, D.E. Clay, K.G. Cassman. 2011. Maize-N: A decision tool for nitrogen management in maize. Agron. J. 103:1276-1283.

Roberts, D.F., V.I. Adamchuk, J.F. Shanahan, **R.B. Ferguson**, J.S. Schepers. 2011. Estimation of surface soil organic matter using a ground-based active sensor and aerial imagery. J. Precision Agriculture 12:82-102.

Wortmann, C.S., D.D. Tarkalson, C.A. Shapiro, A.R. Dobermann, **R.B. Ferguson**, G.W. Hergert, and D. Walters. 2010. Cropping system effect on nitrogen use efficiency of irrigated corn in Nebraska. Agron. J. 103:76-84.

Dobermann, A., C.S. Wortmann, **R.B. Ferguson**, G.W. Hergert, C.A. Shapiro, D.D. Tarkalson, D. Walters. 2010. Nitrogen response and economics for irrigated corn in Nebraska. Agron. J. 103:67-75.

Solari, F., J. Shanahan, **R. Ferguson**, V. Adamchuk. 2010. An active sensor algorithm for corn N recommendations based on a chlorophyll meter algorithm. Agron. J. 102:1090-1098.

Wortmann, C.S., A.J. Liska, **R.B. Ferguson**, R.N. Klein, D.J. Lyon, I. Dweikat. 2010. Dryland performance of sweet sorghum and grain crops for biofuel in Nebraska. Agron. J. 102:319-326.

Abunyewa, A.A.., **R.B. Ferguson**, C.S. Wortmann, D.J. Lyon, S.C. Mason, R.N. Klein. 2010. Skip-row and plant population effects on sorghum grain yield. Agron. J. 102:296-302.

Wortmann, C. A. Doberrnann, **R. Ferguson**, G. Hergert, C. Shapiro, D. Tarkalson. 2009. High-yielding corn response to applied phosphorus, potassium, and sulfur in Nebraska. Agron. J. 101:546-555.

Hodgen, P., J. Schepers, W. Raun, J. Shanahan and **R. Ferguson**. 2009. Uptake of point source depleted 15N fertilizer by neighboring corn plants. Agron. J. 101:99-105.

Roberts, D.F., V.I. Adamchuk, J.F. Shanahan, **R.B. Ferguson**, and J.S. Schepers. 2009. Optimization of crop canopy sensor spacing for detecting nitrogen stress in corn. Agron. J. 101:226-231.

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**Education and Training**

| *Institution* | *Area* | *Degree* | *Year Awarded* |
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| University of Wisconsin-Madison | Meteorology | B.S. | 1986 |
| University of Missouri-Columbia | Atmospheric Science | M.S. | 1989 |
| University of Missouri-Columbia | Atmospheric Science | Ph.D. | 1994 |

**Research and Professional Experience**

| *Years* | *Position* |
|---|---|
| 2011-present | Professor and Director, National Drought Mitigation Center (NDMC), School of Natural Resources, University of Nebraska-Lincoln (UNL)<br>Current appointment: 30% NDMC Director, 35% service/outreach, 23% research, 10% teaching, and 2% university service. Administer the research and outreach programs of the NDMC; conduct research on the impacts of drought and assist with post-drought evaluations; develop new monitoring and impact assessment methodologies; analyze current drought plans and assist local, state, tribal, and federal officials, as well as the private sector, with drought preparedness and drought mitigation issues; and assist in the organization and conduct of workshops and conferences, as well as the preparation of technical and non-technical reports. |
| 8/07-6/11 | Associate Professor and Director, NDMC, School of Natural Resources, UNL |
| 7/95-7/07 | Climate Impacts Specialist, NDMC, UNL |
| 2/95-7/95 | Physical Scientist, AScI Corporation, Columbia, Missouri |

**Collaborators and Affiliations**

Alvord, C. – NIDIS; Anderson, C. - Iowa State University; Anderson, M. – USDA/ARS; Awada, T. - University of Nebraska-Lincoln; Bathke, D. – National Drought Mitigation Center; Bernadt, T. – National Drought Mitigation Center; Brown, J. - United State Geological Survey; Cassman, K. - University of Nebraska-Lincoln; Crimmins, M. – University of Arizona; Darby, L. – NIDIS; Ding, Y. - National Drought Mitigation Center; Dubrovsky, M. - Czech Republic; Ferguson, D. – University of Arizona; Fontaine, M. - Herrera Environmental Consultants, Inc.; Fuchs, B. – University of Nebraska-Lincoln; Garfin, G. – Arizona; Goddard, S. - University of Nebraska-Lincoln; Harvey, F.E. - University of Nebraska-Lincoln; Hiza-Redsteer, M. – USGS; Howe, C. – Colorado; Hubbard, K. - University of Nebraska-Lincoln; Knutson, C. - National Drought Mitigation Center; Kogan, F. – NOAA/NESDIS; Liska, A. - University of Nebraska-Lincoln; McNutt, C. – NIDIS; Mehta, V. – CRCES Narumalani, S. – University of Nebraska-Lincoln; Oglesby, R. - University of Nebraska-Lincoln; Olsen, R. - Corps of Engineers; Powers, T. - University of Nebraska-Lincoln; Pryor, S. - Indiana University; Pulwarty, R. - NIDIS; Reed, B. - United State Geological Survey; Rosenberg, N. – CRCES; Rundquist, D. – University of Nebraska-Lincoln; Ryu, J. - Idaho; Schoengold, K. - University of Nebraska-Lincoln; Scott, S. - National Drought Mitigation Center; Shulski, M. – University of Nebraska-Lincoln; Smith, K. - National Drought Mitigation Center; Steinemann, A. – Scripps; Supalla, R. - University of Nebraska-Lincoln; Svoboda, M. - National Drought Mitigation Center; Swain, S. – Texas Tech University; Tadesse, T. - National Drought Mitigation Center; Takle, E. - Iowa State University; Thomas, S. – University of

Colorado-Denver; Trnka, M. - Czech Republic; Verdin, J. – NIDIS; Volesky, J. - University of Nebraska-Lincoln; Wall, N. - National Drought Mitigation Center; Wardlow, B. – University of Nebraska-Lincoln; Widhalm, M. – Purdue University; Wilhelmi, O. - NCAR; Wilhite, D. - University of Nebraska-Lincoln; Wood, D. - National Drought Mitigation Center; Woudenberg, D. - National Drought Mitigation Center; Wu, H. - Trinity River Basin

**Synergistic Activities**

- *Professional Membership:* Co-Chair (2009-present) National Integrated Drought Information System (NIDIS) Program Implementation Team; Member (2009-present) NIDIS Engaging the Preparedness Communities Working Group; Member (2009-present) SCIPP RISA Stakeholder Services Committee; Member (2006-2009) NIDIS Program Implementation Team; Co-Chair (2006-2009) NIDIS Engaging the Preparedness Communities Working Group; Member (2007-present) Nebraska Climate Assessment and Response Committee; Board Member (2007-2010) Center for Great Plains Studies Board of Governors
- *Leadership*: Co-Convener, 2010, AGU Fall Meeting Session on Drought and Food Security.
- *Review:* Reviewer, March 2007, National Research Council Review Team for the Climate Change Science Program's Synthesis and Assessment Product 3.3: Weather and Climate Extremes in a Changing Climate.

**Recent Publications**


Fuchs, B., M. Svoboda, D. Wilhite, and **M. Hayes**. 2013. Drought Indices for Drought Risk Assessment in a Changing Climate. In: Handbook of Engineering Hydrology Vol. 2: Modeling Climate Changes and Variability, S. Eslamian, ed., Taylor and Francis (In Press).

McNutt, C., **M. Hayes**, L. Darby, J. Verdin, and R. Pulwarty. 2013. Developing Early Warning and Drought Risk Reduction Strategies. In: L. Botterill and G. Cockfield, eds., Science for Decision Making Under Uncertainty: Drought Risk Management and Policy, CRC Press/Taylor and Francis Publishers, pp. 151-170.

Mehta, V., C. Knutson, N. Rosenberg, J. R. Olsen, **M. Hayes**, N. Wall, and T. Bernadt, 2013. Decadal climate information needs of stakeholders for decision support in water and agriculture production sectors: a case study in the Missouri River Basin. *Weather, Climate, and Society*, 5(1): 27-42. http://dx.doi.org/10.1175/WCAS-D-11-00063.1

Swain, S., B. Wardlow, S. Narumalani, D. Rundquist, and **M. Hayes**. 2013. Relationships between vegetation indices and root zone soil moisture under maize and soybean canopies in the U.S. Corn Belt: a comparative study using close-range sensing approach. *International Journal of Remote Sensing*, 34(8): 2814-2828. DOI: 10.1080/01431161.2012.750020.

Wilhite, D. A., **M. J. Hayes**, and M. Svoboda. 2013. Drought. Encyclopedia of Environmetrics. Abdel H. El-Shaarawi and Walter P. Piegorsch, editors. John Wiley and Sons (In Press).

Botterill, L. C. and **M. Hayes**, 2012. Drought triggers and declarations: science and policy considerations for drought risk management. *Natural Hazards*, 64: 139-151.

Fontaine, M., A. Steinemann, and **M. Hayes**. 2012. State drought programs and plans: survey of the western U.S. *Natural Hazards* Review, doi: 10.1061/(ASCE)NH.1527-6996.0000094.

**Hayes, M.** 2012. The Drought Risk Management Paradigm in the Context of Climate Change. In: Climate Change Impacts, Vulnerability, and Adaptation in the Midwest, S. Pryor, ed., University of Indiana Press, pp. 212-225.

**Hayes, M. J.**, M. D. Svoboda, B. D. Wardlow, M. C. Anderson, and F. Kogan. 2012. Drought Monitoring: Historical and Current Perspectives. In: Remote Sensing of Drought: Innovative Monitoring Approaches, B. Wardlow, M. Anderson, and J. Verdin, eds., Taylor and Francis, pp. 1-19.

Tadesse, T., B. D. Wardlow, M. D. Svoboda, **M .J. Hayes**. 2012. Predicting Remote Sensing Based Seasonal Greenness: the Vegetation Outlook (VegOut). In: Remote Sensing of

Drought: Innovative Approaches to Monitoring, B. Wardlow, M. Anderson, and J. Verdin, eds., Taylor and Francis, pp. 75-94.

Ding Y., **M. Hayes**, and M. Widhalm. 2011. Measuring economic impacts of drought: a review and discussion. *Disaster Prevention and Management,* 20(4): 434-446.

Ferguson, D., C. Alvord, M. Crimmins, M. H. Redsteer, **M. Hayes**, C. McNutt, R. Pulwarty, M. Svoboda. 2011. Drought Preparedness for Tribes in the Four Corners Region. Report from April 2010 Workshop. Tucson, AZ: Climate Assessment for the Southwest.

**Hayes, M.**, M. Svoboda, N. Wall, and M. Widhalm. 2011. The Lincoln Declaration on Drought Indices: Universal meteorological drought index recommended. *Bulletin of the American Meteorological Society*, 92(4): 485-488.

**Hayes, M.**, D. Wilhite, M. Svoboda, and M. Trnka. 2011. Investigating the Connections between Climate Change, Drought, and Agricultural Production. In: Handbook on Climate Change and Agriculture, R. Mendelsohn and A. Dinar, eds., Edward Eigar Publishing Ltd., pp. 73-86.

Hlavinka, P., M. Trnka, J. Balek, D. Semeradova, **M. Hayes**, M. Svoboda, J. Eitzinger, M. Mozny, M. Fischer, E. Hunt, and Z. Zalud. 2011. Development and evaluation of the SoilClim model for water balance and soil climate estimates. *Agricultural Water Management*, 98(8): 1249-1261.

Knutson, C. L., T. Haigh, **M. Hayes**, M. Widlham, J. Nothwehr, and M. Kleinschmidt. 2011. Farmer perceptions of sustainable agriculture practices and drought risk reduction in Nebraska, USA, *Journal of Renewable Agriculture and Food Systems,* 26(3): 255-266.

Wang, J. and **M. Hayes**. 2011. Improving communication and collaboration for drought vulnerability analysis in China. Submitted to *Acta Meteorologica Sinica*.

Tadesse, T., B. Wardlow, **M. Hayes**, M. Svoboda, and J. Brown. 2010. The Vegetation Condition Outlook (VegOut): a new method for predicting vegetation seasonal greenness. *GIScience and Remote Sensing* 47 (1): 25-52.

Wardlow, B., **M. Hayes**, M. Svoboda, T. Tadesse, and K. Smith. 2009. Sharpening the focus on drought: new monitoring and assessment tools at the National Drought Mitigation Center. *Earthzine*, unpaginated, http://www.earthzine.org/2009/03/30/sharpening-the-focus-on-drought-%e2%80%93-new-monitoring-and-assessment-tools-at-the-national-drought-mitigation-center/.

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**Education and Training**

| *Institution* | *Area* | *Degree* | *Year Awarded* |
|---|---|---|---|
| North Carolina State University | Meteorology | B.S. | 1996 |
| University of Nebraska – Lincoln | Agricultural Meteorology | M.S. | 1998 |
| University of Minnesota | Climatology and Soil Science | Ph.D. | 2002 |

**Research and Professional Experience**

| *Years* | *Position* |
|---|---|
| 2009-present | Director, NOAA High Plains Regional Climate Center<br>Assistant Professor, School of Natural Resources, University of Nebraska – Lincoln |
| 2007-present | Adjunct Professor, Geography Program, University of Alaska Fairbanks |
| 2002-2009 | Research Professional, Alaska Climate Research Center<br>Geophysical Institute, University of Alaska Fairbanks |
| 1999-2002 | Graduate Research Assistant, Department of Soil, Water, and Climate<br>University of Minnesota |
| 1999 | Research Technician, High Plains Regional Climate Center<br>University of Nebraska – Lincoln |
| 1997-1998 | Graduate Research Assistant, Climate and Bio-Atmospheric Sciences Group<br>University of Nebraska – Lincoln |

**Collaborators and Affiliations**

Member: American Geophysical Union, American Meteorological Society, American Association of State Climatologists.
Member: Center for Great Plains Studies Board of Directors (2012 – present)
Member: School of Natural Resources Graduate Committee (2010 - present)
Collaborators: Peter Bieniek, Tim Brown, Roger Bruning, Kenneth Cassman, Art DeGaetano, Jerry Hatfield, Beth Hall, Michael Hayes, Steve Hilberg, Qi Hu, Kenneth Hubbard, David Klein, Cody Knutson, John Lindquist, Marjorie McGuirk, Shannon McNeeley, Blake Moore, Robert Oglesby, Linda Prokopy, Kelly Redmond, Kevin Robbins, Jim Specht, Eric Stevens, Gene Takle, Richard Thoman, John Walsh, Elizabeth Walter-Shea, Gerd Wendler, Don Wilhite, Jinsheng You, Lisa Pitlik-Zillig

**Synergistic Activities**

Reviewer: Journal of Geophysical Research, Climate Dynamics, Danish Journal of Geography, Arctic, Journal of Disaster Research, Meteorology and Atmospheric Physics, Environmental Studies and Sciences, Bulletin of the American Meteorological Society.
Conference Organizer: Climate Prediction Applications Science Workshop – Des Moines, IA, March 1 – 4, 2010.

Session Co-Chair: Atmospheric Circulation, Dynamics, and Chemistry session at Global Change Connection to the Arctic Conference (GCCA-6) – Tokyo, Japan, December 12-13, 2005.

**Recent Publications**

***Peer-Reviewed Articles***

1. Kunkel K.E., L.E. Stevens, S.E. Stevens, L. Sun, E. Janssen, D. Wuebbles, M.C. Kruk, D.P. Thomas, M.D. Shulski, N.A. Umphlett, K.G. Hubbard, K. Robbins, L. Romo, A. Akyuz, T. Pathak, T.R. Bergantino, J.G. Dobson, 2013. *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment, Part 4: Climate of the U.S. Great Plains*, NOAA Technical Report NESDIS 142-2.
2. Pathak T., K. Hubbard, M. Shulski, 2012. *Soil Temperature: A guide for planting agronomic and horticulture crops in Nebraska*, University of Nebraska NebGuide, g2122.
3. Saito K., S. Yamaguchi, H. Iwata, Y. Harazono, K. Kosugi, M. Lehning, **M. Shulski**, 2012. *Climatic physical snowpack properties for large-scale modeling examined by observations and a physical model*. Polar Science, 6(1), 79-95.
4. Bieniek P.A., U.S. Bhatt, R.L. Thoman, H. Angeloff, J. Partain, J. Papineau, F. Fritsch, E. Holloway, J.E. Walsh, C. Daly, **M. Shulski**, G. Hufford, D.F. Hill, S. Calos, R. Gens, 2012. *Climate divisions for Alaska based on objective methods*, Journal of Climate, 51(7), 1276-1289.
5. Klein D. and **M. Shulski**, 2011. *Reindeer and lichens incompatible in a Bering Sea island ecosystem.* Arctic, 64 (3), 353-361.
6. McNeeley S. and **M. Shulski**, 2011. *Anatomy of a closing window: Vulnerability to changing seasonality in Interior Alaska*. Global Environmental Change, doi:10.1016/j.gloenvcha.2011.02.2003.
7. DeGaetano A.T., T.J. Brown, S.D. Hilberg, K. Redmond, K. Robbins, P. Robinson, **M. Shulski**, and M. McGuirk, 2010. *Towards regional climate services: The role of NOAA's Regional Climate Centers*. Bulletin of the American Meteorological Society, 91, 1633-1644.
8. Wendler G., **M. Shulski**, and B. Moore, 2010. *Changes in the climate of the Alaskan North Slope and the ice concentration of the adjacent Beaufort Sea*. Theoretical and Applied Climatology, 99, 67-74.
9. **Shulski M.**, J. Walsh, E. Stevens, and R. Thoman, 2009. *Diagnosis of extended cold season temperature anomalies in Alaska*. Monthly Weather Review, 138 (2), 453-462.
10. Wendler G., and **M. Shulski**, 2009. *A century of climate change for Fairbanks, Alaska*. Arctic, 62 (3): 295-300.
11. Klein, D., and **M. Shulski**. 2009. *Lichen recovery following heavy grazing by reindeer delayed by climate warming*, Ambio, 38, 11-16.
12. Damoah R., N. Spichtinger, R. Servranckx, M. Fromm, E. Eloranta, I. Razenkov, P. James, **M. Shulski**, C. Forster, and A. Stohl, 2006. *Transport modeling of a pyro-convection event in Alaska*. Atmospheric Chemistry and Physics, 6,173-185.
13. Wendler G., **M.D. Shulski**, and B. Hartmann, 2005. *Potential climatic effects of cirrus contrails for the subarctic setting of Fairbanks, Alaska*. Theoretical and Applied Climatology, 81,149-159.
14. Wendler G., B. Hartmann, C. Wyatt, **M.D. Shulski**, and H. Stone, 2005. *Midsummer energy balance for the ice covered southern seas*, Boundary Layer Meteorology, 117,131-148.
15. Fan X., J.-F. Chou, B.-R. Guo, and **M.D. Shulski**, 2004. *A coupled simple climate model and its global analysis*. Theoretical and Applied Climatology, 79, 31-43.
16. **Shulski M.D.**, and M.W. Seeley, 2004. *Application of snowfall and wind statistics to snow transport modeling for snowdrift control in Minnesota*. Journal of Applied Meteorology, 43, 1711-1721.
17. **Shulski M.D.**, E.A. Walter-Shea, K.G. Hubbard, G.Y. Yuen, and G. Horst, 2004. *Penetration of photosynthetically active and ultraviolet radiation into alfalfa and tall fescue canopies*. Journal of Agronomy, 96, 1562-1571.
18. Yuen G.Y., C.C. Jochum, L.J. Giesler, **M.D. Shulski**, E.A. Walter-Shea, and K.G. Hubbard. 2002, *UV-B biodosimetry in turfgrass canopies*. Crop Science, 42, 859-868.

***Books and Other Publications***

1. **Shulski, M.** and G. Wendler. 2007. *The Climate of Alaska*, University of Alaska Press,
2. **Shulski, M.**, and H. M. Mogil. 2009. *Alaska's weather and climate*, Weatherwise, Jan/Feb 2009, 14-21.
3. Klein, D., J. Walsh, and **M. Shulski**, 2009. *What killed the reindeer of St. Matthew Island?*, Weatherwise, Nov/Dec 2009, 33-38.

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**Education and Training**

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| University of Nebraska-Lincoln | Agricultural Meteorology (Micrometeorology) | M.S. | 1992 |
| University of Nebraska-Lincoln | Agricultural Meteorology (Micrometeorology) | Ph.D. | 2000 |

**Research and Professional Experience**

| *Years* | *Position* |
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| 2010-present | Research Associate Professor, School of Natural Resources, University of Nebraska-Lincoln (UNL) |
| 2004 – 2010 | Research Assistant Professor, School of Natural Resources, UNL |
| 2001 - 2004 | Postdoctoral Research Associate, School of Natural Resources, UNL |
| 1996 - 2001 | Research Technologist, School of Natural Resources, UNL |

**Collaborators and Affiliations**

Anatoly Gitelson, UNL School of Natural Resources; Timothy Arkebauer, Dept of Agron. and Hort.; Andres Vina, Dept of Fisheries and Wildlife, Michigan ST; Dan Walters, Dept of Agron. and Hort.; Tagir Gilmanov, SDSU Dept of Biology and Microbiology; Phillip Sims, USDA Agricultural Research Service; Tilden Meyers, NOAA/ARL; James Bradford, USDA-Agric. Research Service, Niall Hanan, Colorado State Natural Resource Ecol. Lab; Joseph Berry, Carnegie Institute Dept of Global Ecology; Elizabeth Walter-Shea, UNL School of Natural Resources; Scott Denning, Colorado State Dept of Atmospheric Science; Jeffrey Masek, NASA Goddard Space Flight Center Biospheric Sciences Branch; Andrew Richardson, Univ. of New Hampshire Complex Systems Research Center; David Hollinger, USDA For. Ser.; Kenneth Davis, Penn State Dept of Meteorol.; Lawrence Flanagan,Univ. of Lethbridge Dept of Biol. Sciences; Gabriel Katul, Duke Univ. School of the Environ. and Earth Sciences; William Munger, Harvard Univ. Division of Engineering and Appl. Science/Dept of Planetary Science; Daniel Ricciuto, UNL School of Natural Resources; Steven Wofsy, Harvard Univ. Division of Engineering and Applied Science/Dept of Planetary Science; Ramesh Singh, UNL Dept of Biological Systems Engineering, Ayse Irmak, UNL School of Natural Resources/Dept of Civil Engineering; Achim Dobermann, Inter. Rice Research Institute; Kenneth Cassman, UNL Dept of Agron. and Hort.; Johannes Knops, UNL School of Biol. Sciences; Kenneth Hubbard, UNL School of Natural Resources, Wenping Yuan, Beijing Normal Univ. College of Global Change and Earth System Science, Jiquan Chen, Univ. of Toledo Dept of Environ. Sciences; Ankur Desai, Univer. of Wisconsin Atmospheric and Oceanic Sciences Dept; John Baker, Univ. of Minnesota, Dept of Soil, Water, and Climate; Jerry Hatfield, USDAARS National Soil Tilth Lab; Derrel Martin, UNL Dept of Biological Systems Engineering Graduate and Postdoctoral

Advisors – M.S. and Ph.D.: Shashi Verma, University of Nebraska-Lincoln; Postdoctoral: Shashi Verma Thesis Advisor and Postgraduate-Scholar Sponsored – M.S. and Ph.D.: Shashi Verma, University of Nebraska-Lincoln. Ph.D.: Shashi Verma, Dr. Timothy Arkebauer, Dr. John Doran (retired)

**Synergistic Activities**

- Peer review of manuscripts submitted to Journal of Geophysical Research – Biogeosciences; Journal of Geophysical Research – Atmospheres; Agricultural and Forest Meteorology; Agricultural Ecosystems and Environment; Wetlands; Great Plains Research; Agronomy Journal
- Chair of Conference Session: Agricultural Management Strategies and Implications for Climate Change, 29th Conference on Agricultural and Forest Meteorology of the American Meteorological Society (2010)
- Contribute to developing science of novel data processing and quality control necessary for accurate estimation of the regional and continental carbon balance in collaboration with leading scientists in the US, Canada and Europe to improve our understanding of the global carbon cycle
- Provide detailed, high-quality datasets of water and carbon dioxide exchange to a national data archive center and to scientists/graduate students at UNL, nationally and internationally

**Publications**

***Refereed Journal Publications***


1. Arkebauer, T.J., E.A. Walter-Shea, M.A. Mesarch, **A.E. Suyker**, and S.B. Verma. 2009. Scaling up CO2 fluxes from leaf to canopy in maize-based agroecosystems. *Agricultural and Forest Meteorology*. doi: 10.1016/j.agrformet.2009.04.013.
2. Hollinger, D.Y., S.V. Ollinger, A.D. Richardson, T.P. Meyers, D.B. Dail, M.E. Martin, N.A. Scott, T.J. Arkebauer, D.D. Baldocchi, K.L. Clark, P.S. Curtis, K.J. Davis, A.R. Desai, D. Dragoni, M.L. Goulden, L. Gu, G.G. Katul, S.G. Pallardy, K.T. Paw U, H.P. Schmid, P.C. Stoy, **A.E. Suyker**, and S.B. Verma. 2009. Albedo estimates for land surface models and support for a new paradigm based on foliage nitrogen concentration. *Global Change Biology*. doi: 10.1111/j.1365-2486.2009.02028.x.
3. Lagos, L.O., D.L. Martin, S.B. Verma, **A.E. Suyker**, S. Irmak. 2009. Surface energy balance model of transpiration from variable canopy cover and evapotranspiration from residue-covered or bare-soil systems. *Irrigation Scie*nce. 28 51-64, doi: 10.1007/s00271-009-0181-0.
4. Lokupitiya, E., S. Denning, K. Paustian, I. Baker, K. Schaefer, S.B. Verma, T. Meyers, C.J. Bernacchi, **A.E. Suyker**, and M. Fischer. 2009. Incorporation of crop phenology in Simple Biosphere Model (SiBcrop) to improve land-atmosphere carbon exchanges from croplands. *Biogeosciences*. 6:969-986.
5. **Suyker, A.E.**, and S.B. Verma. 2009. Evapotranspiration of irrigated and rainfed maize-soybean cropping systems. *Agricultural and Forest Meteorology.* 149:443-452.
6. Yuan, W., Y. Luo, A.D. Richardson, R. Oren, S. Luyssaert, I.A. Janssens, R. Ceulemans, X. Zhou, T. Grunwald, M. Aubinet, C. Berhofer, D.D. Baldocchi, J. Chen, A.L. Dunn, J. Deforest, D. Dragoni, A.H. Goldstein, E. Moors, J.W. Munger, R.K . Monson, **A.E. Suyker**, G. Starr, R.L. Scott, J. Tenhunen, S.B. Verma, T. Vesala, and S.C. Wofsy. 2009. Latitudinal patters of magnitude and interannual variability in net ecosystem exchange regulated by biological and environmental variables. *Global Change Biology.* 15:2905-2920.. doi: 10.1111/j.1365-2486.2009.01870.x.
7. Sakamoto, T., B.D. Wardlow, A.A. Gitelson, S.B. Verma, **A.E. Suyker**, and T.J. Arkebauer. 2010. A Two-Step Filtering approach for detecting maize and soybean phenology with time-series MODIS data. *Remote Sensing of Environment.* 114:2146-2159.
8. **Suyker, A.E.**, and S.B. Verma. 2010. Coupling of carbon dioxide and water vapor exchanges of irrigated and rainfed maize-soybean cropping systems and water productivity. *Agricultural and Forest Meteorology*. 150:553-563.
9. Xiao, J., Q. Zhuang, B.E. Law, J. Chen, D.D. Baldocchi, D.R. Cook, R. Oren, A.D.

Richardson, S. Wharton, S. Ma, T.A. Martin, S.B. Verma, **A.E. Suyker**, R.L. Scott, R.K. Monson, M. Litvak, D.Y. Hollinger, G. Sun, K.J. Davis, P.V. Bolstad, S.P. Burns, P.S. Curtis, B.G. Drake, M. Falk, M.L. Fischer, D.R. Foster, L. Gu, J.L. Hadley, G.G. Katul, R. Matamala, S. McNulty, T.P. Meyers, J.W. Munger, A. Noormets, W.C. Oechel, K.T. Paw U, H.P. Schmid, G. Starr, M.S. Torn, S.C. Wofsy. 2010. A Continuous Measure of Gross Primary Production for the Conterminous U.S. Derived from MODIS and AmeriFlux Data. *Remote Sensing of Environment*, 114, 576-591.

10. Yuan, W., S. Liu, G. Yu, J. Bonnefond, J. Chen, K. Davis, A.R. Desai, A.H. Goldstein, D. Gianelle, F. Rossi, **A.E. Suyker**, and S.B. Verma. 2010. Global estimates of evapotranspiration and gross primary production based on MODIS and global meteorology data. *Remote Sensing of Environment.* 114:1416-1431.
11. Kalfas, J.L., X. Xiao, D.X. Vanegas, S.B. Verma, and **A.E. Suyker**. 2011. Modeling gross primary production of irrigated and rain-fed maize using MODIS imagery and $CO_2$ flux tower data. *Agricultural and Forest Meteorology* 151:1514-1528.
12. Singh, R.K., S. Liu, L.L. Tieszen, **A.E. Suyker**, and S.B. Verma. 2011. Estimating seasonal evapotranspiration from temporal satellite images. *Irrigation Science.* DOI:10.1007/s0027-011-0287-z.
13. Singh, R.K., A. Irmak, E. Walter-Shea, S.B. Verma and **A.E. Suyker**. 2011. Spectral data-based estimation of soil heat flux. *Transactions of the ASABE* 54(5): 1589-1597.
14. Lagos, L.O., D.L. Martin, S.B. Verma, S. Irmak, A. Irmak, D.E. Eisenhauer, and **A.E. Suyker**. 2011. Surface energy balance model of transpiration and evaporation from residue-covered or bare-soil systems: Model evaluation. *Irrigation Science*, (on-line) Aug. 2011. DOI10.1007/s00271-011-0298-9.
15. Irmak, A., R.K. Singh, E. Walter-Shea, S.B. Verma and **A.E. Suyker**. 2011. Comparison and Analysis of Empirical Equations for Soil Heat Flux for Different Cropping Systems and Irrigation Methods. *Transactions of the ASABE*. 54(1): 67-80.
16. Sakamoto, T., A.A. Gitelson, B.D. Wardlow, S.B. Verma, and **A.E. Suyker**. 2011. Estimating daily gross primary production of maize based only on MODIS WDRVI and shortwave radiation data. *Remote Sensing of Environment*. 115:3091-3101.
17. Dietze, M.C., R. Vargas, A.D. Richardson, P.C. Stoy, A.G. Barr, R.S. Anderson, M. Altaf Arain, I.T. Baker, T. A. Back, J.M. Chen, P. Ciais, L.B. Flanagan, C.M. Gough, R.F. Grant, D. Hollinger, C. Izaurralde, C.J. Kucharik, P. Lafleur, S. Liu, E. Lokupitiya, Y. Luo, J.W. Munger, C. Peng, B. Poulter, D.T. Price, D.M. Ricciuto, W.J. Riley, A. Kumar Sahoo, K. Schaefer, **A.E. Suyker**, H. Tian, C. Tonitto, H. Verbeeck, S.B. Verma, and W. Wang. 2011. Characterizing the performance of ecosystem models across time scales: A spectral analysis of the North American Carbon Program site-level synthesis. *Journal of Geophysical Research-Biogeosciences* 116, G04029, doi:10.1029/2011JG001661..
18. Gitelson, A., Peng, Y., Masek, J., Rundquist, D., Verma, S., **Suyker, A**., Baker, J.M., Hatfield, J.L., Meyers, T. 2012. Remote estimation of crop gross primary production with Landsat data. *Remote Sensing of Environment*. 121:404-414.
19. **Suyker, A.E**., and S.B. Verma. 2012. Gross primary production and ecosystem respiration of irrigated and rainfed maize-soybean cropping system over 8 years. *Agricultural and Forest Meteorology*, http://dx.doi.org/10.1016/j.agformet.2012.05.021.
20. Singh, R.K., S. Liu, L.L. Tieszen, **A.E. Suyker**, and S.B. Verma. 2012 Novel approach for computing photosynthetically active radiation for productivity modeling using remotely sensed images in the Great Plains, United States. *Journal of Applied Remote Sensing Letters*, 6(1).
21. Sakamoto, T., A.A. Gitelson, B.D. Wardlow, T.J. Arkebauer, S.B. Verma, **A.E. Suyker**, and M. Shibayama. 2012. Application of day and night digital photographs for estimating maize biophysical characteristics. *Precision Agriculture*, 13, 285-301.

22. Sakamoto, T., A.A. Gitelson, A.L. Nguy-Robertson, T.J. Arkebauer, B.D. Wardlow, **A.E. Suyker**, S.B. Verma, and M. Shibayama. 2012. An alternative method using digital cameras for continuous monitoring of crop status. *Agricultural and Forest Meteorology*, 154-155, 113-126.

***Relevant Non-refereed Technical Publications***

1. Gu, L., W.M. Post, D.D. Baldocchi, T.A., Black, **A.E. Suyker**, S.B. Verma, T. Vesala, S.C. Wofsy. 2009. Characterizing the seasonal dynamics of plant community photosynthesis across a range of vegetation types. In: Noormets, A. (Ed.), Phenology of Ecosystem Processes, Springer Science+Business Media, LLC, New York, NY, pp 35-58 DOI 10.1007/978-1-4419-0026-5_2.
2. Liu, S., Z. Tan, M. Chen, J. Liu, A. Wein, Z. Li, S. Huang, J. Oeding, C. Young, S.B. Verma, **A.E. Suyker**, S. Faulkner, and G.W. McCarty. 2012. The General Ensemble Biogeochemical Modeling System (GEMS) and its Applications to Agricultural Systems in the United States. Chapter in Managing Agricultural Greenhouse Gases, Mark Liebig, Alan J. Franzluebbers, Ronald F. Follett, editors, Elsevier. 309-323.

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## Education and Training

| *Institution* | *Area* | *Degree* | *Year Awarded* |
|---|---|---|---|
| Northwest Missouri State University | Geography/Geology | B.S. | 1994 |
| Kansas State University | Geography | M.A. | 1996 |
| University of Kansas | Geography | Ph.D. | 2006 |

## Research and Professional Experience

| *Years* | *Position* |
|---|---|
| 2012-present | Director and Associate Professor, CALMIT, School of Natural Resources, University of Nebraska Lincoln<br>Current appointment: 15% CALMIT Director, 35% research, 38% teaching, and 12% service. Provide leadership, coordinate projects, supervise staff, and administer Center activities for CALMIT. Conduct research on the use of remote sensing and GIS for drought monitoring and the characterization of land use/land cover and vegetation dynamics (phenology and biophysical characteristics). Advise and mentor graduate students in Geography and SNR interested in the use of remote sensing and GIS for environmental monitoring and agricultural and natural resource applications. Teach various remote sensing courses such as Introduction of Remote Sensing, Digital Image Analysis, Applications of Remote Sensing in Agriculture and Natural Resources, and special topics (e.g., drought monitoring tools). |
| 2006-2012 | Assistant Professor and GIScience Program Area Leader, National Drought Mitigation Center (NDMC), School of Natural Resources, University of Nebraska-Lincoln |
| 1999-2006 | NASA Earth System Science Graduate Student Research Fellow, Kansas Applied Remote Sensing Program, University of Kansas |
| 1996-1999 | Remote Sensing Scientist, U.S. Geological Survey's Center for Earth Resources Observation Science (EROS) |

## Synergistic Activities

- ***Book Editor:*** Remote Sensing and Drought: Innovative Monitoring Approaches. Boca Raton, FL:CRC Press (2012)
- ***Professional Memberships:*** Director, Remote Sensing Specialty Group, Association of American Geographers (2011-present; Associate Editor of Agriculture and Remote Sensing section, Earthzine (2009 – present); Working group member, National Phenology Network (NPN) Land Surface Phenology and Remote Sensing Working Group; Working group member, NASA Soil Moisture Active Passive (SMAP) Satellite Applications Working Group
- ***Reviewer:*** NASA MEASURES, (2012); NASA Postdoctoral Program (2011- 2012)
- ***Grants Received:*** The Quick Drought Response Index (QuickDRI): An Integrated Approach for Rapid Response Agricultural Drought Monitoring,NASA Earth Science Applications: Water

Resources, (2012 –2013); Development of a Multi-scale Remote Sensing-Based Framework for Mapping Drought Over North America NASA Earth Science Applications: Water Resources, (2012 – 2013); Development of a Multi-scale Remote Sensing-Based Framework for Mapping Drought Over North America, NASA Earth Science Applications: Water Resources, (2012 – 2013); Evapotranspiration and Drought Monitoring Using GOES-R Products for NIDIS. NOAA GOES-R Risk Reduction Program (2012 – 2013); Dual Assimilation of Microwave and Thermal-Infrared Satellite Observations of Soil Moisture into NLDAS for Improved Drought Monitoring. NOAA Modeling, Analysis, Predictions, and Projections (MAPP) Competition (2011 – 2014);Use of Satellite Data and Model Products in Improving the Categorization, Delineation, and Mitigation of Agricultural Drought. McNider, NASA Gulf of Mexico Program,(2010 – 2012); A GOES Thermal-Based Drought Early Warning Index for NIDIS, NOAA Climate Dynamics and Experimental Prediction (CDEP) Competition (2009 – 2012).

**Collaborators and Affiliations**

Albright, T. (University of Nevada-Reno), Anderson, M.C. (USDA ARS), Brewer, M. (NOAA/NCDC), Brown, J.C. (University of Kansas), Christy, J. (University of Alabama-Huntsville), Doorn, B. (NASA HQ), Egbert, S.L. (University of Kansas), Hain, C. (University of Maryland/NASA GSFC), Gitelson, A.A. (CALMIT, University of Nebraska-Lincoln), Hayes, M. (NDMC, University of Nebraska-Lincoln), McNider, D. (University of Alabama-Huntsville), Mecikalski, J.R. (University of Alabama-Huntsville), McNutt, C. (NOAA/NIDIS); Mo, K.C. (Climate Prediction Center NCEP/NWS/NOAA), Nghiem, S. (NASA JPL), O'Brien, J.J. (COAPS, Florida State University), Pidgeon, A. (University of Wisconsin-Madison), Price, K.P. (Kansas State University), Reed, B.C. (USGS), Rodell, M. (NASA GSFC), Svoboda, M.D. (NDMC, University of Nebraska-Lincoln), Verdin, J.P. (USGS EROS), Verma, S.P. (University of Nebraska-Lincoln), and Wilhite, D.A. (University of Nebraska-Lincoln).

**Publications**


Swain, S., **B.D. Wardlow**, S. Narumalani, D. Rundquist, and M. Hayes. 2012. Relationships between vegetation indices and root zone soil moisture under maize and soybean canopies in the U.S. Corn Belt: a comparative study using close-range sensing approach. *International Journal of Remote Sensing*, In press.

Swain, S., D. Rundquist, T. Arkebauer, S. Narumalani, and **B. Wardlow**. 2012. Non-invasive estimation of relative water content in soybean leaves using infrared thermography. *Israel Journal of Plant Sciences*, 60:25-36.

Sakamoto, T., A.A. Gitelson, A.L. Nygun-Robertson, T.J. Arkebauer, **B.D. Wardlow**, A.E. Suyker, S.B. Verma, and M. Shibayama. 2012. An alternative method using digital cameras for continuous monitoring of crop status. *Agriculture and Forest Meteorology*, 154-155:113-126.

Sakamoto, T., A.A. Gitelson, **B.D. Wardlow**, T.J. Arkebauer, S.B. Verma, A.E. Suyker, and M. Sibayama. 2012. Application of day and night digital photographs for estimating maize biophysical characteristics. *Precision Agriculture*, 13:285-301.

**Wardlow, B.D.**, T. Tadesse, J.F. Brown, K. Callahan, S. Swain, and E. Hunt. 2012. The Vegetation Drought Response Index (VegDRI): an integration of satellite, climate, and biophysical data. In *Remote Sensing of Drought: Innovative Monitoring Approaches*, eds. B.D. Wardlow, M.A. Anderson, and J. Verdin, Boca Raton, FL:CRC Press, 51-74.

**Wardlow, B.D.**, M.A. Anderson, J. Sheffield, B. Doorn, J.P. Verdin, X. Zhan, M. Rodell. 2012. Future opportunities and challenges in remote sensing of drought. In *Remote Sensing of Drought: Innovative Monitoring Approaches*, eds. B.D. Wardlow. M.A. Anderson, and J.P. Verdin, Boca Raton, FL:CRC Press, 389-409.

Tadesse, T., **B.D. Wardlow**, M. Hayes, and M. Svoboda. 2012. The Vegetation Outlook (VegOut): a new method for predicting vegetation seasonal greenness. In *Remote Sensing of Drought: Innovative*

*Monitoring Approaches*, eds. B.D. Wardlow. M.A. Anderson, and J.P. Verdin, Boca Raton, FL:CRC Press, 75-94.

Nghiem, S.V., **B.D. Wardlow**, D. Allured, M.D. Svoboda, D. LeComte, M. Rosencrans, S.K. Chan, and G. Neumann. 2012. Microwave remote sensing of soil moisture – science and applications. In *Remote Sensing of Drought: Innovative Monitoring Approaches*, eds. B.D. Wardlow. M.A. Anderson, and J.P. Verdin, Boca Raton, FL:CRC Press, 197-226.

Hayes, M., M. Svoboda, **B.D. Wardlow**, M.C. Anderson, and F. Kogan. 2012. Drought monitoring: historical and current perspectives. In *Remote Sensing of Drought: Innovative Monitoring Approaches*, eds. B.D. Wardlow. M.A. Anderson, and J.P. Verdin, Boca Raton, FL:CRC Press, 1-22.

Anderson, M.C., C. Hain, **B.D. Wardlow**, A. Pimstein, J.R. Mecikalski, and W.P. Kustas, 2012. A drought index based on thermal remote sensing of evapotranspiration. In *Remote Sensing of Drought: Innovative Monitoring Approaches*, eds. B.D. Wardlow. M.A. Anderson, and J.P. Verdin, Boca Raton, FL:CRC Press, 145-168.

Sakamoto, T., A.A. Gitelson, A.L. Nguy-Robertson, T.J. Arkebauer, **B.D. Wardlow**, A.E. Suyker, S.B. Verma, and M. Shibayama, 2011. Estimating daily gross primary production of maize based only on MODIS WDRVI and shortwave radiation data. *Remote Sensing of Environment*, 115:3091-3101.

Swain, S., **B.D. Wardlow**, S. Narumalani, T. Tadesse, and K. Callahan. 2011. Assessment of vegetation response to drought in Nebraska using Terra-MODIS land surface temperature and normalized difference vegetation index. *GIScience and Remote Sensing* 48(3):432-455.

Sakamoto, T., **B.D. Wardlow**, and A.A. Gitelson. 2011. Detecting region-based corn phenology in the U.S. Corn Belt using MODIS WDRVI data. *IEEE Transactions on Geoscience and Remote Sensing* 49(6):1926-1936.

Anderson, M.C., C. Hain, **B. Wardlow**, A. Pimstein, J.R. Mecikalski, and W.P. Kustas. 2011. Evaluation of a drought index based on thermal remote sensing of evapotranspiration over the continental U.S. *Journal of Climate* 24:2025-2044.

Sakamoto, T., **B.D. Wardlow**, A.A. Gitelson, S.B. Verma, A.E. Suyker, and T.J. Arkebauer. 2010. The two-step filtering approach for detecting maize and soybean phenology with time-series MODIS data. *Remote Sensing of Environment* 114(10):2146-2159.

Masialeti, I., S.Egbert, and **B.D. Wardlow**. 2010. A comparative analysis of phenological curves for major crops in Kansas. *GIScience and Remote Sensing* 47(2):241-259.

**Wardlow, B.D.** and S.L. Egbert. 2010. A comparison of MODIS 250-m evi and ndvi data for crop mapping in the U.S. Central Great Plains. *International Journal of Remote Sensing* 31(3):805-830.

Tadesse, T., **B.Wardlow**, M. Hayes, M. Svoboda, and J. Brown. 2010. The Vegetation Outlook (VegOut): a new method for predicting vegetation seasonal greenness. *GIScience and Remote Sensing* 47(1):25-52.

Albright, T., A. Pidgeon, C. Rittenhouse, M. Clayton, C. Flather, P. Culbert, **B. Wardlow**, and V. Radeloff. 2010. Effects of drought on avian community structure. *Global Change Biology* doi:10,1111/j.1365-2486.02120x.

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**Education and Training**

| *Institution* | *Area* | *Degree* | *Year Awarded* |
|---|---|---|---|
| University of Nebraska, Lincoln, NE | Civil Engineering | Ph.D. | 1998 |
| University of Nebraska, Lincoln, NE | Environ. Engineering | M. S. | 1996 |
| Montana State University, Bozeman, MT | Soil Physics | M. S. | 1993 |
| Montana State University, Bozeman, MT | Soil Science | B. S. | 1989 |
| Ricks College, Rexburg, ID | Agricultural Business | Assoc. | 1985 |

**Research and Professional Experience**

| *Years* | *Position* |
|---|---|
| 5/99-present | USDA, ARS, Research Scientist, Environmental Management Research Unit, U. S. Meat Animal Research Center, Clay Center, NE |
| 1/99-5/99 | USDA, ARS, Research Associate, Biological Engineering Research Unit, U.S. Meat Animal Research Center, Clay Center, NE |
| 1/95-12/98 | USDA, National Needs Fellow - Civil Engineering, University of Nebraska, Lincoln, NE |
| 1/93-1/95 | Research Technologist in Soil and Environmental Chemistry, University of Nebraska, Lincoln, NE |
| 8/91-12/92 | Research Technician in Soil Physics, Montana State University, Bozeman, MT |

**Collaborators and Affiliations**

Fifteen years of experience researching the environmental impact on air, water and soil from confined animal feeding operations. Air research experience includes studies measuring the denitrification potential of feedlot pen surfaces. The biological denitrification potential of feedlot surfaces were spatially dependant. Some areas maintained high potential even when soil temperatures were near freezing. Another important study was a cooperative effort measuring the total reduced sulfur levels in the vicinity of feedlots. It was determined that total reduced sulfur levels did not exceed Nebraska regulatory levels. This finding was the basis for an exemption for feedlots from regulatory requirements by the Nebraska Department of Environmental Quality. On-going air quality research includes a team effort to quantify the spatial ammonia structure and emission rates from the deep-bedded beef cattle barn surfaces. Understanding where the majority of ammonia is being emitted will allow for precision management practices to be developed. Another on-going study is evaluating the effect of feeding dried distillers' grain on spatial odor and gaseous emissions from feedlot surfaces. Knowing the locations within the pen odors are being emitted will provide insight for the application of antimicrobial compounds for mitigating odor events.

Research in the area of water quality documented the effectiveness and sustainability of an alternative feedlot runoff control system. The system uses a short resident-time solid separation basin and a vegetative treatment area (VTA) for nutrient and water utilization to produce a grass hay crop. The system was shown to be sustainable in that more nitrogen was removed in the harvested hay than was applied in runoff, and no water was measured leaving the system to surface runoff or deep infiltration. The EMI technique used to determine VTA performance at the U.S. MARC has been instrumental for documenting VTA performance of a multi-state VTA study. Also, a recently completed study using these same EMI techniques was applied to map the spatially variable manure accumulations on feedlot surfaces. This mapping technology will be instrumental for developing precision management practices for controlling soil and surface water contamination from feedlots.

Several studies have been conducted focusing on manure nutrient impact on soils. One investigation evaluated the application of animal manure as a soil fertilizer amendment. This study concluded that soil conductivity dynamics as measured by electromagnetic induction (EMI) mapping were closely related to crop and soil status. Another long-term study determined that manure effectively supplied all of the nitrogen needs of a corn silage crop without any yield losses but it resulted in unacceptably high levels of phosphorus that persisted for years following the final application. Following this long-term study, an investigation documented the physical, chemical and biological health of a soil system greatly improved through the use of animal-based manure fertilizers particularly with respect to soil carbon status. A separate study demonstrated a cover crop planted post-harvest adequately retained nitrogen near the surface, but reduced crop yield due to competition 4 out of 10 years. A follow-up study compared early and late cover crop destruction dates. Preliminary data suggests early cover crop destruction limited yield reduction while retaining nutrients mineralized late in the growing season.

**Synergistic Activities**

Member, American Society of Agricultural and Biological Engineers (ASABE)
National Committees:
- SE412 Agric. Byproduct & Animal Mortality Mgmt Systems
- SE305 Environment Air Quality
- SW263 Land Application of Animal Waste.

Nebraska Section ASABE:
- Secretary/Treasurer

Member, American Society of Agronomy (ASA)
Member, Soil Science Society of America (SSSA)

**Recent Publications**

**Woodbury, B.L.**, S.M. Lesch, R.A. Eigenberg, D.N. Miller and M.J. Spiehs. 2009. Electromagnetic induction sensor data to identify areas of manure accumulation on a feedlot surface. Soil Sci. Society Am. J. 73(6):2068-2077.

Gilley, J.E., J.R. Vogel, E.D. Berry, R.A. Eigenberg, D.B. Marx and **B.L. Woodbury**. 2009. Nutrient and bacterial transport in runoff from soil and pond ash surfaces. Trans. ASABE. 52(6):2077-2085.

Gilley, J.E., J.R. Vogel, R.A. Eigenberg, D.B. Marx and **B.L. Woodbury**. 2010. Nutrient transport in runoff from feedlots as affected by wet distiller's grain diet. Trans. ASABE. 53(2):545-552.

Berry, E.D, J.E. Wells, T.M. Arthur, **B.L. Woodbury**, J.A. Nienaber, T.M. Brown-Brandl, and R.A. Eigenberg. 2010. Soil Versus Pond Ash Surfacing of Feedlot Pens: Occurrence of *Escherichia coli* O157:H7 in Cattle and Persistence in Manure**.** Journal of Food Protection 73(7):1269-1277.

Gilley, J.E., L.M. Durso, R.A. Eigenberg, and **B.L. Woodbury**. 2010. Nutrient transport in runoff as affected by diet, tillage and manure application rate. Transactions of the ASABE. 53 (6): 1895-1902.

Eigenberg, R.A., **B.L. Woodbury**, J.A. Nienaber, M.J. Spiehs, D.B. Parker, and V.H. Varel. 2010. Conductivity and multiple linear regression for precision monitoring of beef feedlot manure and runoff. J. Environ. Eng. Geophysics. 15(3):175-183.

Gilley, J.E., E.D. Berry, R.A. Eigenberg, D.B. Marx, and **B.L. Woodbury**. 2010. Nutrient Transport in Runoff from Feedlots as Affected by Wet Distiller's Grain Diet. Transactions of the ASABE. 53(2):545-552.

**Woodbury, B.L.**, R.A. Eigenberg, V.H. Varel, S. Lesch, and M.J. Spiehs. 2010. Using electromagnetic induction technology to predict volatile fatty acid, source area differences. Journal of Environmental Quality. 40:1416-1422.

Gilley, J.E., J.R. Vogel, R.A. Eigenberg, D.B. Marx, and **B.L. Woodbury**. 2011. Runoff, erosion, and size distribution of sediment from beef cattle feedlots. Trans. of the ASABE. 54(2): 435-440.

Gilley, J.E., L.M. Durso, R.A. Eigenberg, D.B. Marx, and **B.L. Woodbury**. 2011. Narrow grass hedge control of nutrient loads following variable manure application. Trans. of the ASABE. 54(3):847-855.

Spiehs, M.J., **B.L. Woodbury**, B.E. Doran, R.A. Eigenberg, K.D. Kohl, V.H. Varel, E.D. Berry, and J. Wells. 2011. Environmental conditions in beef deep-bedded monoslope facilities: a descriptive study. Trans. of the ASABE. 54(2):663-673.

Vogel, J.R., J.E. Gilley, **B.L. Woodbury**, E.D. Berry, and R.A. Eigenberg. 2011. Transport of trace elements in runoff from unamended and pond-ash amended feedlot surfaces. Trans. of the ASABE. 54(4):1269-1279.

Fortuna, A.M., C.W. Honeycutt, G. Vandemark, T.S. Griffin, R.P. Larkin, Z. He, B.J. Wienhold, K.R. Sistani, S.L. Albrecht, **B.L. Woodbury**, H.A. Torbert, J.M. Powell, R.K. Hubbard, R.A. Eigenberg, R.J. Wright, J.R. Alldredge and J.B. Harsh. 2012. Links among nitrification, nitrifier communities and edaphic properties in contrasting soils receiving dairy slurry. Journal of Environmental Quality. 41:262-272.

Parker, D., J. Ham, **B. Woodbury**, L. Cai, M. Spiehs, M. Rhoades, S. Trabue, K. Casey, R. Todd, N. Cole. 2012. Standardization of flux chamber and wind tunnel flux measurements for quantifying volatile organic compound and ammonia emissions from area sources at animal feeding operations. Atmospheric Environment, In Press doi:10.1016/j.atmosenv.2012.03.068.

Parker, D.B., J. Gilley, **B. Woodbury**, K-H Kim, S. Bartelt-Hunt, X. Li, D. Snow, G. Galvin. 2012. Odorous VOC emission following land application of swine manure slurry. Atmospheric Environment (In Press). doi:10.1016/j.atmosenv.2012.01.001.

Spiehs, M.J., D.N. Miller, **B.L. Woodbury**, R.A. Eigenberg, V.H. Varel and D.B. Parker. 2012. Effect of feeding wet distillers grains with soluble to beef cattle on air and manure quality. Applied Engineering in Agriculture. 28(3): 423-430.

Eigenberg, R.A., **B.L. Woodbury**, B.W. Auvermann, D.B. Parker and M.J. Spiehs. Energy and nutrient recovery from cattle feedlots. ISRN Renewable Energy. dio: 10-5402/2012/723829. 2012

**Woodbury, B.L.**; R.A. Eigenberg, D.B. Parker and M.J. Spiehs. Effect of Pond Ash on Pen Surfaces Properties. Trans. of the ASABE. (In Press).

**APPENDIX 2 – LIST OF LTAR-AFFILIATED FACULTY**

| Name | Rank | Affiliation | Research Focus |
|---|---|---|---|
| Don Adams | District Director | West Central Research and Extension Center | beef cattle nutrition |
| Timothy J. Arkebauer | Professor | Agronomy and Horticulture | whole plant physiology and plant water relations |
| Tala Awada | Professor | School of Natural Resources | impacts of woody species expansion on ecosystem functions with emphasis on water, carbon and grasslands health |
| Guillermo Baigorria | Assistant Professor | School of Natural Resources | crop modeling |
| Dave Billesbach | Research Assistant Professor | Biological Systems Engineering and co-director, AmeriFlux QA/QC lab | carbon, water, and greenhouse gas fluxes in grassland, cropland, and Arctic ecosystems |
| Xun-Hong Chen | Professor | School of Natural Resources | hydrology |
| Galen Erickson | Professor | Animal Science | beef cattle and greenhouse gases |
| Richard Ferguson | Professor | Agronomy and Horticulture | soil fertility |
| Michael Hayes | Professor and Director | National Drought Mitigation Center, School of Natural Resources | drought mitigation |
| Gary Hergert | Professor | PREC and Agronomy and Horticulture | soil and nutrient management, N leaching, soil water balance |
| Suat Irmak | Professor | Biological Systems Engineering | irrigation engineering |
| Virginia L. Jin | Assistant Professor | USDA-ARS, AMRU; Adjunct, Agronomy and Horticulture | biogeochemistry, soil microbial ecology, global change ecology, and stable isotope ecology |
| Ayse Kilic | Assistant Professor | School of Natural Resources and Civil Engineering | surface energy balance, evapotranspiration, irrigated systems, remote sensing, geographic information systems, hydrologic information systems |
| Mark Kuzila | Professor | School of Natural Resources | soil science |

| Name | Rank | Affiliation | Research Focus |
|---|---|---|---|
| Derrel Martin | Professor | Biological Systems Engineering | irrigation |
| Walter Schacht | Professor | Horticulture and Agronomy | Rangeland ecology and management |
| Marty R. Schmer | Assistant Professor | USDA-ARS, AMRU; Adjunct, Agronomy and Horticulture | lifecycle analysis, biofuel feedstock production, site specific management |
| Martha Shulski | Director and Assistant Professor | NOAA High Plains Regional Climate Center, School of Natural Resources | climate |
| Andrew E. Suyker | Research Associate Professor | School of Natural Resources | carbon sequestration, ET, water use efficiency, and greenhouse gas fluxes in natural and managed ecosystems |
| Gary E. Varvel | Professor | USDA-ARS, AMRU; Adjunct, Agronomy and Horticulture | cropping systems, nutrient management, soil management |
| Elizabeth A. Walter-Shea | Associate Professor | School of Natural Resources | climate variability and crop production |
| David Wedin | Professor | Agronomy and Horticulture | plant and ecosystem ecology |
| Brian J. Wienhold | Professor | USDA-ARS, AMRU; Adjunct, Agronomy and Horticulture | nutrient management, soil management, spatially variable landscapes |
| Bryan Woodbury | Associate Professor | USDA-ARS, EMRU; Adjunct Biosystems Engineering | livestock waste management, feedlot emissions, |
| Haishun Yang | Associate Professor | Agronomy and Horticulture | crop modeling |
| Arthur Zygielbaum | Lecturer | School of Natural Resources | local, regional, and global remote sensing of vegetation status, and water quality |

**APPENDIX 3 – RESEARCH SITES**

| **UNL-managed Field Sites** | **Size (hectares)** | **Year Acquired** | **Annual Precip. (mm)** | **Cropping systems (examples)** | **Beef & Grassland (examples)** | **Water Resources (examples)** | **Monitoring Networks** | **Location** |
|---|---|---|---|---|---|---|---|---|
| Agricultural Research & Development Center | 3890 | 1962 | 719 | Wienhold et al. 2006, Wilhelm et al. 2010, Gitelson et.al. 2006, Liska et al. 2009 | Schmer et al. 2012, Bremer et al. 2010, Watson et al 2012 | Suyker and Verma 2010; Helmers et al. 2006 | ADWN, NSM, NADP, Ameriflux, REAP | Mead, NE |
| Rogers Memorial Farm | 130 | 1947 | 726 | Rathke et al. 2007, | | Willhelm and Wortman 2004 | GRACEnet | Lincoln, NE |
| Haskell Agricultural Laboratory | 195 | 1957 | 673 | Knezevic 2007, Shapiro et al. 2001, Ferguson et al. 1991 | Mader et al. 2006 | | ADWN, NSM | Concord, NE |
| South Central Agricultural Laboratory | 260 | 1968 | 676 | Cahoon et al. 1999, | | Irmak et al. 2012, Irmak 2010 | ADWN, NSM, NADP, REAP | Clay Center, NE |
| USDA Meat Animal Research Center | 260 | 1964 | 676 | | Parker et al., 2012 a, b; Woodbury et al, in press; | | GRACEnet | Clay Center, NE |

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|---|---|---|---|---|---|---|---|---|
| (MARC) | | | | | Spiehs et al., 2012. | | | |
| Barta Brothers Ranch | 2430 | 1996 | 577 | | Stephenson et al. 2012, Mousel et al. 2011 | Istanbull-uoglu et al. 2012, Sridhar et al. 2006, Wang et al. 2009 | ADWN, NSM, RGLMN | Rose, NE |
| West Central Research and Ext. Center | 608 | 1904 | 510 | Tarkalson et al. 2009 | Volesky et al. 2007, | | ADWN, NSM, NADP | North Platte, NE |
| Gudmundsen Sandhills Laboratory | 5185 | 1978 | 437 | | Reece et al. 2007, Volesky et al. 2011 | Healey et al. 2011, Miao et al. 2007, Billesbach et al. 2012 | ADWN, NSM, USCRN, RGLMN, Ameriflux | Whitman, NE |
| Panhandle Research and Extension Center | 235 | 1974 | 386 | Pavlista et al. 2010 | Jenkins et al. 2009, Luebbe et al. 2011 | | ADWN, NSM | Scottsbluff, NE |
| High Plains Agricultural Laboratory | 970 | 1970 | 427 | | | | ADWN, NSM | Sidney, NE |

**APPENDIX 4 – LIST OF ACTIVE DATA MONITORING PROGRAMS**

| Data Collection Program | Sites* | Start Date | End Date | Agro-Ecosystems Studied | Variables Measured/ Sampling Frequency | References for Data and Methods |
|---|---|---|---|---|---|---|
| ***Cropping Systems*** | | | | | | |
| *Crop response and fate of nutrients and pesticides under Tillage by Crop Rotation* | SCAL (Clay Center) | 1976 | pres. | Chisel/disk, ridge-till and slot plant, crop rotation with furrow-irrigation (corn/corn, corn/soybean) | Nitrogen, other nutrients, pesticides, soil water, residue | Zara, et al., 1994; Katupitiya, et al., 1997; Cahoon, et al., 1999 |
| *Crop response to Nitrogen Rate by Tillage by Nitrogen Timing by Nitrification Inhibitor* | SCAL | 1986 | pres. | continuous sprinkler-irrigated corn production (no-till, chisel/disk) | Nitrogen, soil water, residue | Schepers et al., 1990; Ferguson et al., 1991; Katupitiya et al., 1997 |
| *Cropping Intensity and Rotation* | ARDC (Mead) | 1983 | Pres. | Cropping Intensity Rotation (three monocultures, two two-year rotations, and two four-year rotations) | Soil carbon, crop yields, soil quality | Varvel, 2006; Varvel and Wilhelm, 2011, Helmers et al., 2001, Wienhold et al., 2006 |
| *Tillage Study* | Rogers Mem. Res. Farm (RMRF) | 1979 | Pres. | tillage intensity (six treatments ranging from plow tillage to no-tillage), and crop (continuous corn, continuous soybean, and corn-soybean rotation) | Greenhouse gas emissions, crop yields, soil carbon contributes to GRACEnet | Wilhelm and Wortmann 2004, Varvel and Wilhelm, 2010 and 2011, Rathke et al., 2007 |
| *Biofuel Feedstock Studies* | ARDC | 1998 | Pres. | Annual – perennial feedstock system comparison and switchgrass management | crop yield and N content and greenhouse gas emissions contribute to REAP | Varvel et al., 2008, Wilhelm et al., 2010, Johnson et al., 2010, Varvel and Wilhelm, 2008, Wienhold et al., 2011, Wienhold and Gilley, 2010, Perrin et al., 2008; Kiniry eta l., 2008; Schmer et al., 2006, 2010a, 2010b, 2011, and 2012), Liebig et al., 2008 |

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|---|---|---|---|---|---|---|
| *Remote Sensing of Crop Health and Biophysical Parameters* | ARDC | 1999 | 2011 | no-till irrigated continuous maize system, no-till irrigated maize-soybean rotation, and no-till rainfed maize-soybean rotation. | Hyperspectral reflectance, top of canopy temperature – data obtained weekly during growing season | Gitelson, A.A., Rundquist, D.C. (numerous references) |
| *Amelioration Practices for Residue Removal* | SCAL | 2010 | Pres. | Continuous corn, residue removal and N-rate variables | Yield, soil carbon, soil moisture, greenhouse gas emissions | |
| *Pennycress as an Oilseed Feedstock* | ARDC and SCAL | 2012 | Pres.. | Pennycress as a winter annual oilseed in a corn – soybean rotation | Yield, | |
| *Crop Yields* | ARDC, SCAL, RMRF | 1976 | pres. | Corn and soybean cropping systems | Plot yields, field level yield | |
| *Deficit irrigation in a semi-arid climate* | PREC | 2005 | Pres. | Deficit to full ET irrig for corn, wheat, dry bean, canola | Yield, soil carbon, soil moisture | Hergert, 2010; Hergert et al., 2011 |
| *Long-Term Dryland Tillage Plots* | PREC-HPAL | 1970 | Pres. | Wheat-fallow plots comparing convn, .chem fallow & subtillage. | Yield, soil carbon, soil moisture | Lyon et al., 1996; Peterson et al., 1998 |
| *Long-term manuring and continuous corn* | PREC-SB | 1912 | Pres. | 100 year continuous corn with 2 manure and N rate variables | Yield, soil carbon | Anderson & Peterson, 1973; Eghball et al., 1996 |
| ***Beef Cattle and Grassland Systems*** | | | | | | |
| *N use efficiency on smooth bromegrass pasture* | ARDC | 2005 | Pres. | Smooth bromegrass pasture at different levels and types of N input | Cattle and grass production and N budget of pasture system | Greenquist et al., 2009 & 2011; Watson et al., 2012 |

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| *Sandhills grassland production* | GSRL and BBR | 1997 | Pres. | Grazed Sandhills rangeland (upland) | Annual above-ground production and botanical composition | Schacht et al., 2000; Stephenson et al., in press |
| *Grassland response to grazing period length* | BBR | 2010 | Pres. | Grazed Sandhills rangeland (upland) | Annual above-ground production, botanical composition, soil N and C budget | Volesky, Schacht, and Mamo |
| *Grassland response to grazing strategy (stocking density)* | BBR | 2010 | Pres. | Grazed Sandhills meadow | Annual above- and below-ground production, botanical composition, soil N and C budget, and soil microbial composition | Schacht, Volesky, Mamo, Drijber, and Wedin |
| *Vegetation dynamics in the Sandhills* | Bessey Division, US Forest Service | 1926 | Pres. | Grazed Sandhills rangeland (upland) | Frequency of occurrence of grassland plant species | Stubbendieck and Tunnell, 2008 |
| *Grassland response to fire and mowing* | ARDC | 1981 | Pres. | Seeded grassland (warm-season tall grasses) in eastern Nebraska | Ground cover, botanical composition, and soil quality | Schacht et al., 1996 |
| *Ecology and water* | Sandhills | 2001 | pres | Vegetation cover change, biodiversity, invasive woody species | Biomass, biodiversity, soil moisture, water balance | Eggemeyer et al., 2006 & 2009 Awada et al., 2013 |

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| ***Water Resources*** | | | | | | |
| *Water and energy fluxes* | GSRL (Sandhills) | 2003 | pres. | Three key Sandhills ecosystems: dune, meadow, wetlands | carbon, water, and energy flux (hourly), soil moisture (hourly) | Arkebauer et al., 2009, Billesbach et al., 2012 |
| | ARDC (Mead) | 2003 | pres. | no-till irrigated continuous maize system, no-till irrigated maize-soybean rotation, and no-till rainfed maize-soybean rotation. | carbon, $N_2O$ and $CH_4$, water, and energy flux (hourly), soil carbon, soil moisture (hourly) | Suyker et al. 2004, 2005, Suyker and Verma, 2008, 2009, 2010. |
| | SCAL | 2005 | pres. | irrigated maize-soybean rotation (subsurface irrigation) | carbon, water, and energy flux (hourly), soil moisture (hourly) | S.Irmak, 2010 |
| *Evapotranspiration mapping* | Central Platte Region | 1997 2007 2011 | | Regional ecosystems including irrigated agriculture, rainfed agriculture, grasslands, riparian systems, wetlands. | Evapotranspiration at 30 m using surface energy balance (monthly) | Kilic: Irmak et al., 2010, Irmak and Ratcliffe 2012 |
| | North Platte and South Platte region | 1997 2002 2005 | | Regional ecosystems including irrigated agriculture, rainfed agriculture, grasslands, riparian systems, wetlands. | Evapotranspiration at 30 m using surface energy balance (monthly) | Kilic: Irmak et al., 2009, Hergert et al., 2009 |
| *Ground-water* | Thousands of measurements taken by differe | 1929 | pres. | High Plains Aquifer & Alluvial Systems | Legal locations, Depth to water from ground surface, test-hole | http://snr.unl.edu/data/water/NebGW_Levels.asp & http://water.usgs.gov/ogw/data.html |

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| | nt agencies across the state | | | | logs | |
| *Surface-water* | All major streams and reservoirs | Pre 1910 | pres. | All of the proposed LTAR | Stream discharge and reservoir records | USGS, CSD, NRD's, US Bureau of Reclamation |
| *Irrigation diversions and water balances* | Major irrigation projects | Pre 1920 | pres. | Platte River systems and tributaries; Sandhills | Canal diversion, return flows | US Bureau of Reclamation, USGS, DNR, NRD's |
| ***Weather and Climate Data*** | | | | | | |
| *Standard Meteorological Measurements* | High Plains Regional Climate Center, UNL | 1969 | pres. | HPRCC data support all systems studied in the proposed LTAR | Air Temperature, precipitation, wind speed and direction, relative humidity, solar radiation, soil temperature, soil moisture (every fifteen minutes to daily) | Hubbard: Hubbard et al., (1989, 2005) |
| *National Atmospheric Deposition Program* | Mead (1979-pres.), North Platte Agricul. Exp. Station (1985-pres.) | 1979 | pres. | Air quality and nutrient balance | Precipitation, wet Nitrogen and other deposition (1979-present, sampled daily) | http://nadp.sws.uiuc.edu/ |
| *National Drought Monitoring Program* | | 1999 | pres. | National drought program supports | U.S. Drought | http://droughtmonitor.unl.edu |

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| | | | | all systems studied in the LTAR | Monitor (weekly) | |
| | | 2005 | pres. | | Drought Impact Reporter | http://droughtreporter.unl.edu |
| | | 2005 | pres. | | Vegetation Drought Response Index (bi-weekly) | http://vegdri.unl.edu |
| | | 2013 | pres. | | Drought Risk Atlas | |

*: ARDC: Agricultural Research & Development Center; RMF: Rogers Memorial Farm; HAL: Haskell Agricultural Laboratory; SCAL: South Central Agricultural Laboratory; BBR: Barta Brothers Ranch; WCRE: West Central Research and Ext. Center; GSL: Gudmundsen Sandhills Laboratory; PREC: Panhandle Research and Extension Center; NPAES: North Platte Agricultural Experiment Station

Additional references cited in the table:


1. Hergert, G., A. Irmak, R.G. Allen, J. Kjaersgaard, I. Ratcliffe, and G.Stone. 2009. Demonstrate and adapt remote sensing technology to produce and utilize consumptive water use maps for the Nebraska Panhandle. USDA-NRCS Conservation Innovation Grant-Semiannual Progress Report. Agreement Number: 68-3A75-6-154. April 2009. 15 p.
2. Irmak, A., I. Ratcliffe, P. Ranade. 2010. Seasonal Evapotranspiration Mapping Using Landsat Visible and Thermal Data with METRIC$^{tm}$ for Central Platte Natural Resources District, NE. CPNRD Final Report. 120 p.
3. Irmak, A. and I. Ratcliffe. 2012. Seasonal Evapotranspiration Mapping Using Landsat Visible and Thermal Data with METRIC$^{tm}$ for Central Platte Natural Resources District, NE. CPNRD Final Report. 120 p.
4. Irmak, A., D. Rundquist, Sunil Narumalani, G. Hergert, and G. Stone. 2009. Satellite-based energy balance to assess riparian water use. UNL. Lincoln, NE. USGS 104b final report. 11 p.
5. Irmak, S. 2010. Nebraska Water And Energy Flux Measurement, Modeling, And Research Network (NEBFLUX).Transactions of the ASABE. Vol. 53(4): 1097-1115. 2010 American Society of Agricultural and Biological Engineers ISSN 2151-0032 1097
6. Schacht, W.H., J. Stubbendieck, T.B. Bragg, A.J. Smart, and J.W. Doran. 1996. Soil quality response of reestablished grasslands to mowing and burning. J. Range Manage. 49:458-463.
7. Schacht, W.H., J.D. Volesky, D. Bauer, A.J. Smart, and E.M. Mousel. 2000. Plant community patterns on upland prairie in the eastern Nebraska Sandhills. The Prairie Naturalist 32:43-58.
8. Stubbendieck, J. and S.J. Tunnell. 2008. Seventy-eight years of vegetation dynamics in a Sandhills Grassland. Natural Areas J. 28:58-65.