Annual Report for Period: 11/2011 - 10/2012
Submitted on: 09/22/2012
Principal Investigator: Blair, John M.
Award ID: 0823341
Organization: Kansas State University
Submitted By:
Blair, John - Principal Investigator
Title:
Konza Prairie LTER VI: Grassland Dynamics and Long-Term Trajectories of Change

Project Participants

Senior Personnel

Name: Blair, John
Worked for more than 160 Hours: Yes
Contribution to Project:
Dr. Blair is the Konza Prairie LTER lead PI and project director. Provides overall LTER project leadership and coordination. Research expertise in ecosystem ecology and terrestrial biogeochemistry; soil ecology, including decomposition, soil nutrient cycling, litter/soil/plant nutrient dynamics; effects of climate change and other disturbances on ecosystem processes; ecology of soil invertebrates; and restoration ecology.

Name: Hartnett, David
Worked for more than 160 Hours: Yes
Contribution to Project:
Konza LTER VI Co-PI and former Director of the Konza Prairie Biological Station (the primary research site for the Konza LTER program). Expertise in grassland plant population ecology; the role of belowground bud banks in grassland communities; plant mycorrhizal interactions in grasslands; plant-herbivore interactions; fire ecology. Also involved in ILTER activities, and Co-Director of the Institute for Grassland Studies.

Name: Joern, Anthony
Worked for more than 160 Hours: Yes
Contribution to Project:
Konza LTER VI Co-PI. Provides expertise on insect population and community studies; plant-herbivore-predator interactions; long-term consumer population dynamics; responses of insect herbivores to fire and grazing; temporal dynamics in ecological studies. Oversees the Konza LTER tong-term grasshopper abundance dataset, and studies on the role of insect herbivores and climate change in mesic grasslands. Is leading the new LTER VI patch-burning grazing study, and assessing impacts of fire-grazing interactions on spatial patterning. Co-Director of the KSU Institute for Grassland Studies (with D. Hartnett).

Name: Dodds, Walter
Worked for more than 160 Hours: Yes
Contribution to Project:
Konza LTER VI Co-PI. Dr. Dodds provides leadership for the Konza LTER aquatic research group. Research expertise in aquatic ecology; phycology; nutrient cycling and retention in streams; groundwater chemistry; watershed-level hydrologic export; water quality. Dr. Dodds is also leading the new reiparian vegetation removal study as part of the LTER VI funding cycle. This study will assess the impacts of riparian land-cover change on grassland streams.

Name: Nippert, Jesse
Worked for more than 160 Hours: Yes
Contribution to Project:
Dr. Nippert is a co-PI on the Konza LTER VI project, and contributes expertise in plant ecology and ecophysiology, and plant responses to environmental variability and change. Dr. Nippert oversees the application of environmental sensor networks to assess spatial variability in microclimate, and plant responses on core LTER watersheds at the Konza Prairie LTER site. He also directs the KSU Stable Isotope Mass Spectroscopy Laboratory, and provides expertise on the application of stable isotopes to ecological studies.

Name: Knapp, Alan
Worked for more than 160 Hours: Yes

Contribution to Project:

Provides research expertise in grassland ecology, plant ecology, physiological ecology, global change studies, plants-herbivore interactions, invasive species ecology. Dr. Knapp also provides leadership for LTER studies of plant productivity and responses to climatic variability and climate change, and conducts multi-site research involving SGS and KNZ LTER sites. Supported by a subcontract to Colorado State University.

Name: Johnson, Loretta

Worked for more than 160 Hours: Yes

Contribution to Project:

Provides research expertise in plant ecology, plant-soil interactions, and ecological genomics. Oversees a long-term water x N amendment experiment at Konza Prairie, and is establishing a new study of the impacts of climate on success of local vs. non-local ecotypes of dominant grasses.

Name: Briggs, John

Worked for more than 160 Hours: Yes

Contribution to Project:

Konza LTER investigator and Director of the Konza Prairie Biological Station (the primary research site for the Konza LTER program). Dr. Briggs oversees studies of grass-shrub interactions and the causes and consequences of woody plant encroachment into grasslands. Directs research into patterns and controls of ANPP in grasslands, as well as studies of the relationship between ANPP and species richness. Also provides expertise in database management, GIS and remote sensing studies.

Name: Gido, Keith

Worked for more than 160 Hours: Yes

Contribution to Project:

Provides expertise in aquatic ecology; stream communities and ecosystems; the effects of fish on stream ecosystem properties such as primary productivity, nutrient cycling, community structure (species richness and diversity), decomposition and transport of particulate organic matter (POM); impacts of altered hydrologic regimes on stream ecosystems. Oversees the LTER experimental stream facility. Coordinates regional assessments of stream fish communities.

Name: Goodin, Douglas

Worked for more than 160 Hours: Yes

Contribution to Project:

Provides expertise on remote sensing of ecological data, including patterns of plant productivity and spatial distributions of grazing and fire effects; research on climatology in the Central Plains (Dr. Goodin serves on the LTER Climate Committee); research on the impacts of burning on air quality.

Name: Koelliker, James

Worked for more than 160 Hours: Yes

Contribution to Project:

Expertise in hydrologic modeling; soil water flux, and water-use by grassland plant communities. Dr. Koelliker is responsible for implementing irrigation treatments and soil moisture measurements for the long-term Irrigation Transect Study at Konza Prairie. Is in phased retirement, and will transfer his LTER duties to new LTER investigator, Dr. Stacy Hutchinson.

Name: Macpherson, Gwendolyn

Worked for more than 160 Hours: Yes

Contribution to Project:

Expertise in hydrogeology; subsurface hydrology; long-term studies of groundwater flux and biogeochemistry at Konza LTER site. Supported by a subcontract to the University of Kansas.

Name: McKane, Robert

Worked for more than 160 Hours: Yes

Contribution to Project:

EPA Scientist (Corvallis, OR) with expertise in ecosystem modeling. He collaborates on research to assess the impacts of climate and management on ecosystem processes (productivity, hydrologic flux, biogeochemistry) at Konza Prairie, and the surrounding Flint Hills region. Currently working with scientists from EPA, Georgia Institute of Technology, and KSU to develop and apply the GTHM-PSM ecohydrology model to the Konza Prairie LTER site. GTHM-PSM links a land surface hydrology model (GTHM: Georgia Tech Hydrology Model) with a terrestrial biogeochemistry model (PSM: Plant-Soil-Model) in a spatially-distributed (GIS) framework.

Name: Rice, Charles

Worked for more than 160 Hours: Yes

Contribution to Project:

Expertise in soil microbial ecology; responses of grassland microbial communities to fire, grazing climatic variability; soil C and N dynamics; denitrification in grasslands; effects of management on soil C sequestration. Contributor and author for IPCC AR4.

Name: Sandercock, Brett

Worked for more than 160 Hours: Yes

Contribution to Project:

Expertise in avian population ecology and conservation biology. Dr. Sandercock oversees long-term sampling of grassland bird populations at the Konza LTER site, and conducts research on factors that influence population dynamics of grassland bird species. Also collaborating with researchers in Uruguay to study population dynamics of Upland Sandpipers, a migratory bird species that breeds in North American tallgrass prairies. Co-PI for Konza Prairie site-based REU program during LTER VI.

Name: Collins, Scott

Worked for more than 160 Hours: Yes

Contribution to Project:

Expertise in grassland ecology and plant community ecology; ecological analyses of spatial and temporal dynamics; ecological responses to disturbance; analysis of species distribution and abundance; local-regional interactions; productivity-diversity relationships.

Name: Ferguson, Carolyn

Worked for more than 160 Hours: Yes

Contribution to Project:

Expertise in plant systematics, plant population biology, and plant-pollinator interactions. Dr. Ferguson oversees the KSU Herbarium, and also provides expertise on electronic databasing of biological collections. Dr. Ferguson is also PI of GK-12 grant, which includes students and faculty scientists from the Konza LTER program.

Name: Garrett, Karen

Worked for more than 160 Hours: Yes

Contribution to Project:

Provides expertise on plant diseases; epidemiology; role of plant pathogens in native plant communities; application of genomic approaches to plant ecology.

Name: Jumponnen, Ari

Worked for more than 160 Hours: Yes

Contribution to Project:

Expertise on fungal ecology, particularly mycorrhizae and other endophytic fungi; diversity of soil microbial communities; application of molecular methods to characterize soil microbial communities. Co-PI for Konza Prairie site-based REU program during LTER VI.

Name: Kaufman, Glennis

Worked for more than 160 Hours: Yes

Contribution to Project:

Expertise on the ecology of grassland mammals; long-term monitoring of small mammal population dynamics in relation to climate, management and land-cover changes. Responsible for overseeing LTER datasets on small mammal dynamics.

Name: Price, Kevin

Worked for more than 160 Hours: Yes

Contribution to Project:

Professor with joint appointments in Agronomy and Geography at KSU. Expertise on application of remote sensing approaches to the study of grasslands; development of remote sensing indices to assess spatial and temporal patterns of plant productivity, grazing intensity, woody plant cover, etc.

Name: Whiles, Matt

Worked for more than 160 Hours: Yes

Contribution to Project:

Expertise in invertebrate ecology; research focused on assessment of patterns and controls of secondary productivity in grassland streams; ecology of soil invertebrates in grasslands. Participant in new riparian vegetation removal experiment. Supported by subcontract to Southern Illinois University.

Name: Zolnerowich, Gregory

Worked for more than 160 Hours: Yes

Contribution to Project:

Expertise in grassland insect biodiversity and insect systematics, particularly of parasitic wasps. Dr. Zolnerowich oversees the KSU Museum of Entomological and Prairie Arthropod Research, and provides expertise on electronic databasing of biological collections.

Name: Kaufman, Donald

Worked for more than 160 Hours: Yes

Contribution to Project:

Research focus is on the ecology of small mammals, and temporal and spatial dynamics of consumer populations in grasslands.

Name: Wisely, Samantha

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Wisely is a wildlife population biologist, with expertise in uses of both ecological and molecular tools to investigate how environmental change affects biological processes at multiple scales. Her Konza-related research includes studies of how human-induced habitat changes affects the population dynamics and connectivity of carnivores, and epidemiological processes associated with wildlife vectors.

Name: Baer, Sara

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Baer provides expertise on grassland restoration, particularly with respect to plant community dynamics and long-term changes in ecosystem properties and processes. She is responsible for directing research on grassland restoration ecology at the Konza site, including recovery of ecosystem properties in restored grasslands, and the influence of genotypic differences in cultivars and native vegetation on ecological processes in restored grasslands. Dr. Baer oversees the new Restoration Chronosequence study being initiated as part of the LTER VI project. Supported with a subcontract to Southern Illinois University.

Name: Harrington, John

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Harrington is a Professor of Geography with expertise in climatology and climate change, land-use/land-cover change, and natural resource applications of remote sensing and GIS. Dr. Harrington is leading many of the new social science related initiatives within our LTER program, and has been representing the KNZ LTER program at numerous LTER Network social science planning and cross-site activities (valuation of ecosystem services, impacts of land-cover change, etc.).

Name: McLauchlan, Kendra

Worked for more than 160 Hours: Yes

Contribution to Project:

Research at Konza includes studies of plant pollen as indicators of plant community change in the Central Plains, and uses of stable isotopes and tree rings as indicators of past climates.

Name: Craine, Joseph

Worked for more than 160 Hours: Yes

Contribution to Project:

Research Assistant Professor at KSU. Research at Konza includes studies of plant traits in relationship to species distributions; studies of bison grazing; and studies of soil biogeochemistry.

Name: Fay, Philip

Worked for more than 160 Hours: Yes

Contribution to Project:

USDA/ARS scientist and LTER collaborator. Research expertise in plant ecology and plant ecophysiology; impacts of climatic variability and climate change in grasslands; plant-insect interactions.

Name: Horne, Eva

Worked for more than 160 Hours: Yes

Contribution to Project:

Research in behavioral ecology of grassland reptiles; responses of reptile and amphibian populations to fire and grazing. Dr. Horne also assists with administration of the Konza Prairie Biological Station, and coordination of research permits and projects at the site.

Name: Wilson, Gail

Worked for more than 160 Hours: Yes

Contribution to Project:

Gail Wilson provides expertise on the role of mycorrhizal fungi in grasslands, and is responsible for long-term studies of the impacts of of mycorrhizal fungi on plant community dynamics and on soil structure and C storage in grasslands. She is supported with subcontract to Oklahoma State University.

Name: Smith, Melinda

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Smith is currently Assistant Professor at Yale University. She and her students are conducting research on plant population and community dynamics at Konza Prairie, and the impacts of climate change. She also directs site-based activities related to the multi-site Nutrient Network (NutNet) project. Supported with a subcontract to Yale University.

Name: Olson, K

Worked for more than 160 Hours: Yes

Contribution to Project:

KC Olson is an associate professor animal science, who brings expertise on the physiology and management of cattle in mesic grasslands. Dr. Olson is an active participant in the new patch-burn grazing study, and will oversee assessment of animal performance as a management-related aspect of this LTER study.

Name: Hutchinson, Stacy

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Hutchinson is a Professor of Biological and Agricultural Engineering, and has assumed responsibility for overseeing the water addition treatments and soil moisture monitoring in the long-term Irrigation Transect Experiment at the Konza site. This was previously the responsibility of Dr. Jim Koelliker until his retirement in 2010

Name: Daniels, Melinda

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Melinda Daniels is an Assistant Professor of Geography and new senior personnel with the Konza LTER program. Her research expertise is in fluvial geomorphology and she has initiated new measurements of stream morphology, erosion and sediment transport at the Konza Prairie LTER site.

Name: Jensen, Bill

Worked for more than 160 Hours: Yes

Contribution to Project:

Emporia State University. Effects of patch-burn grazing on brood parasitism of Dickcissel nests in the Flint Hills tallgrass prairie.

Post-doc

Name: Laws, Angela

Worked for more than 160 Hours: Yes

Contribution to Project:

Angela Laws is a post-doctoral associate working with Dr. Tony Joern on studies of grasshopper herbivory, and the impacts of climate change on tri-trophic interactions in grassland invertebrate food webs at Konza Prairie.

Graduate Student

Name: Avolio, Meghan

Worked for more than 160 Hours: Yes

Contribution to Project:

Ph.D. student at Yale University (Advisor: Melinda Smith). Research on grassland plant communities, mycorrhizae, climate change, nitrogen deposition, and genetic structure of plant communities.

Name: Bowe, Sarah

Worked for more than 160 Hours: Yes

Contribution to Project:

M.S. student (Advisor: Samantha Wisely). Research on exurbanization and woody expansion in the Flint Hills: the influence of habitat configuration on host ecology and rabies epidemiology. Completed 2010.

Name: Carter, Dan

Worked for more than 160 Hours: Yes

Contribution to Project:

Ph.D. student (Advisor: John Blair). Research on factors influencing trajectories of recovery in tallgrass prairie restorations. Serves as KNZ graduate student representative. Participant in the KSU GK-12 program.

Name: Carter, Jacob

Worked for more than 160 Hours: Yes

Contribution to Project:

M.S. student (Advisor: Jesse Nippert). Studies of the ecophysiology of an invasive species in western grasslands. Completed 2010.

Name: Chang, Cynthia

Worked for more than 160 Hours: Yes

Contribution to Project:

PhD 2012, advisor Melinda Smith. Dimensions of diversity and their direct and indirect effects on tallgrass prairie ecosystem functioning. Yale University. New Haven, CT. 165 pp.

Research on grassland community and ecosystem ecology, plant population biology.

Name: Klug, Page

Worked for more than 160 Hours: Yes

Contribution to Project:

Ph.D. graduate student (Advisor: Kim With). Studying interactions between grassland birds and their snake predators.
Klug, P.E. 2009. Interactions between grassland birds and their snake predators: the potential for conservation conflicts in the tallgrass prairie. PhD dissertation, Kansas State University. Manhattan, KS. 126 pp

Name: Koerner, Sarah

Worked for more than 160 Hours: Yes

Contribution to Project:

Ph.D. student from the University of New Mexico (Advisor: Scott Collins). Research on plant community and ecosystem responses to fire, grazing and climate, using a combination of sites/experiments in North America (Konza Prairie) and South Africa (Kruger National Park). Ms. Koerner was supported, in part, with an NSF Doctoral Dissertation Improvement Grant, with additional logistical support from the KNZ LTER grant. Completed 2012.

Name: LaPierre, Kimberly

Worked for more than 160 Hours: Yes

Contribution to Project:

Ph.D. student from Yale University, working with Dr. Melinda Smith on plant responses to altered nutrient availability and grazing (part of the cross-site NutNet project).

Name: Lease, Amanda

Worked for more than 160 Hours: Yes

Contribution to Project:

M.S. student from Colorado State University, working with Dr. Alan Knapp on ecotypic variation in dominant grass species in tallgrass prairie and shortgrass steppe. Field work is being done at the KNZ and SGS LTER sites.

Name: Ott, Jacquiline

Worked for more than 160 Hours: Yes

Contribution to Project:

Ph.D student working with Dr. Dave Hartnett. Belowground bud bank phenology and its contribution to grass plant architecture.

Name: Parsons, Sheena

Worked for more than 160 Hours: Yes

Contribution to Project:

M.S. student (Advisor: Tony Joern). Research on grasshoppers and herbivory in tallgrass prairie.

Name: Reisinger, Alex

Worked for more than 160 Hours: Yes

Contribution to Project:

Ph.D. student (Advisor: Walter Dodds). Studies of spatial and temporal variation of stream and riparian denitrification: the influence of riparian vegetation. Completed 2010.

Name: Riley, Alyssa

Worked for more than 160 Hours: Yes

Contribution to Project:

Ph.D. student (Advisor: Walter Dodds). Stream ecosystem response to woody expansion. Riley, A.J. 2011. Effects of riparian woody vegetation encroachment on prairie stream structure and function with emphasis on whole-stream metabolism. PhD Dissertation, Kansas State University. Manhattan, KS.

Name: Rolfsmeier, Susan

Worked for more than 160 Hours: Yes

Contribution to Project:

Graduate student working in the area of plant systematics (Advisor: Carolyn Ferguson).

Name: Rostkowski, Steven

Worked for more than 160 Hours: Yes

Contribution to Project:

M.S. student (completed 2010) working with Dr. John Blair on soil invertebrate ecology, and responses of soil communities to climate change. Rostkowski, S.C., Jr. 2011. Long-term effects of climate change on grassland soil systems: A reciprocal transplant approach. MS Thesis, Kansas State University. Manhattan, KS. 80 pp.

Name: Tucker, Sally

Worked for more than 160 Hours: Yes

Contribution to Project:

M.S. student (Advisor: Jesse Nippert). Studying the use of plant-based traits to explain the success and relative abundance of individual species in grassland communities.

Name: VanderWeide, Ben

Worked for more than 160 Hours: Yes

Contribution to Project:

M.S. student (Advisor: David Hartnett). Research on the role of bud banks in tallgrass prairie stability and invasibility

Name: Whiting, Dan

Worked for more than 160 Hours: Yes

Contribution to Project:

Graduate student at Southern Illinois University (Advisor: Matt Whiles). Research on longitudinal patterns of macroinvertebrate production, energy flow, and trophic structure in a tallgrass prairie stream

Name: Sousa, Bridget

Worked for more than 160 Hours: Yes

Contribution to Project:

Ph.D student from the University of Kentucky working at Konza Prairie in the area of avian ecology; co-advised locally by Brett Sandercock. Sousa, B.F. 2012. Ecology of mating patterns and sexual selection in dickcissels breeding in managed prairie. PhD Dissertation, University of Kentucky. Lexington, KY. 166 pp

Name: An, Nan

Worked for more than 160 Hours: Yes

Contribution to Project:

Nan An is a Ph.D. student in the Dept of Geography, working with Dr. Kevin Price on using remotely-sensed data to scale ground-based estimates of ANPP to achieve watershed-to-regional estimates of plant productivity in the Flint Hills region. This research is utilizing remote sensing imagery and Konza Prairie LTER estimates of ANPP from core LTER watersheds at the Konza Prairie Biological Station. MS Thesis 2009, Estimating annual net primary productivity of the tallgrass prairie ecosystem of the Central Great Plains using AVHRR NDVI. University of Kansas. Lawrence, Kansas.

Name: Hoover, David

Worked for more than 160 Hours: Yes

Contribution to Project:

Colorado State University PhD student, advisor Alan Knapp. Research project is climate extremes and grassland responses.

Name: Winders, Kyle

Worked for more than 160 Hours: Yes

Contribution to Project:

Winders, K. 2010. Ecosystem Processes of Prairie Streams and the Impact of Anthropogenic Alteration on Stream Ecological Integrity. MS Thesis, Kansas State University. Manhattan, KS.

M.S. student (Advisor: Walter Dodds) studying stream and riparian responses to patch-burning and grazing. Completed 2010.

Name: Gomez, Jesus

Worked for more than 160 Hours: Yes

Contribution to Project:

MS student from Puerto Rico working with Dr. Tony Joern on role of grassland disturbance on arthropod food webs.

Name: Hartman, Jeffrey

Worked for more than 160 Hours: Yes

Contribution to Project:

MS Thesis, Responses of switchgrass (Panicum virgatum L.) to precipitation amount and temperature, completed in 2011. Advisor, Jesse Nippert.

Name: Ratajczak, Zak

Worked for more than 160 Hours: Yes

Contribution to Project:

PhD student working with Dr. Jesse Nippert. Research area involves woody encroachment.

Name: Killian, Paul

Worked for more than 160 Hours: Yes

Contribution to Project:

MS completed 2012 (Advisor: John Briggs). 2012. Mechanisms driving woody encroachment in the tallgrass prairie: an analysis of fire behavior and physiological integration. MS Thesis, Kansas State University. Manhattan, KS. 72 pp.

Name: Tsypin, Misha

Worked for more than 160 Hours: Yes

Contribution to Project:

MS thesis research, with Dr. G.L. Macpherson, at the 2-4 Mor - 2-5 Mor well sites, refurbishing the soil lysimeters at 2-5 Mor site, and installing soil-gas samplers. He is comparing soil- and groundwater chemistry and gases, dissolved species and stable isotopes, before and immediately after major rainfall events.

Name: Robbins, Michael

Worked for more than 160 Hours: Yes

Contribution to Project:

Ph.D. student,(Advisor: G.L.Macpherson) is in the research and design phases for work planned to be located, in part, in the N04d watershed at Konza. He is designing a soil-gas monitoring system.

Name: Martin, Erika

Worked for more than 160 Hours: Yes

Contribution to Project:

Studying the inter- and intra-specific interactions among prairie stream fish species found in Kings Creek on Konza Prairie (Advisor: Keith Gido).

Name: Veach, Allison

Worked for more than 160 Hours: Yes

Contribution to Project:

PhD student (advisor, Walter Dodds) working on riparian woody vegetation removal.

Name: Forrestel, Elisabeth

Worked for more than 160 Hours: Yes

Contribution to Project:

PhD student (advisor, Melinda Smith at Yale) working with population genetics in tallgrass plant species.

Name: Soong, Jenny

Worked for more than 160 Hours: Yes

Contribution to Project:

PhD student (advisor, Francesca Cotrufo in Soil and Crop Science at CSU) working on soil carbon cycling.

Name: Wilcox, Kevin

Worked for more than 160 Hours: Yes

Contribution to Project:

Colorado State University PhD student, advisor Alan Knapp.

Name: Larson, Danelle

Worked for more than 160 Hours: Yes

Contribution to Project:

PhD student (advisor, Walter Dodds) working in the area of water quality and amphibians with the Patch Burn Experiment on Konza and SCALER experiment on Konza.

Name: Ricketts, Andrew

Worked for more than 160 Hours: Yes

Contribution to Project:

PhD student (advisor, Sam Wisely) working with small mammal responses to patch burn grazing.

Name: Klopf, Ryan

Worked for more than 160 Hours: Yes

Contribution to Project:

PhD student (advisor, Sara Baer at SIU) working on temporal changes in ecosystem functions such as soil C and N cycling in high and low diversity prairie restorations.

Name: Erndt, Kim

Worked for more than 160 Hours: Yes

Contribution to Project:

PhD student (advisor, Matt Whiles at SIU) examining some of the biological responses to restoration efforts in the headwaters of a prairie stream watershed located on Konza Prairie.

Name: Sylvain, Zac

Worked for more than 160 Hours: Yes

Contribution to Project:

PhD student (advisor, Diana Wall in Biology at CSU) working on belowground faunal responses to climate change.

Name: Vandermyde, Jodi

Worked for more than 160 Hours: Yes

Contribution to Project:

MS student (advisor, Matt Whiles at SIU) examining aquatic invertebrates and organic matter of two streams on Konza Prairie in Kansas before and after a prairie restoration method of removing all vegetation covering the stream.

Name: Carson, Michael

Worked for more than 160 Hours: Yes

Contribution to Project:

MS student working with John Blair. Research area is 'Long-term responses of a grassland ecosystem to fire and nutrient additions'.

Name: Raynor, Edward

Worked for more than 160 Hours: Yes

Contribution to Project:

Anthony Joern and John Briggs are co-advisors. Research subject is herbivore foraging with an emphasis on bison.

Name: Williamson, Melinda

Worked for more than 160 Hours: Yes

Contribution to Project:

MS thesis, Controls on bud activation and tiller initiation in tallgrass prairie: The effect of light and nitrogen, completed 2010 (Advisor, Gail Wilson at OSU).

Name: Gregory, Andrew

Worked for more than 160 Hours: Yes

Contribution to Project:

PhD 2011, advisor Brett Sandercock. The influence of behavioral and landscape ecology on Greater Prairie-Chicken (Tympanuchus cupido) genetic structure and evolution. Kansas State University. Manhattan, KS. 129 pp

Name: Mohler, Rhett

Worked for more than 160 Hours: Yes

Contribution to Project:

PhD 2011, advisor Doug Goodin. Multi-scale burned area mapping in tallgrass prairie using in situ spectrometry and satellite imagery. Kansas State University. Manhattan, KS.

Name: Tiemann, Lisa

Worked for more than 160 Hours: Yes

Contribution to Project:

PhD 2011, advisor Gwen Macpherson. Soil microbial community carbon and nitrogen dynamics with altered precipitation regimes and substrate availability. University of Kansas. Lawrence, KS.

Name: Buck, Tyler

Worked for more than 160 Hours: Yes

Contribution to Project:

MS 2010, Nate Brunsell advisor. The impact of land cover change on water and carbon cycling in the US central plains grasslands. University of Kansas. Lawrence, KS.

Name: Commerford, Julie

Worked for more than 160 Hours: Yes

Contribution to Project:

MA 2010, advisor Kendra McLauchlan. Calibrating vegetation cover and pollen assemblages in the Flint Hills of Kansas, USA. Kansas State University. Manhattan, KS. 73 pp.

Name: Lohnes, Rebecca

Worked for more than 160 Hours: Yes

Contribution to Project:

MS 2010, Brett Sandercock collaborator. Nest site selection and nest thermal properties of common nighthawks on the tallgrass prairie of Kansas. Cornell University. Ithaca, NY.

Name: McNew, Lance

Worked for more than 160 Hours: Yes

Contribution to Project:

PhD 2010, advisor Brett Sandercock. An analysis of Greater Prairie-chicken demography in Kansas: the effects of human land use on the population ecology of an obligate grassland species. Kansas State University. Manhattan, KS. 149 pp.

Name: Petrie, Matt

Worked for more than 160 Hours: Yes

Contribution to Project:

MA Thesis 2010, advisor Nate Brunsell. Climate forcings and the nonlinear dynamics of grassland ecosystems. University of Kansas. Lawrence, KS.

Name: Sprinkle, Jacob

Worked for more than 160 Hours: Yes

Contribution to Project:

MS 2010, advisor Gail Wilson. Bud bank density regulates invasion by exotic plants. Oklahoma State University. Stillwater, OK. 65 pp.

Name: Blevins, Erikka

Worked for more than 160 Hours: Yes

Contribution to Project:

MS 2010, advisor Kim With. Influence of landscape context on patterns of occupancy, abundance, and gene flow among collared lizards in the Flint Hills of Kansas. Kansas State University. Manhattan, KS.

Name: Jackson, Karen

Worked for more than 160 Hours: Yes

Contribution to Project:

Graduate Student from Southern Illinois University, Matt Whiles advisor.
Establishing baseline conditions for remnant tallgrass prairie streams preceding patch-burn grazing treatments.

Name: Horton, AJ

Worked for more than 160 Hours: Yes

Contribution to Project:

Graduate student from Colorado State University.
Quantifying the role of soil fauna on litter decomposition and soil C and N dynamics using isotope labeling.

Name: Song, Jennifer

Worked for more than 160 Hours: Yes

Contribution to Project:

Graduate student from Colorado State University.

Name: Grudzinski, Bart

Worked for more than 160 Hours: Yes

Contribution to Project:

Advisor M.D. Daniels. Influence of grazing treatments on nutrient and bacteria concentrations in the Flint Hills, Kansas.

Name: Liu, Huan

Worked for more than 160 Hours: Yes

Contribution to Project:

Advisor Gwen Macpherson. Working on groundwater hydrology and geochemistry at the Konza LTER site.

Name: West, Ray

Worked for more than 160 Hours: Yes

Contribution to Project:

PhD student working under Gail Wilson. Bud bank demography: Density of native grass meristems as a predictor of rangeland invasibility.

Name: Greer, Mitchell

Worked for more than 160 Hours: Yes

Contribution to Project:

PhD student working under Gail Wilson. Assessing above- and belowground community composition following the establishment of a warm-season invasive grass: a look at individual plant response and its effects on the soil and small mammal communities.

Undergraduate Student

Name: Balsters, John

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Barrick, James

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Fabrycky, Caleb

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Heasty, Ben

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with collection and processing of LTER samples.

Name: Heasty, Rod

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Kurtz, Travis

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Legler, Meagan

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Mathews, Brad

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with sorting of plant material and field work.

Name: Meyer, Nick

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Orlowski, Kathryn
Worked for more than 160 Hours: Yes
Contribution to Project:
Assists with collection and processing of LTER samples.

Name: Ruder, Gloria
Worked for more than 160 Hours: Yes
Contribution to Project:
Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Schmeidler, Megan
Worked for more than 160 Hours: Yes
Contribution to Project:
Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Schreck, Whitney
Worked for more than 160 Hours: Yes
Contribution to Project:
Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Seibel, Caleb
Worked for more than 160 Hours: Yes
Contribution to Project:
Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Stephan, Mark
Worked for more than 160 Hours: Yes
Contribution to Project:
Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Sullivan, Brian
Worked for more than 160 Hours: Yes
Contribution to Project:
Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Tulp, Kevin
Worked for more than 160 Hours: Yes
Contribution to Project:
Assists with collection and processing of LTER samples.

Name: Tyner, Jennifer
Worked for more than 160 Hours: Yes
Contribution to Project:
Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Van Allen, Jake
Worked for more than 160 Hours: Yes
Contribution to Project:
Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Wilson, Jake
Worked for more than 160 Hours: Yes
Contribution to Project:
Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Woodroof, Ike

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Wood, Rachel

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Young, Sean

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Kohler, Brady

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Miles, Samantha

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with LTER data entry and data checking

Name: Doll, Rebecca

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Falls, Julianna

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Mathews, Elliot

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Mau, Marvin

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with collection and processing of LTER samples, and other general lab and field activities.

Name: Calhoun, Michelle

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with collection and processing of LTER samples.

Name: Welti, Ellen

Worked for more than 160 Hours: Yes

Contribution to Project:

Works with arthropod food webs under Dr. Tony Joern. Graduated in 2012, and is currently a PhD student in the KSU Division of Biology.

Name: Tatarko, Anna

Worked for more than 160 Hours: Yes

Contribution to Project:

Works with arthropod food webs under Dr. Tony Joern.

Name: Sheldon, Wade

Worked for more than 160 Hours: Yes

Contribution to Project:

Works with arthropod food webs under Dr. Tony Joern.

Name: Stowers, Mark

Worked for more than 160 Hours: Yes

Contribution to Project:

Undergrad Honors student working with bison behavior and GIS under the direction of Dr. Tony Joern and Konza IM Adam Skibbe.

Name: Lickteig, Spencer

Worked for more than 160 Hours: Yes

Contribution to Project:

Working under Dr. Ari Jumpponen on contemporary evolution in fungal communities led by anthropogenic stressors.

Name: Orozco, Gracie

Worked for more than 160 Hours: Yes

Contribution to Project:

Working in the lab of Dr. Jesse Nippert.

Name: Culbertson, Teall

Worked for more than 160 Hours: Yes

Contribution to Project:

Working in the lab of Dr. Jesse Nippert.

Name: Jackson, Whitley

Worked for more than 160 Hours: Yes

Contribution to Project:

Working in the lab of Dr. Jesse Nippert.

Name: Armstrong, Graham

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with sorting of plant material and field work.

Name: Frerker, Maggie

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with lab analyses.

Name: Kentopp, Brandon

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with sorting of plant material and field work.

Name: Miller, Amanda

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with sorting of plant material and field work.

Name: Ott, Luke

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with sorting of plant material and field work.

Name: Wilson, Nick

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with sorting of plant material and field work.

Name: Schreiner, Spencer

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with sorting of plant material and field work.

Name: Siders, Adam

Worked for more than 160 Hours: Yes

Contribution to Project:

Working with Dr. Sam Wisely. Analyzed and presented the KPBS deer population study.

Name: Huff, Breanna

Worked for more than 160 Hours: Yes

Contribution to Project:

Completed her Honors' Thesis (undergraduate)under G.L.Macpherson, comparing water chemistry from 1991-1993 to samples she collected in 2008-2009 in a nest of wells on the east side of the N04d stream, about 36 m from the riparian zone. She showed that alkalinity increased about 15% over that time period, and in situ pH decreased by more than 0.5 pH units, corroborating findings from Macpherson et al., 2008, who found similar results in wells near or within the encroaching woody riparian zone (Huff and Macpherson, 2009).

Name: Ohmes, Karen

Worked for more than 160 Hours: Yes

Contribution to Project:

Completed her undergraduate research project under G.L Macpherson, quantifying the CO2 loss from about 400 m of the lower portion of the N04d stream (Ohmes et al., 2009). This will become part of the calculation of the carbon balance sheet for the watershed, in progress.

Name: Sonnentag, Tammy

Worked for more than 160 Hours: Yes

Contribution to Project:

Works under information management providing data entry services.

Name: Estes, Courtney

Worked for more than 160 Hours: Yes

Contribution to Project:

Part-time support for GIS and mapping project.

Name: Atwell, Taylor

Worked for more than 160 Hours: Yes

Contribution to Project:

Technical support for field work.

Name: Johnson, Elizabeth

Worked for more than 160 Hours: Yes

Contribution to Project:

Technical support for field work.

Name: O'Brien, Jay

Worked for more than 160 Hours: Yes

Contribution to Project:

Technical support for field work.

Name: Thompson, Nate
Worked for more than 160 Hours: Yes
Contribution to Project:
Technical support for field work.

Name: Wendt, Nathan
Worked for more than 160 Hours: Yes
Contribution to Project:
Atmospheric Science student, will aid in efforts related to the eddy covariance towers at Konza. Working with Nathaniel Brunsell at KU.

Name: McCrea, Evan
Worked for more than 160 Hours: Yes
Contribution to Project:
undergraduate research assistant working on restoration ecology projects through SIUC Undergraduate Assistantship

Name: Leloneck, Nick
Worked for more than 160 Hours: Yes
Contribution to Project:
undergraduate research assistant working on restoration ecology projects

Name: Adkinson, Brett
Worked for more than 160 Hours: Yes
Contribution to Project:
Assisted with field and lab work.

Name: Boutte, Jake
Worked for more than 160 Hours: Yes
Contribution to Project:
Assists with sorting of plant material and field work.

Name: Cook, Kevin
Worked for more than 160 Hours: Yes
Contribution to Project:
Assists with sorting of plant material and field work.

Name: Ernst, Jamie
Worked for more than 160 Hours: Yes
Contribution to Project:
Assists with sorting of plant material and field work and data checking.

Name: Heimbach, Luc
Worked for more than 160 Hours: Yes
Contribution to Project:
Assists with sorting of plant material, field work, data checking, and lab work.

Name: Kratzberg, Ray
Worked for more than 160 Hours: Yes
Contribution to Project:
Assists with sorting of plant material and field work.

Name: Ruder, Toby
Worked for more than 160 Hours: Yes
Contribution to Project:
Assists with sorting of plant material and field work.

Name: Samms, Grant

Worked for more than 160 Hours: Yes

Contribution to Project:

Field and lab assistant, collecting field samples, sorting samples and other duties as assigned.

Name: Sparks, Jack

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with sorting of plant material and field work.

Name: Weber, Nick

Worked for more than 160 Hours: Yes

Contribution to Project:

Assists with sorting of plant material and field work.

Name: Then, Christopher

Worked for more than 160 Hours: Yes

Contribution to Project:

Advisor was Bill Jensen at Emporia State University. Effects of patch-burn grazing on brood parasitism of Dickcissel nests in the Flint Hills tallgrass prairie.

Name: Zuercher, John

Worked for more than 160 Hours: Yes

Contribution to Project:

Field and lab assistant, collecting field samples, sorting samples and other duties.

Name: Noel, Eric

Worked for more than 160 Hours: Yes

Contribution to Project:

Field and lab assistant, collecting field samples, sorting samples and assisting with chemical analyses.

Name: Mortensen, Severin

Worked for more than 160 Hours: Yes

Contribution to Project:

Data entry and organization.

Technician, Programmer

Name: Towne, Gene

Worked for more than 160 Hours: Yes

Contribution to Project:

Research scientist; long-term plant community data; grazing studies.

Name: Ramundo, Rosemary

Worked for more than 160 Hours: Yes

Contribution to Project:

LTER analytical lab supervisor; research cooridinator.

Name: Kuhl, Amanda

Worked for more than 160 Hours: Yes

Contribution to Project:

research assistant; field crew leader

Name: O'Neal, Patrick

Worked for more than 160 Hours: Yes

Contribution to Project:

research assistant, field technician

Name: Taylor, Jeff

Worked for more than 160 Hours: Yes

Contribution to Project:

research assistant, field technician

Name: Choubey, Rahul

Worked for more than 160 Hours: Yes

Contribution to Project:

Providing part-time support to the information manager as an assistant programmer. The primary focus of this position is in web-site and content management development. Expected products from his services include a new web site as well as a content management portal.

Name: Subramanian, Arthi

Worked for more than 160 Hours: Yes

Contribution to Project:

Providing part-time support to the information manager as an assistant programmer. The primary focus of this position is in web-site and content management development. Expected products from his services include a new web site as well as a content management portal.

Name: Anusha Nukala, Leela

Worked for more than 160 Hours: Yes

Contribution to Project:

Providing part-time support to the information manager as an assistant programmer. The primary focus of this position is in web-site and content management development. Expected products from his services include a new web site as well as a content management portal.

Other Participant

Name: Skibbe, Adam

Worked for more than 160 Hours: Yes

Contribution to Project:

LTER Information Manager. His responsibilities include data management, database design and implementation, and overseeing KNZ LTER computer network activities. Mr. Skibbe also provides GIS support and expertise for the Konza LTER program.

Name: Gadbury, Carol

Worked for more than 160 Hours: Yes

Contribution to Project:

LTER Program Assistant. Provides administrative support for the management and operation of LTER programs.

Name: Wright, Valerie

Worked for more than 160 Hours: Yes

Contribution to Project:

Educational Coordinator, SLTER program. (Retired in 2012)

Name: Baker, Annie

Worked for more than 160 Hours: Yes

Contribution to Project:

Served as assistant for the Konza SLTER program until 2011.

Name: Haukos, Jill

Worked for more than 160 Hours: Yes

Contribution to Project:

In January of 2012 Jill Haukos was hired as the new Director of the Konza Environmental Education Program (KEEP), replacing Valerie Wright who retired in 2012. Jill provides directs our K-12 education program, including the Konza Prairie SLTER program, and serves as the KNZ LTER education representative for LNO activities. Jill also oversees the Konza docent program, and some of our public outreach activities. Support for this position comes from both the both the KNZ LTER grant and the Konza

Prairie Biological Station.

Name: Evans, Jan

Worked for more than 160 Hours: Yes

Contribution to Project:

Assistant to the Konza SLTER and Konza Environmental Education Program (KEEP). Hired in 2012 and supported, in part, with SLTER funds.

Research Experience for Undergraduates

Name: Graver, Tina

Worked for more than 160 Hours: Yes

Contribution to Project:

Investigation of plant functional traits in the Flint Hills, Kansas (Mentor: Kendra McLauchlan)

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: Ohio Wesleyan University, OH

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2009

REU Funding: REU site award

Name: Hixon-Bowles, Kelsey

Worked for more than 160 Hours: Yes

Contribution to Project:

Generality of nematode bacterial defense pathways (Mentor: Michael Herman). Project builds on early studies of soil nematode communities and responses to long-term resource manipulations.

Years of schooling completed: Freshman

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2009

REU Funding: REU site award

Name: Kearns, Brian

Worked for more than 160 Hours: Yes

Contribution to Project:

Change in vocal culture of Spiza americana based on density, distance, and habitat (Mentor: Tim Parker).

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: Whitman College, WA

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2009

REU Funding: REU site award

Name: Pavlovic, Nathan

Worked for more than 160 Hours: Yes

Contribution to Project:

Nitrogen and phosphorus addition affect microbial polar lipid metabolism in a grassland ecosystem; utilized a long-term LTER fertilization study (Mentors: Richard Jeannotte and Ruth Welti)

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: Grinnell College, IA

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2009

REU Funding: REU site award

Name: Presuma, Dumi

Worked for more than 160 Hours: Yes

Contribution to Project:

REU study focused on the variables affecting nitrogen uptake in prairie streams (Mentors: Alex Reisinger (grad student) and Walter Dodds)

Years of schooling completed: Junior

Home Institution: Same as Research Site

Home Institution if Other: Bethune-Cookman University, FL

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2009

REU Funding: REU supplement

Name: Ratajczak, Zakary

Worked for more than 160 Hours: Yes

Contribution to Project:

Positive micro-climate feedbacks lead to expansion of the shrub Cornus drummondii in tallgrass prairie: source water partitioning (d18O and dD), litter dynamics and leaf area index (Mentor: Jesse Nippert). Zack is currently (as of 2011) a PhD student working on the Konza LTER project under the direction of Jesse Nippert.

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: Vassar College, NY

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2009

REU Funding: REU site award

Name: Spurr, Rebecca

Worked for more than 160 Hours: Yes

Contribution to Project:

Landscape-level variation in temperature sensitivity of soil carbon respiration (Mentor: Joe Craine)

Years of schooling completed: Sophomore

Home Institution: Other than Research Site

Home Institution if Other: St. Olaf College, MN

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2009

REU Funding: REU site award

Name: Wilson, Maya

Worked for more than 160 Hours: Yes

Contribution to Project:

Ecology of the Texas horned lizard (Phrynosoma cornutum) in the Flint Hills of Kansas (Mentor: Eva Horne)

Years of schooling completed: Sophomore

Home Institution: Other than Research Site

Home Institution if Other: Franklin and Marshall College, PA

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2009

REU Funding: REU site award

Name: Sterne, Gabriela

Worked for more than 160 Hours: Yes

Contribution to Project:

Dickcissel site fidelity and local vocal culture (Mentor: Tim Parker)

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: Whitman College, WA

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2009

REU Funding: REU site award

Name: Novick, Aaron

Worked for more than 160 Hours: Yes

Contribution to Project:

Individual recognition in collared lizards (Mentor: Eva Horne)

Years of schooling completed: Sophomore

Home Institution: Other than Research Site

Home Institution if Other: The College of Wooster

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2010

REU Funding: REU site award

Name: Foo, Cecily

Worked for more than 160 Hours: Yes

Contribution to Project:

Dialect change in Dickcissels (Spiza americana): due to song changes in individuals (Mentor: Tim Parker).

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: Whitman College

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2010

REU Funding: REU site award

Name: Ballinger, Kristen

Worked for more than 160 Hours: Yes

Contribution to Project:

REU study assessing Dickcissel site fidelity and local vocal culture (Mentor: Tim Parker)

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: Whitman College

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2010

REU Funding: REU site award

Name: Wieme, Rachel

Worked for more than 160 Hours: Yes

Contribution to Project:

Grazing alters distribution of root classes by depth in tallgrass prairie (Mentors: Jesse Nippert and Joe Craine). Study used LTER watershed level fire and grazing treatments, as well supporting LTER data.

Years of schooling completed: Sophomore

Home Institution: Other than Research Site

Home Institution if Other: St. Olaf College

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2010

REU Funding: REU site award

Name: Bratt, Anika

Worked for more than 160 Hours: Yes

Contribution to Project:

Assessment of variability in ecosystem metabolism rates in a prairie headwater stream (Mentor: Walter Dodds). This study used measured O2, discharge and light to model stream metabolism dynamics of N2B, which is part of the Kings Creek watershed, a core LTER sampling area. The student measured daily rates for one day per week during the summer growing season, and used longer-term data to examine seasonal and weekly variability.

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: St. Catherine University

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2010

REU Funding: REU supplement

Name: Kahl, Hanna

Worked for more than 160 Hours: Yes

Contribution to Project:

Vocal culture of Spiza americana: social tutor system and the effects of geographic barriers (Mentor: Tim Parker).

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: Whitman College

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2010

REU Funding: REU site award

Name: Heatherington, Chelsea

Worked for more than 160 Hours: Yes

Contribution to Project:

Conducted a population genetic study of the Konza Prairie bison herd (Mentor: Mark Ungerer).

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: University of Florida

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2010

REU Funding: REU site award

Name: Delfing, Elizabeth

Worked for more than 160 Hours: Yes

Contribution to Project:

Determination of 18S ribosomal RNA gene copy number in five nematode species(Mentors: Brian Darby and Michael Herman). Field aspects of the project were conducted at Konza Prairie, and were directly relevant to the goals of a long-term belowground plot experiment.

Years of schooling completed: Sophomore

Home Institution: Other than Research Site

Home Institution if Other: Capital University

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2010

REU Funding: REU site award

Name: Singer, Caitlin

Worked for more than 160 Hours: Yes

Contribution to Project:

Ecology of isopods in tallgrass prairie (Mentor: Bruce Snyder).

Years of schooling completed: Sophomore

Home Institution: Other than Research Site

Home Institution if Other: Arizona State University

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2010

REU Funding: REU site award

Name: Bennett, Amanda

Worked for more than 160 Hours: Yes

Contribution to Project:

The effects of climate extremes on forbs in the tallgrass prairie (Mentor: Melinda Smith). REU student participated in the Climate Extremes Experiment, which examines the effects of extreme heat and drought conditions on the tallgrass prairie, focusing specifically on co-dominant C4 grasses and Solidago canadensis, a dominant C3 forb. Rainfall was reduced by 75% in half of the 40 plots studied, with the other half receiving ambient rainfall throughout the course of the experiment to establish wet and dry conditions. In addition to these precipitation manipulation treatments, each plot received one of four heat treatments consisting of +0, +3, +6, and +9 degrees Celsius above ambient temperature over a two-week period to simulate a heat wave. Throughout the growing season, growth measurements were taken periodically on marked individuals within each plot. Additional measurements of productivity conducted included water potential, specific leaf area, biomass, and life cycle analysis.

Years of schooling completed: Sophomore

Home Institution: Other than Research Site

Home Institution if Other: Yale University

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2010

REU Funding: REU supplement

Name: Song, Runqi

Worked for more than 160 Hours: Yes

Contribution to Project:

Climate change and invasibility of a tallgrass prairie ecosystem (Mentors: David Hoover and Melinda Smith).

Years of schooling completed: Freshman

Home Institution: Other than Research Site

Home Institution if Other: Yale University

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2010

REU Funding: REU site award

Name: Potter, Arjun

Worked for more than 160 Hours: Yes

Contribution to Project:

The effects of nutrient additions on patterns of above-ground herbivory (Mentor:Melinda Smith). Nitrogen, phosphorus, and potassium increase plant growth by facilitating the manufacture of primary and secondary metabolites. As herbivory is largely driven by forage palatability, nutrient additions to vegetation should impact palatability and thus spatial patterns of herbivory in nutrient-limited communities such as the grasslands in Konza Prairie. We collected plant samples from 6-8 focal species between areas with and without the yearly addition of 10g/m2 of N, P, (and K) in areas with a short-term (2 years) and long term (7 years) fertilization regimes. We assessed type and extent of leaf damages visually and collected data on a number of plant traits, such as plant height, number of green, senesced, and emergent leaves, leaf area, dry weight, and toughness. Focal species were chosen to represent major species and functional groups (cool-season & warm-season grasses, forbs) and a diversity of growth patterns. Nutrient additions showed no affect on rates of folivory, though binary measurements (presence or absence of damage) for Andropogon and Sorghastrum individuals indicated that significantly fewer Sorghastrum tillers showed damage in plots fertilized long-term with N and P. There were significant differences in herbivory levels between species, and herbivory levels were negatively correlated with plant toughness and the ratio of green to senesced leaves, indicating that plants with leaf damage were more likely to be delicate-leaved and have a higher proportion of dying leaves.

Years of schooling completed: Sophomore

Home Institution: Other than Research Site

Home Institution if Other: Cornell University

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2010

REU Funding: REU supplement

Name: Gelderman, Theodore

Worked for more than 160 Hours: Yes

Contribution to Project:

Landscape level variation in the temperature sensitivity of soil carbon respiration (Mentor: Joe Craine).

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: Carleton College

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2010

REU Funding: REU site award

Name: Klodd, Annie

Worked for more than 160 Hours: Yes

Contribution to Project:

Consistent Relationship between total Foliar N and Canopy
Density in Grazed (bison and cattle) and Ungrazed Tallgrass Prairie (Mentor: Jesse Nippert)

Years of schooling completed: Sophomore

Home Institution: Other than Research Site

Home Institution if Other: Grinnell College

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2010

REU Funding: REU site award

Name: Blanchard, Benjamin

Worked for more than 160 Hours: Yes

Contribution to Project:

The Effects of Habitat Heterogeneity on the Distribution and Composition of Ant Communities in a Tallgrass Prairie (Mentor: Tony Joern)

Years of schooling completed: Sophomore

Home Institution: Other than Research Site

Home Institution if Other: University of Michigan - Ann Arbor

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2010

REU Funding: REU site award

Name: Patterson, Judith

Worked for more than 160 Hours: Yes

Contribution to Project:

REU project focused on exploring crayfish movement using PIT tags and mobile and stationary antennas (Mentor: Martha Mather). Project provided preliminary data for a more in-depth study to be conducted in association with LTER stream research in Kings Creek.

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: University of Illinois -Champaign-Urbana

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2011

REU Funding: REU site award

Name: Bansbach, Lauren

Worked for more than 160 Hours: Yes

Contribution to Project:

Comparative Assessment of Fecal Bacteria Levels in Prairie Streams (Mentor: Walter Dodds)

Years of schooling completed: Sophomore

Home Institution: Other than Research Site

Home Institution if Other: Missouri State University

Home Institution Highest Degree Granted(in fields supported by NSF): Master's Degree

Fiscal year(s) REU Participant supported: 2011

REU Funding: REU site award

Name: Zarate, Patricia

Worked for more than 160 Hours: Yes

Contribution to Project:

Effects of anthropogenic conditions on spore loads and foliar fungal lesion area in native oaks (Mentor: Ari Jumpponen). Used Konza LTER gallery forest sampling sites.

Years of schooling completed: Freshman

Home Institution: Other than Research Site

Home Institution if Other: Swarthmore College

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2011

REU Funding: REU site award

Name: Daniels, Lynsey

Worked for more than 160 Hours: Yes

Contribution to Project:

The Effect of Fire on Tree Recruitment Along the Forest-Grassland Ecotone (Mentors: David Hartnett, Jesse Nippert). This project is related to ongoing LTER studies to document the causes and consequences of woody plant expansion into tallgrass prairie. Utilized sampling locations along the Kings Creek gallery forest.

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: St. Joseph's University

Home Institution Highest Degree Granted(in fields supported by NSF): Master's Degree

Fiscal year(s) REU Participant supported: 2011

REU Funding: REU site award

Name: Siders, Adam

Worked for more than 160 Hours: Yes

Contribution to Project:

Adam worked under the direction of Keith Gido and Walter Dodds. He studies the spatial relationships of in-stream metabolism, and methods for scaling local metabolism measurements to whole streams. The project involved measurement of diel oxygen changes in a linear transect along Kings Creek as well as diurnal changes in side pools and other sub habitats. Tracer releases were used to characterize gas exchange rates and hydrology.

Years of schooling completed: Freshman

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2012

REU Funding: REU supplement

Name: Kuhn, Thomas

Worked for more than 160 Hours: Yes

Contribution to Project:

REU student working under the direction of Tony Joern on bison grazing patterns in tallgrass prairie. The student is using a combination of GIS techniques and remotely sensed images available for Konza Prairie to map the distribution of wallows and bison trails to document landscape level patterns of bison use of the site. Both features are conspicuous on the landscape and are providing important insights into how bison perceive and affect the landscape. As a result of his REU experience, Thomas is continuing to work for the Konza LTER program as GIS technician following his graduation with a BS in Geography (2012), and plans to apply for graduate school in the near future.

Years of schooling completed: Junior

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2012

REU Funding: REU supplement

Name: Gabauer, Katie

Worked for more than 160 Hours: Yes

Contribution to Project:

REU student (Atmospheric Science major at the University of Kansas) working under the direction of Dr. Nate Brunsell. Katie's research focused on using data flux towers and associated sensor networks on Konza Prairie to examine the coupling between atmospheric and groundwater CO2 concentration. Using six years of eddy covariance data and approximately monthly groundwater data she explored the hypothesis that groundwater can be a sink for atmospheric carbon. Katie also participated in groundwater sampling and laboratory analysis, soil moisture and vadose zone monitoring, as well as learning the instrumentation necessary for eddy covariance monitoring of surface-atmosphere exchange processes.

Years of schooling completed: Freshman

Home Institution: Other than Research Site

Home Institution if Other: University of Kansas

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2012

REU Funding: REU supplement

Name: Sojka, Jennifer

Worked for more than 160 Hours: Yes

Contribution to Project:

REU student worked with Brett Sandercock (mentor) studying the effects of patch-burn grazing on nesting success of grassland birds. This project was associated with a new LTER VI initiative to assess the impacts of rotational patch-burn grazing management on habitat heterogeneity and conservation of grassland biodiversity.

Years of schooling completed: Freshman

Home Institution: Other than Research Site

Home Institution if Other: Lake Forest College

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2012

REU Funding: REU site award

Organizational Partners

The Nature Conservancy

Konza Prairie Biological Station is a Nature Conservancy site, established on land purchased by the Nature Conservancy and managed by the Division of Biology at KSU. Konza LTER scientists interact with TNC scientists and officers on a broad range of management-related issues, including grassland conservation, restoration ecology, and grazing management.

USGS

The USGS collects and provides data on the hydrology and chemistry of Kings Creek, a USGS benchmark stream located on the Konza Prairie LTER site, and the Konza LTER program facilitates the transfer of these data to the Hydro-DB database. The Konza LTER site is also a part of the USArray component of the USGS EarthScope project- a continental-scale seismic observatory.

U S Department of Energy

DOE, through the National Institute for Climate Change Research (NICCR) program, provides partial financial support for a long-term study of grassland responses to climate change being conducting at the Konza LTER site (the Rainfall Manipulation Plots (RaMPs) project]. In addition, DOE funding through the Office of Biological and Environmental Research (BER) supports research at the Konza LTER site to link genetic and genomic responses of plant species to community and ecosystem responses to key environmental drivers (led by Dr. Melinda Smith, Yale University, with several KNZ LTER collaborators). The most recent of these projects (The Climate Extremes Experiment (CEE)initiated in 2010) is examining threshold responses of the tallgrass prairie ecosystem to temperature and precipitation extremes. Finally, the Konza LTER program provides support for a CO2 flux tower site,which is part of the Ameriflux network of net C exchange measurement sites.

Kansas State of

The state of Kansas provides an operating budget for Konza Prairie Biological Station personnel and general site maintenance.

Environmental Protection Agency

The US EPA jointly operates a CASTNet (Clean Air Standards and Trends Network) site located at the Konza Prairie LTER site. The Konza Prairie LTER program provides site support and the EPA provides analytical services and compiles data on atmospheric nutrient concentrations, dry deposition rates, and tropospheric ozone concentrations. The EPA Region 7 office also supports a collaborative modeling project, which is using using Konza LTER data to build linked models of hydrology and biogeochemistry that can be used to assess the effects of alternate land-use scenarios in the Flint Hills region. This project is led by Drs. Bob McKane (EPA) and Mark Stigglet (Georgia Tech), in collaboration with LTER PIs John Blair, John Briggs, Doug Goodin and Loretta Johnson.

Southern Illinois University at Carbondale

Collaborative Konza LTER research is supported by subcontracts to: (1) Dr. Matt Whiles and students to support research on stream invertebrate ecology and soil macroinvertebrate ecology; (2) Dr. Sara Baer and students to support research on grassland restoration ecology.

NASA

NASA provides financial and logistical support, and access to remotely sensed data, for remote sensing studies at the Konza LTER site. NASA also operates, with Konza LTER support, a Cimel sun photometer at the site. Konza Prairie LTER research sites have also served as validation sites for MODIS, and other NASA sponsored programs.

University of Kansas Main Campus

Dr. Gwen Macpherson (Dept of Geology) and her students conduct collaborative research on groundwater hydrology and chemistry as part of the Konza Prairie LTER program. We also provide a subcontract and logistical/technical support to Dr. Nathaniel Brunsell(Dept of Geography), who oversees flux tower operations at the Konza site. Dr. Brunsell's research addresses the role of land-use/land-cover change land surface heterogeneity in vegetation, moisture, soil type, topography on water and energy fluxes from local to regional scales. This research uses a combination of field measurements, remote sensing and numerical modeling, and is integrated with flux tower studies at the Konza LTER site. Finally, Dr. Sharon Billings and her students are conducting research on the effects of variable rainfall amounts across a natural precipitation gradient on soil microbial communities, which includes Konza Prairie as a study site. The Konza LTER program provides logistical support for these studies, and several Konza LTER PIs (Blair, Nippert) are collaborators in these projects.

National Oceanic and Atmospheric Administration (NOAA)

Konza Prairie is part of the U.S. Climate Reference Network (USCRN). USCRN is a network of climate stations developed as part of a National Oceanic and Atmospheric Administration (NOAA) initiative. Its primary goal is to provide future long-term homogeneous observations of temperature and precipitation that can be coupled to long-term historical observations for the detection and attribution of present and future climate change. Data from the USCRN is used in operational climate monitoring activities and for placing current climate anomalies into an historical perspective. The USCRN also provides the United States with a reference network that meets the requirements of the Global Climate Observing System (GCOS).

Colorado State University

Dr. Alan Knapp (Biology Department, Colorado State University) collaborates on many aspects of the Konza LTER program. His research includes studies of grassland ecology, plant ecophysiology, responses to climatic variability and climate change, and the ecology of plant invasions. Knapp's LTER research is supported by a subcontract to Colorado State University,which also provides support for students participating in cross-site research that utilizes the Konza Prairie LTER site and database. Grants to Knapp at CSU also support other LTER-related activities at the Konza site (e.g., climate change studies in RaMPs experiment, comparative studies of ecological processes in North American and South African grasslands). Blair and Gene Kelley (SGS PI) also collaborate on research on soil weathering and P availability across Great Plains climatic gradients.

University of New Mexico

Collaboration with Dr. Scott Collins and students in studies of plant community dynamics and long-term responses to fire, grazing, climatic variability and nutrient additions. Dr. Collins conducts long-term measurements of plant species richness and diversity in several key LTER experiments, and the Konza LTER program supports research visits by Dr. Collins and his students, and assists with the implementation and maintenance of long-term experiments under his direction (e.g., the P addition experiment). Collins, Blair, Knapp and M. Smith are also collaborators on a study of ecological convergence in North American and South African grasslands.

Yale University

Dr. Melinda Smith of Yale University is an LTER collaborator and participates in several aspects of Konza LTER research, including studies of plant community dynamics, the ecology of plant invasions, genomic responses of plants to climate change, and comparisons of the ecology of North American and South African grasslands. Dr. Smith and her students also oversee the NutNet project at Konza as apart of a multi-site study of the effects of nutrient amendments and herbivory on herbaceous community and ecosystem dynamics. The Konza LTER program provides a subcontract to Yale University and logistical support for these studies. Several other KNZ co-PIs are collaborators on the DOE-funded ecological genomics studies being conducted at the Konza LTER site, as well as the NSF-funded study of ecological responses to fire and grazing in North American and South African grasslands.

USDA CSREES

The Konza Prairie LTER site is part of the USDA CREES supported National Atmospheric Deposition Program (NADP), a network of more than 200 sites that monitors precipitation chemistry in the US. Konza Prairie support staff maintain the NADP collection equipment, and oversee local sample collection and processing. The NADP program provide sample analyses and data access. NADP is supported by the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, under agreement no. 2002-39138-11964.

Oklahoma State University

The Konza LTER program provides a subcontract to Oklahoma State University to support collaborative research with Dr. Gail Wilson. Dr. Wilson's research focuses primarily on the role of mycorrhizae in grasslands, and the the ecology of Bothriochloa bladhii (Caucasian bluestem), an important invasive grass species.

Averaves - Investigaci?n y Conservaci?n

In 2008, with supplemental NSF funding, we initiated an international collaboration with researchers in Uruguay to expand ongoing studies of the demography of Upland Sandpipers (Bartramia longicauda), a migratory shorebird that breeds in the temperate grasslands of North America, and winters in the pampas of Uruguay and Argentina. Understanding seasonal components of demography is relevant for understanding the life-history strategies of migratory birds, and for identifying the environmental factors that determine population dynamics. This study builds on the efforts of Konza LTER co-PI Brett Sandercock, whose long-term studies of the biology of Upland Sandpipers have yielded extensive demographic data from Konza Prairie during the breeding period in the northern hemisphere. The objective of this international initiative is to expand our demographic study to examine the ecology of Upland Sandpipers during the nonbreeding period of their life-cycle in Uruguay. The study is being conducted in collaboration with Matilde Alfaro of Barrios of Averaves - a conservation research group for birds based in Montevideo, Uruguay.

University of Oklahoma Norman Campus

Kansas State University and the University of Oklahoma are partners (along with the University of Kansas and Oklahoma State University) in a Track II EPSCoR Program to develop a cyberCommons for ecological forecasting. A large portion of the research involves enhancing field sensor networks and data transmission capabilities at the Konza LTER site, and using Konza data to inform and validate ecosystem models being developed and parametrized at OU.

Other Collaborators or Contacts

The Konza Prairie LTER program serves as a platform for collaborative research involving numerous scientists from KSU and from other institutions. The infrastructure, long-term experiments and databases supported by the LTER program facilitates interactions between scientists with diverse disciplinary interests and expertise, and has led to numerous collaborative interactions of Konza LTER scientists and investigators from other institutions around the world. Here we highlight a few of the collaborations taking place during the LTER VI funding period.

Since 1996, Konza Prairie has been a part of a network of flux tower sites, providing long-term measurements of carbon dioxide, water vapor, and energy exchange through the eddy covariance technique. Between 2006 and 2010, we expanded our studies of terrestrial ecosystem-atmosphere exchange, by adding two additional towers at the Konza Prairie Biological Station (KPBS) and one tower at the Nelson Environmental Study Area (NESA) with additional support from the Kansas NSF EPSCoR program. At Konza Prairie, new eddy covariance equipment for monitoring CO2, H2O and energy fluxes was installed on watersheds 1D (annually burned) and 4B (burned every four years). The Konza site now has continuous data streams from multiple towers allowing comparison of fluxes from 1) different landscape positions (annually burned uplands vs. lowlands); 2) different land-use regimes (annual vs. intermediate prescribed fire frequencies), and 3) areas with different plant community/life-forms (grass-dominated vs. significant woody vegetation expansion. A new eddy covariance tower was also installed in 2007 at the Nelson Environmental Study Area (NESA) outside of Lawrence, KS. The data stream from this tower has been integrated with Konza LTER towers to provide important new information on C flux in an area with higher annual precipitation and greater forest development than the KPBS site.

The Konza Prairie site has been part of the National Atmospheric Deposition Program (NADP) since 1982, and in 2002, Konza became a site for the EPA Clean Air Standards and Trends Network (CASTNet). In 2003 Konza became a site in NOAA's US Climate Reference Network (USCRN). Data from these networks continue to contribute to national monitoring programs, and provide important site-specific data for use by the Konza Prairie LTER program. In turn, the Konza LTER program supports these programs through cooperative instrument maintenance and sample collection, where appropriate.

Because of the long-term, watershed-level experimental treatments maintained as part of the Konza LTER program, and the availability of multiple long-term datasets and archived samples for these watersheds, the Konza Prairie LTER site continues to be a focal site for researchers from other institutions. A few examples of collaborative studies conducted at the Konza Prairie site during the LTER VI funding period include:

- assessing the role of evolutionary trade-offs in enzyme activities in microbial community function, led by Mark Bradford (Yale), Noah Fierer (U Colorado) and Rebecca McCulley (U Kentucky)

- a cross-site comparison of soil microbial-plant interactions in fertilized and unfertilized soil, led by Katie Suding (UC Berkeley)

- isotopic approaches to separate heterotrophic and autotrophic sources of soil CO2 and their responses to warming and altered precipitation in grassland ecosystems, led by Dr. Weixin Cheng, UC Santa Barbara

- studies of the patterns and controls of soil black carbon storage, a multi-site study directed by Johannes Lehmann (Cornell University);

- studies of trace gas flux from mesic grasslands led by Emily Elliott (University of Pittsburgh)

- stable isotope studies of litter decomposition directed by Francesca Cotrufo (Colorado State University);

- studies of soil microbial community composition, C cycling and responses to altered precipitation patterns, a multi-investigator project directed by Dave Myrold (U of Oregon);

- modeling of ecosystem responses to climate change and land management, directed by Bob McKane (EPA);

- studies of the role of dissolved organic C in streams from a range of ecosystem types, directed by Dr. Rudolph Jaffee (Florida International University)

- a cross-site study of methane uptake rates and the identity of methane oxidizing bacteria, led by Dr. Joe van Fischer (Colorado State University)

Konza LTER scientists are also involved in a variety of international collaborative efforts. For example, Konza LTER scientists and scientists from South Africa are conducting collaborative studies of ecological responses to fire and grazing in North American and Southern African grasslands [J. Blair (KSU), M. Smith (Yale), Alan Knapp (CSU), Scott Collins (UNM) and collaborators in South Africa (Kevin Kirkman and Richard Fynn at the University of KwaZulu-Natal, Pietermarizburg)]. Konza co-PI David Hartnett maintains collaborations with colleagues in Botswana, and has supported exchanges of graduate students there. In 2008, Hartnett re-visited field sites in Botswana with another LTER scientist (Gail Wilson) and LTER graduate student Jacqueline Ott to conduct research on bud bank ecology and the regulation of dynamics of southern African grasslands. In addition, Hartnett and Joern are Co-Directors of the Institute for Grassland Studies at KSU, which promotes international collaborative research on grassland ecology, and in 2009 Hartnett led a field class on a trip to South Africa and Botswana. In 2010, Konza LTER scientists participated in hosting a visit from a delegation from the University of Limpopo, South Africa. Also, in 2010, LTER co-PI Jesse Nippert received an international supplement to support his developing studies of woody plant encroachment into grasslands in South Africa. In 2009, Konza LTER scientist Brett Sandercock continued a collaborative study (funded by an LTER international supplement) with scientists in Uruguay to assess population dynamics of a migratory grassland bird (the Upland Sandpiper) in its northern and southern hemisphere ranges.Konza LTER scientist Samantha Wisely is working with students in Paraguay on wildlife conservation issues. In 2009, Konza Prairie LTER Scientists were invited to China to consult on grassland and herbivore studies (Joern) and to participate in an international conference (Blair and Knapp) organized by the Chinese Academy of Sciences. This resulted in separate research visits to the Konza LTER site by multiple Chinese scientists in 2010, including Dr. Shuguang Hao (Chinese Academy of Sciences), Dr. Yingzhi Gao (Northeast Normal University), Dr. Nianpeng He (Director, Inner Mongolian Grasslands Ecosystem Research Station), and Dr. Xin Xiaoping (Director, Hulunber Grassland Observation and Research Station). These visits typically included presentations of ongoing research in China, and discussions regarding potential future collaborations. In 2010, LTER co-PI Dodds hosted a visitor from Denmark (Dr. Tenna Riis, Aarhus University) to demonstrate stable isotope methods for studying stream N cycling at Konza. This resulted in a return visit by Dr. Dodds in the summer of 2010 to conduct collaborative research in Denmark.

In addition to the activities indicated above, Konza Prairie continues to host numerous visits by international scientists and students, including: Dr. Marjan Jongen of the Instituto Superior de Agronomia, Lisbon, Portugal; Matilde Alfaro-Barrios of Averaves-Investigaci?n y Conservaci?n, Uruguay; Rosa Roca, Servicio Regional de Investigaci?n y Desarrollo Agroalimentario, Spain. The Konza LTER program also provides on-site research opportunities (as well as logistic and/or financial support) for graduate students and post-doctoral scholars from a number of international venues (e.g., in 2008: Elske Koppenaal, Groningen University, The Netherlands. In 2009: Nicholas Zaloumis, University of Cape Town, South Africa. In 2009-11: Nicole Hagenah, University of KwaZulu-Natal, South Africa. In 2011: Akalak Kunsorn, visiting PhD student from the University of Chiang-Mai, Thailand.

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

Context for the 2012 Annual Report of Activities for the Konza Prairie LTER Program

The Konza Prairie LTER Program is a comprehensive, interdisciplinary research program that contributes to synthetic ecological studies and conceptual and theoretical advances in the field of ecology, and provides a mechanistic and predictive understanding of ecological processes in mesic grasslands. The Konza Prairie LTER program also offers educational and training opportunities for students at all levels, provides outreach and public education activities, contributes knowledge to address land-use and management issues in grasslands, and provides infrastructure and data in support of scientific pursuits across a broad range of disciplines.

Konza was one of 6 original LTER sites, and pre-LTER research extends selected datasets back >30 years. The focal site for our core LTER research is the Konza Prairie Biological Station, a 3487-ha area of native tallgrass prairie in the Flint Hills of northeastern Kansas. The KPBS was established in 1971, with land acquired by the Nature Conservancy and deeded to Kansas State University, and became a part of the LTER Network in 1981. With funding from the LTER program we have amassed long-term datasets on processes such as hydrology, nutrient cycling, plant productivity and community composition, including many that now span more than 25 years. These long-term records provide unique insights into the dynamic nature of tallgrass prairie ecosystems, serve as a critical baseline for identifying and interpreting ecological responses to a variety of global change pressures, and are available as a resource for the broader scientific community. The Konza LTER program encompasses studies at, and across, multiple ecological levels and a variety of spatial and temporal scales. The unifying conceptual framework guiding this research has been that fire, grazing and climatic variability are essential and interactive factors shaping the structure and function of mesic grassland ecosystems. The interplay of these natural disturbances across a heterogeneous landscape leads to the high species diversity and complex, non-linear behavior characteristic of these grassland ecosystems. Because grazing and fire regimes are managed in grasslands worldwide, Konza LTER data are relevant not only for understanding grasslands globally, but also for addressing broader ecological issues such as productivity-diversity relationships, disturbance and community stability, top down vs. bottom up controls of ecological processes, and the interplay of mutualistic and antagonistic biotic interactions. In addition, because human activities are directly (management of grazing and fire) and indirectly (changes in atmospheric chemistry and climate) altering the key drivers of ecological processes in these grasslands, we are able to use Konza LTER studies and data to address critical issues related to global change, including the ecology of invasions, land-use and land-cover change, human activities and water quality, and ecosystem responses to climate change. Thus, our long-term research program initiated 30 years ago to understand the effects of natural disturbances in this grassland, now has additional and immediate relevance for understanding and predicting the consequences of global change taking place in the grasslands of North America, and around the world.

A major aspect of our LTER activities in 2011-12 continues to be the implementation of watershed-level fire and grazing studies, and associated long-term data collection to document both short-term and long-term dynamics in response to these treatments. The Konza LTER program is built around a long-term database on ecological patterns and processes derived from a fully replicated watershed-level experimental design, in place since 1977 with some modifications to accommodate new long-term studies initiated in LTER V and VI (e.g., the watershed-level 'Fire Reversal' and Season of Fire experiments, the Riparian Woody Vegetation Removal experiment, the Patch-Burn Grazing Studies, and others). This unique experimental design includes replicate watersheds subject to different fire and grazing treatments (Fig. 1), as well as a number of long-term plot-level experiments which allow us to address the mechanisms underlying responses to various fire and grazing regimes.

In addition to fire and grazing, climatic variability, climate extremes and directional climate change are key drivers of grassland dynamics, and important focal areas for Konza LTER activities. The effects of climate are being addressed by long-term studies encompassing the natural climatic variability, and possible directional changes, characteristic of this region, as well as manipulations of water availability and temperature in ongoing field experiments in both terrestrial (i.e., the Irrigation Transect Study and the Rainfall Manipulation Plots (RaMPs) Experiment) and aquatic (i.e., Experimental Stream Studies) habitats. Within core LTER watersheds, permanent sampling transects are replicated at various topographic positions (n=4/topo. position/watershed), where ANPP, plant species composition, plant and consumer populations, soil properties, and key above- and belowground processes are measured. The collection of diverse data from common sampling locations facilitates integration among our research groups. In total, the Konza LTER Program incorporates explicit study of the major factors influencing mesic grasslands in a long-term experimental setting. It is a rigorous ecological research program designed to elucidate patterns and processes inherently important in grasslands, and address the potential impacts of global change in these ecosystems. Towards this end, we currently maintain >90 long-term datasets in association with long-term experiments ongoing as part of this program, and many more research activities of planned shorter duration.

We are currently in the fourth year (2011-2012) of our most recent LTER grant (LTER VI, 2008-2014), and our major activities continue to address a broad spectrum of fundamental ecological questions, but with an emphasis on understanding the consequences of global change for ecological dynamics in grasslands, a theme relevant to understanding, managing and conserving grasslands worldwide. Our activities focus on long-term responses to facets of global change most relevant to grasslands and grassland streams ? changes in land-use (altered fire and grazing regimes, grassland restoration) and land-cover (species changes, particularly increases in woody plant cover); climate change and altered hydrology in both terrestrial and aquatic environments; and altered nutrient cycles (enhanced N deposition) ? and we couple long-term observations with manipulative studies to provide mechanistic explanations for these responses. Our research activities also address biotic interactions (competition, mutualism, predation, herbivory) in grasslands, in order to provide insight into a broad range of general ecological phenomena. In total, our activities during LTER VI are designed to:

1. maintain and expand the strong core LTER experiments and data sets on fire, grazing and climatic variability begun over 25 years ago, with the goal of refining our understanding of the major abiotic and biotic factors determining grassland structure and function;
2. continue developing a mechanistic and predictive understanding of grassland dynamics and trajectories of change in response to global change drivers, using ongoing and new long-term experiments and datasets coupled with shorter-term supporting studies;
3. support and promote new synthesis activities based on our LTER results and data from other sites and studies, to use these syntheses to expand the inference of KNZ results, and to develop and test ecological theory;
4. continue education and outreach activities to make our results relevant to society.

Consistent with our goals as a long-term ecological research program, many of the long-term experiments and datasets initiated in previous LTER grants are being continued throughout the current funding period, while several new experiments and datasets were, and are, being initiated, as detailed in the original Konza LTER VI proposal. The value of these long-term experiments and datasets continues to increase with time. In addition, results from these long-term studies have new relevance as we move towards evaluating the ecological impacts of a suite of global change phenomena occurring at the Konza LTER site and in grasslands worldwide. Space constraints prevent us from listing all LTER activities, but below we highlight a few selected activities from our most recent funding period.

Summary of Major Konza Prairie LTER Research Activities (2011-2012):

Fire Ecology in Tallgrass Prairie.
We continued the long-term, watershed-level fire experiments, and associated data collection efforts, that have been central to our 'core' long-term studies since the initiation of the Konza LTER program (Figs. 1 and 2). Specifically, we continued long-term experiments on the effects of different fire frequencies (1, 2, 4 and 20 year fire return intervals), as well as watershed-level treatments designed to determine the

effects of seasonal timing of fires (spring, summer, autumn and winter), and experiments designed to assess the potential for changes in long-term fire treatments to reverse trajectories of land-cover change (the Fire Reversal experiment). Watersheds with different long-term fire return intervals continue to be focal areas for plant and consumer sampling and measurement of a suite of ecosystem parameters. Many of our core datasets are based on documenting long-term responses to these watershed-level manipulations, and these watersheds continue to be used by numerous visiting researchers. For example, in 2012 watersheds with different fire regimes were used for studies of genetic plant population structure and community invasibility by graduate students from Yale (Melinda Smith, PI), studies of methanotrophic bacterial communities by researchers from Colorado State University (Joe von Fischer, PI), studies of Panicum virgatum ecotypic variation and physiology by students from St. Joseph University (Clint Springer, PI), studies of C cycling and decomposer communities by researchers from Colorado State University (Francesca Cotfuro, PI), and for studies of climate change by graduate students from Colorado State University and the University of New Mexico.

The 'season-of-fire' experiments (assessing the ecological consequences of fires at different times of the year) have taken on added significance in recent years, as questions about the impact of regional grassland burning and EPA regulations regarding air quality and have focused on the ecological importance of burning. This problem is exacerbated by the narrow window during which management-related (cattle pasture) spring burning typically takes place in the Flint Hills. Our data suggests that management-related burning could be spread out in time without adverse effects on grassland productivity or species composition, and will a lessen impact on spring air quality in major metropolitan areas. Findings from the season of fire project have been published in applied ecology journals (Towne and Kemp 2003, 2008), presented at various management-related meetings (e.g., the 2009 Natural Areas Research Conference in Nashville, TN) and highlighted during on-site field presentations for groups such as the EPA Region 7, Kansas Department of Wildlife and Parks, USDA Natural Resources and Conservation Service, and the Natural and Environmental Resources Committee of the Kansas Farm Bureau. The role of LTER studies on fire will continue to grow in importance as the issue of managing fire and smoke in the Midwest grows.

Assessing the Interactive Effects of Fire and Grazing in a Grassland Landscape.
Native ungulates were an important driver of ecological processes in tallgrass prairie, and bison were reintroduced to Konza Prairie between 1987 and 1992. The bison herd at is maintained in ten watersheds covering 1,012 hectares, and stocked at rate to remove approximately 25% of the ANPP on average. Bison grazing activity is dynamic, and individuals select grazing sites in a highly variable manner throughout the year, especially in response to fire, and with big differences among years. In 2011-12, we continued studies of bison grazing preferences and spatial distributions of their activities, based on both observations and collars fitted with GPS units to quantify spatial and temporal movement patterns of the bison herd. These data are allowing us to document landscape-level patterns of activity, and to recognize gradients of potential grazing impact within and among watersheds, including interactions with different fire frequency treatments over the long term. Our goal is to develop a quantitative grid of bison use intensity, which will aid in assessing the impacts of bison on vegetation dynamics and ecosystem processes at Konza Prairie, and will provide supporting data for a wide variety of studies. The watershed-scale fire-grazing experimental design at Konza Prairie is also being used in a newly funded NSF project (Joern, Biggs and others, 2010-2013) to assess nitrogen-driven ecosystem feedbacks affecting the landscape-level distributions and foraging activity of bison and the resulting consequences for creating landscape-level heterogeneity, which drives responses by dominant insect grazers. The primary hypothesis is that the variable spatial distribution of foliar-N content at landscape scales in response to fire and grazing coupled to the physical structure of the habitat determines landscape use by bison, thereby increasing habitat heterogeneity of variable suitability for other important insect herbivores affecting ecosystem function.

In 2012, our LTER research on bison incorporated an LTER-supported REU student with expertise in remote sensing and GIS (Thomas Kuhn, mentored by Tony Joern). Using GIS techniques and remotely sensed images available for Konza Prairie, Thomas has been mapping the distribution of wallows and bison trails to document landscape level patterns of bison use of the site. Both features are conspicuous on the landscape and provide important insights into how bison perceive and affect the landscape. Bison Wallows: Four main categories of wallows were identified (active, inactive, reclaimed, and other similar bison disturbance). In the approximately 1000ha available to bison, a total of 3737 wallows were mapped, consisting of 2401 active, 755 inactive, 485 reclaimed, and 96 'other' wallows. Wallows exist primarily in flat areas of Konza, and are typically grouped together. Wallow location also correlates with areas of high bison presence and large grazing lawns. Efforts are underway to identify landscape features associated with wallows by constructing a statistical model that best predicts the location of wallows and the transition probabilities over time among these four states. Bison Trails: Bison use the entire portion of Konza Prairie within the fenced grazed site. Major bison trails are evident that serve as conduits for longer moves compared with movement associated with foraging and quiescent activities. Major bison trails (defined as trails visible at a magnification of 1:3200) were mapped. The major trails link areas of high bison usage. Most major trails follow paths with slopes ranging between 0 and 10 degrees. Exceptions consist of trails connecting two nearby areas of high usage separated by a steep slope. Comparing the major existing trails with paths generated using an ArcGIS tool that calculates the Least Cost Path shows that bison trails represent energetically efficient paths from one high use area to another. Bison movement is quantified using GPS collars on 15 bison that record local positions every 30min-2hr (depending on season). Longer bison movements across multiple watersheds can be linked to major trails. Shorter movements (0-82m) by bison typical of foraging periods, occur exclusively in flat areas, areas which highlight a reticulated network of minor trails that fully cover the area. Grazing Lawns: Preliminary efforts to map grazing lawns are underway using available remotely sensed imagery. This portion of the project is proving quite challenging, but progress is being made. Other ongoing studies indicate that grazing lawn location correlates well with increased foliar N concentration and flat areas with high bison use, attributes that will be included in models along with time since fire and other landscape features to best predict grazing lawn locations

Isotopic Studies of Bison Water Sources
Reliable access to water by large grazers commonly limits spatial distributions and patterns of movement. Predicting and measuring resource consumption by large, unmanaged grazers is still poorly understood, and yet the conservation implications for many species are very significant. Historically, water sources consumed by large grazers are estimated based on proximity to water sources (using GPS or observational data). But similar to ecological studies of plant water use, proximity and availability does not always predict use. Co-PI Nippert and students used the stable isotopic signature of water extracted from faecal samples of bison to identify the water-sources consumed over time. Our results show that the sources of water consumed by this bison herd varied seasonally, with the greatest dependence on ephemeral puddles and water from forage from April-Oct, and with increased dependence on streamwater during the colder months. This research has two big implications for ecological research of large grazers: 1. We show how the extraction of water from faecal samples and subsequent use of the water isotopic signature allows us to identify spatially-explicit water-use and sources consumed by large-animal grazers. And, 2. Our results have broad ecological implications for bison (and other larger grazer) research. At the location studied, access to a reliable water source (stream networks) did not predict consumption. These results are valuable for landscape predictions of resource-use and they also point to the possibility that future changes in climate may directly impact foraging patterns and landscape utilization by altering the sources of water available for consumption by bison.

Comparative Studies of Fire-Grazer Interactions in North America and South Africa.
The long-term fire and grazing treatments maintained by the Konza Prairie LTER program are also contributing to the goals of a recently-renewed (2009-2012) NSF-funded project to assess the generality of ecological responses to fire and grazing in North American (Konza Prairie) and South African (Kruger National Park and the University of KwaZulu-Natal's Ukulinga research site) grasslands. These grasslands have very different geological and evolutionary histories as well as different diversities of mammalian herbivores. The NSF-funded 'Savannah Convergence' project is being directed by Konza LTER scientists Smith, Knapp, Blair and Collins. The Konza LTER program provides supporting data on climate, soils, nutrient availability, and patterns of ANPP and plant community composition in response to different long-term fire regimes and the presence or absence of bison in North American grasslands. In turn, the NSF Savanna Convergence project provides novel data on the effects of allowing or excluding grazer activity in areas subject to different fire return intervals. Activities at Konza Prairie in 2011-12 included monitoring spatial and temporal patterns of grazer utilization of plots subjected to annual burning, four-year fire return intervals and long-term fire suppression, as well as assessing patterns of ANPP and changes in plant community composition in plots subject to grazing or from which grazers are excluded. In summer 2012, we also collected soil cores from inside and outside of exclosures in all three burning treatments, and we are currently analyzing these samples to assess long-term interactions of fire and grazing on soil C and pools.

Cattle Grazing and Habitat Heterogeneity at the Landscape Scale: Konza LTER Patch Burn Experiment
Long-term studies of the Konza LTER based on bison grazing activities indicate that fire-grazing interactions promote habitat heterogeneity in many ways and at many scales. These include plant species composition, primary production and vegetation structure, and redistribution of nutrients by large mammalian consumers. Because mammalian grazers graze most intensely in recently burned watersheds, a shifting mosaic pattern of habitat suitability is created at a multiple watershed level scale. In turn, abundances and distributions of consumers also respond to habitat changes resulting from fire-grazing interactions. To increase our understanding of the spatio-temporal dynamics of fire-grazing interactions, we initiated a new patch-burn grazing experiment as part of LTER VI. This entailed modifying our former watershed-level experimental design to include two new, large replicate grazing units, each encompassing a mosaic of three individual watershed units (patches) subject to asynchronous prescribed fire and variable fire histories. This experiment required substantial field preparation, and coordination with collaborators in the Department of Animal Sciences. The patch-burn project will expand our understanding of the role of fire-grazing interactions based on native bison grazing to domesticated cattle grazing, the dominant management activity of the greater Flint Hills tallgrass ecosystem, and will address effects of fire and cattle grazing on grassland terrestrial and stream dynamics, and the promotion of biodiversity.

Our overarching hypothesis is that increased habitat heterogeneity resulting from management activity will support increased biodiversity at all levels, while maintaining acceptable levels of cattle productivity/ condition. Response variables include changes in plant biomass and species composition, soil resources, abundances and diversity of birds, small mammals, grasshoppers, and stream invertebrates, and changes in stream geomorphology and biogeochemistry (see Stream Studies section for further details).

This ongoing experiment is taking place across two areas of KPBS (Shane Creek and Southern Cattle Units), each treated with 3-year rotations of annual burning. In 2008-10, we established new watershed boundaries, erected fences around the new grazing units (see Fig 1), and established watering locations. Konza LTER scientists held numerous planning meetings with scientists from Animal Sciences at KSU, and representatives from The Nature Conservancy (there is great interest in the potential use of patch-burning grazing to promote conservation in areas managed for cattle production). The first phase of this project was initiated in summer of 2010, with the implementation of patch burning in a three-watershed unit (the Southern Cattle Units) and the initiation of new stocking rates to complete the proposed experimental design. We began the second phase of the project in 2011, in the second three-watershed unit (Shane Creek Units). Seasonal grazing at moderate stocking rates (5 months/y stocked at 25 ha/ cow-calf animal unit) is applied to each 3-watershed area. A treatment employing traditional annual burning and season-long grazing characteristic for the Flint Hills grasslands in Kansas provides for a control comparison for each area. In addition, comparisons with ungrazed watersheds subjected to annual burns provide a second control for understanding the effects of fire-grazing interactions.

In 2012, we continued the planned rotation fire-grazing treatments, and continued to collect data on plant, soil and consumer responses. Co-investigators Sandercock and Jennsen continued research on the effects of the patch-burn grazing treatments on the ecology of grassland birds and small mammals. Bird sampling included distance sampling on line transects to determine species diversity and avian abundance. Nest searching was conducted to locate nests of common songbird species and to examine spatial variation in rates of nest parasitism and nest survival. The same field protocols were used for birds at Konza Prairie and also a separate set of field sites in Chase County near Cottonwood Falls, Kansas. Graduate student Drew Ricketts continued his second years of a study on the responses of small mammals to patch-burn grazing, with an emphasis on deer mouse demography. Small mammal communities were sampled with replicated trapping grids, utilizing standard techniques to examine responses of the small mammal community as a whole to this new range management technique. Additionally, we will employ artificial burrows, mark re-capture methods, and molecular techniques to gain a detailed understanding of deer mouse demography in rangeland communities in the northern Flint Hills. In addition to small mammal sampling, we are quantifying vegetative responses to patch-burn grazing with the standard habitat metrics of visual obstruction readings and percent cover of different cover classes such as forbs, grasses, litter, etc.

The patch-burn grazing experiment is an excellent opportunity to increase linkages between programs in basic grassland ecology and more applied programs at KSU. Of equal importance, this will provide new outreach opportunities to encourage wildlife conservation and more sustainable practices by regional land managers and cattle producers. Dr. K.C. Olson, associate professor of cow-calf nutrition and management, is a new LTER collaborator for this project. His research includes nutritional management of cattle on native rangelands and factors influencing grazing behavior. Konza LTER scientists also visited Walda Prairie (a research site operated by the Kansas Biological Survey), which is establishing a similar patch-burn experiment, and have consulted with Brian Obermeyer (Director of the Flint Hills Initiative for The Nature Conservancy) who oversees patch burn experiments at the Tallgrass Prairie National Preserve and the Flint Hills Tallgrass Prairie Preserve. Konza also hosted a visit by Dr. Joe Fargione (Regional Science Director of the Central U.S. Region TNC) in 2009, which included a visit to the Konza site and discussion of how to use the results from the patch-burn experiment to promote TNC goals. Finally, Konza LTER scientists (Dodds and Whiles) are participating in a cross-site comparison of impacts of patch-burn grazing on stream ecosystems at a site in Missouri and at Konza Prairie. Activities in 2009 and 2010 included establishment of new graduate student project to sample stream sites in Missouri, and gather preliminary data on streams within the future patch-burn watersheds at Konza. By coordinating and cooperating with the numerous patch-burn grazing experiments in our region, we will increase the visibility and applicability of our long-term grazing experiments.

Measuring Spatial Variability in Plant Physiology and Landscape Energy Balance Using Sensor Networks.
Variability in topography, soil type, vegetative cover, and species composition all contribute to spatial variability in the surface energy balance across the landscape. Quantifying this variation is necessary to estimate carbon and water balances the scales used to make land management decisions (i.e., field or watershed scale). Furthermore, measures of spatial variability will aid in the interpretation of plant physiological responses of the grassland community, topo-edaphic variability in primary productivity, improve hydrologic modeling, and enhance the interpretation of data from remote sensing platforms and flux towers. Since 2010, we have deployed a 10-station sensor network in 2 annually-burned watersheds and two 4-year burned watersheds to measure the spatial variation in the surface energy balance at 3 topographic positions. Measurements at each station included: air and soil temperature, canopy temperature, relative humidity, wind speed, surface temperature, soil heat flux, and soil water content. Data are accessible real-time using a wireless network. Ancillary bi-weekly measurements include vegetative growth, LAI, and plant height. Data from the sensor network and flux data from the eddy covariance towers are being coupled with a numerical modeling technique to approximate latent heat and sensible heat fluxes at each station in the network parameterized using bi-weekly biomass clipping data, measurements of canopy LAI (leaf area index) and plant height of the common C4 grasses. Results from the first 3 years of this study indicate: (1) high spatial variability is present within and across watersheds and (2) topographic patterns of growth and canopy development vary strongly according to burn history, and (3) interannual variability in microclimate is a strong driver of seasonal dynamics in carbon assimilation and aboveground growth, corresponding to climate conditions between day of year 180-210.

In 2012, we continued to collect data streams from two eddy flux towers on two of the LTER core watersheds, allowing comparison of C and water fluxes from different land-use regimes (annual vs. intermediate prescribed fire frequencies) and areas with different plant community/life-forms (grass-dominated vs. significant woody vegetation expansion). This research is supported by a subcontract with LTER collaborator Nate Brunsell (Atmospheric Scientist from the University of Kansas). In 2012, we focused on maintaining and utilizing the eddy covariance stations and associated data sources, and in addition to Konza site-specific studies, we have been conducting comparative data analyses with two additional flux towers in the state of Kansas (Lawrence and Salina) to assess water use efficiency and the role of land cover variation on water and carbon cycling. We also combined these data with other Ameriflux towers nationally in a study of the underlying thermodynamic stability of the fluxes in relation to land use. Ultimately, the goal of this effort is to derive a potential metric of sustainability that could be used to evaluate alternate land-use practices or land covers. Additional efforts have focused on the 1D Ameriflux tower to calibrate an ecophysiological model (AGRO-BGC) to examine the impacts of potential changes in precipitation on the annual carbon and water cycles (results presented at ESA meeting in Portland).

Evaluating the Effects of Climatic Variability and Climate Change in Tallgrass Prairie.
In addition to fire and grazing, our LTER VI research continues to focus on climatic variability as a critical factor affecting the structure and function of tallgrass prairie ecosystems. Within grasslands, the importance of both amounts and timing of precipitation inputs as forcing functions makes them particularly responses to inherent climatic variability and vulnerable to the changes predicted by global climate change models. Having a long-term dataset spanning decades of natural climatic variability is one important avenue for studying ecological responses to climatic variability (Nippert et al. 2006, Heisler and Knapp 2008, Craine et al. 2009, La Pierre et al. 2011). However, in LTER VI we continue several manipulative experiments designed to augment our long-term data and address potential mechanisms underpinning grassland responses to climatic variability and climate change. The first is an irrigation experiment, in which supplemental water is being added to two transects in annually burned tallgrass prairie to eliminate plant water deficits during the growing season (Knapp et al. 2001, Hutchinson et al. 2006, Williams and Rice 2007). This project began in 1991, and has been expanded to include a nitrogen addition treatment in order to evaluate potential interactions between precipitation and N limitations. A new synthesis of plant community and plant productivity data from this project was completed in 2012.

A second major project examining the effects of climate and climate change in these grasslands utilizes field-scale Rainfall Manipulation Plots (RaMPs) in which the timing and amounts of rainfall events are being experimentally manipulated in intact native tallgrass prairie plots (Fig. 3). This project is allowing us to assess the effects of altered precipitation regimes on individual plant ecophysiological responses, plant community composition, and ecosystem-level processes. Details regarding the experimental approach and the initial results of this experiment are provided in Fay et al. (2000, 2003), and some recent results are highlighted in the accompanying 'Findings' section of this report. In addition to core long-term response variables on plant, soil and ecosystem responses to changes in timing of rainfall and warming, this project was used in 2009-12 by graduate students from Yale to assess potential population-level genetic responses to climate change, and by a new collaborator from UC Santa Cruz (Weixin Cheng) who is funded with a DOE NICCR grant to use a stable isotope approach to separate root and bulk soil respiratory responses to climate change drivers.

Plant Physiological Ecology: Linking Species-Specific Water Flux and Gas Exchange Dynamics to Hydraulic Architecture.
We investigated the linkage between the hydraulic architecture of grasses to physiological patterns of water use across a range of species and conditions. The rate of stomatal conductance (gs) and photosynthesis (A) increased acropetally along the leaves of 5 grass species, which is a unique feature of this growth form (Ocheltree et al. 2012). The internal structure of leaves also changed acropetally in order to minimize the pressure gradient across the mesophyll that would otherwise occur as a result of increasing gs. The resistance to water movement through the mesophyll represented 80-?‐90% of leaf resistance in six genotypes of Sorghum bicolor L. (Moench). This resistance was most important in controlling gs and A when water was readily available, but as soil-?‐moisture decreased it was the efficient transport of water through the xylem that was most important in maintaining plant function. We have also investigated the relationship between hydraulic architecture and stomatal responses of grasses to increasing Vapor Pressure Deficit (D). Grasses with a larger proportion of their hydraulic resistance within the xylem were less sensitive to increasing D and plants with high root conductance maintained higher rates of gas exchange D increased. We have alsoinvestigated the tolerance of grasses to extreme drought events to test if there was a trade-?‐off between drought tolerance and growth in grasses. Plants with drought tolerant leaf traits typically sacrificed the ability to move water efficiently through their leaves. Having drought tolerant leaves did not limit the plants ability to have high rates of gas exchange, and, in fact, the most drought tolerant plants had the high rates of gs when expressed on a mass basis. Leaf-?‐level drought tolerance did contribute to species' occurrence, as the drought intolerant species I studied are not commonly found in low precipitation systems. The results presented here highlight the importance of studying the hydraulic architecture of plants to provide a better understanding of what controls plant function across a range of environmental conditions.

Plant Physiological Ecology: Phenotypic Variation in Switchgrass Populations.
Population-level adaptation to broad-scale regional climates or intra-specific variation in genome size of the genetically and phenotypically diverse C4 grass species, Panicum virgatum L. (switchgrass) may drive responses of this species by future precipitation variability associated with climate change. P. virgatum plants from natural populations originating from Kansas, Oklahoma, and Texas, U.S.A, received frequent, small precipitation events ('ambient') or infrequent, large precipitation events ('altered') to simulate contrasting rainfall variability expected for this region. We measured leaf-level physiology, aboveground biomass, and genome size for each individual. Gas exchange rates and aboveground biomass varied significantly by population origin but did not differ by genome size. Altered precipitation treatments reduced leaf-level physiological rates, however this result did not vary by population or genome size. Our results suggest that trait variation in P. virgatum is primarily attributed to population-level adaptation across a latitudinal gradient, not genome size, and that neither population-level adaptation nor genome size may be important predictors of P. virgatum responses to future climatic conditions. Since 2010, this research has involved collaboration by LTER Co-PI Nippert and Dr. Clint Springer (St. Joseph University), and graduate and undergraduate students from

both KSU and St. Joseph College (a non-doctoral degree granting institution).

Mycorrhizal Studies.
Understanding how mycorrhizal associations are affected by plant invasions may be a critical aspect of the conservation and restoration of native ecosystems. LTER co-investigator Gail Wilson and colleagues examined the competitive ability of old world bluestem, a non-native grass (Bothriochloa bladhii), and the influence of Bothriochloa competition on AM root colonization of native warm-season prairie grasses (Andropogon gerardii or Schizachyrium scoparium). Competition by the non-native resulted in significantly reduced biomass production and AM colonization of the native grasses. To assess plant-soil feedbacks of Bothriochloa spp., a second greenhouse study examined soil alterations indirectly by assessing biomass production and AM colonization of native warm-season grasses planted into soil collected beneath Bothriochloa spp. This study was conducted using soil from four replicate prairie sites throughout Kansas (Konza and Hays sites) and Oklahoma (OSU Stillwater Range Research and Klemme Range Research Stations). Our results indicate a major mechanism in plant growth suppression following invasion by Bothriochloa spp. is the alteration in soil microbial communities. Plant growth was tightly correlated with AM root colonization demonstrating mycorrhizae play an important role in the invasion of these systems by Bothriochloa spp. and indicating restoration of native AM fungal communities may be a fundamental consideration for the successful establishment of native grasses into invaded sites. Wilson presented these data at 2012 Oklahoma Invasive Plant Council.

Wilson's OSU PhD student (Mitch Greer) is completing his research assessing plant-microbial feedbacks of invasive non-native warm-season grasses. Greer's research involves multiple field sites throughout Nebraska, Kansas, Oklahoma, and Texas; including Konza Prairie.

In 2012, Wilson's OSU PhD student (Sally Kittrell) initiated her research assessing mycorrhizal-wetland plant associations in field (Konza Prairie, KS, and Tallgrass Prairie Preserve, OK) and greenhouse studies. Mycorrhizal associations and wetland plants have not been well-assessed. As plants transition from terrestrial upland to facultative and obligate wetland species at lower topographic positions, questions arise as to how dependent these hydrophytic species are on mycorrhizal fungal associations. Our primary objective is to lay a framework for understanding the responses of plant-mycorrhizal mutualism in ephemeral wetland areas, as well as continuous wetlands.

Bud Banks and Grassland Invasibility.
Perennial grass species in tallgrass prairie ecosystems are maintained primarily through the vegetative outgrowth from their belowground bud banks. In 2012, we completed an LTER study by Melinda Williamson (OSU MS student) and LTER investigators Gail Wilson and Dave Hartnett to assess the role of nitrogen, light quantity and spectral quality as key regulators of bud bank dynamics and resultant tillering in six native grass species (Submitted to Botany; in revision). We provide empirical data to assess interactions of nitrogen with light quantity, and the role they have on bud outgrowth and tiller initiation in six grass species in two functional groups (C3 and C4 photosynthetic pathways). We also examine the role of light spectral quality (R:FR) on bud outgrowth in these same six grass species. Strong interactions between nitrogen and light were observed in the C3 species, but not in the C4 species. Generally, C3 species responded favorably to N, while C4 species were not responsive to N amendments. Light spectral quality elicited species-specific responses in both of the functional groups, with sensitivity to R:FR reductions observed in four of the six species. Therefore, C3 and C4 functional groups exhibited significantly different responses to these two cues. The results of this study suggest that environmental cues such as these may be important in determining patterns of species composition and population dynamics in response to current and future global changes.

Ray West (OSU PhD student), Gail Wilson, and Dave Hartnett completed greenhouse studies examining varying densities of belowground meristems (bud bank) to test that grassland invasibility is regulated by a minimum threshold in bud bank density. Our data indicated that increases in size of the bud bank increased grassland stability, thereby reducing invasibility by exotic species. Biomass production of the exotic species profoundly increased in greenhouse mesocosms that contained no belowground meristems. A corresponding field study has been completed on KPBS. Plots were established with 0%, 33%, 66%, and 100% of the native belowground meristems removed and an exotic grass species has been seeded into each plot. These field data correspond with that of our greenhouse studies, concurring grassland invasibility is decreased with stable belowground bud bank populations. These findings improve our understanding of plant invasion and suggest that restoring and maintaining bud banks should be a priority for land managers seeking to prevent and limit plant invasions.

Studies of Plant Roots Characteristics Across the Konza Landscape.
C4 grass species in tallgrass prairie can exhibit both high root production and deep rooting in the soil profile (> 2 m). The production of deep roots in tallgrass prairie has been historically presumed as a mechanism for water uptake when surface soils are dry. Nippert and students examined changes in root biomass, total root length, root width, and theoretical hydraulic conductivity using roots collected from deep soil cores in upland and lowland topographic positions in grazed and ungrazed watersheds of the Konza Prairie. Root biomass, total root length, and theoretical hydraulic conductivity were highest in roots found in the top 20 cm of the soil profile, and then declined exponentially with increasing soil depth. Compared to grazed areas, ungrazed locations had more root biomass and total root length of roots in the most superficial soil layers. Theoretical hydraulic conductivity of axial root xylem did not vary by topographic position or grazing contrasts, and declines in conductivity by depth were driven by changes in the number of vessels per stele, rather than changes in vessel size. Thus, irrespective of differences by grazing treatment or topographic position, significant reductions in root biomass, total root length, and theoretical hydraulic

conductivity of grass roots at soil depths greater than 1 m suggest deep roots in this grassland have limited functional significance for water uptake.

Restoration Ecology and Grasslands.
Forecasting tallgrass prairie community and ecosystem response to environmental change is a core objective of LTER VI. Restoration studies in tallgrass prairie have become a core part of the Konza Prairie (KNZ) LTER program over the last decade, and are particularly timely because human activities have resulted in widespread loss and degradation of this ecosystem. Three multi-year (to include some multi-site) restoration experiments aim to develop and test hypotheses relevant to key issues in basic ecology while also addressing applied questions related to improving the structure, function, and sustainability of prairie restorations. The core restoration projects at KNZ include: (1) the 1998-established soil heterogeneity plots, (2) the 2006-established cultivar and non-cultivar grass source plots that contain a seeded-diversity gradient, and (3) the 2010-initiated chronosequence plots. Collectively, these studies are providing insights into the roles of biotic and abiotic variation on the restoration of tallgrass prairie communities and associated ecosystem functioning.

The first restoration experiment at KNZ (initiated in 1998 and recently highlighted in the June 2012 LTER Newsletter) is a long-term study of the role of soil resource availability and heterogeneity in the restoration of plant community structure (diversity) and ecosystem processes. This test of the 'heterogeneity hypothesis' has demonstrated important determinants of diversity in newly-restored prairie. Over a decade of study has revealed declines in plant diversity in all treatments, but more species have been maintained in plots with the most soil heterogeneity. A recently acquired grant through the NSF-LTREB Program will enable us to assess longer-term trajectories of plant community and ecosystem recovery and test whether variability in community structure in space and time creates vacancies and resources to promote biodiversity. In the 2012 field season (on-going), we measured plant composition, light availability, inorganic N availability, and total soil C and N in this experiment, representing the 15th year of restoration. These data will be synthesized using time-series analyses to establish the long-term plant community and soil response to the heterogeneity treatments prior to performing annual seed addition (starting in 2013) to address the role of ecological heterogeneity in promoting biodiversity. We have a developed the species list for re-introduction and seed-collection has been a major focus of the 2012 field season.

The 2006-established cultivar-seeded diversity experiment has investigated the role of two factors related to socioeconomic filter in community assembly: selection of seed sources (cultivars or locally-sourced seed) and selection of diversity of species to reintroduce. A parallel experiment was set up at the same time in Belleville, IL to address whether climate may interact with sources and diversity of seeds used to affect developing community structure and ecosystem process. This experiment was idle in 2011-2012, but the Ph.D. student has successfully synthesized the data from this study for his dissertation. The plant community response has been summarized in a manuscript prepared for Ecological Applications entitled 'Convergent and contingent community patterns in two tallgrass prairies restored across a precipitation gradient.' The soil and ecosystem responses to these factors have been synthesized in a dissertation chapter entitled 'Ecosystem function in two tallgrass prairies restored across a precipitation gradient.' The Ph.D. student, Ryan Klopf, is expected to defend his dissertation in Fall of 2012.

In accordance with the LTER VI proposal, we initiated a restoration chronosequence in an agricultural field using the same species, seeding rates, and restoration techniques to examine the extent to which inter-annual variation in environmental conditions during restoration affects species establishment, developing community composition, and ecosystem functioning. The first block of three 20 m x 20 m and two 10 m x 20 m plots was installed in 2010. The second and third consecutive year of plant community composition (at two scales) and ANPP was collected from Block I in the 2011 and 2012 (on-going) field seasons. Seed for the second restoration installation was collected in 2011, cleaned during the winter, and analyzed for purity, germination, and dormancy. Block II was delineated and four 20 m x 20 m plots were seeded in June of 2012. A secondary objective of this study posed in the LTER VI proposal was to elucidate the role of consumers in community development during restoration. To address this, we installed eight 25 m2 (3.2 m high) open-top fences (2 per plot) to exclude animals unable to pass through a 5.0 cm x 7.5 cm mesh (i.e., deer, turkey, large rabbits, etc.). All plant and soil response variables measured in Block I will also be measured in block II, along with comparison of animal exclusion on developing community structure and potentially responses soil processes (i.e., accrual of N in root biomass and net N mineralization). Stem browsing will also be quantified within and outside of the animal exclosures.

Studies of Woody Vegetation Expansion into Grasslands.
Forest encroachment and the expansion of shrubs into grasslands is a widespread phenomenon, occurring in grasslands around the world. This is a serious conservation concern in tallgrass prairies, where woody plant encroachment leads to losses of grassland species and declines in biodiversity. There are also important potential changes in ecosystem processes accompanying grass-to-woodland conversions, though these have not been well documented in many grasslands. Woody plant increases can be directly attributed to alterations in land management (reduction in fire frequency) and may be indirectly facilitated by other factors (increased CO_2 concentration, N deposition, habitat fragmentation, etc.). We have been assessing the causes and consequences of this ecosystem conversion from C4 grass to C3 shrub-dominance by initiating and continuing studies on (1) on the landscape-scale pattern of conversion, (2) the mechanisms facilitating woody plant establishment and spread and (3) the ecological consequences of conversion from dominance by one growth form to another. Thus, we are evaluating the patterns, mechanisms and ecological consequences of an ecosystem in transition from C4 grassland to closed-canopy C3

shrub/woodland.

LTER investigator Briggs and students have been collecting data for woody plant cover on selected LTER watersheds since 1981 covering the range of burning treatments (annually burned, burned every ~4 years and a low-fire frequency (burned once since 1981)). In summer 2011, we re-sampled those watersheds, using a high-precision GPS (~10 cm accuracy) to record the species, location, height (trees) and area (for shrubs) of the dominant woody plants in all selected watersheds. In addition, in 2012 we continued an experiment begun in 2001 to assess the legacy effects of fire history on trajectories of response to altered fire frequency. Long-term fire treatments were 'reversed' on two watersheds previously burned annually in spring and two watersheds protected from fire for ~20 yrs (the 'Fire Reversal Experiment'). The new fire treatments started in 2001, and an assessment of plant and soil responses to the reversal of fire treatments was done in 2006 and 2011. In 2011-12, we continued re-sampling woody plant using GPS and field sampling methods on these watersheds. We are in the process of analyzing these data. In addition, these ground-collected data will be used as verification as we attempt to use various remote sensing platforms (Quickbird and aerial photographs) to estimate the cover of woody plants on watersheds that are not sampled using ground-based methods. The results of this study will be used to interpret the long-term responses to the fire reversal treatments, and will be relevant for new LTER VI experiments focused on the consequences of woody plant encroachment into grasslands.

Abiotic and Biotic Controls of Predator-Prey Interactions.
Understanding how biotic and abiotic factors combine to affect species interactions is an important challenge in ecology. However, the effects of biotic and abiotic factors on species interactions are often studied separately. In 2011-12, we continued a multi-year field experiment (begun in 2007) using a model plant-grasshopper-spider food chain to understand how key biotic and abiotic factors (morning temperature, food quality, herbivore density, predation) interact to affect grasshopper performance and trophic interactions, including the occurrence of trophic cascades. Field enclosures containing one-, two-, or three- level food chains are placed over natural vegetation. Large chambers with movable roofs surrounding some of the enclosures are covered with plastic sheeting or 50% shade cloth to either increase or decrease morning temperatures. Because grasshoppers prefer warmer temperatures than wolf spiders, we can either expand or contract the amount of time that grasshoppers and spiders are both active by altering morning temperatures, thus influencing the potential for encounters between these species. Grasshopper?spider interactions are temperature dependent. At lower temperatures, predator effects are strengthened and trophic cascades are observed. However, when temperatures are increased, the effects of predators are weakened and no trophic cascades are observed. This experiment will help us gain a mechanistic understanding of how the environmental context influences species interactions. Furthermore, examining multiple biotic and abiotic factors simultaneously enables us to identify non-linear and compensatory interactions among factors that could not be identified by examining them separately.

Responses of Grassland Spider Communities to Fire and Bison Grazing.
This project (directed by LTER co-PI Joern, with graduate student Jesus Gomez) evaluates the role of spatial and temporal habitat heterogeneity from managed burning and bison grazing to our understanding of species diversity for the spider assemblage, an important and functionally important arthropod predator community at Konza Prairie. Spiders are ubiquitous predators in terrestrial systems that utilize various hunting strategies: web building, sit and wait, trap doors and active pursuit. Spiders partition their habitat within watersheds at small scales to maximize the effectiveness of a particular hunting strategy and reduce interspecific competition, while potentially exhibiting landscape level responses at the large scale along gradients of habitat differentiation. Responses of spider communities to major disturbances in grassland ecosystems have not been studied in detail. The main goal of this research project is to understand how the spider predator assemblage responds to large-scale habitat disturbances. At KPBS unique long term manipulations (fire frequency and bison grazing) at watershed levels have resulted in a mosaic of grassland and shrub lands scenarios. This mosaic of habitat types may result in a diverse series of scale-dependent spider community assemblages.

Little information on spider responses to habitat heterogeneity was available for Konza Prairie until this study began. To date, a spider community composed of 75 species (~ 60% identified to species) belonging to 60 genera and 17 families exists along a gradient of habitat types at KPBS. The habitat complexity and heterogeneity hypothesis predicts that the overall abundance and species diversity of spiders increases with spatial heterogeneity of habitat structure, which in turn reflects fire-grazing interactions. To address this hypothesis, 23 sites were sampled along a gradient of habitat types that range from grass dominated habitat to gallery forest in both bison grazed and ungrazed watersheds. Vegetation characteristics were also evaluated using standard techniques to quantify vegetation structure and heterogeneity. To date, results from this study indicate that species richness doubles from early to mid/season. Increases in spider abundance increases on ungrazed sites may result from increased spatial heterogeneity and microhabitat diversity in response to plant growth over the summer. Spider species abundance and diversity is influenced by effects of fire frequency on vegetation. But, spider diversity and abundance also increased over the summer independent from fire frequency. This increase in species richness may be promoted by higher microhabitat availability later in the growing season in response to from plant growth differentiation. Increased microhabitat diversity may facilitate resource partitioning and the coexistence of more spider species, especially web-builders. Spider abundance and species richness increased with increasing spatial heterogeneity in vegetation structure in the early season. Bison grazing influenced habitat heterogeneity by maximizing microhabitat availability and use early in the summer. In July/August, previously existing spatial heterogeneity in vegetation structure was no longer evident, suggesting a switch to the importance of total structural volume of vegetation to explain increased spider diversity. Preliminary observations from ongoing surveys for web-builder spider community suggest that spider diversity and abundance declines very fast as plant community becomes dominated by grasses, spatial and temporal structural heterogeneity is reduced, and woody plants and shrubs become less abundant.

Long-Term Studies of Small Mammal Dynamics.

LTER investigators Don and Glennis Kaufman continued to assess small responses to watershed-level fire and grazing treatments. In 2012, they sampled 14 LTER core trap lines in both spring and fall. This will provide 32 years of continuous data. They also continue to analyze data and write manuscripts from core trap lines, seasonal trap lines, and reversal trap lines (details of recent analyses are provided in the Project Findings section).

Grassland Stream Studies.

Grassland stream studies are an important component of the Konza LTER program. Hydrology of Konza streams continues to be documented at four weir sites operated by the LTER program, plus a USGS gauging station located on Kings Creek and seasonal sampling of fish assemblages at four permanent sites is ongoing. In 2011-2012, we continued long-term monitoring of stream discharge, chemistry, macro-invertebrates and fishes. In 2012, we also continued new monitoring of stream geomorphology and sediment transport (Melinda Daniels). These data will yield new information over decadal time scales about sediment and nutrient transport, and how these trends are related to changes in woody riparian vegetation expansion and in-stream biodiversity, as well as the impacts on interannual climatic variability and associated stream hydrology. We also continued mesocosm experiments testing the effects of consumer diversity on ecosystem properties of tallgrass streams and scaling of those effects.

We continued two experiments in 2011-2012. Dodds, Whiles and Daniels continued a new cross site project titled 'Biotic integrity of prairie streams as influenced by patch burn grazing and riparian protection' which is funded by the Missouri Department of Conservation for research at Missouri, and paired with estimates of response to patch burn grazing at Konza funded by the LTER. Through this effort, we are examining potential responses of Missouri headwater streams (water chemistry, physical habitat, biological integrity) to patch burn grazing with no riparian fencing and patch burn grazing with riparian fencing (and control watersheds with no grazing). This project is based on the Osage Prairie reserve in SW Missouri, and data from this study will be used in comparisons with data from the Konza LTER patch burn grazing experiment. Experiments at both locations concluded their pre-data period and cattle were placed on both sites in Spring 2011. A draft manuscript of preliminary data, led by graduate student Danelle Larsen at KSU, is in revision. Karen Jackson, an MS student at SIU, presented results of her pre-manipulation sampling at the 2012 Society for Freshwater Science (formerly NABS) meetings. The Konza experimental watersheds do not have fenced treatments, but can be compared to traditional cattle grazing, ungrazed prairie, and bison grazed prairie. Results of this project will have direct relevance to management of remnant and restored tallgrass prairie, as patch burn grazing is rapidly gaining favor as a management tool even though there is little information on how it may impact biotic integrity in and water quality of headwater streams. We found that ecosystem characteristics are similar across these two sites, with good water quality characteristic at both sites. We continued more detailed geomorphological sampling at both sites, as well as monitoring relative levels of fecal coliform. Geomorphological monitoring across sites documented a severe channel erosion response to watershed grazing introduction. Dodds' MS student, D. Larsen, also concluded an intensive herpetofaunal component to the research at the Missouri study sites.

In 2008-09, we initiated the LTER VI riparian vegetation removal experiment in two watersheds where a 30- 50m stretch of woody vegetation was removed in a 20 m wide swath. Initial results indicated strong response of filamentous algae to the vegetation removal. The analyses of results of much of this experiment were published in 2012. Through this study, we documented that vegetation removal (restoration to natural riparian conditions of grassland streams) lead to 1) increased denitrification rates (Reisinger 2010), 2) shifts in communities with fewer leaves and bryophytes, and more filamentous algae, 3) corresponding shifts in ecosystem metabolism related to more light reaching the stream and less detrital leaf materials (Riley and Dodds 2012). Jodi Vandermyde, an MS student at SIU, has been examining invertebrate and benthic organic matter responses to this manipulation and will defend her thesis and submit her results for publication during fall semester 2012 (see below). This project formed the foundation for the whole-stream riparian forest removal manipulation on KPBS.

We continued work on the whole-watershed riparian vegetation removal project. We finished preliminary (pre) sampling of sediments, algae, stream invertebrates, terrestrial insect inputs to streams, and riparian spider communities for a more extensive (entire watershed) removal. K. Erndt (Ph.D. student and IGERT fellow at SIU) is leading the in-stream and riparian invertebrate responses component of this study, and she presented preliminary results of her research at the Society for Freshwater Science (formerly NABS) meetings in spring 2012. We also completed baseline sampling of geomorphology, oxygen dynamics, riparian sediments, and vegetation transects. Pre sampling ended in Winter 2011 and post-manipulation sampling is now underway.

During Winter 2010-2011 woody riparian vegetation was removed from 4.8 km of stream riparian area, 30 m from each side of the main channel, and 10 m for small side channels on watershed N02B. Our hypothesis is that headwater streams yield less water and retain more nutrients with increased riparian canopy cover. We expect that increased riparian forest cover reduces stream water flow (as a result of increased transpiration), reduces grasses that retain sediments, and subsidizes the stream channels with nutrient-poor/ carbon-rich leaves, leading to greater nutrient retention. We predict that woody invasion alters aquatic invertebrate communities and riparian vegetation and invertebrate populations. Long term data suggest reduced water yield with no substantial changes in precipitation or temperature on Konza, providing correlative data for reduced water yield related to riparian vegetation. We mechanically removed all woody vegetation within 10 m of either side of a 4-km reach immediately upstream of a weir with a long-term hydrology and water chemistry record (N02B), and will continue to mechanically control woody vegetation for 6 yrs. We have 2 comparison gauged watersheds and 15 yrs of before-removal water quality data from this watershed. We will continue our standard monitoring regime at this weir to assess the effects of the riparian removal on nutrient and sediment transport. We are examining a variety of potential biological responses to this removal including 1) stream invertebrates, 2) riparian invertebrates, 3) riparian vegetation, 4) riparian soil fungi and 5) stream algal community composition. We also initiated a riparian restoration comparison by re-seeding smaller areas of the removal.

LTER investigators Whiles and Gido continued investigations of stream community structure function, stream food web dynamics, and patterns and controls of secondary productivity in grassland streams. Long-term monitoring of fish assemblages in 2012 represents the 18th year of data collection from Kings Creek. In addition, Gido completed the 5th year of parallel fish monitoring in Fox Creek on the Tall Grass Prairie Preserve (approximately 80 km south of Konza), which was initiated to help regionalize data collected from Konza. Frequent sampling along a gradient of headwater springs to downstream perennial reaches will help us understand the importance of landscape connectivity on the stability of native fish populations. These data were used in two manuscripts submitted in summer 2012 by graduate students testing habitat associations of fishes (Erika Martin lead author) and testing models of species richness (James Whitney). In summer 2011, graduate students Erika Martin and Allison Veach conducted a mesocosm experiment testing the effects of community diversity on heterogeneity of ecosystem properties of prairie streams across multiple spatial scales. A companion field study was initiated in summer 2012 to test the effects of natural variation in consumer diversity on ecosystem properties in both Kings Creek and Fox Creek. These experiments will help evaluate our ability to scale results from small scale experiments to entire stream reaches.

A new stream geomorphology program was initiated in 2010, establishing long term monitoring sites in 10 Konza watersheds across a range of fire and grazing treatments and including the riparian removal watershed. Initial baseline samples of channel cross sectional morphology and sediment substrate characteristics have documented significant differences between ungrazed, bison grazed and cattle grazed stream channels. Bedload transport and suspended load transport traps have also been installed in 10 Konza streams and initial samples, while still in the early stages of analysis, also seem to demonstrate substantial process differences between grazing treatments. The monitoring network was extended beyond Konza to complimentary sites in pastures intensively managed by the KSU Agronomy Department for beef cattle production to include sites more representative of the private ranch lands throughout the region. Temporal resolution of suspended sediment sampling was upgraded with the installation of six ISCO stormflow samplers. The ISCOS were recently deployed for a diurnal sampling campaign to evaluate temperature or time dependent fluctuations in suspended load dynamics at baseflow to test the hypothesis that grazer activity in stream channels varies with temperature and between species. This diurnal sampling campaign will be repeated when grazers are temporarily removed from the treatment watersheds during the Fall round-up. Konza LTER has partially supported one PhD student (Bartosz Grudzinski, KSU Geography) to conduct this work. A draft manuscript based on this initial cross-watershed comparative study, led by graduate student Bartosz Grudzinski, is in preparation for submission in Fall of 2012. These results were also presented at the Fall 2011 American Geophysical Union and 2012 Association of American Geographers national meetings. Daniels and Grudzinski will submit a related DDRI proposal to the NSF Geography and Spatial Sciences October 2012 RFP. Two additional Daniels graduate students are in the early phases of investigating: 1) long term hydrologic records collected at tree Konza tributary gages and the USGS Kings Creek gage, and 2) the in-channel large wood loading in the Kings Creek main stem and three ungrazed Kings Creek tributaries. Danelle Larson (ne. Russell), Bartosz Grudzinnski, Walter Dodds, Tony Joern, Adam Skibbe, and Melinda Daniels submitted a manuscript linking bison grazining to long-term sediment collections in grazed and ungrazed streams.

We added a new faculty member at Kansas State University through the Kansas Cooperative Fish and Wildlife Unit (Martha Mather). Dr. Mather and her postdoctoral researcher Joe Smith oversaw an REU student who investigated crayfish movement. Kansas State University, Civil Engineering has also added a new Assistant Professor, Natalie Mladenov. We are collaborating with her and an NSF-funded postdoctoral researcher, Janine Rueegg, to analyze the long term trends of dissolved organic carbon from LTER funded measurements.

LTER investigators Whiles, Gido and Dodds initiated an NSF Macrosystems project: Scale, Consumers and Lotic Ecosystem Rates (SCALER): from decimeters to continents. This project will help us understand how regular measurements made as part of the Konza LTER scale to entire watersheds and how such measurements and scaling applies to other sites (LUQ, CWT, ARC, BNZ). Preliminary experiments for this project were completed on Konza in 2012, and a new postdoc (Janine Rueegg) was hired. A data manager (Sufhang Jai) who will oversee data management for this project and work with the LTER network office and the KNZ information manager to make these data fit the LTER data requirements, and ultimately to allow them to be served by the LTER network office. These preliminary experiments also included an LTER REU student Adam Siders, who is investigating spatial heterogeneity in stream metabolism; a project complimentary to this research.

Continued participation in the LINX (Lotic Intersite Nitrogen eXperiment) resulted in an NSF funded workshop at Konza (Dodds and Whiles) to compare food webs of Konza streams to those in other biomes, from tropical to arctic. Analyses and modeling continues of this effort.

Groundwater Hydrology and Geochemistry

In addition our surface stream studies, we continue to monitor physical and chemical hydrogeology, including water levels, nutrients and water geochemistry under the direction of Gwen Macpherson (KU). Water levels in all wells at Konza N04D watershed and water chemistry in selected wells continue to be measured for the long-term data base; high-frequency (5-minute) data collection of water-level and temperature continues in one well. Some of the water-level data was used as part of the calibration for a new 5166 km2 regional model, completed in 2011 under the direction of David Steward (KSU), that shows the hydrogeology of the Konza LTER site in the context of regional groundwater flow and the data will also be used by Andrea Brookfield (Kansas Geological Survey, KGS) in a regional flow model that includes the thermal response of aquifers to climate change.

Water geochemistry investigations include a KU M.S. student's (MishaTsypin) thesis research (M.S., December 2011) that has focused on soil- and groundwater chemistry and gases (CO_2), dissolved species and stable isotopes, in relation to major rainfall events. One manuscript is in press, and a second one is in draft form, waiting for more isotope data. A new effort is underway to better measure groundwater pH at the site, with support from the Konza LTER for a downhole pH sonde and from the KU Dept. of Geology for a field computer to operate the sonde, both purchased in 2011. Initial results were presented at the Geological Society of America (GSA) national meeting (October 2011). A new M.S. student (Huan Liu, started the program Fall 2011) completed the first of two sessions of field work this summer. His research is quantifying the amount of dissolved inorganic carbon (DIC) from groundwater discharge to streams that is sequestered as particulate organic carbon in a prairie stream. He is comparing Konza, summer and late fall seasons, with a karst region in China (Guilin).

An undergraduate (KU; Rachelle Warren, B.S. May 2012), under Macpherson's direction, has analyzed and compiled the chemistry of throughflow (soil water moving ~horizontally from recharge point toward streams) produced during rapid snowmelt events (RSEs); Macpherson is expanding the investigation of the micronutrient and some of the macronutrient content of the water. Two events were sampled (2009 and 2011) and climate data are being examined to assess any long-term changes that might lead to more frequent RSEs. Macpherson continues work on interpretations of elemental chemistry data from sequential chemical extractions of soil; the soil environment is the first environment encountered by water that eventually recharges groundwater, and so has a large influence on the groundwater chemistry. Macpherson also continues work to investigate the possibility of long-term trends in chemical weathering at the Konza LTER site (Macpherson, 2010), considering the long-term increase in groundwater CO_2. Macpherson is also writing a review of the history of investigations in below-ground CO_2 relevant to groundwater. These manuscripts and an unrelated project are the focus of a six-month sabbatical at the University of Pittsburgh (June ? December 2012).

Remote Sensing and Fire Frequency (Doug Goodin and others) - Optical remote sensing is widely used for mapping burned area in a wide variety of ecosystems including tallgrass prairie. Typically, these remote sensing observations rely on the spectral contrast between the burn remnant and its surrounding non-burned vegetation. Numerous methods for extracting this information have appeared in the remote sensing literature, however the majority of these methods have been developed for use in forests or cropland ? systems where the spectral contrast between burned and unburned is great and the contrast does not change rapidly over time. Tallgrass prairie presents a challenge for burn mapping because the burn season typically occurs just before (and in some cases at the beginning of) the active canopy season, thus the burn remnants occur against a continually changing background. In addition, the technical challenge of burn mapping in tallgrass prairie is increased because the burning season coincides with the cloudiest time of the year, and also because the burns are often rather small relative to the spatial resolution of the satellite sensors most suitable for mapping them. Addressing these problems requires a more detailed understanding of the temporal pattern of spectral reflectance of burned and unburned prairie. We addressed this problem by collecting in-situ radiometry samples from burned and unburned sites at Konza Prairie. These In situ hyperspectral radiometer samples of burned and unburned tallgrass prairie were used to simulate several MODIS bands and indices that are commonly used for burned area detection. These indices were tested for their ability to differentiate between burned and unburned areas starting at the time of burning (April) and ending in late August.

Of the existing burn indices we tested. Most showed some ability discriminate between burned and unburned sites immediately after the burn had occurred. However, the discriminant ability of most of these indices decayed very quickly. Of particular note was the fact that the Normalized Difference Vegetation Index (NDVI) a widely used data product in remote sensing, showed virtually no ability to identify burns more than a few days old. Fire-specific spectral indices such as GEMI, GEMI-B, NBR, and MODIS band 7 (LMIR), also showed little capability for differentiating burned from unburned areas longer than several days after the burn. Others, including BAI, MIRBI, and MODIS bands 3 (red), 4 (NIR), 5 (LNIR), and 6 (SMIR) were able to differentiate between burned and unburned areas well into the growing season?in some cases even through the entire length of the sample. The performance of particular bands and indices often depended on grazing and other factors that influenced pre-burn biomass.

Social Science Activities

Konza LTER investigators, led by John Harrington (KSU, Professor of Geography) continued several cross-site activities supported, in whole or part, by social science supplements to the core LTER grant. These activities included: (1) The LTER cross-site fragmentation effort (with CAP, SEV, SES, and JRN) and (2) the LTER cross-site MALs (Maps and Locals) effort. A co-authored article in Urban Ecosystems (by York et al. and available on-line first in Feb. 2011) summarized the cross-site fragmentation effort. MALs is a collaborative effort of LTER sites that seek to study changing social-ecological systems using a mixed methods comparative approach. The project was launched in 2009 through the

Social Science Supplement funding opportunity of the LTER Network and a second round of funding was obtained in 2010. The objective of MALS is to: 1) use spatial representation of land cover and land use to identify patterns of landscape change in regions in and around LTER sites; and, 2) integrate Local Ecological Knowledge (LEK) and other existing social data into theories and models of social-ecological change and their implications for human livelihoods. Forty-two interviews on LEK were obtained in the summer of 2010 and that qualitative data was the substance of Iris Wilson's Master's thesis (Perceptions of Climate and Environmental Change in Northcentral Kansas).

22nd Annual Konza Prairie LTER Investigator's Workshop.
The Konza Prairie LTER program hosted its 21st annual LTER Workshop on June 3, 2012, at the Konza Prairie Biological Station Meeting Hall (KMH). The KMH is the result of an extensive renovation of an historic limestone barn, built in 1910. Extensive remodeling of the former barn, completed in fall of 2008, created a modern and highly flexible meeting space at the field station, while preserving the historic character of this traditional early 20th-century stone building. The facility includes the Cortelyou Lecture Hall, which seats approximately 100 people and includes high-quality A/V capabilities and wireless internet access. The KMH also includes a large multi-purpose room, which includes 1,850 square feet of space that can be configured for workshops, posters and other research displays, social gatherings, and education programs. The Konza LTER workshop is an annual event that brings together senior scientists, students and staff for a day of research presentations, planning activities, and informal social interactions. These meetings are increasingly important for bringing together local and off-campus investigators. The 2012 workshop included investigators, students, staff and docents from Kansas State University, as well as researchers and students from Colorado State University, Oklahoma State University, Southern Illinois University, and Yale University. The 2012 workshop included a full day of oral presentations, featuring primarily LTER graduate students and post-docs, as well as poster presentations from graduate students and co-investigators. Topics ranged from soil and plant processes, to grassland stream ecology, to impacts of regional land-cover change. Presentations included updates on the status of ongoing LTER activities, highlights of recent research accomplishments, and planning for new experiments being implemented as part of the Konza LTER VI renewal. An LTER PI planning meeting followed the formal presentations.

Information Management.
Information management continues to be a priority for the Konza Prairie LTER program. The focus in 2012 was placed squarely on updating specific aspects of our on-line database, with emphasis on data completeness, accessibility and EML integration. In 2012, these activities were directed by Adam Skibbe (Konza LTER Information Manager) and Carol Gadbury (LTER Program Assistant and Archivist), with assistance from LTER student employees Caleb Siebel, Severin Mortensen, Jamie Ernst and Tammy Sonnentag (data enterers), Leela Anusha (programmer) and Mark Sowers (geographic information systems).

In 2012 we continued to work towards our long-term goals (assuring data integrity and security; facilitating access to datasets and metadata; enhancing the utility of data and metadata for current and future generations; ensuring compatibility with current LTER standards and best practices, and with the developing Network Information System (NIS), with added focus on preparation, and working on suggestions from the 2011 NSF site review.

As mentioned, the primary focus for 2012 has been on making the Konza IMS and data products NIS compliant. To do this we have been working towards updating our EML to ensure completeness of the metadata, adding links to data packages, and ultimately updating from version 2.0.1 to 2.1, the current standard. Additionally we have developed workflows to automatically export and store harvestable .CSV files for direct download access by the NIS on our website. Though this is an ongoing processes, we have thus far made major strides towards this goal.

A continued goal is to make all new LTER data available on-line as soon as possible, as well as continuously working towards filling in any gaps that may exist in our digital holdings. Additionally, we wish to point out that these on-line data continue to be made available to outside investigators without restriction. We continue to offer data downloads via a variety of search and browse options in the 'Data' section of our website, as both ASCII text files and SQL Server download with a query option. As mentioned above, many of our data products are now also available via Metacat, the NIS data portal.

The Konza LTER IMS continues to include an up-to-date list of all Konza LTER publications including journal articles, conference proceedings, books and book chapters, theses and dissertations, and electronic publications supported by Konza LTER program. The list is searchable by key words, author name, and date. We have linked personnel with publications through a dynamic connection with our SQL Server database, making it easy for users to find specific personnel information and related publications.

Mr. Skibbe continued to collaborate with other LTER information managers on the LTERMapS network-wide online GIS mapping interface (http://www.lternet.edu/map/). Phase two of 'MapS' was started in the Fall of 2011 but was put on hold in lieu of work on the GeoNIS, a value added geodatabase project to serve as the back end for LTERMapS, as well as an online repository for LTER Network geospatial data. With money from the 2011 IM supplement Mr. Skibbe attended a workshop in early 2012 to begin work on development of the GeoNIS framework, as well as best practices for archiving spatial data for harvest into the NIS.

In addition to the GeoNIS, 2012 supplement funds were used to hire additional student support staff and send Mr. Skibbe and a technician to the SensorNIS meeting last fall. The SensorNIS meeting resulted in a plan to implement a series of data workflows for both streaming and non-streaming Konza LTER datasets, an approach that will aid in QA/QC and data access. We hope to implement some of these plans in the following year.

Some 2012 hardware supplement money went towards the purchase and deployment of a series of field devices for data collection. Specifically, given the availability of data collection software, GPS, and interface with our existing data loggers we decided to deploy a series of Apple iPad and iPod touch devices with ruggedized cases. We are hoping these devices change the way much of our data is collected in the future.

The Konza LTER program has continued to work towards increasing our spatial data offerings, both in historic data as well as newly collected data, digitizing and rectifying a series of historic aerial photographs, and developing a detailed GIS of past and current research plot locations. Using high-resolution GPS unties we have collected approx. 95% of sample locations related to LTER datasets. These data will be error checked and made available via our website as datasets sometime later this fall.

In 2012, we continued to update a variety of our metadata and procedural protocols to ensure any changes in technique or structure of our datasets are accounted for. Work on our data catalog (metadata), our methods manual (techniques), as well as our data entry procedural handbook is an ongoing process. In addition, we continue to improve and build on various workflows for data processing (from field data collection through entry, and QA/QC) to support prompt data entry and updates.

Educational Activities.
Graduate student training continues to be an important component of our LTER program. During this funding period, we provided stipends and/or other support (computer, laboratory, field vehicles, etc.) for >20 graduate students. In addition to KSU students, the Konza Prairie site continues to be used by graduate students from a number of other U.S. institutions including in 2008-2012: Colorado State University (Greg Buis, Amanda Lease, David Hoover, Kevin Wilcox, Ashley, Shaw, Jenny Song), Cornell University (Rebecca Lohnes), Southern Illinois University (Ryan Klopf, Dan Whiting, Kim Erndt, Jodi Vandermyde), St. Joseph's University (Kim O'Keefe, Nick Tomeo), Yale University (Cynthia Chang, Meghan Avolio, Kimberly LaPierre, Beth Forrestel), Oklahoma State University (Wes Sprinkle, Ray West, Melinda Williamson), University of Kansas (Lisa Tiemann, Tyler Buck, M Petrie), University of Kentucky (Bridget Sousa), University of Minnesota (Charlotte Riggs), University of Missouri (Sarah Harris) and the University of New Mexico (Sally Korner), among others.

The Konza LTER program also offers research experiences for a large number of undergraduate students. In 2012, we supported 2 LTER REU students with supplements, and contributed support to the REU site program. Summer 2012 was the 17th year that Konza Prairie and the Division of Biology at K-State have offered a 10-week summer undergraduate research program. Participants in the structured program included 10 students supported by NSF-funded REU Site and Supplements, and 7 students supported by a related NSF-funded Undergraduate Research Mentoring (URM) program, being co-led by LTER investigator Ari Jumpponen.

The Konza Prairie LTER program has a strong history of providing research experiences for students from under-represented groups, which we strive to continue during LTER VI. In the past, we have participated in the ESA SEEDS (Strategies for Ecology Education Development and Sustainability) program. In 2005 we hosted two SEEDS students working on the Konza site, and in 2006, we hosted one SEEDS student. From June 4-9, 2006, the Konza Prairie LTER program hosted a SEEDS student field, which included 19 students from 16 schools across the country, including the territories of American Samoa and Puerto Rico; one SEEDS faculty from Yale University; and three SEEDS staff from the Ecological Society of America. The program for this involved field and laboratory activities that included a large number of LTER PIs and graduate students, and was well received by both ESA staff and SEEDS students. A report on the Konza field trip is available on the SEEDS web site (http://www.esa.org/seeds/fieldtrips/past.php). In 2009, one of our former REU students (Jorge Mendoza, REU in 2008) was selected for the KSU Developing Scholars Program, and paired with Konza LTER investigator Brett Sandercock as his research mentor (www.k-state.edu/media/newsreleases/jan09/mendoza11309.html). In 2010, Konza undergraduate student researcher Graciela Orozco (mentored by LTER co-PI Jesse Nippert) was selected for KSU's McNair Scholars program, which prepares underrepresented and first generation students for successful careers as graduate students, professors and professional researchers (www.k-state.edu/media/newsreleases/feb11/labtechs21511.html).

The Konza Schoolyard LTER program is the centerpiece of the Konza Environmental Education Program (KEEP), and continues to be active at both the site and network levels. Formal educational activities at the K-12 level began with the initiation of the Konza Environmental Education Program (KEEP) in 1996, and were greatly expanded with the initiation of the Konza Prairie Schoolyard LTER (SLTER) in 1998. The Konza Prairie Schoolyard LTER (SLTER) program is now entering its 15th year as an science education program for K-12 teachers and their students, built around the successful Konza Prairie LTER program. In January of 2012, Jill Haukos was hired as the new Environmental Education Program Director and in March Jan Evans was hired as the Assistant Environmental Educator. With the arrival of the new staff our program continues to grow and develop to deliver the highest quality environmental education experience possible. Our SLTER program focuses on provides teachers with the educational resources to incorporate field biology and ecological science into their classes, an area which has not received adequate attention or resources in many school districts. All of our science activities are correlated with state and national standards. Further details on the K-12 education program are provided in the Training and Development section of this report.

A novel aspect of our K-12 education program is the development of databases on plant and animal phenology (timing of plant or animal growth and activity) from sites across the state. Students can compare the dates of first biological events for plants (flowering, senescence) and animals (adult insect emergence, mammalian activity) in regions representing varied climates and prairie types across Kansas. This database is updated annually, and allows students to look for trends and changes in emergence or bloom, which are indicative of natural climatic variability, as well as potential directional climate change (www.ksu.edu/konza/keep/phenology.asp). This activity grew out of a local effort by the Konza Environmental Education Program (KEEP) to database Konza Prairie phenological events with the help of 'citizen science' volunteers. Volunteer participation in this local program has increased annually. In the future we hope to expand this program to volunteers in small communities statewide where we also have Satellite SLTER sites.

Cross-Site and LTER Network-Level Activities.
Konza LTER scientists continue to lead and participate in numerous cross-site research projects (with both LTER and non-LTER sites) and LTER Network-level activities. For example, Blair, Knapp and Smith have been regular participants in LTER planning for the future (i.e., the ISSE initiative) and many Konza scientists lead or participate in various LNO and cross-site activities (e.g., the Climate Change working group, Experiments within the LTER network, etc.). Blair chaired the 2011 Science Council meeting Planning Committee, presented at the 2011 NSF Mini-Symposium, and currently serves on the LTER Executive Board (2011-2014). Knapp chairs the publications committee, and Goodin has been a long-time participant on (and former Chair of) the LTER Climate Committee. Other contributions to LTER Network-level activities include service by John Briggs on the Network Information System Advisory Committee (NISAC), and service by David Hartnett on the US ILTER committee. John Harrington contributed to four recent LTER Network-sponsored workshops on integration of social and ecological sciences, and several Konza scientists have had an active role in the EcoTrends project. Konza LTER investigators Knapp and Smith were contributors to the 2012 BioScience issue commemorating the 30th anniversary of the US LTER Network. Konza LTER scientists and students are participants in the Nutrient Network (NutNet) Global Research Cooperative (locally led by M. Smith). There are numerous other examples of cross-site research activities being led by Konza LTER scientists.

The Konza LTER site also continues to be used by researchers from other sites and institutions for a variety of cross-site comparisons. Examples of recent and ongoing studies being done at the Konza Prairie LTER site include:

? assessing the role of evolutionary trade-offs in enzyme activities in microbial community function, led by Mark Bradford (Yale), Noah Fierer (U Colorado) and Rebecca McCulley (U Kentucky)

? a cross-site comparison of soil microbial-plant interactions in fertilized and unfertilized soil, led by Katie Suding (UC Berkeley)

? isotopic approaches to separate heterotrophic and autotrophic sources of soil CO_2 and their responses to warming and altered precipitation in grassland ecosystems, led by Dr. Weixin Cheng (UC Santa Barbara)

? studies of the patterns and controls of soil black carbon storage, a multi-site study directed by Johannes Lehmann (Cornell University);

? studies of trace gas flux from mesic grasslands led by Emily Elliott (U of Pittsburgh)

? stable isotope studies of litter decomposition directed by Francesca Cotrufo (Colorado State University);

? studies of soil microbial community composition, C cycling and responses to altered precipitation patterns, a multi-investigator project directed by Dave Myrold (U of Oregon);

? studies of the role of dissolved organic C in streams from a range of ecosystem types, directed by Dr. Rudolph Jaffee (Florida International University)

? a cross-site study of methane uptake rates and the identity of methane oxidizing bacteria, led by Dr. Joe van Fischer (Colorado State University)

International Collaboration
Konza LTER scientists remain active in a variety of international collaborative efforts. For example, Konza LTER scientists and scientists from South Africa are conducting collaborative studies of ecological responses to fire and grazing in North American and Southern African

grasslands [J. Blair (KSU), M. Smith (Yale), Alan Knapp (CSU), Scott Collins (UNM) and collaborators in South Africa (Kevin Kirkman and Richard Fynn at the University of KwaZulu-Natal, Pietermarizburg)]. In 2009, Konza LTER co-PI Jesse Nippert used support from the Provost's office at K-State to initiate a new collaboration with Dr. Tony Swemmer at the South African Environmental Observation Network (SAEON) in Phalaborwa, South Africa. SAEON supports a long-term network of in-situ environmental observation monitoring and data collection, the equivalent of NEON in the United States. In 2010, Nippert was awarded an international supplement to our core LTER grant to continue and expand these studies on the impacts of woody plant encroachment into South African grasslands, which complements similar work being done at Konza, and in 2012 he continued and expanded that work. Konza co-PI David Hartnett maintains collaborations with colleagues in Botswana, and has supported exchanges of graduate students there. Hartnett and students continued their studies of the comparative population ecology of grasses of North American grasslands and southern African savannas, with a return sampling trip in June 2012. A study of patterns of belowground bud banks, root system architecture, and mycorrhizal symbiosis in 18 southern African semi-arid savanna grasses is currently in progress. A novel finding of this research is that, in some African grasses, mycorrhizal fungi and fungal exudates form a protective sheath around roots, and sheath thickness appears to increase with increasing aridity. This may be an important trait increasing the drought-tolerance of grasses in increasingly arid environments. Hartnett led a summer study-abroad field course on the 'Ecology of African Savannas' in 2009 and 2012, providing international field experience for both KNZ-LTER graduate students and undergraduates and in 2010 published a paper in the Bull. Ecol. Soc. Amer. entitled 'Into Africa: Promoting international ecological research and training in the developing world'. In addition, Hartnett and Joern are Co-Directors of the Institute for Grassland Studies at KSU, which promotes international collaborative research on grassland ecology. In 2010-12, Konza LTER scientist Brett Sandercock continued a collaborative study (funded by an LTER international supplement) with scientists in Uruguay to assess population dynamics of a migratory grassland bird (the Upland Sandpiper) in its northern and southern hemisphere ranges. In 2009, Konza Prairie LTER Scientists were invited to China to consult on grassland and herbivore studies (Joern) and to participate in an international conference (Blair and Knapp) organized by the Chinese Academy of Sciences, and in 2010 Konza supported reciprocal visits from 4 Chinese scientists. Konza Prairie continues to host numerous visits by international scientists and students, including (in 2008-12): Dr. Marjan Jongen of the Instituto Superior de Agronomia, Lisbon, Portugal; Matilde Alfaro-Barrios of Averaves-Investigaci?n y Conservaci?n, Uruguay; Dr. Shuguang Hao (Chinese Academy of Sciences); Dr. Yingzhi Gao (Northeast Normal University); Dr. Nianpeng He (Director, Inner Mongolian Grasslands Ecosystem Research Station), and Dr. Xin Xiaoping (Director, Hulunber Grassland Observation and Research Station); Juergen Kreyling, University of Bayreuth, Germany. The Konza LTER program also provides on-site research opportunities (as well as logistic and/or financial support) for graduate students from a number of international venues (e.g., in 2008: Elske Koppenaal, Groningen University, The Netherlands. In 2009: Nicholas Zaloumis, University of Cape Town, South Africa).

Konza Prairie hosts Grasslands in a Global Context Symposium

On September 12-14, 2011, Kansas State University hosted an international symposium entitled 'Grasslands in a Global Context' to celebrate two important milestones for the Konza Prairie Biological Station (KPBS) and the Konza Prairie Long-Term Ecological Research (LTER) program (KNZ) - 40 years since the establishment of KPBS as a biological research station and 30 years since the initiation of the Konza LTER program. In that time, KPBS and the associated KNZ LTER program have grown into a world-class grassland ecological research facility and program, which supports the research activities of scientists and students from institutions across the US, as well as collaboration with international scientists from around the word. Over 1,100 articles in multiple scientific journals and books, and more than 230 student theses and dissertations, have been published based on research at KPBS. In addition to far-reaching scientific impacts, results from Konza research have contributed to grassland management and governmental policy decisions, and are highlighted in a growing number of textbooks. To celebrate these milestones, we invited internationally-recognized leaders with extensive experience in multiple grassland ecosystems and paired them with current KNZ LTER investigators, with the goal of developing a current, comparative synthesis of grassland/savanna ecosystems based on a comparative analysis of studies at Konza Prairie and grasslands in different regions and with different climates and evolutionary histories. This synthesis was aimed at synthesizing key findings from 40-years of research in tallgrass prairie at the KPBS and comparing these to studies in other grass-dominated ecosystems, with the goal of identifying generalities in the structure and function of grassland and savanna ecosystems around the globe, recognizing continental level differences of critical importance, while identifying significant research gaps that can drive future studies. The symposium included approximately 200 participants. In addition to KNZ LTER scientists from multiple institutions, invited speakers and panel members included Osvaldo Sala (U of Arizona), Peter Adler (Utah State U), Sally Archibald (CSIR, South Africa), William Bond (U of Capetown, South Africa), David Briske (Texas A&M), Doug Frank (Syracuse U), Sam Fuhlendorf (Oklahoma State U), Nancy Grimm (U of Arizona), Richard Hobbs (U of Western Australia), Herbert Prins (Wageningen U, The Netherlands), Bob Scholes (CSIR, South Africa), David Tilman (U of Minnesota), and Shiqiang Wan (Henan U and CNAS, China). The three-day symposium included presentations on a wide range of ecological process and dynamics in both terrestrial and aquatic grassland communities and ecosystems. A critical feature of the conference was grouping presentations by thematic area, with local and international speakers paired to maximize our ability to recognize key similarities and differences in the drivers that affect grassland structure and functioning globally. In addition to oral presentations and panel discussion, there were over 60 poster presentations, and numerous opportunities for informal interactions among meeting participants.

For a list of Konza-Related Extramural Grants (not including LTER funding) active during the current reporting period (2011-2012), please see the attached 'Activities' pdf.

Findings: (See PDF version submitted by PI at the end of the report)

Konza Prairie Research Findings:
Here we present a selected subset of recent results from the Konza Prairie LTER Program. A complete of publications for the current funding period is included in the FastLane publication databas.

Plant Community and Ecosystem Responses to Long-term Fire and Grazing Treatments, and Environmental Heterogeneity.
Though grazing and fire have some comparable effects on ecosystem processes in grasslands, their effects on plant species composition and community structure are often divergent and lead to directional changes in community structure that accrue over time and require long-term data to fully resolve. A recent analyses by Collins and Calabrese (2012) used long-term plant community data collected on watersheds with different fire and grazing histories (20 yr of variable burning treatments and 13 yr of grazing by bison) to address the following two questions: 1) How do fire and grazing by bison affect the composition and structure of tallgrass prairie plant communities and their temporal stability? And, 2) Are these responses modulated by topographic location? Data on plant community composition from permanent sampling transects at upland, slope and lowland topographic positions on core LTER watersheds was analyzed using multivariate approaches to determine how community structure, life forms and individual species responded to the cumulative, long-term effects of contrasting fire return intervals in the presence and absence of native grazers. We found that species diversity was greatest in sites that were infrequently burned and grazed by bison. Community response to fire and grazing also differed across the topographic gradient. In general, frequent burning favored the dominant C4 grasses, which in turn reduced the abundance of C3 forbs, especially in lowland sites. Community stability was positively correlated with species richness across treatments and topographic positions. Fire, grazing and soil type affected overall plant community composition, but surprisingly there were no significant interactions among these drivers at the community level. As a result, each landscape component contributes uniquely to landscape-scale diversity and dynamics. Species richness and community stability were maximized across the landscape with infrequent fire (every 4? 20 yr) and bison grazing across a range of soil types. Unlike previous studies, richness did not differ along the topographic gradient. In addition, richness on slope sites, which are abundant throughout the Flint Hills region, was particularly responsive to fire frequency. The dominant C4 grasses appear to regulate community diversity. Grass cover was negatively correlated with forb richness. However, grass cover is regulated by fire and grazing; fire increases and grazing reduces the collective abundance of these tall clonal C4 species. Despite these general patterns, the abundance of dominant species increases or decreases in response to fire frequency and grazing, depending on topographic position. At the whole site scale, we found diversity enhanced community and functional type stability, but grazing modulated this response. Overall, this study demonstrates how richness, diversity and composition respond to grazing and variable fire frequency over the long term, and how these responses are modulated by topographic position.

Grassland Restoration Studies.
In 2012, the first synthetic review of how soil ecological knowledge can be applied to restore ecosystem services, led by S. Baer, was published in Soil Ecology and Ecosystem Services (D. Wall, editor). This peer-reviewed book chapter summarizes ecosystem services (and functions) promoted through ecological restoration in general, provides a conceptual framework of the relationship between soil legacy and ecosystem function in the context of restoration, and organizes knowledge and manipulation of soil properties and processes applied to improve ecosystem functions and services during restoration. The chapter highlights findings from KNZ the 1998-heterogeneity experiment, i.e., the role of soil nutrient availability in soil on restoration of plant diversity (Baer et al. 2003) and the complexity of maintaining soil manipulations with developing plant-soil feedback during restoration (Baer and Blair 2008).

Gibson et al. (2012, published in Oikos) is a modeling simulation of the role of genotypic diversity of foundation species in community assembly (in a restoration context) that demonstrates environmental heterogeneity modulates whether relationships between genotypic diversity and species are positive or negative. The conceptual model published here is a modification of the classical filter model of community assembly to include how dominant species may alter the biotic filter to affect species diversity during restoration, originally developed to demonstrate the potential role of dominant species propagule sources in restoration being tested at Konza Prairie and in Illinois.

Bach et al. (2012, published in Environmental Management) compared soil processes and soil microbial community structure in grasslands restored with high and low diversity seed mixes through the Conservation Reserve Program. This research represents a regional extension of on-going investigation of the role of human decisions in community assembly that are unique to restoration. This manuscript demonstrates the important role of C4 grasses and arbuscular mycorrhizae fungi in driving recovery of soil C and N pools and fluxes during grassland restoration.

Rachel K. Goad (M.S. Thesis, Southern Illinois University) investigated whether native prairie plant assemblages were locally adapted to their 'home' soil microbial communities by reciprocally crossing the same 4-species plant assemblage established from seeds obtained at Konza Prairie and a remnant prairie in Illinois with soil inocula obtained from both prairies where seeds were obtained and an agricultural soil. Local adaptation to soil microflora was not evident, but the productivity of Konza-sourced plants was higher in agricultural soil from Illinois (largely due to the response of big bluestem) suggesting negative feedback between Konza plants and the soil microbiota in prairie soil, which could promote coexistence and diversity.

Positive Feedback Mechanisms Drive Shrub Encroachment in Tallgrass Prairie.
In the last century, woody vegetation has expanded in grasslands and savannas worldwide, with impacts on carbon cycling and regional biodiversity. In the Flint Hills of northeastern Kansas, USA, the shrub Corus drummondii has expanded into the tallgrass prairie despite the maintenance of antecedent fire frequencies. To better understand dynamics and drivers of woody encroachment in tallgrass prairie, we established transects spanning the shrub ? grass ecotone. Our results showed source water partitioning (using xylem-water δ2H and δ18O) between C. drummondii and the C4 grass Andropogon gerardii, with C. drummondii relying upon intra-annually stable soil water below 30 cm depth. Early summer canopy development reduced light availability at the ecotone, a response that favors woody vegetation over C4 grasses. At the ecotone and shrub center, fine fuels decreased by ~50% after 4 years of growth minimizing the impact of subsequent fires on shrub biomass. These shrub-mediated changes represent positive feedback mechanisms that can drive subsequent C. drummondii expansion into the grassland matrix. These same changes may also facilitate woody seedling establishment. Because C. drummondii exhibits strong controls on ecosystem structure and its clones can avoid competition with grasses by accessing deep soil water sources, the ecological threshold for woody expansion in tallgrass prairies may be the event of woody establishment. Once established, the predominate woody encroacher of this region (Cornus drummondii) may bypass typical establishment barriers, resulting in a localized positive feedback loop. These shrubs expand radially into the grassland matrix via rhizatomous clones and we found that these developing stems utilize the same deep soil water source as their parent shrub (likely via rhizatomous transfer). The ability to access deep-water sources circumvents competition for water with grasses, a process that would otherwise restrict seedling establishment. Additionally, fine fuels declined exponentially at the shrub/grass interface, reducing the potential impacts of subsequent fires. The release from resource/fire limitation should result in a positive feedback system as clonal expansion allows individual shrubs to reach up to 200 m2, compared to <1 m2 as single-stemmed individuals. This interpretation is consistent with long-term data on site (26 years), where we found that the size of shrubs that are both clonal and deeply rooted has increased 16-fold and aerial coverage has increased from 0 to ~28%. In contrast, the cover of non-clonal species has remained the same and shallow-rooted clonal species have only increased marginally. Together, these results suggest that positive feedbacks facilitate woody encroachment in mesic tallgrass prairie, but by promoting the expansion of existing shrubs rather than the establishment of new individuals. The reduced competition for water and decreased intensity of fires following encroachment represents a reversal of the factors that maintain grass dominance, highlighting the likely possibility that tallgrass prairie is a bi-stable system. Therefore, any global change phenomena (land-use, increased CO2, N-deposition) that facilitates or lowers resilience to initial woody establishment in grasslands, may lead to abrupt non-linear state-shifts in grassland ecosystems.

Woody encroachment is a widespread and acute phenomenon affecting grasslands and savannas worldwide. Looking beyond the borders of the Konza site, Ratajczak et al. (2012) performed a meta-analysis of 29 studies from 13 different grassland/savanna communities in North America (including LTER data from Konza) to determine the consequences of woody encroachment on plant species richness. In all 13 communities, species richness declined with woody plant encroachment (average decline = 45%). Species richness declined more in communities with higher precipitation (r2 = 0.81) and where encroachment was associated with a greater change in annual net primary productivity (ANPP; r2 = 0.69). Based on the strong positive correlation between precipitation and ANPP following encroachment (r2 = 0.87), we hypothesize that these relationships occur because water-limited woody plants experience a greater physiological and demographic release as precipitation increases. The observed relationship between species richness and ANPP provides support for the theoretical expectation that a trade-off occurs between richness and productivity in herbaceous communities. We conclude that woody plant encroachment leads to significant declines in species richness in North American grassland/savanna communities.

Bud Banks and Plant Population Dynamics
A recent Konza LTER study (N'Guessan and Hartnett 2011) focused on the dominant grass Shizachyrium scoparium (little bluestem) demonstrated that, although this species lacks compensatory growth capacity, its belowground bud bank traits are key to explaining its persistence under frequent grazing. Specifically, the maintenance of a large pool of dormant buds across a wide range of grazing intensities, and the shift in bud position and plant architecture contributes to its grazing tolerance and grazing avoidance respectively. Ott and Hartnett (2011 and in press) showed that large interspecific differences in grass bud natality, longevity, and controls on dormancy and outgrowth can explain differences in grass population dynamics and predict their population resilience or sensitivity to environmental change, and ultimately plant community change. In addition, another study by Ott and Hartnett (in press) demonstrated that unique features of the modular construction of grasses and phylogenetic constraints explain patterns of seed and vegetative reproduction in grasses and the lack of a trade-off between these two modes of reproduction as predicted by life history theory. This study contributes to an increasing body of KNZ research indicating that meristems limitation as well as resource limitation is important to understanding plant population responses in grasslands. Our recently completed experiments in collaboration with Oklahoma State University (Wilson and students) also showed that light spectral quality (R:FR) is important in regulating bud dormancy and tiller activation in three of six grass species studied. Nitrogen resulted in species-specific responses, with each species responding differently to N amendments. This indicates that alterations in nitrogen availability, light availability, or shifts in spectral quality may affect grassland plant communities through differential demographic responses among grass species. Overall, these findings will lead to improved predictive models of grassland responses to environmental change.

Linking plant growth responses across topographic gradients in tallgrass prairie

Using a transect spanning a topographic gradient in annually-burned tallgrass prairie, Nippert et al. (2011) measured changes in the growth of four abundant C4 grass species, LAI, biomass, and cumulative carbon flux using two closely located eddy flux towers. We hypothesized that responses along the topographic gradient could be partitioned into position descriptions (e.g., upland / lowland), and the magnitude of growth and carbon flux would vary as a function of topographic position, but the patterns across positions would be similar. Annual carbon flux was greater in lowland versus upland locations, indicating that the source areas contributing to tower fluxes varied. For most of the growth variables measured, a 4-position topographic classification based on soil depth was the best. The magnitude of biomass production, LAI and changes in plant growth varied, with increasing values from the lowland to slope to break and upland positions. Differences in growth by landscape position reflected the greater production of flowering culms by Andropogon gerardii and Sorghastrum nutans in lowland. Varying growth responses by these species may be a significant driver of biomass and carbon flux differences by topographic position, at least for wet years. These results suggest infrequent temporal or limited spatial sampling of plant growth, LAI, or biomass would contribute to a location bias and incompletely describe the turbulent carbon fluxes from this grassland. Thus, measuring the biological responses associated with small-scale landscape variability, and accounting for this variability should improve model predictions of carbon flux at larger scales.

Grassland Responses to Climatic Variability and Climate Change.
In 2011-12 we continued several long-term experiments focused on responses of grasslands to changes in climate and climatic variability. Here we summarize findings and recent published results from two of those experiments.

The first is the Rainfall Manipulation Plots (RaMPs) Experiment in which the timing and amounts of rainfall events are being experimentally manipulated in intact native tallgrass prairie plots (see Activities section for additional details). Results to date from this experiment have identified several critical aboveground and belowground community and ecosystem processes grasslands that are responsive to changes in the timing of rainfall events and/or elevated temperature. For example, altered rainfall timing (longer inter-rainfall droughts interspersed with larger individual precipitation events, with no change in annual rainfall amounts) significantly reduced aboveground net primary productivity by 13-22% (ANPP) in 5 out of 12 years, despite high year-to-year variability in ambient rainfall patterns and mean plant productivity. Averaged across all years, ANPP was 10% lower in the altered rainfall timing treatment ($P<0.001$). Soil CO2 flux was also affected by altered rainfall timing, with rainfall timing x date interactions in all years, and significant main effects of the rainfall treatments in dry years. When significant main effects occurred, it was due to reductions in mean annual soil CO2 flux under altered rainfall timing. As with ANPP, soil CO2 flux was positively correlated with mean seasonal soil water content and negatively correlated with indices of soil moisture variability. This important finding suggests that increases in the temporal variability in soil water content resulting from climate change will significantly alter key C cycling processes in grassland ecosystems. We expect continued reductions in both ANPP and soil CO2 flux with more variable rainfall regimes, and we predict that increased temperatures will exacerbate variability in surface soil water content and further alter C cycling, leading to changes in soil C and N pools. We are continuing our climate manipulations to assess the longer-term responses to altered rainfall and temperature regimes, as well as potential changes in specific soil C and N pools.

Fay et al. (2011) assess the relative impacts of inter- vs. interannual rainfall variability and effects of elevated temperature using 10-years of data from the RaMPs experiment. During this 10-year window, total growing season rainfall varied 2-fold, and we found 50?200% interannual variability in plant growth and aboveground net primary productivity (ANPP), leaf carbon assimilation (ACO2), and soil CO2 efflux (JCO2) despite only 40% variation in mean volumetric soil water content (0?15 cm). Interannual variation in soil moisture was thus amplified in most measures of ecosystem response. Differences between years explained the greatest portion (14?52 %) of the variation in these processes. Experimentally increased intra-annual season rainfall variability doubled the amplitude of intra-annual soil moisture variation and reduced by 15 %, causing most ecosystem processes to decrease 8?40%in some or all years with increased rainfall variability compared to ambient rainfall timing, suggesting reduced ecosystem rainfall use efficiency. Warming treatments increased soil temperature at 5 cm depth, particularly during spring, fall, and winter. Warming advanced canopy green up in spring, increased winter JCO2 , and reduced summer JCO2 and forb ANPP, suggesting that the effects of warming differed in cooler versus warmer parts of the year. We conclude that (1) major ecosystem processes in this grassland may be substantially altered by predicted changes in interannual climate variability, intra-annual rainfall variability, and temperature, (2) interannual climate variation was a larger source of variation in ecosystem function than intra-annual rainfall variability and warming, and (3) effects of increased growing season rainfall variability and warming were small, but ecologically important. The relative effects of these climate drivers are likely to vary for different ecosystem processes and in wetter or drier ecosystems.

The RaMPs project has also become an important resource for other research groups interested in long-term responses to climate manipulations, and we continue to provide both data and samples in support of these efforts. For example, Evans and Wallenstein (2011) used soil samples from the RaMPs project to assess how a history of intensified rainfall would alter microbial functional response to drying and rewetting events, whether this historical legacy was mediated through altered microbial community composition, and how long community and functional legacies persisted under similar conditions. Using soils from the long-term RaMPs rainfall treatments, they measured respiration, microbial biomass, fungal:bacterial ratios and bacterial community composition after collecting soils from the field experiment, and after subjecting them to a series of additional drying?rewetting pulses in the lab. Although rainfall history affected respiration and microbial biomass, the differences between field treatments did not persist throughout our 115-day drying?rewetting incubation. However, soils accustomed to more extreme rainfall did change less in response to lab moisture pulses. In contrast, bacterial community composition did not differ between rainfall manipulation treatments, but became more dissimilar in response to drying?rewetting pulses depending on their previous field conditions. These results suggest that environmental history can affect contemporary rates of biogeochemical processes both through changes in abiotic drivers and through changes in microbial community structure. Likewise, Finzi et al. (2012) used soil samples from the RaMPs project to assess potential impacts of altered moisture and temperature on response of proteolytic enzymes, enzymes that cleave protein into component amino acids, to experimental manipulations of air/soil temperature and precipitation. The response of proteolytic enzyme activity (stimulation vs. repression) depended on whether the experimental manipulations increased or decreased seasonal soil moisture deficit. Samples from different biomes (arctic to hot, dry grasslands) plotted along a single line suggesting a convergence in the effect of climate on the activity of this class of enzymes.

A second long-term climate manipulation experiment is the Irrigation Transect Experiment. A recent analysis of 19-years of plant community and plant productivity responses to supplemental water addition in this experiment is the basis for an in press manuscript that will be featured as a 'Spotlight' manuscript in a forthcoming issue of Functional Ecology. This manuscript by Collins et al. used plant community data to assess a theoretical model of non-linear ecosystem responses to chronically altered resource availability (the Hierarchical Response Framework (HRF), proposed by Smith et al. 2009). Collins et al (2012) found, surprisingly, that community structure changed very little during 19 years of supplemental water additions to alleviate soil water stress. Any changes in species diversity and community structure that were detected varied from year to year and were inconsistent with the treatment effects over time. Thus, despite complete removal of growing season water limitation for almost two decades, the tall, perennial C4 grasses maintained dominance in this system. This resistance to chronic water addition was surprising given that ecosystem structure and function across central US grasslands is widely accepted to be driven by precipitation amount, and at Konza Prairie aboveground productivity has been shown to be water limited 75% of the time. However, despite the overall lack of change in plant community structure, Collins et al. (2012) did highlight a change in relative abundance of one C4 tallgrass species (Panicum virgatum). This grass species was always present but was less abundant than the dominant C4 grass, Andropogon gerardii, in the community for the first 10 years of the experiment. However, P. virgatum became dominant after a decade of water additions and remained so for the next nine years. This response, they argued, is consistent with one HRF prediction - that with chronic resource alterations, extended lag periods might be expected before a period of community reordering occurs. Knapp et al. (2012) present a companion paper that test another prediction of the HRF; that initial responses in ecosystem function to resource addition are expected to be relatively modest and dominated by ecophysiological processes, but much greater alterations in function will occur when community reordering occurs. Such reordering is expected to occur as species that are better able to exploit changes in resources increase in abundance. To test this prediction, they compared responses of aboveground net primary production (ANPP), a key ecosystem function, to irrigation for two key time periods identified by Collins et al. (2012) ? the initial 10 year period of dominance by A. gerardii and the subsequent 9 years of dominance by P. virgatum. The response in ANPP was consistent with HRF predictions: water addition increased ANPP by 37% in the first decade of the experiment and by 64% after reordering of the dominant C4 grasses. This dramatic increase in ecosystem function occurred despite a modest shift in community structure (i.e., only a change in the identity of the most abundant grass without a change in composition overall. The increase in ANPP observed in the second half of the experiment is particularly noteworthy when placed within the broader context of regional patterns of ANPP, since levels of ANPP in the last 9 years of this study far exceeded those expected for the amount of water received (Fig 1 bottom). Such dramatic and rapid shifts in ANPP have been documented previously, but only when one growth form replaces another (forest or shrub encroachment into grasslands) or with substantial nutrient additions. While Collins et al. (2012) provide an intriguing example of plant community structure being surprisingly resistant to chronic alterations of a limiting resource (water) additional insight can be drawn when these results are combined with ANPP data. Ecologists have long recognized that changes in limiting resources can lead to major alterations in community composition and structure, often with similar consequences for ecosystem function. But Collins et al. (2012) and Knapp et al. (2012) demonstrate that such community shifts are not required for chronic resource alterations to lead to dramatic changes in ecosystem function. In other words, overall stability in community richness, diversity or growth form dominance does not preclude a large functional response to chronic resource alterations ? such as those expected to occur with global change (Smith et al. 2009). The results in Collins et al. (2012) also demonstrate that even relatively simple, single factor experiments can be valuable for testing global change theory, particularly if they are long-term (Knapp et al. 2012).

The Ecology of Tallgrass Prairie Streams

Dodds completed a cross-site publication with aquatic scientists at a variety of LTER sites and this analysis was accepted for publication (Dodds et al. in press). Dodds also collaborated with Dr. Rudolf Jaffe on black carbon in Konza streams compared to that found in other systems (Jaffe et al. in press). Surprisingly, even with the high burn frequency on Konza, levels of black carbon are not very high.

We are completing data analyses on a small scale (stream reach scale) woody vegetation removal experiment where we have documented that vegetation removal (restoration to natural riparian conditions of grassland streams) lead to 1) increased denitrification rates (Reisinger 2010), 2) shifts in communities with fewer leaves and bryophytes, and more filamentous algae (Riley et al 2012), 3) corresponding shifts in ecosystem metabolism related to more light reaching the stream and less detrital leaf materials (Riley et al. 2012), and 4) corresponding changes in invertebrate communities related to changes in food availability. Jodi Vandermyde, an MS student at SIU, has been examining invertebrate and benthic organic matter responses to this manipulation. Jodi's analyses are now complete and she will defend her thesis and submit her results for publication during fall semester 2012. Her results show that stream macroinvertebrates responded significantly to the vegetation removal, with increases in grazers and most other functional groups. However, after one year, invertebrate communities still differed significantly from those in naturally open reaches.

Two manuscripts evaluating fish assemblage dynamics in prairie streams using data from Kings Creek and Fox Creek were recently completed and are in review. One paper Erika Martin tested habitat associations of fishes across hierarchical spatial scales and found that the main drivers of species richness in prairie streams were local scale measures of habitat size. In a second paper. James Whitney estimated colonization and extinction probabilities of fishes across sites to test the importance of local versus regional influencing on fish assemblage structure. Our long-term monitoring data indicated dual control of local and regional influence on structuring prairie streams and highlighted the importance of maintaining connectivity among habitat patches in these systems.

Results from an experimental stream study conducted in summer 2011 indicate that consumers have a major role in determining the distribution of autotrophic biomass in the streams and those effects are heterogeneous across macrohabitats (i.e., pools and riffles). Of particular interest, was that effects of diversity (1 ? 3 species) was driven by a single species, central stoneroller Campostoma anamolum. These grazing minnows elicited a strong ecosystem effect by inhibiting algal filaments from forming large floating mats and redistribute those resources to benthic surfaces.

Konza Prairie Groundwater Studies.
A regional flow model that includes the Konza LTER site (Steward et al., 2011) shows the recharge and discharge areas and the involvement of streams in groundwater. Tsypin's thesis and article in press shows a short but measureable lag time between chemical and isotopic parameters measured in the soil and those in shallow groundwater, including supporting evidence for downward flux of soil CO2 to groundwater (Tsypin and Macpherson, in press), which is significant in light of the long-term increase in groundwater CO2 previously documented at Konza (Macpherson et al., 2008). Preliminary data from the rapid-snowmelt-event project shows levels of nitrate and potassium (macronutrients) in throughflow during the two sampled RSE's to be significantly higher than has ever been measured in groundwater or streamwater at Konza, suggesting the RSE's rob the soil of these nutrients. Micronutrients (B, Co, Ni, Cu, Zn, Mo) in RSE throughflow water are also detectable, and comparisons are underway with preliminary chemical data from selected groundwater and surface water chemistry. Sequential chemical extraction data of soils shows that the rare earth elements in the easily exchangeable fraction are different from those in other extracts. This is not explained by differential aqueous complexation in the soil-water environment, and suggests the exchangeable ions reflect a source different from the bulk of the soil (Macpherson, manuscript in progress). In addition, the distribution of certain elements important to microbial functioning, such Cu, increase in concentration on the organic matter fraction of the soil with depth, showing that Cu released during organic matter degradation is quickly re-sorbed onto remaining organic matter, thus possibly limiting its bioavailability (Macpherson, manuscript in progress). A small increase in the rate of chemical weathering at the Konza LTER is interpreted from the long-term major-element chemistry data set, despite the strong dependence of chemical weathering rates on the highly variable annual stream discharge (results presented at GSA, October 2011; and manuscript in progress).

Mycorrhizal Ecology.
Recent studies with support from LTER funding and conducted, in whole or in part, on Konza Prairie Biological Station have been focusing on the role of mycorrhizae on grassland invasibility, grassland restoration, soil C sequestration, wetland-mycorrhizal interactions, and ecosystem processes.
Mycorrhiza and resource allocations: Research in collaboration with colleagues at Northern Arizona University (N.C. Johnson) and Argonne National Laboratory (R.M. Miller) has demonstrated that AM fungi generate the full spectrum of mycorrhizal functioning from mutualism to parasitism through manipulating C, N, and P availability using cross-site comparisons and within site fertilization (N.C. Johnson, G.W.T. Wilson, and R.M. Miller ? submitted to Ecological Monographs). Our cross-site locations were Konza Prairie Biological Station, Cedar Creek LTER, and Fermi Prairie (Argonne National Laboratory). Results of our experiments provide strong support that P-for-C trade can directly control of mycorrhizal function through equal exchange mechanisms, while N availability indirectly control mycorrhizal function through its effects on C supply and C demand. These results may be a useful guide for fertilizer management to enhance mycorrhizal benefits in grassland restoration, and help develop testable hypotheses of mechanisms by which resources control AM function.

We conducted a series of experiments to test complementary models within a stoichiometric framework (Baoming, J., C.A. Gehring, N.C. Johnson, G.W.T. Wilson, and R.M. Miller ? submitted to Molecular Ecology). We have shown co-adapted plants and AM fungi develop over time such that the fitness of both plants and fungi is maximized under local soil conditions. However, the dominant species of AM fungal spores in the inoculum differed from those in experimental roots.

An overview of mycorrhizal ecology in grasslands was the focus of a recently accepted book chapter: Arbuscular Mycorrhizas and Grassland Ecosystems 2012. R.M. Miller, G.W.T. Wilson, and N.C. Johnson. Chapter 3: Pp. 59-85. In: D. Southwood (Ed.). Biocomplexity of Plant-Fungal Interactions. Wiley-Blackwell, Oxford, UK. This chapter discusses mycorrhizal research from KPBS, Cedar Creek, Fermi, and African grasslands.

Mycorrhiza and plant traits: Reinhart, K., G.W.T. Wilson, and M. Rinella. 2012. Predicting plant responses to mycorrhizae: Integrating evolutionary history and plant traits. Ecology Letters. 15: 689-695. Using plant-mycorrhizal response data from KPBS, we assessed whether 1) plant responses to mycorrhizae (i.e. mycorrhizal responsiveness [MR]) and root colonization (RC) vary according to plant phylogeny and exhibit a phylogenetic signal and 2) MR and RC can be more accurately predicted with phylogenetic predictor (i.e. MR or RC of the most closely related species available) relative to a null model and models with predictors based on plant traits (i.e. MR or RC of a plant with a similar characteristic [e.g. annual vs. perennial]). Our study illustrated the complex evolutionary associations among species and constraints of using phylogenetic information, relative to plant traits, to predict how a plant species will interact with AMF.

Small Mammal Population Dynamics.
Konza LTER research on small population dynamics is being led by Don and Glennis Kaufman and students. Their studies of small mammal populations spans nearly 30 years and multiple land-use and land-cover types at the Konza LTER site. Here we summarize the results of two recent studies.

Native ungulates and fire, along with climate, were important drivers shaping the tallgrass prairie of North America. Because no endemic small mammals occur in the tallgrass prairie, it is important to understand how small mammals from other faunal regions (e.g., coniferous and deciduous forests and deserts) adapted to grazing and fire in this recent habitat. Historically, American bison was the predominant large mammalian herbivore in the tallgrass prairie, but it largely has been replaced by domestic cattle. Previously, we have shown in a short-term study that the deer mouse (Peromyscus maniculatus) was more abundant in bison-grazed areas then in cattle-grazed areas in spring before annual fires, but was similar in abundance in grazed and ungrazed areas after fire. It is important to understand the interactions that occur between fire and bison grazing and to extend our understanding to other species of small mammals through our long-term studies. We examined the responses of small mammals to fire and bison grazing at three scales: macro-, meso-, and micro-scales. At the macro-scale, deer mice responded positively to grazing, whereas white-footed mice (P. leucopus), western harvest mice (Reithrodontomys megalotis), Elliot's short-tailed shrews (Blarina hylophaga), and prairie voles (Microtus ochrogaster) responded negatively; these patterns generally held across annual, occasional, and infrequent burns. We also found at the meso-scale (a grazing lawn in an infrequently burned area) that deer mice responded positively to the grazing lawn despite the lack of fire, whereas Elliot's short-tailed shrews disappeared from the grazing lawn although they occurred at nearby sites where a lawn was not present. At the micro-scale, bison create patches of grazed and ungrazed areas within burned treatments. At the micro-scale, we found that responses of small mammals were more observable in infrequent than annual burns and in spring as compared to autumn. Overall, the prairie deer mouse responded positively to grazing and fire at all three scales and generally represents the 'canary' species in a healthy tallgrass prairie. In contrast, western harvest mice, prairie voles, and Elliot's short-tailed shrews respond negatively to fire and grazing at the three scales and require a mosaic of burned and unburned and ungrazed sites to thrive in tallgrass prairie. But, white-footed mice (a woodland form) generally do not respond to fire or grazing, except that they are responding to the expansion of woody vegetation in prairies that occurs with infrequent fires.

Due to the general suppression of fire in prairies since European settlement and the experimental regime in which prescribed fire is infrequent (4, 10, and 20 years between fires), woody vegetation has expanded on Konza Prairie, a native tallgrass prairie, over the past 30 years. Our long-term studies (30 years in length) of small mammals on Konza Prairie demonstrate a general increase in abundance of the white-footed mouse (Peromyscus leucopus; a mouse generally found in forested sites) through time with the expansion of woody vegetation. 75% and 84% of the variation in number of white-footed mice present in autumn and spring, respectively, can be explained by the number of spring fires at a treatment site. That is, few individuals occur on sites that have had annual fires, but ~600 individuals were observed with similar sampling effort where only 1 fire has occurred during the past 30 years and woody invasion is extensive. In less densely invaded prairie, local hotspots for white-footed mice include shrub patches embedded in the prairie, shrub and tree patches associated with ravines, and breaks site with encroaching shrubs. The spatiotemporal distributional pattern on Konza Prairie shows a highly significant, predictable pattern of occurrence that is related to environments and conditions that favor the white-footed mouse. Furthermore, our experimental study sites show that white-footed mice begin to invade an annually burn site within 10 years after it is reversed to a long-term unburned site and as shrubs encroach, but the opposite pattern is not true. That is, only a slight decrease has occurred in number of white-footed mice when a long-term unburned site was reversed to an annually burned site (shrub islands and tree patches still present and only slightly decreased in size). This study suggests that more than fire is required to reverse the negative effects of woody expansion in native prairie. The presence of white-footed mice in native prairie can serve as an indicator that restoration needs to begin to maintain and preserve native prairies, such as the tallgrass ecosystem.

Konza-based Nutrient Network Experiment
Both top-down and bottom-up effects can influence plant community structure. Theory predicts that these factors may interact in complex and interesting ways. However, little work has been done to develop empirical evidence for these indirect interactions. The Nutrient Network (NutNet) was established specifically to examine the relative importance of multiple resource limitation and bottom-up versus top-down controls of herbaceous-dominated systems. Replicate plots (n=3 per treatment combination) have been established at more than 50 sites around the world in a randomized block design (n=3 blocks) with a total of 10 treatment combinations per block (control, N, P, K, NP, NK, PK, NPK, caged control, caged NPK). The nutrient addition treatments involve the addition of a relatively high level of N, P, or K plus micronutrients to ensure alleviation of nutrient limitation. The herbivore removal (caged) treatment excludes vertebrate herbivores from the plots, but does not prevent access by invertebrate herbivores. At Konza Prairie, NutNet studies are being directed by LTER investigator Melinda Smith and her

students, with direct support from the core LTER grant.

After four years of treatment application we have found that at Konza precipitation during anthesis and nitrogen and phosphorus additions drive variation in ANPP. We found that plant functional traits also vary with nutrient additions at Konza. The dominant species at this site (Andropogon gerardii, Sorghastrum nutans, and Schizachyrium scoparium) do not vary in trait space with nutrient additions, while species which are known to invade plots under chronic nutrient addition regimes (Ambrosia psilostachya, Dicanthelum oligosanthes, and Solidago missouriensis) all increase in trait space toward an area corresponding to faster growth and reproduction. The effects of nutrient additions and vertebrate herbivore removals on ANPP and plant traits scale up to higher trophic levels, with N additions resulting in an increase in invertebrate herbivore and parasitoid abundance by altering plant biomass at Konza. In contrast, the rates of per capita invertebrate herbivory were lower in N addition plots. These results provide evidence to support the hypothesis that invertebrate herbivores may be under absolute resource limitation in areas with low plant tissue quality, but switch to relative resource limitation in areas with higher plant tissue quality. The changes in production, plant traits, and invertebrate community structure with chronic nutrient additions at Konza will likely have strong consequences for future ecosystem functioning.

In addition to site-specific results, data from the Konza NutNet experiment is contributing to a series of planned cross-site comparative studies that were the focus of an organized oral session at the 2012 ESA meeting. As one example of the products from this effort, Konza LTER authors (Smith, LaPierre, Collins, Fay) and data from the Konza NutNet experiment were part of a recent cross-site analysis published in Science (Adler et al. 2011). This paper included data from 48 NutNet sites to assess the relationship between net primary productivity and species richness. This relationship has been the focal point of intense debate in ecology about the processes regulating local diversity. The original view, which is still widely accepted, holds that the relationship is hump-shaped, with richness first rising and then declining with increasing productivity. Although recent meta-analyses questioned the generality of hump-shaped patterns, these syntheses have been criticized for failing to account for methodological differences among studies. This study addressed such concerns by conducting standardized sampling in 48 herbaceous-dominated plant communities on five continents. The study found no clear relationship between productivity and fine-scale richness within sites, within regions, or across the globe. These results indicate that ecologists should focus on fresh, mechanistic approaches to understanding the multivariate links between productivity and richness.

Other Cross-Site, Synthesis and Network-level Studies.
Data from a long-term fertilization experiment at Konza (the 'Belowground Plot Experiment') has been made available to several working groups, and has resulted in a series of synthetic papers based on data from multiple research sites across North America. One recent analysis by Cleland et al. (2011) investigated how nutrient availability influences divergence and convergence during the invasion of exotic species into native communities, using multivariate analyses of community composition and functional traits from naturally assembled plant communities in long-term nitrogen addition experiments across North America. They found that the relative abundances of key functional traits differed between the native and exotic plant communities, consistent with limiting similarity or a trait bias in the exotic species pool. Environmental context also played an important role in invasion because sites varied in the identity of the traits that predicted dissimilarity between native and exotic communities. Nitrogen enrichment did not alter these patterns. In general, nitrogen enrichment tended to increase exotic abundance, but this was driven by a dramatic increase in exotics in only a few experiments. When similarity between native and exotic communities was included in the statistical model, N enrichment no longer predicted an increase in exotic relative abundance. Instead, sites with the highest abundance of exotic species were the ones where native and exotic communities had the highest trait similarity. Together, these results suggest that while functionally dissimilar exotic species may be more likely to invade, they are unlikely to become abundant unless they have traits pre-adapting them to environmental conditions in their invaded range. Contrary to prior studies, invasion was not consistently promoted by N enrichment.

In a separate cross-site synthesis, Gough et al. (2012) used LTER data from the Belowground Plot Experiment as part of an NCEAS effort to test tested whether plant height and clonal growth form together predict species responses to nitrogen fertilization because neither trait alone predicted species loss in a previous analysis. Species with a tall-runner growth form commonly increased in relative abundance in response to added nitrogen, while short species and those with a tall clumped clonal growth form often decreased. The ability to increase in size via vegetative spread across space, while simultaneously occupying the canopy, conferred competitive advantage, although typically only the abundance of a single species within each height-clonal growth form significantly responded to fertilization in each experiment. The results suggest that classifying species on the basis of two traits (height and clonal growth form) increases the ability to predict species responses to fertilization compared to either trait alone in predominantly herbaceous plant communities

Konza LTER scientists continue to be active in studies and synthetic analyses that extend beyond the border of the Konza Prairie site. For example, Konza LTER scientists have participated in recent cross-ste studies of woody plant expansion into arid and semi-arid ecosystems (Barger et al. 2011, Ratajczak et al. 2012). The aquatic group participated in the LINX II cross-site nitrogen tracer experiments to assess factors controlling retention and release of nitrate in stream ecosystems. Results of these studies were published in PNAS (Bealuieu et al. 2011), Nature (Mulholland et al. 2008) and Limnology and Oceonography (Mulholland et al. 2009, Hall et al. 2009), indicating that efficiency of nitrogen removal decreases as nitrogen loading increases. Other recent cross-site and synthetic publications included patterns and controls of plant community dynamics (Chalcraft et al. 2008, Cleland et al. 2008), applications of phenological studies to assess 21st century climate change (Morrisette et al. 2009), synthetic review of the impacts of climate change on terrestrial ecosystems (Garrett et al. 2008, Marshall et al. 2008, Gerten et al. 2008, Luo et al.2008), a synthetic review of non-target and invasive species in restored ecosystems (Baer et al. 2012), a synthetic comparison of the value of ecosystem goods and services in native and restored ecosystems (Dodds et al. 2008), and a new conceptual framework for assessing ecosystem responses to chronic resource alterations induced by global changes (Smith et al. 2009).

Finally, it is worth noting that Konza LTER scientists led, and contributed to, a recent perspective article in Frontiers in Ecology and the Environment on an integrated conceptual framework for long-term social ecological research (Collins et al. 2011), as well as multiple papers in the recent BioScience issue commemorating the 30th anniversary of the LTER program (Knapp et al. 2012, Robertson et al. 2012).

Training and Development:

The Konza Prairie LTER program provides educational and training activities for students, developing scientists, and the general public at a wide range of levels, from the education of K-12 students to the training of undergraduate/graduate students and post-doctoral scientists. Konza LTER data and findings are used widely in texts and web-based educational sites. In addition, through our Schoolyard LTER program and targeted KSU programs (e.g., Girls Researching Our World (GROW), GK-12 (Evidence-Based Inquiry into the Distant, Remote or Past) and the Howard Hughes-sponsored KSU Science Teachers Training program) we provide opportunities for high school and junior high school teachers to work with, and learn from, Konza LTER scientists.

Contributions to K-12 Education:

Formal educational activities at the K-12 level began with the initiation of the Konza Environmental Education Program (KEEP) in 1996, and were greatly expanded with the initiation of the Konza Prairie Schoolyard LTER (SLTER) in 1998. The Konza Prairie Schoolyard LTER (SLTER) program is now entering its 15th year as an science education program for K-12 teachers and their students, built around the successful Konza Prairie LTER program.

In January of 2012 Jill Haukos was hired as the new Environmental Education Program Director and in March Jan Evans was hired as the Assistant Environmental Educator. With the arrival of the new staff our program will continue to grow and develop to deliver the highest quality environmental education experience possible.

Our SLTER program continues to prosper with input from Konza LTER PIs and Kansas K-12 educators. The Konza Prairie SLTER program aims to educate students about ecology and global change, with emphasis on regional grasslands, by engaging students and teachers in realistic and relevant science-based activities focused on long-term data collection at our LTER site. These activities were designed to give students an understanding of ecology, provide them the opportunity to collect and interpret their own data, and integrate their data into our long-term SLTER databases via the Internet (keep.konza.ksu.edu). By sharing knowledge generated through long-term data collections we give teachers tools for connecting children to locally and regionally important ecosystems.

The KNZ SLTER program continues to grow with annual Summer Teacher's Workshops, with the most recent held in 2012. These workshops serve to initiate new teachers into the Konza SLTER program. Teachers experience all of the science activities first-hand and are then assisted in the development of new curriculum that incorporates a classroom visit to the Konza Prairie. The workshops are the single strongest tool we have to sell new teachers on the science education available to their students.

In addition to site-based activities, the Konza Prairies Across Kansas (PAK) program continues to provide science education opportunities for students and teachers in schools across Kansas. PAK targets school districts distantly located from Konza but still in a grassland biome. Most of these districts include a high percentage of rural families with limited access to science resources. The teachers from these distant regions are trained at Konza Prairie in a workshop similar to those offered to local teachers. With training and support from the SLTER program, these teachers and their students participate in data collection at native prairie sites near their home schools. This allows direct comparison of ecological processes in different regional prairie types (tall-, mixed- and short-grass prairies) through SLTER databases, since all teachers in the program follow the same protocols. In order to enhance regional coverage and participation in the PAK program, we have targeted school districts in the mixed and shortgrass regions of Kansas. In total, the Konza Environmental Education Program (KEEP), the SLTER program, and the Prairies Across Kansas program educate local and statewide teachers and their students about the unique attributes of prairie ecosystems and important global changes which impact the central US grasslands.

The KNZ SLTER program continues to grow in terms of participating teachers and numbers of students reached. As an example of recent activities, in 2011 82 teachers brought classes to KNZ, including 35 classes that annually participate in SLTER science activities as part of their regular teaching activities. Twelve of these SLTER teachers are from a nearby school district, which has 55% economically disadvantaged students. These teachers brought an additional 14 teachers to KNZ with their students as an introduction to our SLTER program. In 2011, a total of 1,061 students from 17 schools participated in 35 hands-on activities at Konza Prairie. In addition to students participating in site-based SLTER activities, the Prairies Across Kansas program impacted an additional 366 students across the state for a total of 1348 students. Since 1999 we estimate that we have reached > 13,000 students from 3rd grade through high school with SLTER activities at Konza Prairie and another 2400 across the state through PAK. With continued SLTER support in 2013, we anticipate involving ~1000 additional students in activities at Konza, with a number similar to 2011 from around the state participating in PAK activities. Data collected from SLTER activities will continue to be incorporated into SLTER databases. In this way, individual class data can be accessed along with the long-term databases through the Internet and manipulated in the classroom to give students a better understanding of the process of science and the value of long-term ecological information.

The Konza Prairie LTER site is also used as part of the KSU Girls Researching Our World (GROW) Program. This program, funded by the NSF Gender Equity in SMET initiative, provides 6th-8th grade girls with exposure to careers science using environmental stewardship as a theme (www.ksu.edu/grow/). Most recently, KSU was awarded a GK-12 grant to pair graduate students with local high school teachers in a unique science education-focused program - Evidence-Based Inquiry into the Distant, Remote or Past (EIDRoP). To date, four Konza LTER graduate students (Dan Carter, Jacob Carter, Ben Vanderweide, Erica Martin) have participated in the GK-12 program through classroom activities in the Junction City High School, and all have incorporated aspects of the Konza Prairie LTER program into their GK-12 projects.

Contributions to Undergraduate and Graduate Education:

At the college undergraduate and graduate level, Konza Prairie continues to serve as an outdoor laboratory for classes and visiting field courses from numerous educational institutions and LTER research dominates the curriculum. The Konza Prairie LTER program has a strong record of providing training opportunities for undergraduates via employment of research assistants (approximately 25 undergraduate students are supported with LTER funding each year) and through NSF REU supplements and an REU site grant based at Konza Prairie, which supports 8-10 undergraduates per year from institutions throughout the U.S. Summer 2012 was the 17th year that Konza Prairie and the Division of Biology at K-State have offered a 10-week summer undergraduate research program. Participants in the structured program included 10 students supported by NSF-funded REU Site and Supplements.

Konza LTER data are used in an increasing number of undergraduate and graduate ecology courses at Kansas State University, the University of Arizona, Colorado State University, and Ohio University, among others. In addition, findings of Konza Prairie LTER studies are increasingly utilized in undergraduate ecology texts and supplementary teaching materials. For example, Konza Prairie LTER studies are used to demonstrate the role of fire and grazing in grasslands in 'General Ecology, 2nd edition' by D.T. Krohne, and as an example of the importance of long-term research in the 'Ecology' text by Cain et al. A recent Konza study by Collins et al. is featured as a 'case study' in the on-line supplement to 'Ecology. Theory and Applications. 3rd edition' by P. Stiling. Konza studies on top-down regulation of plant community structure are featured in an introductory undergraduate biology text ('Life. The Science of Biology. 7th edition' by Purves, Sadava, Orians and Heller). Konza data are used in several upper-level and graduate texts including 'Freshwater Ecology' (W.K. Dodds), 'The Ecology of Plants' (Gurevitch, Scheiner and Fox), and 'Biogeochemistry. An Analysis of Global Change' (W.H. Schlesinger). Konza LTER graduate students and PIs have also co-authored several educational publications, based on LTER data, for the peer-reviewed ESA-supported Teaching Issues and Experiments in Ecology (TIEE) and other education-based outlets:

Nippert, J.B., and J.M. Blair. 2005. Comparing the influence of precipitation, fire, and topography on plant productivity in the tallgrass prairie. Teaching Issues and Experiments in Ecology, Vol. 3: Issues: Data Set #1 tiee.ecoed.net/vol/v3/issues/data_sets/konza/abstract.html

Dalgleish, H.J. and T.M. Woods. 2007. The effects of bison grazing on plant diversity in a tallgrass prairie (Konza Prairie LTER). Teaching Issues and Experiments in Ecology, Vol. 5: Practice #1. tiee.ecoed.net/vol/v5/practice/dalgleish/abstract.html

Johnson, N.C., V.B. Chaudhary, J.D. Hoeksema, J.M. Moore, A. Pringle, J.A. Umbanhowar, and G.W.T. Wilson. 2009. Mysterious mycorrhizae? A field trip and classroom experiment to demystify the symbioses formed between plants and fungi. American Biology Teacher 71: 424-429.

The Konza LTER program continues to provide training for numerous graduate students at Kansas State University, and has become an important resource for training students from a number of other institutions including the University of Colorado, University of Kansas, University of Kentucky, University of New Mexico, Southern Illinois University, Colorado State University, Cornell University, and Yale University. Currently, approximately 20 graduate students are currently supported, in full or in part, with Konza LTER resources. Several of these students, from KSU and from other institutions, are currently using the Konza LTER site in cross-site or regional studies, some of which involve other LTER sites or international partners. For example, students from KSU and CSU are participating in cross site studies involving the KNZ and SGS LTER sites. During the previous LTER funding cycle (2002-2008), 60 student theses and dissertations were supported by the Konza Prairie LTER program. Below, we begin a new listing of theses and dissertations completed during LTER VI (2009-2014):

2009

An, N. 2009. Estimating annual net primary productivity of the tallgrass prairie ecosystem of the Central Great Plains using AVHRR NDVI. MS Thesis, University of Kansas. Lawrence, Kansas.

Bach, E.M. 2009. Biotic and abiotic drivers of soil microbial community recovery and ecosystem change during grasslands restoration. MS Thesis, Southern Illinois University. Carbondale, IL.

Bowe, S.E. 2009. The influence of host ecology and land cover change on rabies virus epidemiology in the Flint Hills. MS Thesis, Kansas State University. Manhattan, KS.

Buis, G. 2009. Controls of aboveground net primary production in mesic savanna grasslands: An inter-hemispheric comparison. MS Thesis, Colorado State University. Fort Collins, CO. 50 pp

Campbell, R.E. 2009. Variation in benefit from arbuscular mycorrhizal fungal colonization within cultivars and non-cultivars of Andropogon gerardii and Sorghastrum nutans. MS Thesis, Southern Illinois University. Carbondale, IL. 97 pp

Grace, T. 2009. Host associated genetic divergence and sexual isolation in the grasshopper Hesperotettix viridis (Orthoptera: Acrididae). PhD Dissertation, Kansas State University. Manhattan, KS. 127 pp

Klug, P.E. 2009. Interactions between grassland birds and their snake predators: the potential for conservation conflicts in the tallgrass prairie. PhD dissertation, Kansas State University. Manhattan, KS. 126 pp

Ott, J. 2009. Bud bank morphology, dynamics, and production in perennial grasses. MS Thesis, Kansas State University. Manhattan, KS. 93 pp

2010

Buck, T. 2010. The impact of land cover change on water and carbon cycling in the US central plains grasslands. MS Thesis, University of Kansas. Lawrence, KS.

Commerford, J.L. 2010. Calibrating vegetation cover and pollen assemblages in the Flint Hills of Kansas, USA. MA Thesis, Kansas State University. Manhattan, KS. 73 pp.

Lohnes, R.G. 2010. Nest site selection and nest thermal properties of common nighthawks on the tallgrass prairie of Kansas. MS Thesis, Cornell University. Ithaca, NY.

McNew, L.B. 2010. An analysis of Greater Prairie-chicken demography in Kansas: the effects of human land use on the population ecology of an obligate grassland species. PhD Dissertation, Kansas State University. Manhattan, KS. 149 pp.

Petrie, M. 2010. Climate forcings and the nonlinear dynamics of grassland ecosystems. MA Thesis, University of Kansas. Lawrence, KS.

Reisinger, A.J. 2010. Factors affecting denitrification in headwater prairie streams. MS Thesis, Kansas State University. Manhattan, KS.

Sprinkle, J.W. 2010. Bud bank density regulates invasion by exotic plants. MS Thesis, Oklahoma State University. Stillwater, OK. 65 pp.

Tucker, S. 2010. Morphological and physiological traits as indicators of drought tolerance in tallgrass prairie plants. MS Thesis, Kansas State University. Manhattan, KS.

Whiting, D.P. 2010. Macroinvertebrate production, trophic structure, and energy flow along a tallgrass prairie stream continuum. MS Thesis, Southern Illinois University. Carbondale, IL.

Williamson, M.M. 2010. Controls on bud activation and tiller initiation in tallgrass prairie: The effect of light and nitrogen. MS Thesis, Oklahoma State University. Stillwater, OK. 52 pp

Winders, K. 2010. Ecosystem Processes of Prairie Streams and the Impact of Anthropogenic Alteration on Stream Ecological Integrity. MS Thesis, Kansas State University. Manhattan, KS.

2011

Auvenshine, S.D. 2011. Infiltration controls in a tallgrass prairie at a hillslope scale. MS Thesis, Kansas State University. Manhattan, KS. 126 pp

Gregory, A.J. 2011. The influence of behavioral and landscape ecology on Greater Prairie-Chicken (Tympanuchus cupido) genetic structure and evolution. PhD Dissertation, Kansas State University. Manhattan, KS. 129 pp

Hartman, J. 2011. Responses of switchgrass (Panicum virgatum L.) to precipitation amount and temperature. MS Thesis, Kansas State University. Manhattan, KS.

Mikhail, T. 2011. Dissolved inorganic carbon in soil and shallow groundwater, Konza Prairie LTER Site, NE Kansas, USA. MS Thesis, University of Kansas. Lawrence, KS.

Mohler, R. 2011. Multi-scale burned area mapping in tallgrass prairie using in situ spectrometry and satellite imagery. PhD Dissertation, Kansas State University. Manhattan, KS.

Parsons, S. 2011. A generalist grasshopper species (Melanoplus femurrubrum) is adapted to variable environments along a latitudinal gradient . MS Thesis, Kansas State University. Manhattan, KS.

Riley, A.J. 2011. Effects of riparian woody vegetation encroachment on prairie stream structure and function with emphasis on whole-stream metabolism. PhD Dissertation, Kansas State University. Manhattan, KS.

Rostkowski, S.C., Jr. 2011. Long-term effects of climate change on grassland soil systems: A reciprocal transplant approach. MS Thesis, Kansas State University. Manhattan, KS. 80 pp.

Tiemann, L. 2011. Soil microbial community carbon and nitrogen dynamics with altered precipitation regimes and substrate availability. PhD Dissertation, University of Kansas. Lawrence, KS.

2012

Avolio, M.L. 2012. Genetic diversity of Andropogon gerardii: Impacts of altered precipitation patterns on a dominant species. PhD Dissertation, Yale University. New Haven, CT. 258 pp

Chang, C.C. 2012. Dimensions of diversity and their direct and indirect effects on tallgrass prairie ecosystem functioning. PhD Dissertation, Yale University. New Haven, CT. 165 pp

Killian, P.D. 2012. Mechanisms driving woody encroachment in the tallgrass prairie: an analysis of fire behavior and physiological integration. MS Thesis, Kansas State University. Manhattan, KS. 72 pp

Nukala, L.A. 2012. An iPhone application of Konza Prairie LTER. MS Report, Kansas State University. Manhattan, KS. 47 pp

Ocheltree, T.W. 2012. Growth and survival during drought: The link between hydraulic architecture and drought tolerance in grasses. PhD Dissertation, Kansas State University. Manhattan, KS. 1117 pp

Olstad, T.A. 2012. Zen of the Plains: discovering space, place, and self. PhD Dissertation, Kansas State University. Manhattan, KS. 276 pp

Sousa, B.F. 2012. Ecology of mating patterns and sexual selection in dickcissels breeding in managed prairie. PhD Dissertation, University of Kentucky. Lexington, KY. 166 pp

Outreach Activities:

Konza Prairie LTER data and findings are used to support numerous outreach activities at local, regional, national and international levels. At a local level, Konza scientists regularly participate in Kansas Agricultural Experiment Station (KAES) extension and public education events (including on-site tours of LTER research areas for local ranchers and conservationists, and presentations of LTER research findings relevant to grassland management and conservation). The Konza site also hosts a biennial Visitors' Day, with extensive participation by LTER scientists who highlight current LTER activities and their relevance to society (the next visitor's day will occur on September 29, 2012). The Konza Prairie LTER site also supports a 10 km nature trail system open to the public daily, and a trained docent program for group tours of the site.

The trail system includes numbered stations with accompanying trail guide describing the history and ecology of Flint Hills tallgrass prairie.

At the regional level, Konza Prairie hosts frequent field tours of LTER research sites for groups such as The Nature Conservancy, the Flint Hills Alliance, the EPA Region 7 field office, and state of Kansas congressional representatives. In the current LTER VI funding period, this included visits by the Midwestern Science Coordinator for The Nature Conservancy, the Kansas Chapter of The Nature Conservancy, meetings of the Kansas Cooperative Fish and Wildlife Service, the Kansas Department of Wildlife and Parks, USDA Natural Resources Conservation Service personnel, and the Great Plains Plant Systematics Symposium. In 2012, we hosted a meeting The Nature Conservancy's Grasslands Network, and a regional EPSCoR meeting including scientists from KS and OK. Konza LTER scientists communicate research results through regular presentations to regional farming, ranching and conservations groups including the Tallgrass Legacy Alliance, Kansas Society for Range Management, and the Kansas Livestock Association. In August 2012, Konza LTER scientists Joern, Towne and Sandercock participated in a Flint Hills regional meeting on the use of patch-burn grazing as an alternative management strategy to conserve grassland biodiversity. We also present information relevant to regional air and water quality issues. For example, in recent years we presented findings from Konza LTER fire studies to scientists and staff from the EPA Region 7 Office and the Kansas Department of Health and Environment in response to questions about the use of grassland fires in the management and conservation of grasslands. This is becoming an increasingly important issue as concerns grow about the potential adverse effects of grasslands fires on air quality in the Midwest, and there is a need to balance these concerns against an understanding of the importance of fire in the preservation of grassland ecosystems and rangeland resources. In 2008, Konza Prairie LTER research on climate change was featured in a Kansas City Star series on the potential impacts of climate change in Kansas. Konza LTER scientists also contributed publications and presentations geared toward the public through the Kansas Agricultural Experiment Station (KAES) and other regional agencies and organizations. Konza scientists serve on the planning committee for the Flint Hills Regional Discovery Center, using data from the Konza LTER program to inform decisions about the natural history and management of the Flint Hills region. LTER scientists Rice and Blair and ongoing reseasrch projects were featured in press releases surrounding the grand opening of the center in May, 2012. In addition, results from the Konza LTER program have been used in developing ecosystem management and conservation strategies for Nature Conservancy preserves throughout the region. Konza scientist have published numerous articles on application of ecological research to achieve management goals in outlets such as the Journal of Range Management, Restoration Ecology, and Ecological Applications, and have hosted field tours for applied scientists, such as those with the Natural Resources Conservation Service. Finally, the Konza Environmental Education Program has partnered with K-State Libraries and several regional public libraries to bring a collection of over 200 titles and computer-based information on grassland ecology to several regional libraries on a three-month rotating basis. The first two of these were in public libraries in Council Grove and Junction City, Kansas.

At a national level, Konza scientists have served as advisors for a Smithsonian Museum of Natural History exhibit on grasslands and agriculture (Forces of Change), as well as a traveling museum exhibit (Listening to the Prairie). In 2007 Konza Prairie was included in special feature in the April issue of the National Geographic magazine, which explored the tallgrass prairie ecosystem. In 2008, Konza was featured in an educational photographic exhibit at the Department of Interior museum in Washington, D.C., and in 2009 LTER scientists (Blair and Hartnett) were advisors for the developing Museum of Prairiefire, which will provide an interpretive educational focus on grassland ecology, and will partner with the American Museum of Natural History to bring AMNH traveling exhibits to the Kansas City area. In 2008, we hosted the EPA's newly formed National Agricultural Advisory Committee on a tour that featured LTER research. In 2010, we provided research oriented tours and presentations for the Natural and Environmental Resources Committee of the Kansas Farm Bureau, and for US congressional representative Jerry Moran. In 2011, Konza LTER scientists participated in a Soil Institute field training activity for USDA NRCS scientists. In February, 2012, Blair participated in Congressional office visits to promote awareness of LTER science activities, and in September, 2012, Blair and Rice participated in a panel discussion on federal research funding and support of science activities as part of the US Congressional Aides Tour of KSU.

The dissemination of information from the Konza LTER program to the general public has been facilitated by several nationally televised educational productions, including 'Where the Sky Began' (first aired on The Discovery Channel in 1998). Konza Prairie was also the central focus of a major educational documentary film on the history and ecology of the tallgrass prairie ('Last Stand of the Tallgrass Prairie'), which first aired nationally on PBS in April 2001. Both films continue to be broadcast at various dates around the country. In 2009, LTER scientists Towne and Nippert were interviewed at the Konza site by a production crew from NHK (Japan Public Broadcasting) as they filmed a television documentary featuring the native grasslands, indigenous peoples, wild horses and bison of the Great Plains. LTER scientists provided commentary on the ecology of Great Plains grasslands and bison for the program, which aired on NHK Public Broadcasting in Japan in April 2009. Also in 2009, LTER scientists Briggs and Blair were interviewed at the Konza site as part of a documentary project on global change ecology and environmental issues in the Great Plains (http://ecoheartland.com/). This film was featured at the 2009 Tallgrass Film Festival in Wichita, Kansas. The importance of long-term ecological research and climate change experiments were highlighted in the film. In 2012, Konza investigator McLachlan participated in BBC Ice Age series production, filmed in part on Konza Prairie, relating her paleoecology studies on Konza to past bison abundance on the Great Plains. Highlights of recent scientific findings from the Konza LTER program have also been featured on national media outlets (e.g., the DiscoveryChannel.com).

Program development and activities of the Konza Prairie Environmental Education Program (KEEP) continued during 2008-2012, with the appoitment of a new Environmental Educator (Jill Haukos) and a new Educational Program Assistant (Jan Evans). The goals of KEEP are to promote increased understanding and appreciation of the tallgrass prairie ecosystem and the importance of ecological research as a foundation for sound grassland conservation and management. Konza LTER researchers and results provide direct input to the education program, and provide training for Konza Prairie docents. Konza LTER research results have been summarized in training materials and curricula for docents and K-12 teachers, and Konza LTER researchers have participated directly in teacher training during the Konza Schoolyard LTER workshops. The KEEP program features directed tours and on-site educational programs for K-12 classes and teachers, adult education programs led by researchers and trained docents, as well as Schoolyard LTER programs and teacher training workshops. In addition to these formal programs, a 10 km nature trail system on Konza Prairie is open to the public daily and provides numbered stations with an accompanying trail guide describing many aspects of the history and ecology of the Flint Hills tallgrass prairie. Approximately 3000 to 4000 visitors use the self-guided trails annually. As mentioned above, another important public education and outreach activity is the biennial Konza Prairie Visitors' Day ? an open house featuring tours of the LTER research areas and experimental plots by LTER scientists, guided tours of the fire and grazing (bison and cattle) research units, and numerous ecological research and natural history displays.

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Web/Internet Site

URL(s):
http://www.konza.ksu.edu/
http://kpbs.konza.ksu.edu
Description:
The first URL is for the main website for the Konza Prairie LTER program. It is used to disseminate general information about the KNZ LTER program, and is a portal for accessing Konza LTER data and publications.

The second URL is for the Konza Prairie Biological Station.

Other Specific Products

Product Type:

Physical collection (samples, etc.)

Product Description:

The Konza Prairie LTER program includes an extensive collection of physical samples (plants, soil, invertebrates, water samples, etc.), which are archived for future analyses or use by LTER or other researchers.

Sharing Information:

Physical samples archived by the Konza LTER program are available upon request to other researchers.

Contributions

Contributions within Discipline:

The Konza Prairie LTER Program is a comprehensive, interdisciplinary research program designed to contribute to synthetic activities and conceptual and theoretical advances in ecology, and to further an understanding of ecological processes in mesic grasslands. Examples of specific recent contributions to the discipline of ecology are provided in the attached 'Konza LTER Findings' file. Here, we summarize in more general terms the contributions of the Konza LTER program to the advancement of ecology. Konza LTER scientific findings continue to be published in a broad range of high quality journals. In 2010-2011 (the current reporting period), the KNZ program produced or contributed to 110 publications: 91 refereed journal articles (including 17 currently in press), 2 book chapters, and 17 dissertations and theses. These publications cover topics ranging from the ecophysiology of individual organisms to regional patterns of productivity to consequences of global change in grasslands. Konza LTER scientists continue to publish articles in both disciplinarily focused and more general high impact journals (e.g., Nature, Science, PNAS, BioScience), reflecting significant contributions to the field of ecology. In addition to site-based science, Konza publications include substantial contributions to multi-site, collaborative ecological research, and the widespread use of Konza LTER data and resources by the broader ecology community. For example, Konza LTER data were used in several recent multi-site or synthetic efforts, including:

Beaulieu, J.K., J.L. Tank, S.K. Hamilton, W.M. Wollheim, R.O. Hall Jr., P.J. Mulholland, B.J. Peterson, L.R. Ashkenas, L.W. Cooper, C.N. Dahm, W.K. Dodds, N.B. Grimm, S.L. Johnson, W.H. McDowell, G.C. Poole, H.M. Valett, C.P. Arango, M.J. Bernot, A.J. Burgin, C. Crenshaw, A.M. Helton, L. Johnson, J.M. O'Brien, J.D. Potter, R.W. Sheibley, D.J. Sobota, and S.M. Thomas. 2011. Nitrous oxide emission from denitrification in stream and river networks. Proceedings of the National Academy of Sciences of the United States of America 108: 214-219.

Buis, G.M., J.M. Blair, D.E. Burkepile, C.E. Burns, A.J. Chamerlain, P. Chapman, S.L. Collins, R.W.S. Fynn, N. Govender, K. Kirkman, M.D. Smith and A.K. Knapp (In Press) Controls of aboveground net primary production in mesic grasslands and savannas: An interhemispheric comparison. Ecosystems.

Findlay, S., P. Mulholland, S. Hamilton, J. Tank, M. Bernot, A. Burgin, C. Crenshaw, W. Dodds, N. Grimm, W. McDowell, J. Potter, and D. Sobota. 2011. Cross-stream comparison of substrate-specific denitrification potential. Biogeochemistry 104: 381-392.

Garrett, K.A., G.A. Forbes, S. Savary, P. Skelsey, A.H. Sparks, C. Valdivia, A.H.C. van Bruggen, L. Willocquet, A. Djurle, E. Duveiller, H. Eckersten, S. Pande, C. Vera Cruz, and J. Yuen. 2011. Complexity in climate change impacts: An analytical framework for effects mediated by plant disease. Plant Pathology 60: 15-30.

Heisler-White, J.L., J.M. Blair, E.F. Kelly, K. Harmoney, and A.K. Knapp. 2009. Contingent productivity responses to more extreme rainfall regimes across a grassland biome. Global Change Biology 15: 2894-2904.

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Mulholland, P.J., A.M. Helton, G.C. Poole, R.O. Hall, Jr., S.K. Hamilton, B.J. Peterson, J.L. Tank, L.R. Ashkenas, L.W. Cooper, C.N. Dahm, W.K. Dodds, S. Findlay, S.V. Gregory, N.B. Grimm, S.L. Johnson, W.H. McDowell, J.L. Meyer, H.M. Valett, J.R. Webster, C. Arango, J.J. Beaulieu, M.J. Bernot, A.J. Burgin, C. Crenshaw, L. Johnson, B.R. Niederlehner, J.M. O'Brien, J.D. Potter, R.W. Sheibley, D.J. Sobota, and S.M. Thomas. 2008. Excess nitrate from agricultural and urban areas reduces denitrification efficiency in streams. Nature 452: 202-207.

Cleland, E.E., C.M. Clark, S.L. Collins, J.E. Fargione, L. Gough, K.L. Gross, S.C. Pennings, W.D. Bowman, G.P. Robertson, J. Simpson, D. Tilman and K.N. Suding. 2008. Species responses to nitrogen fertilization in North American plant communities, and associated species traits. Ecology (Ecological Archives) 89: 1175.

Knapp, A.K., C. Beier, D.D. Briske, A.T. Classen, Y. Luo, M. Reichstein, M.D. Smith, S.D. Smith, J.E. Bell, P.A. Fay, J.L. Heisler, S.W Leavitt, R. Sherry, B. Smith and E. Weng. 2008. Consequences of more extreme precipitation regimes for terrestrial ecosystems. BioScience 58:811-821.

Dodds, W.K., K.C. Wilson, R.L. Rehmeier, G.L. Knight, S. Wiggam, J.A. Falke, H.J. Dalgleish, and K.N. Bertrand. 2008. Comparing ecosystem goods and services provided by restored and native lands. BioScience 58:837-845.

Spasojevic, M.J., R.J.Aicher, G.R. Koch, E.S. Marquardt, N. Mirotchnick, T.G. Troxler, and S.L. Collins. 2010. Fire and grazing in a mesic tallgrass prairie: impacts on plant species and functional traits. Ecology 91: 1651-1659.

Smith, M.D., A.K. Knapp, and S.L. Collins. 2009. A framework for assessing ecosystem dynamics in response to chronic resource alterations induced by global change. Ecology 90: 3279-3289.

Another metric of the contributions of the Konza LTER program to ecology is the ability to leverage additional non-LTER funds to support Konza-related ecological research. Our success at securing additional funding from a variety of sources has substantially broadened our research base, and allowed us to greatly expand the scope of Konza LTER-related studies. During the current reporting period (2010-2011), approx. $14M in active awards (in addition to LTER funding) contributed to ecological research and training activities at Konza (see Research Activities for a list of KSU-based active funded projects). Finally, with the start of the LTER VI grant we are supporting the participation of several new investigators (Nathaniel Brunsell - Geography/Atmospheric Sciences, University of Kansas; Kendra McLauchlin - Geography KSU; K.C. Olson - Animal Sciences, KSU; Gail Wilson - Oklahoma State University), resulting in additional diversification of our research program.

It is noteworthy that Konza LTER studies are contributing not only to a better understanding of mesic grasslands, but also to a variety of broader ecological issues such as:

the application of ecological theory to restoration ecology (Baer and Blair 2008, Baer et al. 2010, in press, Heneghan et al. 2008);

valuation of ecosystem services in native and restored ecosystems (Dodds et al. 2008);

a novel framework for ecological responses to chronic resource alterations (Smith et al. 2010);

generalized plant community responses to chronic N enrichment (Cleland et al. 2008, Chalcraft et al. 2008);

the role of landscape fragmentation in the spread of pests and disease (Margosian et al. 2009);

factors controlling nitrate retention and removal in a range of stream ecosystems (Hall et al 2009, Mulholland et al. 2009);

the role of unique nutritional niches in the coexistence of generalist insect herbivores (Loaiza et al. 2008, Behmer and Joern 2008);

the extent and limits of ecological generalities derived from one geographic locale to other regions with different evolutionary histories (Swemmer et al. 2007, Buis et al. 2009).

In conjunction with our increasing focus on global change ecology, we also continued to used Konza LTER studies and data to address critical issues related to global change, including the effects of climate change (Heisler et al. 2008, Heisler et al. in press, Fay et al. 2008, Gerten et al. 2008) and land-use and land-cover change (Kitchen et al. 2009, Knapp et al. 2008, McKinley et al. 2008.

As we begin the LTER VI funding cycle, the Konza Prairie LTER program continues to expand its involvement in ecological synthesis activities by contributing to, and in many cases leading, regional and network-level science activities. For example, Konza LTER scientists Blair and Knapp led a working group on climate change in terrestrial ecosystems at the 2009 Science Council meeting, with a follow-up meeting to take place at the 2009 ASM. Doug Goodin is a long-time member of the LTER Climate Committee. John Harrington and KSU Geography students (Judd Patterson and Tom Prebyl) participated in four recent LTER Network-sponsored workshops on integration of social and ecological sciences (at LUQ), ecosystem services and working lands (at KBS and the 2008 Science Council meeting), scenarios of future landscape change (at HFR), and an LTER supplement-funded cross-site site study of socioeconomic drivers and patterns of land-use and

land-cover change (at CAP). Blair, Knapp and Smith have been regular participants in LTER planning for future LTER research priorities (the ISSE initiative), and several Konza scientists have had an active role in the EcoTrends project. Konza LTER scientists and students are participants in the Nutrient Network (NutNet) Global Research Cooperative (locally led by M. Smith). A new initiative to link ecological and health-related disciplines to address the ecology of diseases is being spearheaded by Konza scientist Samantha Wisely.
An example of a recent cross-disciplinary and cross-site project is: Socioecological Gradients and Land-Use Fragmentation: A Cross-Site Comparative Analysis (CAP, JRN, KNZ, SEV, and SGS)

Finally, an important contribution of the Konza LTER program to the advancement of ecology is to provide a unique resource, in the form of the site infrastructure, long-term experiments, and available data that can be used by the general ecological community to address a wide range of ecological questions. Konza Prairie serves as a node in many national networks, including the National Atmospheric Deposition Program (NADP), the EPA Clean Air Standards and Trends Network (CASTNET), NOAA's Climate Reference Network (CERN), and the USGS Hydrologic Benchmark Network. The Konza Prairie site has also been selected as a candidate core site for the developing National Ecological Observatory Network (NEON), and Konza LTER scientists have been active participants in the NEON planning process, and in local and domain-level activities.

Konza LTER scientists continue to make significant contributions to international collaborative efforts in ecology. David Hartnett was co-convener of an NSF-sponsored US-Africa Workshop to enhance collaborative research on the environment in sub-Saharan Africa and is a participant in the 'Sekgwa Project' (U. Botswana and Okavango Research Center) to promote collaborative research and training on the ecology and dynamics of southern African grasslands and savannas. With supplemental LTER funding, Brett Sandercock is collaborating with scientists in Uruguay on a migratory bird project. Finally, several Konza PIs (Knapp, Blair, Smith, Collins) were awarded new NSF funding to extend Konza LTER studies in a test of ecological generalities in South African grasslands (Collaborative Research: Convergence and Contingencies in Grassland Savannas).

Contributions to Other Disciplines:

The Konza Prairie LTER program and our core research experiments attract numerous scientists from a broad spectrum of scientific disciplines beyond ecology. For example, Konza was used by atmospheric scientists from the University of California Berkeley (led by Rob Rhew) to assess fluxes of atmospheric methyl halides in temperate North American grassland ecosystems, employing a recently developed stable isotope tracer technique to separate simultaneous production and consumption fluxes. A hydrogeochemist from the University of Kansas (Gwen Macpherson) is a long-term collaborator in the Konza Prairie LTER program, and we support ongoing long-term studies of groundwater chemistry sampled via permanent wells located on Konza Prairie. An atmospheric scientist from the University of Kansas (Nate Brunsell) is using Konza sites to study the effects of surface heterogeneity on land atmosphere interactions, and is employing a Large Aperture Scintillometer (LAS) to measure sensible heat fluxes over longer path lengths that span Konza watersheds with ongoing C flux measurements. This allows comparison with eddy covariance stations and satellite derived estimates of surface energy fluxes. We collaborate with Gene Kelly (pedologist) and his students (Colorado State University) to assess patterns and controls of silica weathering and patterns of soil weathering and P availability in Great Plains grasslands. Another soil scientist from Cornell (Johannes Leahman) is using Konza LTER treatments to assess the impacts of landscape position and contemporary management practices on black C accumulation in soils. A hydrologist from Biological and Agricultural Engineering (James Koelliker) has been a long-time collaborator on the 'Irrigation Transect Experiment', and has provided numerous training opportunities for Biological and Agricultural Engineering and Hydrology students. Konza Prairie has also become a research platform for several collaborative teams of ecologists and molecular biologists that are part of the KSU Ecological Genomics Initiative. Many of these interdisciplinary teams are using the Konza LTER site and associated long-term experiments to address questions related to the genetic mechanisms underlying plant and animal responses to environmental constraints. The Konza LTER program has also contributed to recent research and synthesis activities in the area of Plant Pathology and Ecological Genomics.

In the last several years, we greatly expanded our interactions with social scientists, in both site-based and LTER network level activities. For example, we supported the activities of a faculty member (Gerrad Middendorf) and graduate student (Derick Cline) in the Department of Sociology at KSU. Dr. Middendorf was also a participant in the multi-site Agrarian Ecosystems in Transition project (Middendorf, G., D. Cline, and L. Bloomquist, 2008. Agrarian Landscape Transition in the Flint Hills of Kansas: Legacies and Resilience. Page 206-237. In Charles Redman and David Foster (eds.) Agrarian Landscapes in Transition: Comparisons of Long Term Ecological & Cultural Change. Oxford University Press. New York.) We also support and collaborate with Senior Investigators in the Department of Geography (Doug Goodin, John Harrington, Kendra McLauchlan and Kevin Price). John Harrington is a co-investigator for the LTER Network-sponsored workshops on ecosystem services in working lands, and a contributor to the broader LNO ecosystem services group led by Terry Chapin and others. Dr. Harrington also represented Konza Prairie in a recently funded cross-site initiative to assess drivers of land-cover change at multiple LTER sites. Geography graduate student Beau Burkitt was supported for cross-site hydrological modeling of future land cover scenarios using SWAT [with Ken Sylvester from SGS and funding from the Agrarian Transitions project). Most recently, KSU hired a new faculty member in Geography with expertise on interactions of humans and the environment (Dr. Kendra McLauchlan), and has worked to incorporate her as appropriate into the Konza LTER program.

Other contributions to disciplines outside the traditional realm of ecology include the operation of flux towers at the Konza site, which has provided data used by micrometeorologists, climatologists, remote sensing scientists and modelers. We also collaborate with atmospheric chemists and modelers from the EPA CASTNet program in sampling concentrations of selected airborne particles and using these to model dry deposition rates, and in 2006, two new seismographs were installed on the site to facilitate ongoing geologic research by USGS scientists and their collaborators. We also collaborate with NASA scientists in the maintenance and operation of a Cimel sun photometer at the Konza site.

Contributions to Human Resource Development:

The Konza Prairie LTER VI program makes significant contributions to human resource development in science, engineering and technology. Our program contributes to the training of undergraduates directly (REU students and others)and indirectly (through the use of Konza LTER data in ecology classes and text books). As documented elsewhere in this report, we also train numerous graduate students, and provide valuable experience in interdisciplinary research and the synthetic use of long-term datasets. In addition to supporting KSU graduate students, the Konza Prairie LTER site is widely utilized by graduate students from other institutions. During the current LTER VI funding period, the site has been used by graduate students from the University of Kansas, University of Colorado, University of Kentucky, University of New Mexico, University of Pittsburgh, University of California - Santa Barbara, Iowa State University, Southern Illinois University, Colorado State University, Cornell University, Yale University, and several others. We also hosted field trips for students from many regional colleges and universities, such as Principia College, Concordia College, University of Minnesota-Mankato, Truman State University, Pittsburgh State University, the University of Colorado, and others.

The Konza Environmental Education program, and the Konza Prairie Schoolyard LTER Program, provide formal and informal research experiences and science education to public groups, children and K-12 teachers, as well as training experience for a graduate student in the College of Education. Konza LTER research in restoration ecology is being used by local high school teachers to develop educational activities as part of Howard Hughes funded teacher training program. In 2008-09, Blair served as consultant for a local high school teacher (Drew Ising), who is establishing a prairie restoration research site, and developing a class module on soils, for his course in Environmental Biology and Ecology at Junction City High School. The Konza LTER program also provides research support for a GK12-sponsored graduate student working with this high school teacher. Finally, the Konza LTER site continues to be used in conjunction with the NSF-funded Girls Researching Our World (GROW) program (www.ksu.edu/grow/), with several KSU scientists and students leading educational activities for 7th and 8th grade girls.

Contributions to Resources for Research and Education:

The Konza LTER program provides a research platform for scientists and students from around the world. The Konza Prairie LTER site (Konza Prairie Biological Station; KPBS) is a 3,487-ha field research site, which includes several buildings devoted to ecological research and education. These physical resources are instrumental in attracting a large number of outside scientists to the site. KPBS facilities include the 4,650 ft.2 Hulbert Center housing a library/conference room, classroom, offices, teaching laboratory, reference herbarium and animal collections, and dormitory-style housing for 15. Two new 2-bedroom housing units expand the accommodation capacity to 25 visiting researchers. The 2,400 ft2 Ecology Laboratory houses 2 analytical laboratories, a soil and root processing lab, a computer room, and researchers' shop. In 2008, the renovation of the ground floor of a historic, 2- story limestone barn at the Konza Prairie Biological Station (KPBS) was completed. The renovated building provides support for the Konza Prairie LTER program and for visiting scientists in the form of a high-quality meeting facility and multi-use space for research, science education, and public outreach programs. Other station buildings include a fire station and shop/maintenance building, storage building for research equipment, and a residence for on-site staff. All KPBS headquarters buildings have T1 Internet connectivity, and the site has wireless data transmission capabilities.

Other LTER-related research infrastructure, includes the large 1000 ha bison research area, 98 small (25 m2) grazing exclosures, and 17 km of access roads and 61 km of fireguards separating the experimental watershed treatment units. KPBS maintains several general-purpose vehicles on-site, as well as specialized equipment (tractors, fire trucks, mowers, soil augers, etc.). The headquarters also include a meteorological station, a CIMEL Sun Photometer, and a dry-deposition monitoring facility (CASTNet). A total of 36 experimental stream units are located in the headquarters area. Other field equipment and instrumentation at the site includes three eddy flux towers for quantifying ecosystem-level C flux, four weirs and associated stream gauging equipment, 46 wells for monitoring groundwater levels and chemistry, numerous TDR probes and neutron access tubes for soil water measurements.

Additional LTER-supported laboratory facilities are located on the KSU campus, approximately 15 km from KPBS. The majority of LTER laboratory space and analytical equipment are located in Bushnell Hall (Biology), including space and equipment for preparing plant, soil and water samples for analysis (drying ovens, grinders, shaker tables, block digestors, vacuum filtration systems). Two walk-in controlled environment chambers (Conviron PGV 36) are located in Bushnell Hall. Bushnell Hall also houses an extensive collection of prairie plant specimens in the KSU Herbarium. Some specific equipment and facilities are located within other Departments (Agronomy, Biological and Agricultural Engineering, Plant Pathology, Geography), reflecting the interdisciplinary nature of our research. Some major analytical equipment available for LTER research includes: 2 Alpkem autoanalyzers (FlowSolution and RFA500) for liquid samples, a Carlo-Erba 1500 automated C/N analyzer for solid samples, a Shimadzu TOC 500 analyzer for dissolved C, a Hitachi UV2000 automated dual-beam spectrophotometer, several gas chromatographs with electron capture, flame ionization and thermal conductivity detectors, a Nikon compound microscope with epifluoresence and video imaging capabilities, 1 LiCor 6400 and 3 LiCor 6200 Portable Photosynthetic Systems (1/4 and 1 L cuvettes), a LiCor 6200 system dedicated for soil CO2 flux measurements, a LiCor 1600 null-balance porometer for stomatal conductance, and 3 pressure chambers (PMS model 1000) for measuring plant water status, 4 Tektronix cable testers (model 1502B) coupled to Campbell CR10 data loggers for TDR soil moisture measurements, a Troxler (model 3221) neutron probe gauge for soil moisture determinations, and a back-pack mounted minirhizotron (Bartz Technology Co. BTC-2) camera system. We also have access to a shared Hewlett Packard HPLC and GC/MS system for characterizing soluble organic compounds. Cold storage facilities for holding samples are available, as are sample preparation rooms for drying and grinding plant and soil samples. Climate controlled greenhouse space is available on the KSU campus. In addition, other 'typical' laboratory equipment (balances, microscopes, etc.) is available in individual investigator laboratories.

Contributions Beyond Science and Engineering:

The Konza Prairie LTER program contributes to increased public awareness of ecological and environmental issues (e.g., biodiversity conservation, habitat loss, ecosystem services, restoration ecology, etc.) through outreach and public education activities, such as the Konza Prairie biennial Visitors' Day and our docent-led public education programs. Konza LTER scientists also conduct an annual fire-training course for researchers and local land managers (35-40 participants/year). In addition, the Konza LTER Program is increasingly called upon to provide data relevant to resource management and regulatory policy. At a local level, Konza scientists participate in Kansas Agricultural Experiment Station public education events by providing information on the ecological consequences of various grassland management practices (e.g., fire frequency and grazing). At the regional level, Konza Prairie scientists are advising EPA Region 7 staff and scientists on the ecological benefits of fire in maintaining native tallgrass prairie habitat and diversity, including several meeting with both regional and national EPA officials. This issue has become very important, as the potential impacts of grassland burning on regional air quality have been receiving increasing scrutiny. Konza scientists also participated in the development of a management and monitoring plan for the Tallgrass Prairie National Preserve, and a training workshop in tallgrass prairie ecology and management for the NPS Rangers at the National Preserve. In 2008, Konza Prairie hosted a field trip for scientists from the Natural Resources Conservation Service. Konza LTER scientists also serve on the planning committee for the Flint Hills Regional Interpretive Center. At a national level, Konza Prairie hosted a delegation of 15 U.S. Congressional Assistants, which highlighted results from the Konza LTER program as an example of the value of long-term ecological studies for the long-term sustainable management of natural resources. Konza scientists have also served as advisors for a Smithsonian Museum of Natural History exhibit on grasslands and agriculture (Forces of Change), as well as a traveling museum exhibit (Listening to the Prairie). In 2008, Konza Prairie was the focus of a photographic exhibit at the Department of Interior Museum in Washington, D.C. In the international arena, Konza Scientists have provided information on grassland management to scientists and park resource managers from South Africa, Australia, and Hungary, with many of these visits focusing on resource management issues of public concern. The Konza Prairie LTER database is also being used to address issues relevant to regulatory policy. Long-term data on Konza Prairie streamwater quality is providing a baseline for regional water quality in the absence of agricultural practices or other disturbances. LTER data on soil chemistry is also being incorporated into ongoing studies to evaluate the potential of grassland management practices to increase soil C sequestration to offset atmospheric CO2 loading.

Finally, the Konza Prairie LTER site, and the unique watershed fire and grazing treatments, have been the focus of several art-related activities. For example, local artist Edward Sturr produces limited edition hand-colored photographs and lithographs of Konza landscapes (www.prairielight.com), and a photographic exhibit of Konza Prairie by nature photographer Judd Patterson (www.juddpatterson.com)was featured at a recent exhibit (A Sea of Tallgrass: the Konza Prairie) at the Department of Interior in Washington, DC. Most recently, the Konza Prairie Biological Station has provided on-site housing for a Visiting Writers series, in conjunction with the KSU English Department. Writers in Residence have included Moya Cannon (2010) and John Price (2011).

Conference Proceedings

Special Requirements

Special reporting requirements: None
Change in Objectives or Scope: None
Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Any Conference

Konza Prairie Research Findings:
Here we present a selected subset of recent results from the Konza Prairie LTER Program. A complete of publications for the current funding period is included in the FastLane publication databas.

Plant Community and Ecosystem Responses to Long-term Fire and Grazing Treatments, and Environmental Heterogeneity.
Though grazing and fire have some comparable effects on ecosystem processes in grasslands, their effects on plant species composition and community structure are often divergent and lead to directional changes in community structure that accrue over time and require long-term data to fully resolve. A recent analyses by Collins and Calabrese (2012) used long-term plant community data collected on watersheds with different fire and grazing histories (20 yr of variable burning treatments and 13 yr of grazing by bison) to address the following two questions: 1) How do fire and grazing by bison affect the composition and structure of tallgrass prairie plant communities and their temporal stability? And, 2) Are these responses modulated by topographic location? Data on plant community composition from permanent sampling transects at upland, slope and lowland topographic positions on core LTER watersheds was analyzed using multivariate approaches to determine how community structure, life forms and individual species responded to the cumulative, long-term effects of contrasting fire return intervals in the presence and absence of native grazers. We found that species diversity was greatest in sites that were infrequently burned and grazed by bison. Community response to fire and grazing also differed across the topographic gradient. In general, frequent burning favored the dominant C_4 grasses, which in turn reduced the abundance of C_3 forbs, especially in lowland sites. Community stability was positively correlated with species richness across treatments and topographic positions. Fire, grazing and soil type affected overall plant community composition, but surprisingly there were no significant interactions among these drivers at the community level. As a result, each landscape component contributes uniquely to landscape-scale diversity and dynamics. Species richness and community stability were maximized across the landscape with infrequent fire (every 4– 20 yr) and bison grazing across a range of soil types. Unlike previous studies, richness did not differ along the topographic gradient. In addition, richness on slope sites, which are abundant throughout the Flint Hills region, was particularly responsive to fire frequency. The dominant C4 grasses appear to regulate community diversity. Grass cover was negatively correlated with forb richness. However, grass cover is regulated by fire and grazing; fire increases and grazing reduces the collective abundance of these tall clonal C4 species. Despite these general patterns, the abundance of dominant species increases or decreases in response to fire frequency and grazing, depending on topographic position. At the whole site scale, we found diversity enhanced community and functional type stability, but grazing modulated this response. Overall, this study demonstrates how richness, diversity and composition respond to grazing and variable fire frequency over the long term, and how these responses are modulated by topographic position.

Grassland Restoration Studies.
In 2012, the first synthetic review of how soil ecological knowledge can be applied to restore ecosystem services, led by S. Baer, was published in *Soil Ecology and Ecosystem Services* (D. Wall, editor). This peer-reviewed book chapter summarizes ecosystem services (and functions) promoted through ecological restoration in general, provides a conceptual framework of the relationship between soil legacy and ecosystem function in the context of restoration, and organizes knowledge and manipulation of soil properties and processes applied to improve ecosystem functions and services during restoration. The chapter highlights findings from KNZ the 1998-heterogeneity experiment, i.e., the role of soil nutrient availability in soil on restoration of plant diversity (Baer et

al. 2003) and the complexity of maintaining soil manipulations with developing plant-soil feedback during restoration (Baer and Blair 2008).

Gibson et al. (2012, published in *Oikos*) is a modeling simulation of the role of genotypic diversity of foundation species in community assembly (in a restoration context) that demonstrates environmental heterogeneity modulates whether relationships between genotypic diversity and species are positive or negative. The conceptual model published here is a modification of the classical filter model of community assembly to include how dominant species may alter the biotic filter to affect species diversity during restoration, originally developed to demonstrate the potential role of dominant species propagule sources in restoration being tested at Konza Prairie and in Illinois.

Bach et al. (2012, published in *Environmental Management*) compared soil processes and soil microbial community structure in grasslands restored with high and low diversity seed mixes through the Conservation Reserve Program. This research represents a regional extension of on-going investigation of the role of human decisions in community assembly that are unique to restoration. This manuscript demonstrates the important role of C_4 grasses and arbuscular mycorrhizae fungi in driving recovery of soil C and N pools and fluxes during grassland restoration.

Rachel K. Goad (M.S. Thesis, Southern Illinois University) investigated whether native prairie plant assemblages were locally adapted to their 'home' soil microbial communities by reciprocally crossing the same 4-species plant assemblage established from seeds obtained at Konza Prairie and a remnant prairie in Illinois with soil inocula obtained from both prairies where seeds were obtained and an agricultural soil. Local adaptation to soil microflora was not evident, but the productivity of Konza-sourced plants was higher in agricultural soil from Illinois (largely due to the response of big bluestem) suggesting negative feedback between Konza plants and the soil microbiota in prairie soil, which could promote coexistence and diversity.

Positive Feedback Mechanisms Drive Shrub Encroachment in Tallgrass Prairie.
In the last century, woody vegetation has expanded in grasslands and savannas worldwide, with impacts on carbon cycling and regional biodiversity. In the Flint Hills of northeastern Kansas, USA, the shrub *Corus drummondii* has expanded into the tallgrass prairie despite the maintenance of antecedent fire frequencies. To better understand dynamics and drivers of woody encroachment in tallgrass prairie, we established transects spanning the shrub – grass ecotone. Our results showed source water partitioning (using xylem-water δ^2H and δ^{18}O) between *C. drummondii* and the C_4 grass *Andropogon gerardii*, with *C. drummondii* relying upon intra-annually stable soil water below 30 cm depth. Early summer canopy development reduced light availability at the ecotone, a response that favors woody vegetation over C_4 grasses. At the ecotone and shrub center, fine fuels decreased by ~50% after 4 years of growth minimizing the impact of subsequent fires on shrub biomass. These shrub-mediated changes represent positive feedback mechanisms that can drive subsequent *C. drummondii* expansion into the grassland matrix. These same changes may also facilitate woody seedling establishment. Because *C. drummondii* exhibits strong controls on ecosystem structure and its clones can avoid competition with grasses by accessing deep soil water sources, the ecological threshold for woody expansion in tallgrass prairies may be the event of woody establishment. Once established, the predominate woody encroacher of this region (*Cornus drummondii*) may bypass typical establishment barriers, resulting in a localized positive feedback loop. These shrubs expand radially into the grassland matrix via rhizatomous clones and we found that these developing stems utilize the same deep soil water source as their parent shrub (likely via rhizatomous transfer). The ability to access deep-water sources circumvents competition for water with grasses, a process that would otherwise restrict seedling establishment. Additionally, fine fuels declined exponentially at the

shrub/grass interface, reducing the potential impacts of subsequent fires. The release from resource/fire limitation should result in a positive feedback system as clonal expansion allows individual shrubs to reach up to 200 m^2, compared to <1 m^2 as single-stemmed individuals. This interpretation is consistent with long-term data on site (26 years), where we found that the size of shrubs that are both clonal and deeply rooted has increased 16-fold and aerial coverage has increased from 0 to ~28%. In contrast, the cover of non-clonal species has remained the same and shallow-rooted clonal species have only increased marginally. Together, these results suggest that positive feedbacks facilitate woody encroachment in mesic tallgrass prairie, but by promoting the expansion of existing shrubs rather than the establishment of new individuals. The reduced competition for water and decreased intensity of fires following encroachment represents a reversal of the factors that maintain grass dominance, highlighting the likely possibility that tallgrass prairie is a bi-stable system. Therefore, any global change phenomena (land-use, increased CO_2, N-deposition) that facilitates or lowers resilience to initial woody establishment in grasslands, may lead to abrupt non-linear state-shifts in grassland ecosystems.

Woody encroachment is a widespread and acute phenomenon affecting grasslands and savannas worldwide. Looking beyond the borders of the Konza site, Ratajczak et al. (2012) performed a meta-analysis of 29 studies from 13 different grassland/savanna communities in North America (including LTER data from Konza) to determine the consequences of woody encroachment on plant species richness. In all 13 communities, species richness declined with woody plant encroachment (average decline = 45%). Species richness declined more in communities with higher precipitation ($r^2 = 0.81$) and where encroachment was associated with a greater change in annual net primary productivity (ANPP; $r^2 = 0.69$). Based on the strong positive correlation between precipitation and ANPP following encroachment ($r^2 = 0.87$), we hypothesize that these relationships occur because water-limited woody plants experience a greater physiological and demographic release as precipitation increases. The observed relationship between species richness and ANPP provides support for the theoretical expectation that a trade-off occurs between richness and productivity in herbaceous communities. We conclude that woody plant encroachment leads to significant declines in species richness in North American grassland/savanna communities.

Bud Banks and Plant Population Dynamics

A recent Konza LTER study (N'Guessan and Hartnett 2011) focused on the dominant grass *Shizachyrium scoparium* (little bluestem) demonstrated that, although this species lacks compensatory growth capacity, its belowground bud bank traits are key to explaining its persistence under frequent grazing. Specifically, the maintenance of a large pool of dormant buds across a wide range of grazing intensities, and the shift in bud position and plant architecture contributes to its grazing tolerance and grazing avoidance respectively. Ott and Hartnett (2011 and *in press*) showed that large interspecific differences in grass bud natality, longevity, and controls on dormancy and outgrowth can explain differences in grass population dynamics and predict their population resilience or sensitivity to environmental change, and ultimately plant community change. In addition, another study by Ott and Hartnett (*in press*) demonstrated that unique features of the modular construction of grasses and phylogenetic constraints explain patterns of seed and vegetative reproduction in grasses and the lack of a trade-off between these two modes of reproduction as predicted by life history theory. This study contributes to an increasing body of KNZ research indicating that meristems limitation as well as resource limitation is important to understanding plant population responses in grasslands. Our recently completed experiments in collaboration with Oklahoma State University (Wilson and students) also showed that light spectral quality (R:FR) is important in regulating bud dormancy and tiller activation in three of six grass species studied. Nitrogen resulted in species-specific responses, with each species responding differently to N amendments. This indicates that alterations in nitrogen availability, light availability, or shifts in spectral quality may affect grassland plant communities through differential demographic responses among grass species. Overall, these findings will lead to improved predictive models of grassland responses to environmental change.

Linking plant growth responses across topographic gradients in tallgrass prairie
Using a transect spanning a topographic gradient in annually-burned tallgrass prairie, Nippert et al. (2011) measured changes in the growth of four abundant C_4 grass species, LAI, biomass, and cumulative carbon flux using two closely located eddy flux towers. We hypothesized that responses along the topographic gradient could be partitioned into position descriptions (e.g., upland / lowland), and the magnitude of growth and carbon flux would vary as a function of topographic position, but the patterns across positions would be similar. Annual carbon flux was greater in lowland versus upland locations, indicating that the source areas contributing to tower fluxes varied. For most of the growth variables measured, a 4-position topographic classification based on soil depth was the best. The magnitude of biomass production, LAI and changes in plant growth varied, with increasing values from the lowland to slope to break and upland positions. Differences in growth by landscape position reflected the greater production of flowering culms by *Andropogon gerardii* and *Sorghastrum nutans* in lowland. Varying growth responses by these species may be a significant driver of biomass and carbon flux differences by topographic position, at least for wet years. These results suggest infrequent temporal or limited spatial sampling of plant growth, LAI, or biomass would contribute to a location bias and incompletely describe the turbulent carbon fluxes from this grassland. Thus, measuring the biological responses associated with small-scale landscape variability, and accounting for this variability should improve model predictions of carbon flux at larger scales.

Grassland Responses to Climatic Variability and Climate Change.
In 2011-12 we continued several long-term experiments focused on responses of grasslands to changes in climate and climatic variability. Here we summarize findings and recent published results from two of those experiments.

The first is the Rainfall Manipulation Plots (RaMPs) Experiment in which the timing and amounts of rainfall events are being experimentally manipulated in intact native tallgrass prairie plots (see Activities section for additional details). Results to date from this experiment have identified several critical aboveground and belowground community and ecosystem processes grasslands that are responsive to changes in the timing of rainfall events and/or elevated temperature. For example, altered rainfall timing (longer inter-rainfall droughts interspersed with larger individual precipitation events, with no change in annual rainfall amounts) significantly reduced aboveground net primary productivity by 13-22% (ANPP) in 5 out of 12 years, despite high year-to-year variability in ambient rainfall patterns and mean plant productivity. Averaged across all years, ANPP was 10% lower in the altered rainfall timing treatment ($P<0.001$). Soil CO_2 flux was also affected by altered rainfall timing, with rainfall timing x date interactions in all years, and significant main effects of the rainfall treatments in dry years. When significant main effects occurred, it was due to reductions in mean annual soil CO_2 flux under altered rainfall timing. As with ANPP, soil CO_2 flux was positively correlated with mean seasonal soil water content and negatively correlated with indices of soil moisture variability. This important finding suggests that increases in the temporal variability in soil water content resulting from climate change will significantly alter key C cycling processes in grassland ecosystems. We expect continued reductions in both ANPP and soil CO_2 flux with more variable rainfall regimes, and we predict that increased temperatures will exacerbate variability in surface soil water content and further alter C cycling, leading to changes in soil C and N pools. We are continuing our climate manipulations to assess the longer-term responses to altered rainfall and temperature regimes, as well as potential changes in specific soil C and N pools.

Fay et al. (2011) assess the relative impacts of inter- vs. interannual rainfall variability and effects of elevated temperature using 10-years of data from the RaMPs experiment. During this 10-year window, total growing season rainfall varied 2-fold, and we found 50–200% interannual variability in plant growth and aboveground net primary productivity (ANPP), leaf carbon assimilation (ACO_2), and soil CO_2 efflux (JCO_2) despite only 40% variation in mean volumetric soil water content (0–15 cm). Interannual variation in soil moisture was thus amplified in most measures of ecosystem response. Differences between years explained the greatest portion (14–52 %) of the variation in these processes. Experimentally increased intra-annual season rainfall variability doubled the amplitude of intra-annual soil moisture variation and reduced by 15 %, causing most ecosystem processes to decrease 8–40%in some or all years with increased rainfall variability compared to ambient rainfall timing, suggesting reduced ecosystem rainfall use efficiency. Warming treatments increased soil temperature at 5 cm depth, particularly during spring, fall, and winter. Warming advanced canopy green up in spring, increased winter JCO_2 , and reduced summer JCO_2 and forb ANPP, suggesting that the effects of warming differed in cooler versus warmer parts of the year. We conclude that (1) major ecosystem processes in this grassland may be substantially altered by predicted changes in interannual climate variability, intra-annual rainfall variability, and temperature, (2) interannual climate variation was a larger source of variation in ecosystem function than intra-annual rainfall variability and warming, and (3) effects of increased growing season rainfall variability and warming were small, but ecologically important. The relative effects of these climate drivers are likely to vary for different ecosystem processes and in wetter or drier ecosystems.

The RaMPs project has also become an important resource for other research groups interested in long-term responses to climate manipulations, and we continue to provide both data and samples in support of these efforts. For example, Evans and Wallenstein (2011) used soil samples from the RaMPs project to assess how a history of intensified rainfall would alter microbial functional response to drying and rewetting events, whether this historical legacy was mediated through altered microbial community composition, and how long community and functional legacies persisted under similar conditions. Using soils from the long-term RaMPs rainfall treatments, they measured respiration, microbial biomass, fungal:bacterial ratios and bacterial community composition after collecting soils from the field experiment, and after subjecting them to a series of additional drying–rewetting pulses in the lab. Although rainfall history affected respiration and microbial biomass, the differences between field treatments did not persist throughout our 115-day drying–rewetting incubation. However, soils accustomed to more extreme rainfall did change less in response to lab moisture pulses. In contrast, bacterial community composition did not differ between rainfall manipulation treatments, but became more dissimilar in response to drying–rewetting pulses depending on their previous field conditions. These results suggest that environmental history can affect contemporary rates of biogeochemical processes both through changes in abiotic drivers and through changes in microbial community structure. Likewise, Finzi et al. (2012) used soil samples from the RaMPs project to assess potential impacts of altered moisture and temperature on response of proteolytic enzymes, enzymes that cleave protein into component amino acids, to experimental manipulations of air/soil temperature and precipitation. The response of proteolytic enzyme activity (stimulation vs. repression) depended on whether the experimental manipulations increased or decreased seasonal soil moisture deficit. Samples from different biomes (arctic to hot, dry grasslands) plotted along a single line suggesting a convergence in the effect of climate on the activity of this class of enzymes.

A second long-term climate manipulation experiment is the Irrigation Transect Experiment. A recent analysis of 19-years of plant community and plant productivity responses to supplemental water addition in this experiment is the basis for an *in press* manuscript that will be featured as a "Spotlight" manuscript in a forthcoming issue of *Functional Ecology*. This manuscript by Collins et al. used plant community data to assess a theoretical model of non-linear ecosystem responses to chronically altered resource availability (the Hierarchical Response Framework (HRF), proposed by Smith et al. 2009). Collins et al (2012) found, surprisingly, that community structure changed very little during 19 years of supplemental water additions to alleviate soil water stress. Any changes in species diversity and community structure that were detected varied from year to year and were inconsistent with the treatment effects over time. Thus, despite complete removal of growing season water limitation for almost two decades, the tall, perennial C4 grasses maintained dominance in this system. This resistance to chronic water addition was surprising given that ecosystem structure and function across central US grasslands is widely accepted to be driven by precipitation amount, and at Konza Prairie aboveground productivity has been shown to be water limited 75% of the time. However, despite the overall lack of change in plant community structure, Collins et al. (2012) did highlight a change in relative abundance of one C4 tallgrass species (*Panicum virgatum*). This grass species was always present but was less abundant than the dominant C4 grass, *Andropogon gerardii,* in the community for the first 10 years of the experiment. However, *P. virgatum* became dominant after a decade of water additions and remained so for the next nine years. This response, they argued, is consistent with one HRF prediction - that with chronic resource alterations, extended lag periods might be expected before a period of community reordering occurs. Knapp et al. (2012) present a companion paper that test another prediction of the HRF; that initial responses in ecosystem function to resource addition are expected to be relatively modest and dominated by ecophysiological processes, but much greater alterations in function will occur when community reordering occurs. Such reordering is expected to occur as species that are better able to exploit changes in resources increase in abundance. To test this prediction, they compared responses of aboveground net primary production (ANPP), a key ecosystem function, to irrigation for two key time periods identified by Collins et al. (2012) – the initial 10 year period of dominance by *A. gerardii* and the subsequent 9 years of dominance by *P. virgatum*. The response in ANPP was consistent with HRF predictions: water addition increased ANPP by 37% in the first decade of the experiment and by 64% after reordering of the dominant C_4 grasses. This dramatic increase in ecosystem function occurred despite a modest shift in community structure (i.e., only a change in the identity of the most abundant grass without a change in composition overall. The increase in ANPP observed in the second half of the experiment is particularly noteworthy when placed within the broader context of regional patterns of ANPP, since levels of ANPP in the last 9 years of this study far exceeded those expected for the amount of water received (Fig 1 bottom). Such dramatic and rapid shifts in ANPP have been documented previously, but only when one growth form replaces another (forest or shrub encroachment into grasslands) or with substantial nutrient additions. While Collins et al. (2012) provide an intriguing example of plant community structure being surprisingly resistant to chronic alterations of a limiting resource (water) additional insight can be drawn when these results are combined with ANPP data. Ecologists have long recognized that changes in limiting resources can lead to major alterations in community composition and structure, often with similar consequences for ecosystem function. But Collins et al. (2012) and Knapp et al. (2012) demonstrate that such community shifts are not required for chronic resource alterations to lead to dramatic changes in ecosystem function. In other words, overall stability in community richness, diversity or growth form dominance does not preclude a large functional response to chronic resource alterations – such as those expected to occur with global change (Smith et al. 2009). The results in Collins et al. (2012) also demonstrate that even relatively simple, single factor experiments can be valuable for testing global change theory, particularly if they are long-term (Knapp et al. 2012).

The Ecology of Tallgrass Prairie Streams

Dodds completed a cross-site publication with aquatic scientists at a variety of LTER sites and this analysis was accepted for publication (Dodds et al. in press). Dodds also collaborated with Dr. Rudolf Jaffe on black carbon in Konza streams compared to that found in other systems (Jaffe et al. in press). Surprisingly, even with the high burn frequency on Konza, levels of black carbon are not very high.

We are completing data analyses on a small scale (stream reach scale) woody vegetation removal experiment where we have documented that vegetation removal (restoration to natural riparian conditions of grassland streams) lead to 1) increased denitrification rates (Reisinger 2010), 2) shifts in communities with fewer leaves and bryophytes, and more filamentous algae (Riley et al 2012), 3) corresponding shifts in ecosystem metabolism related to more light reaching the stream and less detrital leaf materials (Riley et al. 2012), and 4) corresponding changes in invertebrate communities related to changes in food availability. Jodi Vandermyde, an MS student at SIU, has been examining invertebrate and benthic organic matter responses to this manipulation. Jodi's analyses are now complete and she will defend her thesis and submit her results for publication during fall semester 2012. Her results show that stream macroinvertebrates responded significantly to the vegetation removal, with increases in grazers and most other functional groups. However, after one year, invertebrate communities still differed significantly from those in naturally open reaches.

Two manuscripts evaluating fish assemblage dynamics in prairie streams using data from Kings Creek and Fox Creek were recently completed and are in review. One paper Erika Martin tested habitat associations of fishes across hierarchical spatial scales and found that the main drivers of species richness in prairie streams were local scale measures of habitat size. In a second paper. James Whitney estimated colonization and extinction probabilities of fishes across sites to test the importance of local versus regional influencing on fish assemblage structure. Our long-term monitoring data indicated dual control of local and regional influence on structuring prairie streams and highlighted the importance of maintaining connectivity among habitat patches in these systems.

Results from an experimental stream study conducted in summer 2011 indicate that consumers have a major role in determining the distribution of autotrophic biomass in the streams and those effects are heterogeneous across macrohabitats (i.e., pools and riffles). Of particular interest, was that effects of diversity (1 – 3 species) was driven by a single species, central stoneroller *Campostoma anamolum*. These grazing minnows elicited a strong ecosystem effect by inhibiting algal filaments from forming large floating mats and redistribute those resources to benthic surfaces.

Konza Prairie Groundwater Studies.

A regional flow model that includes the Konza LTER site (Steward et al., 2011) shows the recharge and discharge areas and the involvement of streams in groundwater. Tsypin's thesis and article in press shows a short but measureable lag time between chemical and isotopic parameters measured in the soil and those in shallow groundwater, including supporting evidence for downward flux of soil CO_2 to groundwater (Tsypin and Macpherson, in press), which is significant in light of the long-term increase in groundwater CO_2 previously documented at Konza (Macpherson et al., 2008). Preliminary data from the rapid-snowmelt-event project shows levels of nitrate and potassium (macronutrients) in throughflow during the two sampled RSE's to be significantly higher than has ever been measured in groundwater or streamwater at Konza, suggesting the RSE's rob the soil of these nutrients. Micronutrients (B, Co, Ni, Cu, Zn, Mo) in RSE throughflow water are also detectable, and comparisons are underway with preliminary chemical data from selected groundwater and surface water chemistry.   Sequential chemical extraction data of soils shows that the rare earth elements in the easily exchangeable fraction are different from those in other extracts. This is not explained by differential aqueous complexation in the soil-water environment, and suggests the exchangeable ions reflect a source different from the bulk of the soil (Macpherson, manuscript in progress). In addition, the distribution of certain elements important to microbial functioning, such Cu, increase in concentration on the organic matter fraction of the soil with depth, showing that Cu released during organic matter degradation is quickly re-sorbed onto remaining organic matter, thus possibly limiting its bioavailability (Macpherson, manuscript in progress). A small increase in the *rate* of chemical weathering at the Konza LTER is interpreted from the long-term major-element chemistry data set, despite the strong dependence of chemical weathering rates on the highly variable annual stream discharge (results presented at GSA, October 2011; and manuscript in progress).

Mycorrhizal Ecology.

Recent studies with support from LTER funding and conducted, in whole or in part, on Konza Prairie Biological Station have been focusing on the role of mycorrhizae on grassland invasibility, grassland restoration, soil C sequestration, wetland-mycorrhizal interactions, and ecosystem processes.

Mycorrhiza and resource allocations: Research in collaboration with colleagues at Northern Arizona University (N.C. Johnson) and Argonne National Laboratory (R.M. Miller) has demonstrated that AM fungi generate the full spectrum of mycorrhizal functioning from mutualism to parasitism through manipulating C, N, and P availability using cross-site comparisons and within site fertilization (N.C. Johnson, G.W.T. Wilson, and R.M. Miller – *submitted to Ecological Monographs*). Our cross-site locations were Konza Prairie Biological Station, Cedar Creek LTER, and Fermi Prairie (Argonne National Laboratory). Results of our experiments provide strong support that P-for-C trade can directly control of mycorrhizal function through equal exchange mechanisms, while N availability indirectly control mycorrhizal function through its effects on C supply and C demand. These results may be a useful guide for fertilizer management to enhance mycorrhizal benefits in grassland restoration, and help develop testable hypotheses of mechanisms by which resources control AM function.

We conducted a series of experiments to test complementary models within a stoichiometric framework (Baoming, J., C.A. Gehring, N.C. Johnson, G.W.T. Wilson, and R.M. Miller – *submitted to Molecular Ecology*). We have shown co-adapted plants and AM fungi develop over time such that the fitness of both plants and fungi is maximized under local soil conditions. However, the dominant species of AM fungal spores in the inoculum differed from those in experimental roots.

An overview of mycorrhizal ecology in grasslands was the focus of a recently accepted book chapter: *Arbuscular Mycorrhizas and Grassland Ecosystems* 2012. R.M. Miller, G.W.T. Wilson, and N.C. Johnson. Chapter 3: Pp. 59-85. *In*: D. Southwood (Ed.). Biocomplexity of Plant-Fungal Interactions. Wiley-Blackwell, Oxford, UK. This chapter discusses mycorrhizal research from KPBS, Cedar Creek, Fermi, and African grasslands.

Mycorrhiza and plant traits: Reinhart, K., G.W.T. Wilson, and M. Rinella. 2012. Predicting plant responses to mycorrhizae: Integrating evolutionary history and plant traits. *Ecology Letters. 15: 689-695*. Using plant-mycorrhizal response data from KPBS, we assessed whether 1) plant responses to mycorrhizae (i.e. mycorrhizal responsiveness [MR]) and root colonization (RC) vary according to plant phylogeny and exhibit a phylogenetic signal and 2) MR and RC can be more accurately predicted with phylogenetic predictor (i.e. MR or RC of the most closely related species available) relative to a null model and models with predictors based on plant traits (i.e. MR or RC of a plant with a similar characteristic [e.g. annual vs. perennial]). Our study illustrated the complex evolutionary associations among species and constraints of using phylogenetic information, relative to plant traits, to predict how a plant species will interact with AMF.

Small Mammal Population Dynamics.
Konza LTER research on small population dynamics is being led by Don and Glennis Kaufman and students. Their studies of small mammal populations spans nearly 30 years and multiple land-use and land-cover types at the Konza LTER site. Here we summarize the results of two recent studies.

Native ungulates and fire, along with climate, were important drivers shaping the tallgrass prairie of North America. Because no endemic small mammals occur in the tallgrass prairie, it is important to understand how small mammals from other faunal regions (e.g., coniferous and deciduous forests and deserts) adapted to grazing and fire in this recent habitat. Historically, American bison was the predominant large mammalian herbivore in the tallgrass prairie, but it largely has been replaced by domestic cattle. Previously, we have shown in a short-term study that the deer mouse (*Peromyscus maniculatus*) was more abundant in bison-grazed areas then in cattle-grazed areas in spring before annual fires, but was similar in abundance in grazed and ungrazed areas after fire. It is important to understand the interactions that occur between fire and bison grazing and to extend our understanding to other species of small mammals through our long-term studies. We examined the responses of small mammals to fire and bison grazing at three scales: macro-, meso-, and micro-scales. At the macro-scale, deer mice responded positively to grazing, whereas white-footed mice (*P. leucopus*), western harvest mice (*Reithrodontomys megalotis*), Elliot's short-tailed shrews (*Blarina hylophaga*), and prairie voles (*Microtus ochrogaster*) responded negatively; these patterns generally held across annual, occasional, and infrequent burns. We also found at the meso-scale (a grazing lawn in an infrequently burned area) that deer mice responded positively to the grazing lawn despite the lack of fire, whereas Elliot's short-tailed shrews disappeared from the grazing lawn although they occurred at nearby sites where a lawn was not present. At the micro-scale, bison create patches of grazed and ungrazed areas within burned treatments. At the micro-scale, we found that responses of small mammals were more observable in infrequent than annual burns and in spring as compared to autumn. Overall, the prairie deer mouse responded positively to grazing and fire at all three scales and generally represents the "canary" species in a healthy tallgrass prairie. In contrast, western harvest mice, prairie voles, and Elliot's short-tailed shrews respond negatively to fire and grazing at the three scales and require a mosaic of burned and unburned and ungrazed sites to thrive in tallgrass prairie. But, white-footed mice (a woodland form) generally do not respond to fire or grazing, except that they are responding to the expansion of woody vegetation in prairies that occurs with infrequent fires.

Due to the general suppression of fire in prairies since European settlement and the experimental regime in which prescribed fire is infrequent (4, 10, and 20 years between fires), woody vegetation has expanded on Konza Prairie, a native tallgrass prairie, over the past 30 years. Our long-term studies (30 years in length) of small mammals on Konza Prairie demonstrate a general increase in abundance of the white-footed mouse (*Peromyscus leucopus*; a mouse generally found in forested sites) through time with the expansion of woody vegetation. 75% and 84% of the variation in number of white-footed mice present in autumn and spring, respectively, can be explained by the number of spring fires at a treatment site. That is, few individuals occur on sites that have had annual fires, but ~600 individuals were observed with similar sampling effort where only 1 fire has occurred during the past 30 years and woody invasion is extensive. In less densely invaded prairie, local hotspots for white-footed mice include shrub patches embedded in the prairie, shrub and tree patches associated with ravines, and breaks site with encroaching shrubs. The spatiotemporal distributional pattern on Konza Prairie shows a highly significant, predictable pattern of occurrence that is related to environments and conditions that favor the white-footed mouse. Furthermore, our experimental study sites show that white-footed mice begin to invade an annually burn site within 10 years after it is reversed to a long-term unburned site and as shrubs encroach, but the opposite pattern is not true. That is, only a slight decrease has occurred in number of white-footed mice when a long-term unburned site was reversed to an annually burned site (shrub islands and tree patches still present and only slightly decreased in size). This study suggests that more than fire is required to reverse the negative effects of woody expansion in native prairie. The presence of white-footed mice in native prairie can serve as an indicator that restoration needs to begin to maintain and preserve native prairies, such as the tallgrass ecosystem.

Konza-based Nutrient Network Experiment

Both top-down and bottom-up effects can influence plant community structure. Theory predicts that these factors may interact in complex and interesting ways. However, little work has been done to develop empirical evidence for these indirect interactions. The Nutrient Network (NutNet) was established specifically to examine the relative importance of multiple resource limitation and bottom-up versus top-down controls of herbaceous-dominated systems. Replicate plots (n=3 per treatment combination) have been established at more than 50 sites around the world in a randomized block design (n=3 blocks) with a total of 10 treatment combinations per block (control, N, P, K, NP, NK, PK, NPK, caged control, caged NPK). The nutrient addition treatments involve the addition of a relatively high level of N, P, or K plus micronutrients to ensure alleviation of nutrient limitation. The herbivore removal (caged) treatment excludes vertebrate herbivores from the plots, but does not prevent access by invertebrate herbivores. At Konza Prairie, NutNet studies are being directed by LTER investigator Melinda Smith and her students, with direct support from the core LTER grant.

After four years of treatment application we have found that at Konza precipitation during anthesis and nitrogen and phosphorus additions drive variation in ANPP. We found that plant functional traits also vary with nutrient additions at Konza. The dominant species at this site (*Andropogon gerardii*, *Sorghastrum nutans*, and *Schizachyrium scoparium*) do not vary in trait space with nutrient additions, while species which are known to invade plots under chronic nutrient addition regimes (*Ambrosia psilostachya*, *Dicanthelum oligosanthes*, and *Solidago missouriensis*) all increase in trait space toward an area corresponding to faster growth and reproduction. The effects of nutrient additions and vertebrate herbivore removals on ANPP and plant traits scale up to higher trophic levels, with N additions resulting in an increase in invertebrate herbivore and parasitoid abundance by altering plant biomass at Konza. In contrast, the rates of per capita invertebrate herbivory were lower in N addition plots. These results provide evidence to support the hypothesis that invertebrate herbivores may be under absolute resource limitation in areas with low plant tissue quality, but switch to relative resource limitation in areas with higher plant tissue quality. The changes in production, plant traits, and invertebrate community structure with chronic nutrient additions at Konza will likely have strong consequences for future ecosystem functioning.

In addition to site-specific results, data from the Konza NutNet experiment is contributing to a series of planned cross-site comparative studies that were the focus of an organized oral session at the 2012 ESA meeting. As one example of the products from this effort, Konza LTER authors (Smith, LaPierre, Collins, Fay) and data from the Konza NutNet experiment were part of a recent cross-site analysis published in *Science* (Adler et al. 2011). This paper included data from 48 NutNet sites to assess the relationship between net primary productivity and species richness. This relationship has been the focal point of intense debate in ecology about the processes regulating local diversity. The original view, which is still widely accepted, holds that the relationship is hump-shaped, with richness first rising and then declining with increasing productivity. Although recent meta-analyses questioned the generality of hump-shaped patterns, these syntheses have been criticized for failing to account for methodological differences among studies. This study addressed such concerns by conducting standardized sampling in 48 herbaceous-dominated plant communities on five continents. The study found no clear relationship between productivity and fine-scale richness within sites, within regions, or across the globe. These results indicate that ecologists should focus on fresh, mechanistic approaches to understanding the multivariate links between productivity and richness.

Other Cross-Site, Synthesis and Network-level Studies.
Data from a long-term fertilization experiment at Konza (the 'Belowground Plot Experiment') has been made available to several working groups, and has resulted in a series of synthetic papers based on data from multiple research sites across North America. One recent analysis by Cleland et al. (2011) investigated how nutrient availability influences divergence and convergence during the invasion of exotic species into native communities, using multivariate analyses of community composition and functional traits from naturally assembled plant communities in long-term nitrogen addition experiments across North America. They found that the relative abundances of key functional traits differed between the native and exotic plant communities, consistent with limiting similarity or a trait bias in the exotic species pool. Environmental context also played an important role in invasion because sites varied in the identity of the traits that predicted dissimilarity between native and exotic communities. Nitrogen enrichment did not alter these patterns. In general, nitrogen enrichment tended to increase exotic abundance, but this was driven by a dramatic increase in exotics in only a few experiments. When similarity between native and exotic communities was included in the statistical model, N enrichment no longer predicted an increase in exotic relative abundance. Instead, sites with the highest abundance of exotic species were the ones where native and exotic communities had the highest trait similarity. Together, these results suggest that while functionally dissimilar exotic species may be more likely to invade, they are unlikely to become abundant unless they have traits pre-adapting them to environmental conditions in their invaded range. Contrary to prior studies, invasion was not consistently promoted by N enrichment.

In a separate cross-site synthesis, Gough et al. (2012) used LTER data from the Belowground Plot Experiment as part of an NCEAS effort to test tested whether plant height and clonal growth form together predict species responses to nitrogen fertilization because neither trait alone predicted species loss in a previous analysis. Species with a tall-runner growth form commonly increased in relative abundance in response to added nitrogen, while short species and those with a tall clumped clonal growth form often decreased. The ability to increase in size via vegetative spread across space, while simultaneously occupying the canopy, conferred competitive advantage, although typically only the abundance of a single species within each height-clonal growth form significantly responded to fertilization in each experiment. The results suggest that classifying species on the basis of two traits (height and clonal growth form) increases the ability to predict species responses to fertilization compared to either trait alone in predominantly herbaceous plant communities

Konza LTER scientists continue to be active in studies and synthetic analyses that extend beyond the border of the Konza Prairie site. For example, Konza LTER scientists have participated in recent cross-ste studies of woody plant expansion into arid and semi-arid ecosystems (Barger et al. 2011, Ratajczak et al. 2012). The aquatic group participated in the LINX II cross-site nitrogen tracer experiments to assess factors controlling retention and release of nitrate in stream ecosystems. Results of these studies were published in *PNAS* (Bealuieu et al. 2011), *Nature* (Mulholland et al. 2008) and *Limnology and Oceonography* (Mulholland *et al.* 2009, Hall et al. 2009), indicating that efficiency of nitrogen removal decreases as nitrogen loading increases. Other recent cross-site and synthetic publications included patterns and controls of plant community dynamics (Chalcraft *et al.* 2008, Cleland *et al.* 2008), applications of phenological studies to assess 21st century climate change (Morrisette *et al*. 2009), synthetic review of the impacts of climate change on terrestrial ecosystems (Garrett *et al.* 2008, Marshall *et al.* 2008, Gerten *et al.* 2008, Luo *et al.*2008), a synthetic review of non-target and invasive species in restored ecosystems (Baer et al. 2012), a synthetic comparison of the value of ecosystem goods and services in native and restored ecosystems (Dodds et al. 2008), and a new conceptual framework for assessing ecosystem responses to chronic resource alterations induced by global changes (Smith *et al.* 2009).

Finally, it is worth noting that Konza LTER scientists led, and contributed to, a recent perspective article in *Frontiers in Ecology and the Environment* on an integrated conceptual framework for long-term social ecological research (Collins et al. 2011), as well as multiple papers in the recent *BioScience* issue commemorating the 30th anniversary of the LTER program (Knapp et al. 2012, Robertson et al. 2012).

Context for the 2012 Annual Report of Activities for the Konza Prairie LTER Program

The Konza Prairie LTER Program is a comprehensive, interdisciplinary research program that contributes to synthetic ecological studies and conceptual and theoretical advances in the field of ecology, and provides a mechanistic and predictive understanding of ecological processes in mesic grasslands. The Konza Prairie LTER program also offers educational and training opportunities for students at all levels, provides outreach and public education activities, contributes knowledge to address land-use and management issues in grasslands, and provides infrastructure and data in support of scientific pursuits across a broad range of disciplines.

Konza was one of 6 original LTER sites, and pre-LTER research extends selected datasets back >30 years. The focal site for our core LTER research is the Konza Prairie Biological Station, a 3487-ha area of native tallgrass prairie in the Flint Hills of northeastern Kansas. The KPBS was established in 1971, with land acquired by the Nature Conservancy and deeded to Kansas State University, and became a part of the LTER Network in 1981. With funding from the LTER program we have amassed long-term datasets on processes such as hydrology, nutrient cycling, plant productivity and community composition, including many that now span more than 25 years. These long-term records provide unique insights into the dynamic nature of tallgrass prairie ecosystems, serve as a critical baseline for identifying and interpreting ecological responses to a variety of global change pressures, and are available as a resource for the broader scientific community. The Konza LTER program encompasses studies at, and across, multiple ecological levels and a variety of spatial and temporal scales. The unifying conceptual framework guiding this research has been that fire, grazing and climatic variability are essential and interactive factors shaping the structure and function of mesic grassland ecosystems. The interplay of these natural disturbances across a heterogeneous landscape leads to the high species diversity and complex, non-linear behavior characteristic of these grassland ecosystems. Because grazing and fire regimes are managed in grasslands worldwide, Konza LTER data are relevant not only for understanding grasslands globally, but also for addressing broader ecological issues such as productivity-diversity relationships, disturbance and community stability, top down vs. bottom up controls of ecological processes, and the interplay of mutualistic and antagonistic biotic interactions. In addition, because human activities are directly (management of grazing and fire) and indirectly (changes in atmospheric chemistry and climate) altering the key drivers of ecological processes in these grasslands, we are able to use Konza LTER studies and data to address critical issues related to global change, including the ecology of invasions, land-use and land-cover change, human activities and water quality, and ecosystem responses to climate change. **Thus, our long-term research program initiated 30 years ago to understand the effects of natural disturbances in this grassland, now has additional and immediate relevance for understanding and predicting the consequences of global change taking place in the grasslands of North America, and around the world.**

A major aspect of our LTER activities in 2011-12 continues to be the implementation of watershed-level fire and grazing studies, and associated long-term data collection to document both short-term and long-term dynamics in response to these treatments. The Konza LTER program is built around a long-term database on ecological patterns and processes derived from a fully replicated watershed-level experimental design, in place since 1977 with some modifications to accommodate new long-term studies initiated in LTER V and VI (e.g., the watershed-level "Fire Reversal" and Season of Fire experiments, the Riparian Woody Vegetation Removal experiment, the Patch-Burn Grazing Studies, and others). This unique experimental design includes replicate watersheds subject to different fire and grazing treatments (Fig. 1), as well as a number of long-term plot-level experiments which allow us to address the mechanisms underlying responses to various fire and grazing regimes.

In addition to fire and grazing, climatic variability, climate extremes and directional climate change are key drivers of grassland dynamics, and important focal areas for Konza LTER activities. The effects of climate are being addressed by long-term studies encompassing the natural climatic variability, and possible directional changes, characteristic of this region, as well as manipulations of water availability and temperature in ongoing field experiments in both terrestrial (*i.e.*, the Irrigation Transect Study and the Rainfall Manipulation Plots (RaMPs) Experiment) and aquatic (i.e., Experimental Stream Studies) habitats. Within core LTER watersheds, permanent sampling transects are replicated at various topographic positions (n=4/topo. position/watershed), where ANPP, plant species composition, plant and consumer populations, soil properties, and key above- and belowground processes are measured. The collection of diverse data from common sampling locations facilitates integration among our research groups. In total, the Konza LTER Program incorporates explicit study of the major factors influencing mesic grasslands in a long-term experimental setting. It is a rigorous ecological research program designed to elucidate patterns and processes inherently important in grasslands, and address the potential impacts of global change in these ecosystems. Towards this end, we currently maintain >90 long-term datasets in association with long-term experiments ongoing as part of this program, and many more research activities of planned shorter duration.

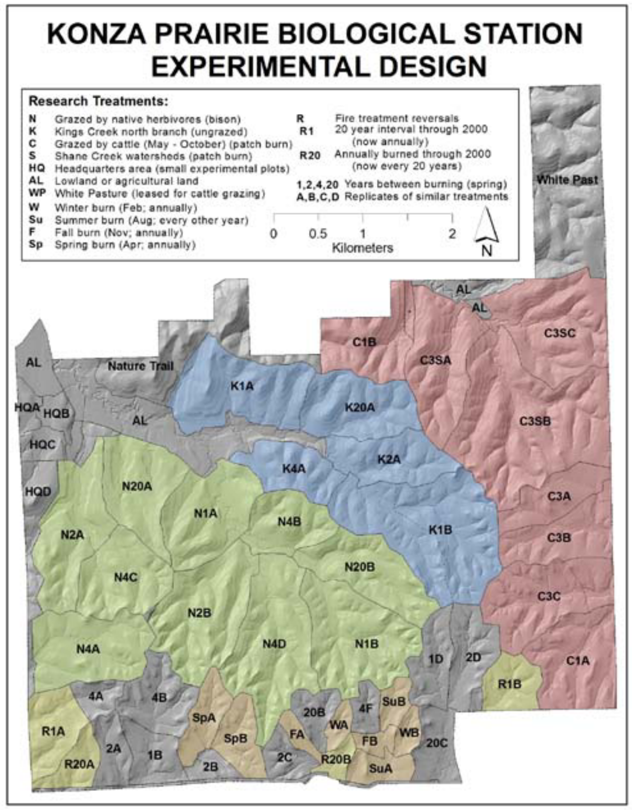

Figure. 1. Konza Prairie site experimental design, and watershed-level fire and grazing treatments. Watersheds with native ungulate (bison) grazing ('N') are light green, and cattle-grazed watersheds ('C') are red. All other watersheds are ungrazed. Numbers designate fire return intervals, and the last letter (A,B,C,D) identifies replicates of the same treatment. Watersheds subject to different seasons of burn (W=winter, F= fall, Sp= spring, SU=summer) are brown, and the Fire Treatment Reversal ('R') watersheds are yellow. Many plot-level experiments are located at the headquarters areas (HQ) in the northwest portion of the site.

We are currently in the fourth year (2011-2012) of our most recent LTER grant (LTER VI, 2008-2014), and our major activities continue to address a broad spectrum of fundamental ecological questions, but with an emphasis on understanding the consequences of global change for ecological dynamics in grasslands, a theme relevant to understanding, managing and conserving grasslands worldwide. Our activities focus on long-term responses to facets of global change most relevant to grasslands and grassland streams – *changes in land-use* (altered fire and grazing regimes, grassland restoration) and *land-cover* (species changes, particularly increases in woody plant cover); *climate change and altered hydrology* in both terrestrial and aquatic environments; and *altered nutrient cycles* (enhanced N deposition) – and we couple long-term observations with manipulative studies to provide mechanistic explanations for these responses. Our research activities also address biotic interactions (competition, mutualism, predation, herbivory) in grasslands, in order to provide insight into a broad range of general ecological phenomena. In total, our activities during LTER VI are designed to:

1. maintain and expand the strong core LTER experiments and data sets on fire, grazing and climatic variability begun over 25 years ago, with the goal of refining our understanding of the major abiotic and biotic factors determining grassland structure and function;
2. continue developing a mechanistic and predictive understanding of grassland dynamics and trajectories of change in response to global change drivers, using ongoing and new long-term experiments and datasets coupled with shorter-term supporting studies;
3. support and promote new synthesis activities based on our LTER results and data from other sites and studies, to use these syntheses to expand the inference of KNZ results, and to develop and test ecological theory;
4. continue education and outreach activities to make our results relevant to society.

Consistent with our goals as a long-term ecological research program, many of the long-term experiments and datasets initiated in previous LTER grants are being continued throughout the current funding period, while several new experiments and datasets were, and are, being initiated, as detailed in the original Konza LTER VI proposal. The value of these long-term experiments and datasets continues to increase with time. In addition, results from these long-term studies have new relevance as we move towards evaluating the ecological impacts of a suite of global change phenomena occurring at the Konza LTER site and in grasslands worldwide. Space constraints prevent us from listing all LTER activities, but below we highlight a few selected activities from our most recent funding period.

Summary of Major Konza Prairie LTER Research Activities (2011-2012):

Fire Ecology in Tallgrass Prairie.

We continued the long-term, watershed-level fire experiments, and associated data collection efforts, that have been central to our "core" long-term studies since the initiation of the Konza LTER program (Figs. 1 and 2). Specifically, we continued long-term experiments on the effects of different fire frequencies (1, 2, 4 and 20 year fire return intervals), as well as watershed-level treatments designed to determine the effects of seasonal timing of fires (spring, summer, autumn and winter), and experiments designed to assess the potential for changes in long-term fire treatments to reverse trajectories of land-cover change (the Fire Reversal experiment). Watersheds with different long-term fire return intervals continue to be focal areas for plant and consumer sampling and measurement of a suite of ecosystem parameters. Many of our core datasets are based on documenting long-term responses to these watershed-level manipulations, and these watersheds continue to be used by numerous visiting researchers. For example, in 2012 watersheds with different fire regimes were used for studies of genetic plant population structure and community invasibility by graduate students from Yale (Melinda Smith, PI), studies of methanotrophic bacterial communities by researchers from Colorado State University (Joe von Fischer, PI), studies of *Panicum virgatum* ecotypic variation and

Figure 2. View of a watershed-level prescribed fire at Konza Prairie. In the foreground is a mowed fireguard separating watersheds assigned to different long-term fire treatments.

physiology by students from St. Joseph University (Clint Springer, PI), studies of C cycling and decomposer communities by researchers from Colorado State University (Francesca Cotfuro, PI), and for studies of climate change by graduate students from Colorado State University and the University of New Mexico.

The "season-of-fire" experiments (assessing the ecological consequences of fires at different times of the year) have taken on added significance in recent years, as questions about the impact of regional grassland burning and EPA regulations regarding air quality and have focused on the ecological importance of burning. This problem is exacerbated by the narrow window during which management-related (cattle pasture) spring burning typically takes place in the Flint Hills. Our data suggests that management-related burning could be spread out in time without adverse effects on grassland productivity or species composition, and will a lessen impact on spring air quality in major metropolitan areas. Findings from the season of fire project have been published in applied ecology journals (Towne and Kemp 2003, 2008), presented at various management-related meetings (e.g., the 2009 Natural Areas Research Conference in Nashville, TN) and highlighted during on-site field presentations for groups such as the EPA Region 7, Kansas Department of Wildlife and Parks, USDA Natural Resources and Conservation Service, and the Natural and Environmental Resources Committee of the Kansas Farm Bureau. The role of LTER studies on fire will continue to grow in importance as the issue of managing fire and smoke in the Midwest grows.

Assessing the Interactive Effects of Fire and Grazing in a Grassland Landscape.
Native ungulates were an important driver of ecological processes in tallgrass prairie, and bison were reintroduced to Konza Prairie between 1987 and 1992. The bison herd at is maintained in ten watersheds covering 1,012 hectares, and stocked at rate to remove approximately 25% of the ANPP on average. Bison grazing activity is dynamic, and individuals select grazing sites in a highly variable manner throughout the year, especially in response to fire, and with big differences among years. In 2011-12, we continued studies of bison grazing preferences and spatial distributions of their activities, based on both observations and collars fitted with GPS units to quantify spatial and temporal movement patterns of the bison herd. These data are allowing us to document landscape-level patterns of activity, and to recognize gradients of potential grazing impact within and among watersheds, including interactions with different fire frequency treatments over the long term. Our goal is to develop a quantitative grid of bison use intensity, which will aid in assessing the impacts of bison on vegetation dynamics and ecosystem processes at Konza Prairie, and will provide supporting data for a wide variety of studies. The watershed-scale fire-grazing experimental design at Konza Prairie is also being used in a newly funded NSF project (Joern, Biggs and others, 2010-2013) to assess nitrogen-driven ecosystem feedbacks affecting the landscape-level distributions and foraging activity of bison and the resulting consequences for creating landscape-level heterogeneity, which drives responses by dominant insect grazers. The primary hypothesis is that the variable spatial distribution of foliar-N content at landscape scales in response to fire and grazing coupled to the physical structure of the habitat determines landscape use by bison, thereby increasing habitat heterogeneity of variable suitability for other important insect herbivores affecting ecosystem function.

In 2012, our LTER research on bison incorporated an LTER-supported REU student with expertise in remote sensing and GIS (Thomas Kuhn, mentored by Tony Joern). Using GIS techniques and remotely sensed images available for Konza Prairie, Thomas has been mapping the distribution of wallows and bison trails to document landscape level patterns of bison use of the site. Both features are conspicuous on the landscape and provide important insights into how bison perceive and affect the landscape. *Bison Wallows*: Four main categories of wallows were identified (active, inactive, reclaimed, and other similar bison disturbance). In the approximately 1000ha available to bison, a total of 3737 wallows were mapped, consisting of 2401 active, 755 inactive, 485 reclaimed, and 96 "other" wallows. Wallows exist primarily in flat areas of Konza, and are typically grouped together. Wallow location also correlates with areas of high bison presence and large grazing lawns. Efforts are underway to identify landscape features associated with wallows by constructing a statistical model that best predicts the location of wallows and the transition probabilities over time among these four states. *Bison Trails*: Bison use the entire portion of Konza Prairie within the fenced grazed site. Major bison trails are evident that serve as conduits for longer moves compared with movement associated with foraging and quiescent activities. Major bison trails (defined as trails visible at a magnification of 1:3200) were mapped. The major trails link areas of high bison usage. Most major trails follow paths with slopes ranging between 0 and 10 degrees. Exceptions consist of trails connecting two nearby areas of high usage separated by a steep slope. Comparing the major existing trails with paths generated using an ArcGIS tool that calculates the Least Cost Path shows that bison trails represent energetically efficient paths from one high use area to another. Bison movement is quantified using GPS collars on 15 bison that record local positions every 30min-2hr (depending on season). Longer bison movements across multiple watersheds can be linked to major trails. Shorter movements (0-82m) by bison typical of foraging periods, occur exclusively in flat areas, areas which highlight a reticulated network of minor trails that fully cover the area. *Grazing Lawns*: Preliminary efforts to map grazing lawns are underway using available remotely sensed imagery. This portion of the project is proving quite challenging, but progress is being made. Other ongoing studies indicate that grazing lawn location correlates well with increased foliar N concentration and flat areas with high bison use, attributes that will be included in models along with time since fire and other landscape features to best predict grazing lawn locations

Isotopic Studies of Bison Water Sources
Reliable access to water by large grazers commonly limits spatial distributions and patterns of movement. Predicting and measuring resource consumption by large, unmanaged grazers is still poorly understood, and yet the conservation implications for many species are very significant. Historically, water sources consumed by large grazers are estimated based on proximity to water sources (using GPS or observational data). But similar to ecological studies of plant water use, proximity and availability does not always predict use. Co-PI Nippert and students used the stable isotopic signature of water extracted from faecal samples of bison to identify the water-sources consumed over time. Our results show that the sources of water consumed by this bison herd varied seasonally, with the greatest dependence on ephemeral puddles and water from forage from April-Oct, and with increased dependence on streamwater during the colder months. This research has two big implications for ecological research of large grazers: 1. We show how the extraction of water from faecal samples and subsequent use of the water isotopic signature allows us to identify spatially-explicit water-use and sources consumed by large-animal grazers. And, 2. Our results have broad ecological implications for bison (and other larger grazer) research. At the location studied, access to a reliable water source (stream networks) did not predict consumption. These results are valuable for landscape predictions of resource-use and they also point to the possibility that future changes in climate may directly impact foraging patterns and landscape utilization by altering the sources of water available for consumption by bison.

Comparative Studies of Fire-Grazer Interactions in North America and South Africa.
The long-term fire and grazing treatments maintained by the Konza Prairie LTER program are also contributing to the goals of a recently-renewed (2009-2012) NSF-funded project to assess the generality of ecological responses to fire and grazing in North American (Konza Prairie) and South African (Kruger National Park and the University of KwaZulu-Natal's Ukulinga research site)

grasslands. These grasslands have very different geological and evolutionary histories as well as different diversities of mammalian herbivores. The NSF-funded "Savannah Convergence" project is being directed by Konza LTER scientists Smith, Knapp, Blair and Collins. The Konza LTER program provides supporting data on climate, soils, nutrient availability, and patterns of ANPP and plant community composition in response to different long-term fire regimes and the presence or absence of bison in North American grasslands. In turn, the NSF Savanna Convergence project provides novel data on the effects of allowing or excluding grazer activity in areas subject to different fire return intervals. Activities at Konza Prairie in 2011-12 included monitoring spatial and temporal patterns of grazer utilization of plots subjected to annual burning, four-year fire return intervals and long-term fire suppression, as well as assessing patterns of ANPP and changes in plant community composition in plots subject to grazing or from which grazers are excluded. In summer 2012, we also collected soil cores from inside and outside of exclosures in all three burning treatments, and we are currently analyzing these samples to assess long-term interactions of fire and grazing on soil C and pools.

Cattle Grazing and Habitat Heterogeneity at the Landscape Scale: Konza LTER Patch Burn Experiment

Long-term studies of the Konza LTER based on bison grazing activities indicate that fire-grazing interactions promote habitat heterogeneity in many ways and at many scales. These include plant species composition, primary production and vegetation structure, and redistribution of nutrients by large mammalian consumers. Because mammalian grazers graze most intensely in recently burned watersheds, a shifting mosaic pattern of habitat suitability is created at a multiple watershed level scale. In turn, abundances and distributions of consumers also respond to habitat changes resulting from fire-grazing interactions. To increase our understanding of the spatio-temporal dynamics of fire-grazing interactions, we initiated a new patch-burn grazing experiment as part of LTER VI. This entailed modifying our former watershed-level experimental design to include two new, large replicate grazing units, each encompassing a mosaic of three individual watershed units (patches) subject to asynchronous prescribed fire and variable fire histories. This experiment required substantial field preparation, and coordination with collaborators in the Department of Animal Sciences. The patch-burn project will expand our understanding of the role of fire-grazing interactions based on native bison grazing to domesticated cattle grazing, the dominant management activity of the greater Flint Hills tallgrass ecosystem, and will address effects of fire and cattle grazing on grassland terrestrial and stream dynamics, and the promotion of biodiversity.

Our overarching hypothesis is that increased habitat heterogeneity resulting from management activity will support increased biodiversity at all levels, while maintaining acceptable levels of cattle productivity/ condition. Response variables include changes in plant biomass and species composition, soil resources, abundances and diversity of birds, small mammals, grasshoppers, and stream invertebrates, and changes in stream geomorphology and biogeochemistry (see *Stream Studies* section for further details).

This ongoing experiment is taking place across two areas of KPBS (Shane Creek and Southern Cattle Units), each treated with 3-year rotations of annual burning. In 2008-10, we established new watershed boundaries, erected fences around the new grazing units (see Fig 1), and established watering locations. Konza LTER scientists held numerous planning meetings with scientists from Animal Sciences at KSU, and representatives from The Nature Conservancy (there is great interest in the potential use of patch-burning grazing to promote conservation in areas managed for cattle production). The first phase of this project was initiated in summer of 2010, with the implementation of patch burning in a three-watershed unit (the Southern Cattle Units) and the initiation of new stocking rates to complete the proposed experimental design. We began the second phase of the project in 2011, in the second three-watershed unit (Shane Creek Units). Seasonal grazing at moderate stocking rates (5 months/y stocked at 25 ha/ cow-calf animal unit) is applied to each 3-watershed area. A treatment employing traditional annual burning and season-long grazing characteristic for the Flint Hills grasslands in Kansas provides for a control comparison for each area. In addition, comparisons with ungrazed watersheds subjected to annual burns provide a second control for understanding the effects of fire-grazing interactions.

In 2012, we continued the planned rotation fire-grazing treatments, and continued to collect data on plant, soil and consumer responses. Co-investigators Sandercock and Jennsen continued research on the effects of the patch-burn grazing treatments on the ecology of grassland birds and small mammals. Bird sampling included distance sampling on line transects to determine species diversity and avian abundance. Nest searching was conducted to locate nests of common songbird species and to examine spatial variation in rates of nest parasitism and nest survival. The same field protocols were used for birds at Konza Prairie and also a separate set of field sites in Chase County near Cottonwood Falls, Kansas. Graduate student Drew Ricketts continued his second years of a study on the responses of small mammals to patch-burn grazing, with an emphasis on deer mouse demography. Small mammal communities were sampled with replicated trapping grids, utilizing standard techniques to examine responses of the small mammal community as a whole to this new range management technique. Additionally, we will employ artificial burrows, mark re-capture methods, and molecular techniques to gain a detailed understanding of deer mouse demography in rangeland communities in the northern Flint Hills. In addition to small mammal sampling, we are quantifying vegetative responses to patch-burn grazing with the standard habitat metrics of visual obstruction readings and percent cover of different cover classes such as forbs, grasses, litter, etc.

The patch-burn grazing experiment is an excellent opportunity to increase linkages between programs in basic grassland ecology and more applied programs at KSU. Of equal importance, this will provide new outreach opportunities to encourage wildlife conservation and more sustainable practices by regional land managers and cattle producers. Dr. K.C. Olson, associate professor of cow-calf nutrition and management, is a new LTER collaborator for this project. His research includes nutritional management of cattle on native rangelands and factors influencing grazing behavior. Konza LTER scientists also visited Walda Prairie (a research site operated by the Kansas Biological Survey), which is establishing a similar patch-burn experiment, and have consulted with Brian Obermeyer (Director of the Flint Hills Initiative for The Nature Conservancy) who oversees patch burn experiments at the Tallgrass Prairie National Preserve and the Flint Hills Tallgrass Prairie Preserve. Konza also hosted a visit by Dr. Joe Fargione (Regional Science Director of the Central U.S. Region TNC) in 2009, which included a visit to the Konza site and discussion of how to use the results from the patch-burn experiment to promote TNC goals. Finally, Konza LTER scientists (Dodds and Whiles) are participating in a cross-site comparison of impacts of patch-burn grazing on stream ecosystems at a site in Missouri and at Konza Prairie. Activities in 2009 and 2010 included establishment of new graduate student project to sample stream sites in Missouri, and gather preliminary data on streams within the future patch-burn watersheds at Konza. By coordinating and cooperating with the numerous patch-burn grazing experiments in our region, we will increase the visibility and applicability of our long-term grazing experiments.

Measuring Spatial Variability in Plant Physiology and Landscape Energy Balance Using Sensor Networks.

Variability in topography, soil type, vegetative cover, and species composition all contribute to spatial variability in the surface energy balance across the landscape. Quantifying this variation is necessary to estimate carbon and water balances the scales used to make land management decisions (i.e., field or watershed scale). Furthermore, measures of spatial variability will aid in the interpretation of plant physiological responses of the grassland community, topo-edaphic variability in primary productivity, improve hydrologic modeling, and enhance the interpretation of data from remote sensing platforms and flux towers. Since 2010, we have deployed a 10-station sensor network in 2 annually-burned watersheds and two 4-year burned watersheds to measure the spatial variation in the surface energy balance at 3 topographic positions. Measurements at each station included: air and soil temperature, canopy temperature, relative humidity, wind speed, surface temperature, soil heat flux, and soil water content. Data are accessible real-time using a wireless network. Ancillary bi-weekly measurements include vegetative growth, LAI, and plant height. Data from the sensor network and flux data from the eddy covariance towers are being coupled with a numerical modeling technique to approximate latent heat and sensible heat fluxes at each station in the network parameterized using bi-weekly biomass clipping data, measurements of canopy LAI (leaf area index) and plant height of the common C4 grasses. Results from the first 3 years of this study indicate: (1) high spatial variability is present within and across watersheds and (2) topographic patterns of growth and canopy development vary strongly according to burn history, and (3) interannual variability in microclimate is a strong driver of seasonal dynamics in carbon assimilation and aboveground growth, corresponding to climate conditions between day of year 180-210.

In 2012, we continued to collect data streams from two eddy flux towers on two of the LTER core watersheds, allowing comparison of C and water fluxes from different land-use regimes (annual vs. intermediate prescribed fire frequencies) and areas with different plant community/life-forms (grass-dominated vs. significant woody vegetation expansion). This research is supported by a subcontract with LTER collaborator Nate Brunsell (Atmospheric Scientist from the University of Kansas). In 2012, we focused on maintaining and utilizing the eddy covariance stations and associated data sources, and in addition to Konza site-specific studies, we have been conducting comparative data analyses with two additional flux towers in the state of Kansas (Lawrence and Salina) to assess water use efficiency and the role of land cover variation on water and carbon cycling. We also combined these data with other Ameriflux towers nationally in a study of the underlying thermodynamic stability of the fluxes in relation to land use. Ultimately, the goal of this effort is to derive a potential metric of sustainability that could be used to evaluate alternate land-use practices or land covers. Additional efforts have focused on the 1D Ameriflux tower to calibrate an ecophysiological model (AGRO-BGC) to examine the impacts of potential changes in precipitation on the annual carbon and water cycles (results presented at ESA meeting in Portland).

Evaluating the Effects of Climatic Variability and Climate Change in Tallgrass Prairie.
In addition to fire and grazing, our LTER VI research continues to focus on climatic variability as a critical factor affecting the structure and function of tallgrass prairie ecosystems. Within grasslands, the importance of both amounts and timing of precipitation inputs as forcing functions makes them particularly responses to inherent climatic variability and vulnerable to the changes predicted by global climate change models. Having a long-term dataset spanning decades of natural climatic variability is one important avenue for studying ecological responses to climatic variability (Nippert *et al.* 2006, Heisler and Knapp 2008, Craine *et al*. 2009, La Pierre *et al.* 2011). However, in LTER VI we continue several manipulative experiments designed to augment our long-term data and address potential mechanisms underpinning grassland responses to climatic variability and climate change. The first is an irrigation experiment, in which supplemental water is being added to two transects in annually burned tallgrass prairie to eliminate plant water deficits during the growing season (Knapp *et al.* 2001, Hutchinson *et al.* 2006, Williams and Rice 2007). This project began in 1991, and has been expanded to include a nitrogen addition treatment in order to evaluate potential

interactions between precipitation and N limitations. A new synthesis of plant community and plant productivity data from this project was completed in 2012.

A second major project examining the effects of climate and climate change in these grasslands utilizes field-scale Rainfall Manipulation Plots (RaMPs) in which the timing and amounts of rainfall events are being experimentally manipulated in intact native tallgrass prairie plots (Fig. 3). This project is allowing us to assess the effects of altered precipitation regimes on individual plant ecophysiological responses, plant community composition, and ecosystem-level processes. Details regarding the experimental approach and the initial results of this experiment are provided in Fay et al. (2000, 2003), and some recent results are highlighted in the accompanying 'Findings' section of this report. In addition to core long-term response variables on plant, soil and ecosystem responses to changes in timing of rainfall and warming, this project was used in 2009-12 by graduate students from Yale to assess potential population-level genetic responses to climate change, and by a new collaborator from UC Santa Cruz (Weixin Cheng) who is funded with a DOE NICCR grant to use a stable isotope approach to separate root and bulk soil respiratory responses to climate change drivers.

Figure 3. Top: View of one of the Rainfall Manipulation Plots (RaMPs) prior to installing IR lamps. Bottom: IR heating lamps in a reference plot in the foreground. See text for a more detailed description of the shelter design and operation.

Plant Physiological Ecology: Linking Species-Specific Water Flux and Gas Exchange Dynamics to Hydraulic Architecture.

We investigated the linkage between the hydraulic architecture of grasses to physiological patterns of water use across a range of species and conditions. The rate of stomatal conductance (*gs*) and photosynthesis (*A*) increased acropetally along the leaves of 5 grass species, which is a unique feature of this growth form (Ocheltree et al. 2012). The internal structure of leaves also changed acropetally in order to minimize the pressure gradient across the mesophyll that would otherwise occur as a result of increasing *gs*. The resistance to water movement through the mesophyll represented 80---90% of leaf resistance in six genotypes of *Sorghum bicolor* L. (Moench). This resistance was most important in controlling *gs* and *A* when water was readily available, but as soil---moisture decreased it was the efficient transport of water through the xylem that was most important in maintaining plant function. We have also investigated the relationship between hydraulic architecture and stomatal responses of grasses to increasing Vapor Pressure Deficit (*D*). Grasses with a larger proportion of their hydraulic resistance within the xylem were less sensitive to increasing *D* and plants with high root conductance maintained higher rates of gas exchange *D* increased. We have alsoinvestigated the tolerance of grasses to extreme drought events to test if there was a trade---off between drought tolerance and growth in grasses. Plants with drought tolerant leaf traits typically sacrificed the ability to move water efficiently through their leaves. Having drought tolerant leaves did not limit the plants ability to have high rates of gas exchange, and, in fact, the most drought tolerant plants had the high rates of *gs* when expressed on a mass basis. Leaf---level drought tolerance did contribute to species' occurrence, as the drought intolerant species I studied are not commonly found in low precipitation systems. The results presented here highlight the importance of studying the hydraulic architecture of plants to provide a better understanding of what controls plant function across a range of environmental conditions.

Plant Physiological Ecology: Phenotypic Variation in Switchgrass Populations.
Population-level adaptation to broad-scale regional climates or intra-specific variation in genome size of the genetically and phenotypically diverse C_4 grass species, *Panicum virgatum* L. (switchgrass) may drive responses of this species by future precipitation variability associated with climate change. *P. virgatum* plants from natural populations originating from Kansas, Oklahoma, and Texas, U.S.A, received frequent, small precipitation events ("ambient") or infrequent, large precipitation events ("altered") to simulate contrasting rainfall variability expected for this region. We measured leaf-level physiology, aboveground biomass, and genome size for each individual. Gas exchange rates and aboveground biomass varied significantly by population origin but did not differ by genome size. Altered precipitation treatments reduced leaf-level physiological rates, however this result did not vary by population or genome size. Our results suggest that trait variation in *P. virgatum* is primarily attributed to population-level adaptation across a latitudinal gradient, not genome size, and that neither population-level adaptation nor genome size may be important predictors of *P. virgatum* responses to future climatic conditions. Since 2010, this research has involved collaboration by LTER Co-PI Nippert and Dr. Clint Springer (St. Joseph University), and graduate and undergraduate students from both KSU and St. Joseph College (a non-doctoral degree granting institution).

Mycorrhizal Studies.
Understanding how mycorrhizal associations are affected by plant invasions may be a critical aspect of the conservation and restoration of native ecosystems. LTER co-investigator Gail Wilson and colleagues examined the competitive ability of old world bluestem, a non-native grass (*Bothriochloa bladhii*), and the influence of *Bothriochloa* competition on AM root colonization of native warm-season prairie grasses (*Andropogon gerardii* or *Schizachyrium scoparium*). Competition by the non-native resulted in significantly reduced biomass production and AM colonization of the native grasses. To assess plant-soil feedbacks of *Bothriochloa spp.*, a second greenhouse study examined soil alterations indirectly by assessing biomass production and AM colonization of native warm-season grasses planted into soil collected beneath *Bothriochloa spp*. This study was conducted using soil from four replicate prairie sites throughout Kansas (Konza and Hays sites) and Oklahoma (OSU Stillwater Range Research and Klemme Range Research Stations). Our results indicate a major mechanism in plant growth suppression following invasion by *Bothriochloa spp.* is the alteration in soil microbial communities. Plant growth was tightly correlated with AM root colonization demonstrating mycorrhizae play an important role in the invasion of these systems by *Bothriochloa spp.* and indicating restoration of native AM fungal communities may be a fundamental consideration for the successful establishment of native grasses into invaded sites. Wilson presented these data at 2012 Oklahoma Invasive Plant Council.
Wilson's OSU PhD student (Mitch Greer) is completing his research assessing plant-microbial feedbacks of invasive non-native warm-season grasses. Greer's research involves multiple field sites throughout Nebraska, Kansas, Oklahoma, and Texas; including Konza Prairie.

In 2012, Wilson's OSU PhD student (Sally Kittrell) initiated her research assessing mycorrhizal-wetland plant associations in field (Konza Prairie, KS, and Tallgrass Prairie Preserve, OK) and greenhouse studies. Mycorrhizal associations and wetland plants have not been well-assessed. As plants transition from terrestrial upland to facultative and obligate wetland species at lower topographic positions, questions arise as to how dependent these hydrophytic species are on mycorrhizal fungal associations. Our primary objective is to lay a framework for understanding the responses of plant-mycorrhizal mutualism in ephemeral wetland areas, as well as continuous wetlands.

Bud Banks and Grassland Invasibility.

Perennial grass species in tallgrass prairie ecosystems are maintained primarily through the vegetative outgrowth from their belowground bud banks. In 2012, we completed an LTER study by Melinda Williamson (OSU MS student) and LTER investigators Gail Wilson and Dave Hartnett to assess the role of nitrogen, light quantity and spectral quality as key regulators of bud bank dynamics and resultant tillering in six native grass species (*Submitted to Botany; in revision*). We provide empirical data to assess interactions of nitrogen with light quantity, and the role they have on bud outgrowth and tiller initiation in six grass species in two functional groups (C_3 and C_4 photosynthetic pathways). We also examine the role of light spectral quality (R:FR) on bud outgrowth in these same six grass species. Strong interactions between nitrogen and light were observed in the C_3 species, but not in the C_4 species. Generally, C_3 species responded favorably to N, while C_4 species were not responsive to N amendments. Light spectral quality elicited species-specific responses in both of the functional groups, with sensitivity to R:FR reductions observed in four of the six species. Therefore, C_3 and C_4 functional groups exhibited significantly different responses to these two cues. The results of this study suggest that environmental cues such as these may be important in determining patterns of species composition and population dynamics in response to current and future global changes.

Ray West (OSU PhD student), Gail Wilson, and Dave Hartnett completed greenhouse studies examining varying densities of belowground meristems (bud bank) to test that grassland invasibility is regulated by a minimum threshold in bud bank density. Our data indicated that increases in size of the bud bank increased grassland stability, thereby reducing invasibility by exotic species. Biomass production of the exotic species profoundly increased in greenhouse mesocosms that contained no belowground meristems. A corresponding field study has been completed on KPBS. Plots were established with 0%, 33%, 66%, and 100% of the native belowground meristems removed and an exotic grass species has been seeded into each plot. These field data correspond with that of our greenhouse studies, concurring grassland invasibility is decreased with stable belowground bud bank populations. These findings improve our understanding of plant invasion and suggest that restoring and maintaining bud banks should be a priority for land managers seeking to prevent and limit plant invasions.

Studies of Plant Roots Characteristics Across the Konza Landscape.

C_4 grass species in tallgrass prairie can exhibit both high root production and deep rooting in the soil profile (> 2 m). The production of deep roots in tallgrass prairie has been historically presumed as a mechanism for water uptake when surface soils are dry. Nippert and students examined changes in root biomass, total root length, root width, and theoretical hydraulic conductivity using roots collected from deep soil cores in upland and lowland topographic positions in grazed and ungrazed watersheds of the Konza Prairie. Root biomass, total root length, and theoretical hydraulic conductivity were highest in roots found in the top 20 cm of the soil profile, and then declined exponentially with increasing soil depth. Compared to grazed areas, ungrazed locations had more root biomass and total root length of roots in the most superficial soil layers. Theoretical hydraulic conductivity of axial root xylem did not vary by topographic position or grazing contrasts, and declines in conductivity by depth were driven by changes in the number of vessels per stele, rather than changes in vessel size. Thus, irrespective of differences by grazing treatment or topographic position, significant reductions in root biomass, total root length, and theoretical hydraulic conductivity of grass roots at soil depths greater than 1 m suggest deep roots in this grassland have limited functional significance for water uptake.

Restoration Ecology and Grasslands.
Forecasting tallgrass prairie community and ecosystem response to environmental change is a core objective of LTER VI. Restoration studies in tallgrass prairie have become a core part of the Konza Prairie (KNZ) LTER program over the last decade, and are particularly timely because human activities have resulted in widespread loss and degradation of this ecosystem. Three multi-year (to include some multi-site) restoration experiments aim to develop and test hypotheses relevant to key issues in basic ecology while also addressing applied questions related to improving the structure, function, and sustainability of prairie restorations. The core restoration projects at KNZ include: (1) the 1998-established soil heterogeneity plots, (2) the 2006-established cultivar and non-cultivar grass source plots that contain a seeded-diversity gradient, and (3) the 2010-initiated chronosequence plots. Collectively, these studies are providing insights into the roles of biotic and abiotic variation on the restoration of tallgrass prairie communities and associated ecosystem functioning.

The first restoration experiment at KNZ (initiated in 1998 and recently highlighted in the June 2012 LTER Newsletter) is a long-term study of the role of soil resource availability and heterogeneity in the restoration of plant community structure (diversity) and ecosystem processes. This test of the 'heterogeneity hypothesis' has demonstrated important determinants of diversity in newly-restored prairie. Over a decade of study has revealed declines in plant diversity in all treatments, but more species have been maintained in plots with the most soil heterogeneity. A recently acquired grant through the NSF-LTREB Program will enable us to assess longer-term trajectories of plant community and ecosystem recovery and test whether variability in community structure in space and time creates vacancies and resources to promote biodiversity. In the 2012 field season (on-going), we measured plant composition, light availability, inorganic N availability, and total soil C and N in this experiment, representing the 15th year of restoration. These data will be synthesized using time-series analyses to establish the long-term plant community and soil response to the heterogeneity treatments prior to performing annual seed addition (starting in 2013) to address the role of ecological heterogeneity in promoting biodiversity. We have a developed the species list for re-introduction and seed-collection has been a major focus of the 2012 field season.

The 2006-established cultivar-seeded diversity experiment has investigated the role of two factors related to socioeconomic filter in community assembly: selection of seed sources (cultivars or locally-sourced seed) and selection of diversity of species to reintroduce. A parallel experiment was set up at the same time in Belleville, IL to address whether climate may interact with sources and diversity of seeds used to affect developing community structure and ecosystem process. This experiment was idle in 2011-2012, but the Ph.D. student has successfully synthesized the data from this study for his dissertation. The plant community response has been summarized in a manuscript prepared for *Ecological Applications* entitled "Convergent and contingent community patterns in two tallgrass prairies restored across a precipitation gradient." The soil and ecosystem responses to these factors have been synthesized in a dissertation chapter entitled "Ecosystem function in two tallgrass prairies restored across a precipitation gradient." The Ph.D. student, Ryan Klopf, is expected to defend his dissertation in Fall of 2012.

In accordance with the LTER VI proposal, we initiated a restoration chronosequence in an agricultural field using the same species, seeding rates, and restoration techniques to examine the extent to which inter-annual variation in environmental conditions during restoration affects species establishment, developing community composition, and ecosystem functioning. The first block of three 20 m x 20 m and two 10 m x 20 m plots was installed in 2010. The second and third consecutive year of plant community composition (at two scales) and ANPP was collected from

Block I in the 2011 and 2012 (on-going) field seasons. Seed for the second restoration installation was collected in 2011, cleaned during the winter, and analyzed for purity, germination, and dormancy. Block II was delineated and four 20 m x 20 m plots were seeded in June of 2012. A secondary objective of this study posed in the LTER VI proposal was to elucidate the role of consumers in community development during restoration. To address this, we installed eight 25 m^2 (3.2 m high) open-top fences (2 per plot) to exclude animals unable to pass through a 5.0 cm x 7.5 cm mesh (i.e., deer, turkey, large rabbits, etc.). All plant and soil response variables measured in Block I will also be measured in block II, along with comparison of animal exclusion on developing community structure and potentially responses soil processes (i.e., accrual of N in root biomass and net N mineralization). Stem browsing will also be quantified within and outside of the animal exclosures.

Studies of Woody Vegetation Expansion into Grasslands.
Forest encroachment and the expansion of shrubs into grasslands is a widespread phenomenon, occurring in grasslands around the world. This is a serious conservation concern in tallgrass prairies, where woody plant encroachment leads to losses of grassland species and declines in biodiversity. There are also important potential changes in ecosystem processes accompanying grass-to-woodland conversions, though these have not been well documented in many grasslands. Woody plant increases can be directly attributed to alterations in land management (reduction in fire frequency) and may be indirectly facilitated by other factors (increased CO_2 concentration, N deposition, habitat fragmentation, etc.). We have been assessing the causes and consequences of this ecosystem conversion from C_4 grass to C_3 shrub-dominance by initiating and continuing studies on (1) on the landscape-scale pattern of conversion, (2) the mechanisms facilitating woody plant establishment and spread and (3) the ecological consequences of conversion from dominance by one growth form to another. Thus, we are evaluating the *patterns, mechanisms* and ecological *consequences* of an ecosystem in transition from C_4 grassland to closed-canopy C_3 shrub/woodland.

LTER investigator Briggs and students have been collecting data for woody plant cover on selected LTER watersheds since 1981 covering the range of burning treatments (annually burned, burned every ~4 years and a low-fire frequency (burned once since 1981)). In summer 2011, we re-sampled those watersheds, using a high-precision GPS (~10 cm accuracy) to record the species, location, height (trees) and area (for shrubs) of the dominant woody plants in all selected watersheds. In addition, in 2012 we continued an experiment begun in 2001 to assess the legacy effects of fire history on trajectories of response to altered fire frequency. Long-term fire treatments were 'reversed' on two watersheds previously burned annually in spring and two watersheds protected from fire for ~20 yrs (the 'Fire Reversal Experiment'). The new fire treatments started in 2001, and an assessment of plant and soil responses to the reversal of fire treatments was done in 2006 and 2011. In 2011-12, we continued re-sampling woody plant using GPS and field sampling methods on these watersheds. We are in the process of analyzing these data. In addition, these ground-collected data will be used as verification as we attempt to use various remote sensing platforms (Quickbird and aerial photographs) to estimate the cover of woody plants on watersheds that are not sampled using ground-based methods. The results of this study will be used to interpret the long-term responses to the fire reversal treatments, and will be relevant for new LTER VI experiments focused on the consequences of woody plant encroachment into grasslands.

Abiotic and Biotic Controls of Predator-Prey Interactions.
Understanding how biotic and abiotic factors combine to affect species interactions is an important challenge in ecology. However, the effects of biotic and abiotic factors on species interactions are often studied separately. In 2011-12, we continued a multi-year field experiment (begun in 2007)

using a model plant-grasshopper-spider food chain to understand how key biotic and abiotic factors (morning temperature, food quality, herbivore density, predation) interact to affect grasshopper performance and trophic interactions, including the occurrence of trophic cascades. Field enclosures containing one-, two-, or three- level food chains are placed over natural vegetation. Large chambers with movable roofs surrounding some of the enclosures are covered with plastic sheeting or 50% shade cloth to either increase or decrease morning temperatures. Because grasshoppers prefer warmer temperatures than wolf spiders, we can either expand or contract the amount of time that grasshoppers and spiders are both active by altering morning temperatures, thus influencing the potential for encounters between these species. Grasshopper–spider interactions are temperature dependent. At lower temperatures, predator effects are strengthened and trophic cascades are observed. However, when temperatures are increased, the effects of predators are weakened and no trophic cascades are observed. This experiment will help us gain a mechanistic understanding of how the environmental context influences species interactions. Furthermore, examining multiple biotic and abiotic factors simultaneously enables us to identify non-linear and compensatory interactions among factors that could not be identified by examining them separately.

Responses of Grassland Spider Communities to Fire and Bison Grazing.
This project (directed by LTER co-PI Joern, with graduate student Jesus Gomez) evaluates the role of spatial and temporal habitat heterogeneity from managed burning and bison grazing to our understanding of species diversity for the spider assemblage, an important and functionally important arthropod predator community at Konza Prairie. Spiders are ubiquitous predators in terrestrial systems that utilize various hunting strategies: web building, sit and wait, trap doors and active pursuit. Spiders partition their habitat within watersheds at small scales to maximize the effectiveness of a particular hunting strategy and reduce interspecific competition, while potentially exhibiting landscape level responses at the large scale along gradients of habitat differentiation. Responses of spider communities to major disturbances in grassland ecosystems have not been studied in detail. The main goal of this research project is to understand how the spider predator assemblage responds to large-scale habitat disturbances. At KPBS unique long term manipulations (fire frequency and bison grazing) at watershed levels have resulted in a mosaic of grassland and shrub lands scenarios. This mosaic of habitat types may result in a diverse series of scale-dependent spider community assemblages.

Little information on spider responses to habitat heterogeneity was available for Konza Prairie until this study began. To date, a spider community composed of 75 species (~ 60% identified to species) belonging to 60 genera and 17 families exists along a gradient of habitat types at KPBS. The habitat complexity and heterogeneity hypothesis predicts that the overall abundance and species diversity of spiders increases with spatial heterogeneity of habitat structure, which in turn reflects fire-grazing interactions. To address this hypothesis, 23 sites were sampled along a gradient of habitat types that range from grass dominated habitat to gallery forest in both bison grazed and ungrazed watersheds. Vegetation characteristics were also evaluated using standard techniques to quantify vegetation structure and heterogeneity. To date, results from this study indicate that species richness doubles from early to mid/season. Increases in spider abundance increases on ungrazed sites may result from increased spatial heterogeneity and microhabitat diversity in response to plant growth over the summer. Spider species abundance and diversity is influenced by effects of fire frequency on vegetation. But, spider diversity and abundance also increased over the summer independent from fire frequency. This increase in species richness may be promoted by higher microhabitat availability later in the growing season in response to from plant growth differentiation. Increased microhabitat diversity may facilitate resource partitioning and the coexistence of more spider species, especially web-builders. Spider abundance and species richness increased with increasing spatial heterogeneity in vegetation structure in the early season. Bison grazing influenced habitat heterogeneity by maximizing microhabitat availability and use early in the summer. In July/August, previously existing spatial heterogeneity in vegetation structure was no longer evident, suggesting a switch to the importance of total structural volume of vegetation to explain increased spider diversity. Preliminary observations from ongoing surveys for web-builder spider community suggest that spider diversity and abundance declines very fast as plant community becomes dominated by grasses, spatial and temporal structural heterogeneity is reduced, and woody plants and shrubs become less abundant.

Long-Term Studies of Small Mammal Dynamics.
LTER investigators Don and Glennis Kaufman continued to assess small responses to watershed-level fire and grazing treatments. In 2012, they sampled 14 LTER core trap lines in both spring and fall. This will provide 32 years of continuous data. They also continue to analyze data and write manuscripts from core trap lines, seasonal trap lines, and reversal trap lines (details of recent analyses are provided in the Project Findings section)..

Grassland Stream Studies.
Grassland stream studies are an important component of the Konza LTER program. Hydrology of Konza streams continues to be documented at four weir sites operated by the LTER program, plus a USGS gauging station located on Kings Creek and seasonal sampling of fish assemblages at four permanent sites is ongoing. In 2011-2012, we continued long-term monitoring of stream discharge, chemistry, macro-invertebrates and fishes. In 2012, we also continued new monitoring of stream geomorphology and sediment transport (Melinda Daniels). These data will yield new information over decadal time scales about sediment and nutrient transport, and how these trends are related to changes in woody riparian vegetation expansion and in-stream biodiversity, as well as the impacts on interannual climatic variability and associated stream hydrology. We also continued mesocosm experiments testing the effects of consumer diversity on ecosystem properties of tallgrass streams and scaling of those effects.

We continued two experiments in 2011-2012. Dodds, Whiles and Daniels continued a new cross site project titled "Biotic integrity of prairie streams as influenced by patch burn grazing and riparian protection" which is funded by the Missouri Department of Conservation for research at Missouri, and paired with estimates of response to patch burn grazing at Konza funded by the LTER. Through this effort, we are examining potential responses of Missouri headwater streams (water chemistry, physical habitat, biological integrity) to patch burn grazing with no riparian fencing and patch burn grazing with riparian fencing (and control watersheds with no grazing). This project is based on the Osage Prairie reserve in SW Missouri, and data from this study will be used in comparisons with data from the Konza LTER patch burn grazing experiment. Experiments at both locations concluded their pre-data period and cattle were placed on both sites in Spring 2011. A draft manuscript of preliminary data, led by graduate student Danelle Larsen at KSU, is in revision. Karen Jackson, an MS student at SIU, presented results of her pre-manipulation sampling at the 2012 Society for Freshwater Science (formerly NABS) meetings. The Konza experimental watersheds do not have fenced treatments, but can be compared to traditional cattle grazing, ungrazed prairie, and bison grazed prairie. Results of this project will have direct relevance to management of remnant and restored tallgrass prairie, as patch burn grazing is rapidly gaining favor as a management tool even though there is little information on how it may impact biotic integrity in and water quality of headwater streams. We found that ecosystem characteristics are similar across these two sites, with good water quality characteristic at both sites. We continued more detailed geomorphological sampling at both sites, as well as monitoring relative levels of fecal coliform. Geomorphological monitoring across sites documented a severe channel erosion response to watershed grazing introduction. Dodds' MS student, D. Larsen, also concluded an intensive herpetofaunal component to the research at the Missouri study sites.

In 2008-09, we initiated the LTER VI riparian vegetation removal experiment in two watersheds where a 30- 50m stretch of woody vegetation was removed in a 20 m wide swath. Initial results indicated strong response of filamentous algae to the vegetation removal. The analyses of results of much of this experiment were published in 2012. Through this study, we documented that vegetation removal (restoration to natural riparian conditions of grassland streams) lead to 1) increased denitrification rates (Reisinger 2010), 2) shifts in communities with fewer leaves and bryophytes, and more filamentous algae, 3) corresponding shifts in ecosystem metabolism related to more light reaching the stream and less detrital leaf materials (Riley and Dodds 2012). Jodi Vandermyde, an MS student at SIU, has been examining invertebrate and benthic organic matter responses to this manipulation and will defend her thesis and submit her results for publication during fall semester 2012 (see below). This project formed the foundation for the whole-stream riparian forest removal manipulation on KPBS.

We continued work on the whole-watershed riparian vegetation removal project. We finished preliminary (pre) sampling of sediments, algae, stream invertebrates, terrestrial insect inputs to streams, and riparian spider communities for a more extensive (entire watershed) removal. K. Erndt (Ph.D. student and IGERT fellow at SIU) is leading the in-stream and riparian invertebrate responses component of this study, and she presented preliminary results of her research at the Society for Freshwater Science (formerly NABS) meetings in spring 2012. We also completed baseline sampling of geomorphology, oxygen dynamics, riparian sediments, and vegetation transects. Pre sampling ended in Winter 2011 and post-manipulation sampling is now underway.

During Winter 2010-2011 woody riparian vegetation was removed from 4.8 km of stream riparian area, 30 m from each side of the main channel, and 10 m for small side channels on watershed N02B. Our hypothesis is that headwater streams yield less water and retain more nutrients with increased riparian canopy cover. We expect that increased riparian forest cover reduces stream water flow (as a result of increased transpiration), reduces grasses that retain sediments, and subsidizes the stream channels with nutrient-poor/ carbon-rich leaves, leading to greater nutrient retention. We predict that woody invasion alters aquatic invertebrate communities and riparian vegetation and invertebrate populations. Long term data suggest reduced water yield with no substantial changes in precipitation or temperature on Konza, providing correlative data for reduced water yield related to riparian vegetation. We mechanically removed all woody vegetation within 10 m of either side of a 4-km reach immediately upstream of a weir with a long-term hydrology and water chemistry record (N02B), and will continue to mechanically control woody vegetation for 6 yrs. We have 2 comparison gauged watersheds and 15 yrs of before-removal water quality data from this watershed. We will continue our standard monitoring regime at this weir to assess the effects of the riparian removal on nutrient and sediment transport. We are examining a variety of potential biological responses to this removal including 1) stream invertebrates, 2) riparian invertebrates, 3) riparian vegetation, 4) riparian soil fungi and 5) stream algal community composition. We also initiated a riparian restoration comparison by re-seeding smaller areas of the removal.

LTER investigators Whiles and Gido continued investigations of stream community structure function, stream food web dynamics, and patterns and controls of secondary productivity in grassland streams. Long-term monitoring of fish assemblages in 2012 represents the 18th year of data collection from Kings Creek. In addition, Gido completed the 5th year of parallel fish monitoring in

Fox Creek on the Tall Grass Prairie Preserve (approximately 80 km south of Konza), which was initiated to help regionalize data collected from Konza. Frequent sampling along a gradient of headwater springs to downstream perennial reaches will help us understand the importance of landscape connectivity on the stability of native fish populations. These data were used in two manuscripts submitted in summer 2012 by graduate students testing habitat associations of fishes (Erika Martin lead author) and testing models of species richness (James Whitney). In summer 2011, graduate students Erika Martin and Allison Veach conducted a mesocosm experiment testing the effects of community diversity on heterogeneity of ecosystem properties of prairie streams across multiple spatial scales. A companion field study was initiated in summer 2012 to test the effects of natural variation in consumer diversity on ecosystem properties in both Kings Creek and Fox Creek. These experiments will help evaluate our ability to scale results from small scale experiments to entire stream reaches.

A new stream geomorphology program was initiated in 2010, establishing long term monitoring sites in 10 Konza watersheds across a range of fire and grazing treatments and including the riparian removal watershed. Initial baseline samples of channel cross sectional morphology and sediment substrate characteristics have documented significant differences between ungrazed, bison grazed and cattle grazed stream channels. Bedload transport and suspended load transport traps have also been installed in 10 Konza streams and initial samples, while still in the early stages of analysis, also seem to demonstrate substantial process differences between grazing treatments. The monitoring network was extended beyond Konza to complimentary sites in pastures intensively managed by the KSU Agronomy Department for beef cattle production to include sites more representative of the private ranch lands throughout the region. Temporal resolution of suspended sediment sampling was upgraded with the installation of six ISCO stormflow samplers. The ISCOS were recently deployed for a diurnal sampling campaign to evaluate temperature or time dependent fluctuations in suspended load dynamics at baseflow to test the hypothesis that grazer activity in stream channels varies with temperature and between species. This diurnal sampling campaign will be repeated when grazers are temporarily removed from the treatment watersheds during the Fall round-up. Konza LTER has partially supported one PhD student (Bartosz Grudzinski, KSU Geography) to conduct this work. A draft manuscript based on this initial cross-watershed comparative study, led by graduate student Bartosz Grudzinski, is in preparation for submission in Fall of 2012. These results were also presented at the Fall 2011 American Geophysical Union and 2012 Association of American Geographers national meetings. Daniels and Grudzinski will submit a related DDRI proposal to the NSF Geography and Spatial Sciences October 2012 RFP. Two additional Daniels graduate students are in the early phases of investigating: 1) long term hydrologic records collected at tree Konza tributary gages and the USGS Kings Creek gage, and 2) the in-channel large wood loading in the Kings Creek main stem and three ungrazed Kings Creek tributaries. Danelle Larson (ne. Russell), Bartosz Grudzinnski, Walter Dodds, Tony Joern, Adam Skibbe, and Melinda Daniels submitted a manuscript linking bison grazining to long-term sediment collections in grazed and ungrazed streams.

We added a new faculty member at Kansas State University through the Kansas Cooperative Fish and Wildlife Unit (Martha Mather). Dr. Mather and her postdoctoral researcher Joe Smith oversaw an REU student who investigated crayfish movement. Kansas State University, Civil Engineering has also added a new Assistant Professor, Natalie Mladenov. We are collaborating with her and an NSF-funded postdoctoral researcher, Janine Rueegg, to analyze the long term trends of dissolved organic carbon from LTER funded measurements.

LTER investigators Whiles, Gido and Dodds initiated an NSF Macrosystems project: Scale, Consumers and Lotic Ecosystem Rates (SCALER): from decimeters to continents. This project will help us understand how regular measurements made as part of the Konza LTER scale to entire watersheds and how such measurements and scaling applies to other sites (LUQ, CWT, ARC, BNZ). Preliminary experiments for this project were completed on Konza in 2012, and a new postdoc (Janine Rueegg) was hired. A data manager (Sufhang Jai) who will oversee data management for this project and work with the LTER network office and the KNZ information manager to make these data fit the LTER data requirements, and ultimately to allow them to be served by the LTER network office. These preliminary experiments also included an LTER REU student Adam Siders, who is investigating spatial heterogeneity in stream metabolism; a project complimentary to this research.

Continued participation in the LINX (Lotic Intersite Nitrogen eXperiment) resulted in an NSF funded workshop at Konza (Dodds and Whiles) to compare food webs of Konza streams to those in other biomes, from tropical to arctic. Analyses and modeling continues of this effort.

Groundwater Hydrology and Geochemistry
In addition our surface stream studies, we continue to monitor physical and chemical hydrogeology, including water levels, nutrients and water geochemistry under the direction of Gwen Macpherson (KU). Water levels in all wells at Konza N04D watershed and water chemistry in selected wells continue to be measured for the long-term data base; high-frequency (5-minute) data collection of water-level and temperature continues in one well. Some of the water-level data was used as part of the calibration for a new 5166 km^2 regional model, completed in 2011 under the direction of David Steward (KSU), that shows the hydrogeology of the Konza LTER site in the context of regional groundwater flow and the data will also be used by Andrea Brookfield (Kansas Geological Survey, KGS) in a regional flow model that includes the thermal response of aquifers to climate change.

Water geochemistry investigations include a KU M.S. student's (MishaTsypin) thesis research (M.S., December 2011) that has focused on soil- and groundwater chemistry and gases (CO_2), dissolved species and stable isotopes, in relation to major rainfall events. One manuscript is in press, and a second one is in draft form, waiting for more isotope data. A new effort is underway to better measure groundwater pH at the site, with support from the Konza LTER for a downhole pH sonde and from the KU Dept. of Geology for a field computer to operate the sonde, both purchased in 2011. Initial results were presented at the Geological Society of America (GSA) national meeting (October 2011). A new M.S. student (Huan Liu, started the program Fall 2011) completed the first of two sessions of field work this summer. His research is quantifying the amount of dissolved inorganic carbon (DIC) from groundwater discharge to streams that is sequestered as particulate organic carbon in a prairie stream. He is comparing Konza, summer and late fall seasons, with a karst region in China (Guilin).

An undergraduate (KU; Rachelle Warren, B.S. May 2012), under Macpherson's direction, has analyzed and compiled the chemistry of throughflow (soil water moving ~horizontally from recharge point toward streams) produced during rapid snowmelt events (RSEs); Macpherson is expanding the investigation of the micronutrient and some of the macronutrient content of the water. Two events were sampled (2009 and 2011) and climate data are being examined to assess any long-term changes that might lead to more frequent RSEs. Macpherson continues work on interpretations of elemental chemistry data from sequential chemical extractions of soil; the soil environment is the first environment encountered by water that eventually recharges groundwater, and so has a large influence on the groundwater chemistry. Macpherson also continues work to investigate the possibility of long-term trends in chemical weathering at the Konza LTER site (Macpherson, 2010), considering the long-term increase in groundwater CO_2. Macpherson is also writing a review of the history of investigations in below-ground CO_2 relevant to groundwater. These manuscripts and an unrelated project are the focus of a six-month sabbatical at the University of Pittsburgh (June – December 2012).

Remote Sensing and Fire Frequency (Doug Goodin and others) - Optical remote sensing is widely used for mapping burned area in a wide variety of ecosystems including tallgrass prairie. Typically, these remote sensing observations rely on the spectral contrast between the burn remnant and its surrounding non-burned vegetation. Numerous methods for extracting this information have appeared in the remote sensing literature, however the majority of these methods have been developed for use in forests or cropland – systems where the spectral contrast between burned and unburned is great and the contrast does not change rapidly over time. Tallgrass prairie presents a challenge for burn mapping because the burn season typically occurs just before (and in some cases at the beginning of) the active canopy season, thus the burn remnants occur against a continually changing background. In addition, the technical challenge of burn mapping in tallgrass prairie is increased because the burning season coincides with the cloudiest time of the year, and also because the burns are often rather small relative to the spatial resolution of the satellite sensors most suitable for mapping them. Addressing these problems requires a more detailed understanding of the temporal pattern of spectral reflectance of burned and unburned prairie. We addressed this problem by collecting in-situ radiometry samples from burned and unburned sites at Konza Prairie. These In situ hyperspectral radiometer samples of burned and unburned tallgrass prairie were used to simulate several MODIS bands and indices that are commonly used for burned area detection. These indices were tested for their ability to differentiate between burned and unburned areas starting at the time of burning (April) and ending in late August.

Of the existing burn indices we tested. Most showed some ability discriminate between burned and unburned sites immediately after the burn had occurred. However, the discriminant ability of most of these indices decayed very quickly. Of particular note was the fact that the Normalized Difference Vegetation Index (NDVI) a widely used data product in remote sensing, showed virtually no ability to identify burns more than a few days old. Fire-specific spectral indices such as GEMI, GEMI-B, NBR, and MODIS band 7 (LMIR), also showed little capability for differentiating burned from unburned areas longer than several days after the burn. Others, including BAI, MIRBI, and MODIS bands 3 (red), 4 (NIR), 5 (LNIR), and 6 (SMIR) were able to differentiate between burned and unburned areas well into the growing season—in some cases even through the entire length of the sample. The performance of particular bands and indices often depended on grazing and other factors that influenced pre-burn biomass.

Social Science Activities
Konza LTER investigators, led by John Harrington (KSU, Professor of Geography) continued several cross-site activities supported, in whole or part, by social science supplements to the core LTER grant. These activities included: (1) The LTER cross-site fragmentation effort (with CAP, SEV, SES, and JRN) and (2) the LTER cross-site MALs (Maps and Locals) effort. A co-authored article in Urban Ecosystems (by York et al. and available on-line first in Feb. 2011) summarized the cross-site fragmentation effort. MALs is a collaborative effort of LTER sites that seek to study changing social-ecological systems using a mixed methods comparative approach. The project was launched in 2009 through the Social Science Supplement funding opportunity of the LTER Network and a second round of funding was obtained in 2010. The objective of MALS is to: 1) use spatial representation of land cover and land use to identify patterns of landscape change in regions in and around LTER sites; and, 2) integrate Local Ecological Knowledge (LEK) and other existing social

data into theories and models of social-ecological change and their implications for human livelihoods. Forty-two interviews on LEK were obtained in the summer of 2010 and that qualitative data was the substance of Iris Wilson's Master's thesis (Perceptions of Climate and Environmental Change in Northcentral Kansas).

22nd Annual Konza Prairie LTER Investigator's Workshop.
The Konza Prairie LTER program hosted its 21st annual LTER Workshop on June 3, 2012, at the Konza Prairie Biological Station Meeting Hall (KMH). The KMH is the result of an extensive renovation of an historic limestone barn, built in 1910. Extensive remodeling of the former barn, completed in fall of 2008, created a modern and highly flexible meeting space at the field station, while preserving the historic character of this traditional early 20th-century stone building. The facility includes the Cortelyou Lecture Hall, which seats approximately 100 people and includes high-quality A/V capabilities and wireless internet access. The KMH also includes a large multi-purpose room, which includes 1,850 square feet of space that can be configured for workshops, posters and other research displays, social gatherings, and education programs. The Konza LTER workshop is an annual event that brings together senior scientists, students and staff for a day of research presentations, planning activities, and informal social interactions. These meetings are increasingly important for bringing together local and off-campus investigators. The 2012 workshop included investigators, students, staff and docents from Kansas State University, as well as researchers and students from Colorado State University, Oklahoma State University, Southern Illinois University, and Yale University. The 2012 workshop included a full day of oral presentations, featuring primarily LTER graduate students and post-docs, as well as poster presentations from graduate students and co-investigators. Topics ranged from soil and plant processes, to grassland stream ecology, to impacts of regional land-cover change. Presentations included updates on the status of ongoing LTER activities, highlights of recent research accomplishments, and planning for new experiments being implemented as part of the Konza LTER VI renewal. An LTER PI planning meeting followed the formal presentations.

Information Management.
Information management continues to be a priority for the Konza Prairie LTER program. The focus in 2012 was placed squarely on updating specific aspects of our on-line database, with emphasis on data completeness, accessibility and EML integration. In 2012, these activities were directed by Adam Skibbe (Konza LTER Information Manager) and Carol Gadbury (LTER Program Assistant and Archivist), with assistance from LTER student employees Caleb Siebel, Severin Mortensen, Jamie Ernst and Tammy Sonnentag (data enterers), Leela Anusha (programmer) and Mark Sowers (geographic information systems).

In 2012 we continued to work towards our long-term goals (assuring data integrity and security; facilitating access to datasets and metadata; enhancing the utility of data and metadata for current and future generations; ensuring compatibility with current LTER standards and best practices, and with the developing Network Information System (NIS), with added focus on preparation, and working on suggestions from the 2011 NSF site review.

As mentioned, the primary focus for 2012 has been on making the Konza IMS and data products NIS compliant. To do this we have been working towards updating our EML to ensure completeness of the metadata, adding links to data packages, and ultimately updating from version 2.0.1 to 2.1, the current standard. Additionally we have developed workflows to automatically export and store harvestable .CSV files for direct download access by the NIS on our website. Though this is an ongoing processes, we have thus far made major strides towards this goal.

A continued goal is to make all new LTER data available on-line as soon as possible, as well as continuously working towards filling in any gaps that may exist in our digital holdings. Additionally, we wish to point out that these on-line data continue to be made available to outside investigators without restriction. We continue to offer data downloads via a variety of search and browse options in the “Data” section of our website, as both ASCII text files and SQL Server download with a query option. As mentioned above, many of our data products are now also available via Metacat, the NIS data portal.

The Konza LTER IMS continues to include an up-to-date list of all Konza LTER publications including journal articles, conference proceedings, books and book chapters, theses and dissertations, and electronic publications supported by Konza LTER program. The list is searchable by key words, author name, and date. We have linked personnel with publications through a dynamic connection with our SQL Server database, making it easy for users to find specific personnel information and related publications.

Mr. Skibbe continued to collaborate with other LTER information managers on the LTERMapS network-wide online GIS mapping interface (http://www.lternet.edu/map/). Phase two of “MapS” was started in the Fall of 2011 but was put on hold in lieu of work on the GeoNIS, a value added geodatabase project to serve as the back end for LTERMapS, as well as an online repository for LTER Network geospatial data. With money from the 2011 IM supplement Mr. Skibbe attended a workshop in early 2012 to begin work on development of the GeoNIS framework, as well as best practices for archiving spatial data for harvest into the NIS.

In addition to the GeoNIS, 2012 supplement funds were used to hire additional student support staff and send Mr. Skibbe and a technician to the SensorNIS meeting last fall. The SensorNIS meeting resulted in a plan to implement a series of data workflows for both streaming and non-streaming Konza LTER datasets, an approach that will aid in QA/QC and data access. We hope to implement some of these plans in the following year.
Some 2012 hardware supplement money went towards the purchase and deployment of a series of field devices for data collection. Specifically, given the availability of data collection software, GPS, and interface with our existing data loggers we decided to deploy a series of Apple iPad and iPod touch devices with ruggedized cases. We are hoping these devices change the way much of our data is collected in the future.

The Konza LTER program has continued to work towards increasing our spatial data offerings, both in historic data as well as newly collected data, digitizing and rectifying a series of historic aerial photographs, and developing a detailed GIS of past and current research plot locations. Using high-resolution GPS unties we have collected approx. 95% of sample locations related to LTER datasets. These data will be error checked and made available via our website as datasets sometime later this fall.

In 2012, we continued to update a variety of our metadata and procedural protocols to ensure any changes in technique or structure of our datasets are accounted for. Work on our data catalog (metadata), our methods manual (techniques), as well as our data entry procedural handbook is an ongoing process. In addition, we continue to improve and build on various workflows for data processing (from field data collection through entry, and QA/QC) to support prompt data entry and updates.

Educational Activities.
Graduate student training continues to be an important component of our LTER program. During this funding period, we provided stipends and/or other support (computer, laboratory, field vehicles, etc.) for >20 graduate students. In addition to KSU students, the Konza Prairie site continues to be used by graduate students from a number of other U.S. institutions including in 2008-2012: Colorado State University (Greg Buis, Amanda Lease, David Hoover, Kevin Wilcox, Ashley, Shaw, Jenny Song), Cornell University (Rebecca Lohnes), Southern Illinois University (Ryan Klopf, Dan Whiting, Kim Erndt, Jodi Vandermyde), St. Joseph's University (Kim O'Keefe, Nick Tomeo), Yale University (Cynthia Chang, Meghan Avolio, Kimberly LaPierre, Beth Forrestel), Oklahoma State University (Wes Sprinkle, Ray West, Melinda Williamson), University of Kansas (Lisa Tiemann, Tyler Buck, M Petrie), University of Kentucky (Bridget Sousa), University of Minnesota (Charlotte Riggs), University of Missouri (Sarah Harris) and the University of New Mexico (Sally Korner), among others.

The Konza LTER program also offers research experiences for a large number of undergraduate students. In 2012, we supported 2 LTER REU students with supplements, and contributed support to the REU site program. Summer 2012 was the 17th year that Konza Prairie and the Division of Biology at K-State have offered a 10-week summer undergraduate research program. Participants in the structured program included 10 students supported by NSF-funded REU Site and Supplements, and 7 students supported by a related NSF-funded Undergraduate Research Mentoring (URM) program, being co-led by LTER investigator Ari Jumpponen.

The Konza Prairie LTER program has a strong history of providing research experiences for students from under-represented groups, which we strive to continue during LTER VI. In the past, we have participated in the ESA SEEDS (Strategies for Ecology Education Development and Sustainability) program. In 2005 we hosted two SEEDS students working on the Konza site, and in 2006, we hosted one SEEDS student. From June 4-9, 2006, the Konza Prairie LTER program hosted a SEEDS student field, which included 19 students from 16 schools across the country, including the territories of American Samoa and Puerto Rico; one SEEDS faculty from Yale University; and three SEEDS staff from the Ecological Society of America. The program for this involved field and laboratory activities that included a large number of LTER PIs and graduate students, and was well received by both ESA staff and SEEDS students. A report on the Konza field trip is available on the SEEDS web site (http://www.esa.org/seeds/fieldtrips/past.php). In 2009, one of our former REU students (Jorge Mendoza, REU in 2008) was selected for the KSU Developing Scholars Program, and paired with Konza LTER investigator Brett Sandercock as his research mentor (www.k-state.edu/media/newsreleases/jan09/mendoza11309.html). In 2010, Konza undergraduate student researcher Graciela Orozco (mentored by LTER co-PI Jesse Nippert) was selected for KSU's McNair Scholars program, which prepares underrepresented and first generation students for successful careers as graduate students, professors and professional researchers (www.k-state.edu/media/newsreleases/feb11/labtechs21511.html).

The Konza Schoolyard LTER program is the centerpiece of the Konza Environmental Education Program (KEEP), and continues to be active at both the site and network levels. Formal educational activities at the K-12 level began with the initiation of the Konza Environmental Education Program (KEEP) in 1996, and were greatly expanded with the initiation of the Konza Prairie Schoolyard LTER (SLTER) in 1998. The Konza Prairie Schoolyard LTER (SLTER) program is now entering its 15th year as an science education program for K-12 teachers and their students, built around the successful Konza Prairie LTER program. In January of 2012, Jill Haukos was hired as the new Environmental Education Program Director and in March Jan Evans was hired as the Assistant

Environmental Educator. With the arrival of the new staff our program continues to grow and develop to deliver the highest quality environmental education experience possible. Our SLTER program focuses on provides teachers with the educational resources to incorporate field biology and ecological science into their classes, an area which has not received adequate attention or resources in many school districts. All of our science activities are correlated with state and national standards. Further details on the K-12 education program are provided in the Training and Development section of this report.

A novel aspect of our K-12 education program is the development of databases on plant and animal phenology (timing of plant or animal growth and activity) from sites across the state. Students can compare the dates of first biological events for plants (flowering, senescence) and animals (adult insect emergence, mammalian activity) in regions representing varied climates and prairie types across Kansas. This database is updated annually, and allows students to look for trends and changes in emergence or bloom, which are indicative of natural climatic variability, as well as potential directional climate change (www.ksu.edu/konza/keep/phenology.asp). This activity grew out of a local effort by the Konza Environmental Education Program (KEEP) to database Konza Prairie phenological events with the help of "citizen science" volunteers. Volunteer participation in this local program has increased annually. In the future we hope to expand this program to volunteers in small communities statewide where we also have Satellite SLTER sites.

Cross-Site and LTER Network-Level Activities.
Konza LTER scientists continue to lead and participate in numerous cross-site research projects (with both LTER and non-LTER sites) and LTER Network-level activities. For example, Blair, Knapp and Smith have been regular participants in LTER planning for the future (i.e., the ISSE initiative) and many Konza scientists lead or participate in various LNO and cross-site activities (e.g., the Climate Change working group, Experiments within the LTER network, etc.). Blair chaired the 2011 Science Council meeting Planning Committee, presented at the 2011 NSF Mini-Symposium, and currently serves on the LTER Executive Board (2011-2014). Knapp chairs the publications committee, and Goodin has been a long-time participant on (and former Chair of) the LTER Climate Committee. Other contributions to LTER Network-level activities include service by John Briggs on the Network Information System Advisory Committee (NISAC), and service by David Hartnett on the US ILTER committee. John Harrington contributed to four recent LTER Network-sponsored workshops on integration of social and ecological sciences, and several Konza scientists have had an active role in the EcoTrends project. Konza LTER investigators Knapp and Smith were contributors to the 2012 BioScience issue commemorating the 30th anniversary of the US LTER Network. Konza LTER scientists and students are participants in the Nutrient Network (NutNet) Global Research Cooperative (locally led by M. Smith). There are numerous other examples of cross-site research activities being led by Konza LTER scientists.

The Konza LTER site also continues to be used by researchers from other sites and institutions for a variety of cross-site comparisons. Examples of recent and ongoing studies being done at the Konza Prairie LTER site include:

- assessing the role of evolutionary trade-offs in enzyme activities in microbial community function, led by Mark Bradford (Yale), Noah Fierer (U Colorado) and Rebecca McCulley (U Kentucky)

- a cross-site comparison of soil microbial-plant interactions in fertilized and unfertilized soil, led by Katie Suding (UC Berkeley)

- isotopic approaches to separate heterotrophic and autotrophic sources of soil CO_2 and their responses to warming and altered precipitation in grassland ecosystems, led by Dr. Weixin Cheng (UC Santa Barbara)

- studies of the patterns and controls of soil black carbon storage, a multi-site study directed by Johannes Lehmann (Cornell University);

- studies of trace gas flux from mesic grasslands led by Emily Elliott (U of Pittsburgh)

- stable isotope studies of litter decomposition directed by Francesca Cotrufo (Colorado State University);

- studies of soil microbial community composition, C cycling and responses to altered precipitation patterns, a multi-investigator project directed by Dave Myrold (U of Oregon);

- studies of the role of dissolved organic C in streams from a range of ecosystem types, directed by Dr. Rudolph Jaffee (Florida International University)

- a cross-site study of methane uptake rates and the identity of methane oxidizing bacteria, led by Dr. Joe van Fischer (Colorado State University)

International Collaboration

Konza LTER scientists remain active in a variety of international collaborative efforts. For example, Konza LTER scientists and scientists from South Africa are conducting collaborative studies of ecological responses to fire and grazing in North American and Southern African grasslands [J. Blair (KSU), M. Smith (Yale), Alan Knapp (CSU), Scott Collins (UNM) and collaborators in South Africa (Kevin Kirkman and Richard Fynn at the University of KwaZulu-Natal, Pietermarizburg)]. In 2009, Konza LTER co-PI Jesse Nippert used support from the Provost's office at K-State to initiate a new collaboration with Dr. Tony Swemmer at the South African Environmental Observation Network (SAEON) in Phalaborwa, South Africa. SAEON supports a long-term network of *in-situ* environmental observation monitoring and data collection, the equivalent of NEON in the United States. In 2010, Nippert was awarded an international supplement to our core LTER grant to continue and expand these studies on the impacts of woody plant encroachment into South African grasslands, which complements similar work being done at Konza, and in 2012 he continued and expanded that work. Konza co-PI David Hartnett maintains collaborations with colleagues in Botswana, and has supported exchanges of graduate students there. Hartnett and students continued their studies of the comparative population ecology of grasses of North American grasslands and southern African savannas, with a return sampling trip in June 2012. A study of patterns of belowground bud banks, root system architecture, and mycorrhizal symbiosis in 18 southern African semi-arid savanna grasses is currently in progress. A novel finding of this research is that, in some African grasses, mycorrhizal fungi and fungal exudates form a protective sheath around roots, and sheath thickness appears to increase with increasing aridity. This may be an important trait increasing the drought-tolerance of grasses in increasingly arid environments. Hartnett led a summer study-abroad field course on the "Ecology of African Savannas" in 2009 and 2012, providing international field experience for both KNZ-LTER graduate students and undergraduates and in 2010 published a paper in the Bull. Ecol. Soc. Amer. entitled "Into Africa: Promoting international ecological research and training in the developing world". In addition, Hartnett and Joern are Co-Directors of the Institute for Grassland Studies at KSU, which promotes international collaborative research on grassland ecology. In 2010-12, Konza LTER scientist Brett Sandercock continued a collaborative study (funded by an LTER international supplement) with scientists in Uruguay to assess population dynamics of a migratory grassland bird (the Upland Sandpiper) in its northern and southern hemisphere ranges. In 2009, Konza Prairie LTER Scientists were invited to China to consult on grassland and herbivore studies (Joern) and to participate in an international conference (Blair and Knapp) organized by the Chinese Academy of Sciences, and in 2010 Konza supported reciprocal visits from 4 Chinese scientists. Konza Prairie continues to host numerous visits by international scientists and students, including (in 2008-12): Dr. Marjan Jongen of the Instituto Superior de Agronomia, Lisbon, Portugal; Matilde Alfaro-Barrios of Averaves-Investigación y Conservación, Uruguay; Dr. Shuguang Hao (Chinese Academy of Sciences); Dr. Yingzhi Gao (Northeast Normal University); Dr. Nianpeng He (Director, Inner Mongolian Grasslands Ecosystem Research Station), and Dr. Xin Xiaoping (Director, Hulunber Grassland Observation and Research Station); Juergen Kreyling, University of Bayreuth, Germany. The Konza LTER program also provides on-site research opportunities (as well as logistic and/or financial support) for graduate students from a number of international venues (e.g., in 2008: Elske Koppenaal, Groningen University, The Netherlands. In 2009: Nicholas Zaloumis, University of Cape Town, South Africa).

Konza Prairie hosts Grasslands in a Global Context Symposium

On September 12-14, 2011, Kansas State University hosted an international symposium entitled "Grasslands in a Global Context" to celebrate two important milestones for the Konza Prairie Biological Station (KPBS) and the Konza Prairie Long-Term Ecological Research (LTER) program (KNZ) - 40 years since the establishment of KPBS as a biological research station and 30 years since the initiation of the Konza LTER program. In that time, KPBS and the associated KNZ LTER program have grown into a world-class grassland ecological research facility and program, which supports the research activities of scientists and students from institutions across the US, as well as collaboration with international scientists from around the word. Over 1,100 articles in multiple scientific journals and books, and more than 230 student theses and dissertations, have been published based on research at KPBS. In addition to far-reaching scientific impacts, results from Konza research have contributed to grassland management and governmental policy decisions, and are highlighted in a growing number of textbooks. To celebrate these milestones, we invited internationally-recognized leaders with extensive experience in multiple grassland ecosystems and paired them with current KNZ LTER investigators, with the goal of developing a current, comparative synthesis of grassland/savanna ecosystems based on a comparative analysis of studies at Konza Prairie and grasslands in different regions and with different climates and evolutionary histories. This synthesis was aimed at synthesizing key findings from 40-years of research in tallgrass prairie at the KPBS and comparing these to studies in other grass-dominated ecosystems, with the goal of identifying generalities in the structure and function of grassland and savanna ecosystems around the globe, recognizing continental level differences of critical importance, while identifying significant research gaps that can drive future studies. The symposium included approximately 200 participants. In addition to KNZ LTER scientists from multiple institutions, invited speakers and panel members included Osvaldo Sala (U of Arizona), Peter Adler (Utah State U), Sally Archibald (CSIR, South Africa), William Bond (U of Capetown, South Africa), David Briske (Texas A&M), Doug Frank (Syracuse U), Sam Fuhlendorf (Oklahoma State U), Nancy Grimm (U of Arizona), Richard Hobbs (U of Western Australia), Herbert Prins (Wageningen U, The Netherlands), Bob Scholes (CSIR, South Africa), David Tilman (U of Minnesota), and Shiqiang Wan (Henan U and CNAS, China). The three-day symposium included presentations on a wide range of ecological process and dynamics in both terrestrial and aquatic grassland communities and ecosystems. A critical feature of the conference was grouping presentations by thematic area, with local and international speakers paired to maximize our ability to recognize key similarities and differences in the drivers that affect grassland structure and functioning globally. In addition to oral presentations and panel discussion, there were over 60 poster presentations, and numerous opportunities for informal interactions among meeting participants.

Konza-Related Extramural Grants (not including LTER funding) active during the current reporting period (2011-2012)

Baer, S.G., J.M. Blair and S.L. Collins. 2012-2017. Collaborative Research: LTREB: The role of ecological heterogeneity in a long-term grassland restoration experiment. NSF LTREB Program $450,000.

Blair, J.M. and A.K. Knapp. 2007-2011. Collaborative Research: Interactive effects of altered rainfall timing and elevated soil temperature on soil communities and ecosystem processes. DOE National Institute for Climate Change Research, $502,552.

Blair, J.M., A.K. Knapp, S.L. Collins, P.A. Fay and M.D. Smith. 2005-2011. Collaborative Research: LTREB long-term ecosystem responses to more extreme precipitation patterns and warming. NSF LTREB Program, $300,000.

Briggs, J.M., D.C. Hartnett and E.A. Horne. 2011-2014. FSML: Expanding lodging capacity for visiting researchers at the Konza Prairie Biological Station for the enhancement of research and training opportunities. NSF FSML program, $238,030.

Cheng, W. 2009-2011. Separating sources of soil CO_2 and their responses to warming and altered precipitation in a grassland ecosystem. DOE National Institute for Climate Change Research, $246,273 (University California – Santa Barbara).

Craine, J.M., Fierer, N., and McLauchlan, K.K. 2008-2011. Testing the consequences of the carbon-quality temperature hypothesis for soil organic matter decomposition. NSF Ecosystems Program, $437,157.

Dodds, W.K, and D. Andreson. 2009-2012. Collaborative Research: EPSCoR R 11 Track 2 Oklahoma & Kansas: A cyberCommons for Ecological Forecasting. NSF EPSCoR, $1,608,168 (KSU portion).

Dodds, W.K., K. Gido, F. Ballantyne, W. Wollheim, A. Helton, M. Whiles, A. Rosemond, J. Kominoski, W. Bowden, M. Flinn, J. Jones, T. Harms, and W. McDowell. 2011-2016. Collaborative Research: Scale, Consumers and Lotic Ecosystem Rates (SCALER): Centimeters to continents. $ 1,198,082 (KSU portion).

Hartnett, D.C. 2011. Development of Southern Africa-KSU research and teaching partnerships in grassland/savanna studies. KSU OIP International Incentive Grant, $2,300.

Hartnett, D.C. 2012-2013. Ecology, distribution, and management of the invasive plant species *Prosopis glandulosa* in Botswana. UB-ORD Botswana Department of Research and Development, $72,774.

Herman, M.H. 2009-2011. EAGER: Studies of native grassland soil nematodes to develop genomic approaches to study community responses in non-model taxa. NSF, $40,000.

Joern, A., J.M. Briggs, D. Goodin, A. Skibbe and E.G. Towne. 2010-2013. Impacts of spatially heterogeneous nitrogen on grazer distribution and activity: Effects on ecosystem function in tallgrass prairie. NSF, $750,000.

Joern, A. and D.C. Hartnett. 2008-2011. Enhancing excellence in grassland ecology: a center for basic grassland research at KSU. KSU Provost's Targeted Excellence Program, $515,000.

Johnson, L.C., S.G. Baer and others. 2008-2011. Ecotypic variation and functional response of an ecologically dominant species across a precipitation gradient and in response to altered precipitation: Test for local adaptation and ecosystem function. USDA Plant Biology and Abiotic Stress Program, $394,439.

Johnson, L.C., B.K. Sandercock, M.A. Herman and A. Joern. 2009-2012. Ecology, evolution, and genomics in changing environments. Graduate Assistance in Areas of National Need (GAANN), Department of Education, $783,936.

Jumpponen, A. and M.A. Herman. 2011-2016. Undergraduate research and mentoring in ecological genomics. NSF Biological Infrastructure URM Program, $749,919.

Knapp, A.K., M.D. Smith, S.L. Collins, W.T. Pockman and Y. Luo. 2012-2017. Collaborative Research: Grassland sensitivity to climate change at local to regional scales: assessing the role of ecosystem attributes versus environmental context. NSF Macrosystems Biology $3,755,556 (U Colorado, U New Mexico, and U Oklahoma)

Koerner, S. and S.L. Collins. 2009-2011. Dissertation Research: Effects of global climate change, loss of mega-herbivore biodiversity, and altered fire regimes on savanna grassland ecosystems. NSF DDIG Program, $14,860.

McKane, R.B. 2009-2011. Development of a decision support framework for assessing the effects of land management decisions on ecosystem services in the central Great Plains region-an EPA Region 7 Regional Applied Research Effort. USEPA Office of Science Policy, $50,000.

McLauchlan, K.K. and S. Sugita. 2008-2010. Improving reconstructions of open vegetation in North America: pollen productivity estimates for grassland plants. NSF Geography and Regional Science Program, $90,005.

McNew, L.B., J.C. Pitman, and B.K. Sandercock. 2010-2013. Impacts of alternative grassland management regimes on the population ecology of grassland birds. Pittman-Robertson Act Funding, Kansas Department of Wildlife and Parks, $633,626.

McNew, L.B., B.K. Sandercock, and J.C. Pitman. 2012-2014. Effects of the Conservation Reserve Program (CRP) State Acres for Wildlife Enhancement (SAFE) Program on bird populations in Kansas. Kansas Department of Wildlife and Parks, $159,004.

Myrold, D., A. Jumpponen, P. Bottomley, N. Verberkmoyer, J. Jansson, and S. Tringe. 2010-2013. Meta-"omics" analysis of microbial carbon cycling responses to altered rainfall inputs in native prairie soils. DOE-BER, $563,729.

Sandercock, B.K., and A. Jumpponen. 2009-2012. REU Site: Ecology, evolution and genomics of grassland organisms. NSF REU Program, $210,720.

Sandercock, B.K., and S.M. Wisely. 2009-2011. Environmental impacts of wind power development on population biology of Greater Prairie-Chickens. U.S. Department of Energy, 20% Wind Energy by 2030 Program, $299,998.

Smith, M.D. 2009-2012. Bridging the divide: Linking genomics to ecosystem responses to climate change. Department of Energy, Program in Ecosystem Research, $372,505.

Smith, M.D. and C. Chang. 2010-2011. Dissertation Research: The relative importance of species, genotype, and trait diversity on ecosystem function of the tall grass prairie under varying environmental conditions. NSF, $14,877.

Smith, M.D., A.K. Knapp, S. Collins, and J.M. Blair. 2009-2012. Convergence and contingencies in savanna grasslands (renewal). NSF, $807,000.

Snyder, B.A. and T.J. Morgan. 2012-2014. Research Experiences for Undergraduates (REU) Site: Undergraduate Research in the Ecology and Evolution of Changing Environments: Mechanisms to Responses. NSF Biological Infrastrcuture REU Program, $287,622.

Whiles, M.R., W.K. Dodds, and S. Johnson. 2010-11. Workshop: Use of ^{15}N tracer addition datasets to quantify and synthesize relationships between stream biodiversity and ecosystem function across environmental and hydrologic gradients. NSF Ecosystems program, $47,790.

Wilcox, B., S. Archer, J. Briggs, D. Elmore, S. Fuhlendorf, W. Polley, C. Hart and B. Wu. 2010-2011. Sustaining rangelands in the southern Great Plains in the 21st Century: Adapting to and mitigating for climate change. USDA AFRI Competitive Grants Program, $50,000.

Wisely, S.M., and B.K. Sandercock. 2009-2011. Environmental impacts of wind power development on population biology of Greater Prairie-Chickens. State Wildlife Grants Program, Kansas Department of Wildlife and Parks, $145,150.

Zolnerowich, G. 2011-2014. Enhancing BiodIS, the Kansas State University Biodiversity Information System. Institute of Museum and Library Services (IMLS) Museums for America-Collections Stewardship program, $150,000.